ANALYSIS OF BREEDING POTENTIAL OF CERTAIN INDUCED MUTANTS OF GROUNDNUT (*Arachis hypogaea* L.) FOR CANOPY AND REPRODUCTIVE ATTRIBUTES

BY

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CERTIFICATE

Miss.G. VANISREE has satisfactorily prosecuted the course of research and that the thesis entitled **ANALYSIS OF BREEDING POTENTIAL OF CERTAIN INDUCED MUTANTS OF GROUNDNUT (*Arachis hypogaea* L.) FOR CANOPY AND REPRODUCTIVE ATTRIBUTES** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the thesis or part thereof has not been previously submitted by her for a degree of any university.

Date: 11-5-1992

(Dr.M.V.R.PRASAD)
MAJOR ADVISOR

CERTIFICATE

This is to certify that the thesis entitled **ANALYSIS OF BREEDING POTENTIAL OF CERTAIN INDUCED MUTANTS OF GROUNDNUT** (*Arachis hypogaea* **L.) FOR CANOPY AND REPRODUCTIVE ATTRIBUTES** submitted in partial fulfilment of the requirements for the degree of **DOCTOR OF PHILOSOPHY** of the Andhra Pradesh Agricultural University, Hyderabad, is a record of the bonafide research work carried out by **Miss.G. VANISREE** under my guidance and supervision. The subject of the thesis has been approved by the Student's Advisory Committee.

No part of the thesis has been submitted for any other degree or diploma. The published part has been fully acknowledged. All the assistance and help received during the course of investigations have been duly acknowledged by the author of the thesis.

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G. Vanisree

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DECLARATION

I, **G. VANISREE** hereby declare that the thesis entitled **ANALYSIS OF BREEDING POTENTIAL OF CERTAIN INDUCED MUTANTS OF GROUNDNUT (*Arachis hypogaea* L.) FOR CANOPY AND REPRODUCTIVE ATTRIBUTES** is a result of the original research work done by me. I further declare that the thesis or part thereof has not been published earlier elsewhere in any manner.

G. Vanisree

Date: 11-5-1992 **(G. VANISREE)**

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ABSTRACT

In the present investigation, on the breeding potential of certain induced mutants of groundnut for canopy and reproductive traits, eighteen groundnut genotypes differing in canopy development were categorised into compact (1), medium compact (2), medium spreading (3) and spreading (4) based on DMRT (Duncan's Multiple Range Test). It was observed that the most compact canopy type (category 1) pertained to sequential branching and the most spreading (category 4) was of alternate branching, while intermediate types (categories 2 and 3) fell in both sequential and alternate branching types, suggesting that canopy compaction formed an important factor for genetic differentiation at sub-specific level in groundnut.

The study revealed that higher dose of nitrogen at the rate of 40 kg/ha supplied as 20 kg as basal and 20 kg as top dressing and 60 cm inter-row spacing could be adopted for better expression of the genetic potential of groundnut genotypes in groundnut breeding programmes. It was also found that the induced mutants representing the intermediate levels of canopy development isolated from parents of extreme canopy types could form tools for breeding for stability of yield performance.

The crosses involving 2x3 as well as 3x3 canopy combinations exhibited significantly higher levels of heterosis indicating that the intermediate levels of genetic divergence were more conducive for recovery of higher levels of heterosis in groundnut. The genetic manipulation of inappropriate canopy of parental material by the way of induced mutants for intermediate

canopy development resulted in the perceptible jump in heterosis and also exhibited wider degrees of variances in F_2 generation. Some agronomically superior segregants were isolated for further use in groundnut breeding.

Genetic analysis of the branching attribute indicated that alternate branching was dominant over sequential branching and segregated in monogenic fashion in F_2. A cross between two mutants with morphologically similar canopy attributes such as narrow leaf and alternate branching characters revealed that these two were genetically dissimilar giving a segregation for branching pattern and leaf shape in F_2. The F_2 segregation pattern of crosses involving aerial podding varied with the branching pattern of the other parent involved. While crosses involving sequential parents and TAP5 showed a F_2 segregation ratio of 3 aerial podding : 1 normal, the crosses of TAP5 with alternate branching showed F_2 ratio of 1 aerial podding : 3 normal. Inheritance of canopy compaction revealed that the trigenic segregation pattern in F_2 was found largely in extreme parental canopy combinations and digenic segregation in crosses with intermediate parental canopy combinations as well as extreme canopy types, while monogenic segregation pattern was observed in only intermediate parental canopy combinations.

The mutational rectification of specific defects of TAP5 an aerial podding genotype resulted in the isolation of slow senescent, alternate branching and other high yielding mutants of TAP5. The occurrence of higher degree of variances in M_2 as compared to M_1 and M_3 generations suggested that TAP5 (sequentially branched Valencia type) had probably attained genetic diploidization with disomic genetic behaviour. The study also revealed that NaN_3 was more effective than EMS, while the EMS was more efficient than NaN_3.

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INTRODUCTION

CHAPTER I

INTRODUCTION

Groundnut plant (*Arachis hypogaea* L.) is exotic to India, having been introduced into the country around 200 years ago by Spanish and Portuguese explorers (Hammons, 1973a). Since then the Indian groundnut cultivation made rapid strides and the crop, despite its meagre diversity has now come to occupy an area of over eight million hectares, thereby creating its own agro-ecological niche largely covering the semi-arid tract of the country (Rao, 1976).

Not-withstanding the history of over sixty years of groundnut breeding in our country, it may be observed that there did not exist any significant genetic improvements for productivity per se among the 'improved cultivars' as compared to the 'local varieties' (Rao, 1976 and Prasad, 1992). Studies carried out by Duncan *et al*. (1978) and more recently by Wells *et al*. (1991) have conclusively shown that even in the United States a long innings of groundnut breeding has only resulted in marginal improvements in productivity largely through the enhanced partitioning of the assimilates to the sink, and not due to growth rate of the crop. This predicament could not be explained better than the observations of Gregory *et al*. (1973) based on a critical insight into the genetic nature of groundnut plant revealing that the extent of genetic variability available in the cultivated groundnut was rather narrow in relation to the requirements of man and that the exploitation of variability at the inter-specific level and induction of gene mutations for wide range of agronomic attributes could be the major approaches to overcome the genetic vulnerability (Hammons, 1976) of cultivated groundnut.

While mutation breeding has been one of the areas of groundnut improvement in India (Patil, 1978; Patil and Mouli, 1978, 1979; and Mouli **etal.**, 1979), it is yet leave its significant impact on groundnut productivity. However, in the recent years the availability of impressive array of new and novel groundnut mutants for canopy development including branching and leaf type on the one hand (Prasad et al., 1984 and Prasad, 1988) and aerial pod development (Prasad, 1985) on the other has provided the needed opportunity to evaluate (a) their breeding utility including inheritance pattern of the mutant allele(s) involved and potential and under take (b) the mutational rectification of certain specific genetic defects of the aerial podding mutant which otherwise would open-up immense potential for groundnut breeding as observed by Wynne and Gregory (1981), more particularly in the light of new knowledge gained with regard to (1) the efficacy of certain canopy based alternate selection criteria for stable productivity and (2) selection of parental genotypes conducive for the recovery of wider degrees of variances down the generations (Nagabhushanam and Prasad, 1992). Hence, the present investigation results of which are presented and interpreted in this thesis.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

2.1 HISTORY OF GROUNDNUT BREEDING

Groundnut breeding, though started as early as 1910, was not pursued with any degree of persistence and was therefore made no spectacular headway as in the case of maize or wheat. This was partly due to the nature of the crop and to the sporadic attempts by workers in different countries. Gregory et al. (1951) in reviewing the previous work on the subject had summed up the position as under : "In reporting the published work on peanut breeding and genetics we have been unable to unfold a sequence of events or to build a co-ordinated body of knowledge. Culminating in recent advanced studies logically derived from the results of previous experiments. Instead we have attempted to preserve the mosaic of unrelated patterns.....".

Van der Stok (1910) was the first to start breeding work on groundnut in Netherlands and East Indies. He was able to isolate a number of pure-lines from the cultivated variety by selection of single plants. He explained the multiplicity of types in land races as due to hybrid variability caused by chance-cross fertilization. Selection of kernels in pod showed that it was not possible to say that forms with a smaller number of seeds per pod will have a higher yield percentage than forms with a smaller number of seeds per pod. Based on detailed studies for a number of years, Badami (1930) stated that preliminary selection should be based on plants with the largest number of mature pods and the final selection on the highest weight of seeds per plant.

In America, early breeding work on groundnut was done in Florida and the results were reported by Stokes and Hull (1930). They found that the existing types did not combine the desirable characters like seed dormancy, erect plant type, large seed, dark green foliage, light tan seed with high or low oil content and stated that such types could only be produced by hybridization. Umen (1933) based on breeding work conducted in the USSR since 1926, reported that pureline selection did not yield very favourable results and considered hybridization as essential.

Bolhuis (1938) reported that line selection was successful and 'Schwartz 21', a type highly resistant to the slime disease and with high yield was evolved. He enumerated high yield, resistance to slime disease, erect foliage, large seeds, pods with more than two seeds, only slight or no constriction and early ripening as the chief aims in groundnut selection. He stated that since further increase in yield seems unlikely, future breeding will probably be concentrated on selection of large pods and early maturity from hybrid material.

Higgins _et al_. (1941) reported that by hybridization and selection,many promising strains were isolated and hybridization between peanut varieties gave rise to a great multiplicity of plant and nut types often quite different in many characteristics from either parent, thereby offering scope for selection. Hull and Carver (1945) were of the opinion that the desired tyes could not be obtained except by resorting to hybridization and also a very large population of progenies would be required for selection of the desired types.

Bouffil (1947) after years of work at Senegal on the improvement of varieties by breeding stated that selection based on external botanical characters and characters like number of pods per plant, the mean weight of a plant, etc., was unsuccessful. It was reported that at present breeding was based on the heredity of the morphological characters of the pod and on the weight of 100 seeds. Darlington (1948) indicated that there was a large scope for enriching the available variation in groundnut by crossing the cultivated groundnut, which was tetraploid with the wild diploid species.

Gregory et al. (1951), based on the breeding attempts made in North Carolina, concluded that hybridization was necessary for the success of practical groundnut breeding. Seshadri (1956) emphasised that improvement of quality in groundnut could be achieved only through hybridization.

Norden (1973) indicated that the possibilities for groundnut improvement by introduction and selection without hybridization were practically exhausted in the USA. According to him, success in breeding through hybridization depends on the availability of transferable genetic variation and will be more likely if the objectives are clearly defined, the correct parents are selected and the hybrid populations are managed properly.

Although groundnut was introduced into India in the 16^{th} century, no systematic attempt in crop improvement was made till the beginning of the 20^{th} century. The department of Agriculture in Mysore was the first in India to start intensive work on the groundnut crop. From 1913 onwards breeding work was taken up at the Agricultural Farm, Hebbal (Bangalore). Similar work on groundnut was started in Madras state with the opening of a Groundnut Research Station at Palakuppam in 1926. Even prior to this, many foreign varieties were imported and tested in the College Farm at Saidapet and at the Agricultural Research Station, Palur, Wherefrom varieties were supplied to Mysore. Subsequently groundnut improvement work was initiated in Punjab, Bombay, Madhya Pradesh and other states.

During the last 80 years, about 85 improved varieties were recommended for cultivation in different groundnut - growing states. Except for "Spanish Improved", the information about the cultivars recommended during the first 3 decades was not well documented. The first attempt to compile the information on the recommended groundnut varieties was made by Ramanamurthy (1974). This document, however, did not give the details about the year of release, centre of origin and pedigree but listed the older varieties recommended for cultivation. Since such details were available for varieties released from 1930 onwards, which number 60 till the end of 1986, it was likely that the older varieties numbering about 25 were developed during the first 3 decades. These varieties were either direct introductions or selections from the introduced stocks. Out of the 60 groundnut varieties released from 1930 onwards, 3 belonged to the Valencia botanical group, 25 to Spanish - bunch group, 17 to Virginia - bunch group and 15 to Virginia runner group. All the methods of breeding common to the self-pollinated crops were employed in the breeding of these varieties. Two varieties were introductions ('Kadiri-2' and 'UF 70-103'), 2 resulted from mass selectin ('TMV1' and 'TMV2'), 34 from pureline selection, 18 from hybridization followed by pedigree method of selection, and 4 from mutation breeding (BG1, BG2, TG1 and Co2) (Basu and Reddy 1987). Up to 1960 no attempt was made to improve the crop through recombination breeding. The first cross derivative, 'C501', developed at Ludhiana was released in 1961. With the advent of All-India Co-ordinated Research Project on oilseeds (AICORPO), work on the hybridization projects was intensified which resulted in the release of 17 more varieties evolved through recombination breeding. However, it has been observed that most of the 'improved varieties' were not significantly superior to the traditional 'local' varieties in terms of productivity. Therefore, sofar, it has not been possible to break the barriers to productivity through breeding (Rao, 1976).

Hybridization and selection among the cultivars is now the most common method used to obtain improved groundnut cultivars (Norden, 1980). Therefore, the available Spanish/Valencia and Virginia types should be carefully analysed for various attributes contributing to yield and related characters, resistance etc and extensive hybridization work between Spanish - Virginia crosses could be most rewarding. Handling of such crosses need not be confined to conventional hybridization and selection methods. An organised programme could take recourse to mass intermating of segregating progenies. Various mating systems could be conceived. Three-way and multiple crosses were likely to be more rewarding than single crosses. Some quantitative genetic work involving single, three-way and double crosses could provide useful guidelines and were strongly recommended (Rao, 1976).

In India, progress in groundnut breeding through hybridization is slow. Several reasons have been ascribed for such a slow progress : difficulty in hybridization and the poor productivity of seed per plant (Venkateswaran, 1980), restricted recombination and hereditary instability (Ratnaswamy, 1980), poor percentage of pod setting after effecting crosses (Tangavelu *et al*., 1980), smaller size of F_2 populations (Reddi, 1980), genetic problems arising out of the segmental alloploid nature and absence of appropriate selection criteria due to lack of clear-cut relationship between canopy characters and yield components (Prasad and Kaul, 1980 and Prasad *et al*., 1984).

From the review of breeding work in India and abroad given above, it would be seen that opinion was rather divided as to the utility of pureline selection in effecting improvement of the groundnut crop. Instances were not wanting to show that this line of improvement pursued by some workers notably in the United States and India was actually helped in the production of high yielding strains with desirable features like bold seed, high oil content and shelling out-turn, etc. When the nature of material handled by workers in different countries were studied, it would become evident that the results were not satisfactory when the source of original supply of seeds was not of diverse origin, because the variation in the material handled was very small. But in cases where such work was attempted with material drawn from numerous sources, fairly satisfactory progress was reported, not only in effecting improvement in yield but also in other qualitative characters (Seshadri, 1962).

With regard to usefulness of undertaking hybridization work for evolving forms with desired plant characters, it was the experience of most of the workers that unless a very large number of progenies of crosses involving suitable parents with adequate genetic diversity was studied there was no prospect of spotting out plants with the desired combination of characters (Seshadri, 1962). This was specially the case when characters involving multiple genes were sought to be transmitted to types which were otherwise desirable. This procedure is all the more necessary for a crop like groundnut which, as stated by Gregory et al.

(1951) "is for all practical purposes hundred per cent inbred, difficult to cross and productive of so few seeds per plant".

It was the opinion of a number of workers in evolving forms resistant to pests and diseases, that marked improvement may not be possible as resistant forms were not found among the cultivated varieties for use in hybridization work. Under such conditions, the only way was interspecific hybridization. Seshadri (1956) emphasised the paramount need to switch over attention to improvement of quality features in groundnut and indicated how this could be achieved through hybridization. Darlington (1948) stated that "perhaps they will open the way to improved varieties from interspecific crosses in this plant which hitherto has been so unresponsive to improvement through the ordinary methods of cross-pollination and selection". For ensuring good results from hybridization in groundnut, Gregory et al. (1951) suggested that "peanut breeder must not only increase the precisions of estimating genetic differences within segregating populations but also must overcome the sterility barriers between the various species of peanuts, gather fundamental biological information on the structure and physiology of the peanut and its relatives and relate these to the problem of improvement through selection".

The main goal for the improvement of groundnut crop in developing countries is larger and more stable yield. Study on interrelationships between canopy characters, physiological attributes and yield components is very much necessitated in order to reach the goal (Rao, 1976). The improvement in the yield of cereals in developing countries has come in part from selection for a different morphological and physiological pattern of growth; also from selection for wider adaptation and more stable yields in adverse environments (Swaminathan, 1975). Hence the breeding objective from the physiological stand point should be to select the new cultivar for the expected length of the particular growing season to which it will be adopted and to use the largest possible proportion of the available growing season for pod filling (Mc Cloud et al., 1980).

In India, where groundnut is extensively cultivated under rainfed conditions, breeding for stability in performance accompanied by resistance to drought gains importance. Hence incorporation of environmental stability and wide adaptability while retaining genetic diversity should be the key feature of the groundnut breeding programme (Hammons, 1976). The instability of the cultivated groundnut particularly for yield is one of the main problems facing the groundnut breeders. For selecting varieties with wider adaptability, studies on variety x environment interactions will be very useful. Well buffered cultivars, with small genotype x environment interactions are usually desired. Stability of yield over seasons and throughout a wide geographical area are important attributes of a commercial peanut cultivar (Reddy, 1988).

2.2 STABILITY OF PERFORMANCE

Wessling (1966) studied the reaction of Spanish, Valencia, Virginia bunch and runner varieties and strains to wet and dry growing seasons in Brazil. He found that the Spanish-Valencia types grew best during the wet seasons, but they were unable to maintain their superiority over the other types during dry season. The Virginia bunch types were least affected by climatic conditions unless at extremes. He concluded that the runner types were divisible into 2 groups, one reacting similarly to the Spanish-Valencia types and the other to the Virginia bunch types.

Chen and Wan (1968) measured the genotype x environment interaction in Taiwan using 13 groundnut cultivars grown at 10 locations for 2 years. Both cultivar x year and cultivar x location interactions were small for yield; but the cultivar x year x location interaction was highly significant.

Ojomo and Adelana (1970) in a study of cultivar x environment interaction with 16 cultivars grown at 3 locations for 3 years in Western Nigeria found significant both cultivar x location and cultivar x year x location interactions.

Joshi et al. (1972) measured the stability of bunch cultivars and local standard at 7 environments in Gujarat. Cultivars showed stability in all environments for yield. One genotype released for cultivation as 'J11' performed consistently well in both poor and good environments.

Ojeda (1973) observed a significant sowing date x variety interaction in groundnut yield trials during 1967 season in Argentina. Wynne et al. (1973) studied 6 groundnut lines representing the 3 botanical groups under 2 short-day photoperiodic treatments. They found the characters related to flowering and fruiting were great ly different under short-day treatments than under long-day treatments.

Singh et al. (1975) tested 8 promising spreading varieties of groundnut in 4 environments of Punjab. Pooled analysis of variance for pod yield showed that the mean differences between the genotypes and genotype x environment interaction component were highly significant. Both the environment (linear) and genotype x environment (linear) components of variation for stability were highly significant. The differences in stability were mainly due to the linear regression. The 'M13' had average stability and high level of performance for pod yield and hence it was considered as an ideal variety in the material studied.

Sangha and Jaswal (1975) studied 12 groundnut varieties for 2 years at 4 locations. The performance of varieties in different years was quite uniform but was inconsistent at different locations. The small and non-significant variety x year interaction indicated that the performance of different varieties in different years was quite similar and suggested that little would be gained by testing the varieties for more than 2 years.

Marenah and Anderson (1977) observed in a trial of 6 varieties during 1973-75 that 'NC15' gave the highest pod yields with or without fungicide application. 'Shulamit' and 'NC17' showed the highest increase in pod yields following fungicide applications.

Sandhu and Khehra (1977) evaluated the parental F_1, F_2, F_3, BC1 and BC2 generations of 'C 501' x 'AK 12-24' and 'C 501' x 'Ah 6595' at 2 locations. A significant genotype x environment interaction was found for pod yield, 100 - seed weight and length of primary and secondary branches but not for the number of primary branches and number of mature pods.

Nur and Gasim (1978) conducted 4 trials during 1969-73 with 5 varieties representing upright bunch, spreading bunch and runner types which were sown on 1^{st} June, 1^{st} July and 1^{st} August. Early sowing resulted in high pod yield but reduced shelling percentage. All the characters studied showed significant variety x sowing date interactions. 'MH 383' was the highest yielding variety at each sowing date.

Tai and Hammons (1978) found large and significant cultivar x location x year interactions and small, year x cultivar and location x cultivar interactions for groundnuts grown in 2 - year field trials, in respect of pod yeld, percentage of sound matured kernels, extra large kernels, and fancy - sized pods and 100 - kernel weight.

Williams et al. (1978) reported that data from 26 trials with 3 - 4 varieties indicating that varieties reacted differently to environment, some varieties being superior under cool - cloudy conditions and the others under warm, sunny - conditions. The cultivars were sensitive to changes in the environment before the fruit filling than during the actual fruit filling phase.

Wynne and Isleib (1978) estimated genotype x environment interactions in 9 Virginia cultivars in 2 separate studies for five years. Both cultivar x location and cultivar x year interactions were small when compared to the variation among cultivars. They concluded that no advantage could be gained by subdividing the production area into subareas for breeding or testing purposes.

Wynne and Sullivan (1978) determined the influence of environment on seedling emergence for 8 Virginia groundnut cultivars in North Carolina in replicated tests conducted at 5 locations over a 3 - year period. Both cultivar x year and cultivar x location x year interactions were significant.

Yadava and Kumar (1978a) studied 11 varieties in 3 environments for phenotypic stability of pod yield, shellig percentage, 100 - seed weight and oil content. The magnitude of the linear component of the genotype x environment interaction was high for pod yield, 100 - seed weight and oil content. Of the varieties studied, '28 - 206' was stable for yield but not for other characters.

Yadava and Kumar (1978b) also used 17 genotypes grown in 4 environments to estimate stability parameters for 100 -

kernel weight, oil content and shelling percentage. The linear and non-linear portions of the genotype x environment interactions were significant for all the 3 traits. In all the environments 'Faizpur' 1-5 had consistently high 100 - kernel weight and oil content and 'Ah 679' had high shelling percentage. The stability parameter for the different traits were apparently governed by independent genetic systems.

Yadava and Kumar (1979) studied the genotype x environment interaction for pod yield and the number of days to maturity in 13 groundnut varieties grown in 4 different years. The linear portion of GEI was significant for both characters, but the non-linear portion was significant only for the number of days to maturity. 'Georgia 119-20' proved to be a high yielding variety suitable for all environments tested and 'NC4X' an early maturing, high yielding variety suitable for less favourable environments.

Mercer - Quarshie (1980) reported that variety x year x locality interaction effects were significant for all the 5 characters, viz., pod yield, number of pods per plant, seed yield, shelling outturn and 100 seed weight. The variety x year interaction was significant only for 100 - seed weight and the variety x locality interaction was significant for seed yield and 100 seed weight. It was concluded that testing in several locations was more important than testing during several years.

Wynne and Coffelt (1980) determined yield and percentage of sound matured kernels and of extra large kernels in a 2 years study for 9 crosses with 8 lines per cross in F4 and F5 generations at 2 locations. Cross Populations and lines within crosses were significantly different for all traits. Cross populations interacted with the year - location environments for all traits, and lines within crosses interacted with the environment for all traits except yield.

Wynne and Gregory (1981) in a review on genotype x environment interactions in groundnut opined that although genotype x environment interactions vary with the material tested and the site chosen for testing, genotype x environment interactions in groundnut appear to be similar to those in several other autogamous species. The yield of a groundnut cultivar in each individual experiment if unique and the environmental conditions differentiating the tests cannot be grouped according to years or locations. This is not surprising considering the indeterminate nature of the groundnut plant.

Shorter and Norman (1983) evaluated 12 cultivars for grain yield in 2 trials, harvested 9-14 days apart at 10 locations. Pattern analysis showed that cultivars of dissimilar genetic origin had different yield responses across environments. An environmental classification based on cultivar x environment interactions indicated that there were no closely related regional environment groups with similar cultivar x environment interactions. It was concluded that lower critical percentage differences between new and established cultivars in pre-release trials can be obtained by adding environments rather than replicates.

Kumar et al. (1984) studied pod yield and 4 yield related quality characters in 12 Spanish bunch genotypes under 3 environments. In general, G X E interactions were significant for all the characters. For pod yield, non-linear components of interaction were significant whereas for 4 others linear components were significant. Non-linear components had higher values for all the traits except for pod yield and days to maturity.

Reddy et al. (1984) studied variety x season interaction in 3 habit groups and Virginia-bunch to be less interactive than Spanish - bunch types. In general, seasonal yield differences were greater than varietal differences and variety x season interaction was high.

Swarnalata et al. (1984) studied the stability of performance of six Virginia varieties, two Spanish varieties and their advance generation mutants and eight cross derivatives in two seasons under two fertility levels. The mutants of MK374, M13 and Robut 33-1 Virginia type varieties were significantly superior than the parental varieties and the varieties derived from hybridization. The mutants derived from above genotypes were high yielding and stable in performance and the stability of some of the compact mutants can be improved by manipulating high plant density.

Norden *et al*. (1986) studied four multiline populations along with their component lines over four years in 2 locations for stability of yield and market quality characters. G X E interactions were highly significant for pod yield and five quality characters including fancy pods percentage, shelling percentage, 100 kernel weight and sound mature kernel yield. Large differences were not present for these characters between sib-lines. However, differences were found in stability estimates from regression coefficients and deviation from regression of multilines compared to the component lines.

Patra and Mohanty (1987) evaluated the seven cross derivatives of groundnut in seven different seasons at Chiplima. The yield stability showed association with stability of shelling percentage, sound mature kernel percentage, 100 kernel weight, but more flexible association with mature, immature and tender pods per plant and pods per unit weight.

Lu *et al*. (1988) evaluated ten newly developed lines of *A. hypogaea* and two standard varieties nine locations in spring and four locations in autumn for two years. Combined analysis for pod and seed yield indicated that the mean squares for genotypes, environment and genotype x environment interactions were significant. Nan-Kai-si 133 and 134 showed the best pod and seed yield stabilities over all environments in the spring and Nan-Kai-si 133 also had best yields over all environments in autumn. However, their yields were not acceptable.

The phenotypic stability of twelve bunch groundnut cultivars grown in field trials was evaluated in eight environments to identify genotypes suitable for _kharif_ and summer season crops by Kanaswami _et al_. (1989). VG 19 and Ah 8407 were significantly superior in yield potential over the grand mean but were unstable. These can be grown in well distributed rainfall and irrigated conditions. None of the genotypes showed stability for pod yield. Five genotypes, which showed stability for many of the yield component traits were identified as ideal genotypes for hybridization and selection of stable genotype with high yield for further exploitation.

Nagabhushanam (1989) studied the stability of a wide range of characters in addition to pod number and pod weight. He observed that the characters such as plant height, number of primaries, number of secondaries, canopy diameter, nodule number and nodule dry weight at 60 days, leaf dry weight, shoot dry weight and root dry weight at 60 days, total dry matter at 60 days and oil per cent were less subjected to the interaction with the environment and were considered as stable. It was suggested that the characters like canopy diameter at 60 days, number of primary branches in _Spanish_ and _Valencia_ genotypes and number of secondaries in _Virginia_ genotypes which also exhibited a strong positive phenotypic correlation and considerable degree of genotypic correlation with kernel yield could be profitably employed a components of selection criteria. An analysis of the stability pattern of all the genotypes belonging to _Virginia_, Spanish and Valencia groups revealed that the genotypes possessing intermediate degrees of canopy development exhibited a greater degree of stability than the rest.

Singh et al. (1990) conducted a study with 5 Spanish bunch groundnut varieties in order to identify the varieties with average stability and a high level of performance for pod yield. Variety x environment interactions; the environment (linear) and variety x environment (linear) components of variation were highly significant. Five different conditions were created by sowing under different dates. The higher yield in rainy-season sowing than in winter-season sowing was due to moisture stress and low temperature during the crop growth period during winter and absence of cold-tolerant lines in groundnut. JL 24 gave the maximum yield followed by Kissan and Jowan. The difference in pod yield was mainly due to a wide range of environmental conditions primarily resulting from different temperatures and moisture stresses.

Birari et al. (1991) tested five bunch erect varieties of groundnut viz., JL 24, SB XI, TG19A, NCAC 589 and PI 270792 in three different seasons. The linear component contributed to a greater extent than non-linear component for G X E. TG 19A, PI 270792 and SBXI exhibited absence of GXE for kernel yield per plant. Further TG19A exhibited the most superior yield performance and insensitivity to environmental fluctuations in respect of 100 kernel weight and oil content. It also showed stable morphological attributes and predictable pod yield. NCAC 589 showed insensitivity to environmental changes for duration to 50 per cent flowering and maturity. They concluded that the study warrants a scope for evaluating the production of this crop through various groundnut based cropping systems either by including TG19A or NCAC589, depending upon the condition of resource availability in Konkan region.

2.3 STRENGTHENING GROUNDNUT BREEDING

Natural variability in the species has provided the resources for the development of varieties and strains suited to different environments and with desirable qualities and high yield of the commercial produce. Yet, the greater yield potential that may be gained by breeding for resistance to diseases, pests and drought, improved pod/kernel relationship and other components of yield and the possible realisation of better qualities of kernel and haulms, call for the search of new genetic variability (Raman, 1988).

The genetic and plant breeding research in groundnut in India has been revolving around the selections from within the available variability, crosses involving the parents with narrow genetic diversity and some exotic introductions to certain extent (Rao, 1976). Looking at the history of domestication of groundnut spanning over a period of 3,500 years (Hammons, 1973a), there appears to be need to enhance genetic variability for groundnut breeding.

The breeding efforts so far carried out have not resulted in the development of varieties with higher degrees of yield productivity. This was explained interms of physiological mechanisms involved by Duncan et al. (1978) that the selection for higher yield through traditional breeding procedures adopted even in Florida, United States did not result in corresponding increase in crop growth rate, but led to the development of the groundnut cultivars that partition more of their assimilate to fruit. Thus the marginal increase in yield was not created any favourable impact on peanut production. Lack of genetic progress with regard to crop growth rate and photosynthetic rates indicates the need to infuse new and novel genetic variability for canopy and reproductive attributes into groundnut breeding programmes to acheive higher levels of dry matter production.

According to Gregory et al. (1973), despite a long history of cultivation, broad sub-specific variability and wide geographic distribution of the cultivated groundnut, defects in its genetic composition with respect to requirements of man are known to exist among its varietal forms. Hence, in view of the genetic vulnerability of this evolving crop species, research for new and novel genetic variability for several important canopy and reproductive characters on one hand and attributes of resistance to pests, diseases and drought on the other, together with characters pertaining to oil quantity and quality are of paramount importance to strengthen the genetic improvement of groundnut.

The complex genetic architecture and developmental rhythm of groundnut plant has been posing challenge to the plant breeders and geneticists who have been aiming at achieving an appropriate genetic restructuring of this 'unpredictable legume' which is not conducive for efficient agronomic management (Gregory et al. 1973). It was increasingly felt that the use of efficient criteria of selection involving certain canopy attributes together with yield components on the basis of physiological efficiency in groundnut breeding would be useful (Cahaner and Ashri 1974). In order to meet this requirement the available genetic variability has to be significantly enlarged and widened by inducing mutations for the above mentioned characters (Prasad, 1988).

Despite extensive breeding work involving wide range of hybridizations, so far we were not able to generate distinctly superior genetic material in terms of agronomic attributes (Rao, 1976; and Duncan et al. 1978). Wynne and Gregory (1981) however, suggested that major advance in groundnut productivity could be achieved through structural alterations in peanut plant conducive for enhancement of fruiting sites. Such an effort calls for induction of new genetic variability through a comprehensive programme of mutation breeding.

2.4 HETEROSIS AND INHERITANCE OF CERTAIN CHARACTERS

2.4.1 Heterosis

Heterosis in F_1 generation expressed in terms of superiority over the better parent is of direct relevance not only for developing hybrids in cross pollinated crops, but is also important in self-pollinated crops, as such heterotic crosses may help the breeder to select appropriate parents which may lead to the isolation of desirable transgressive segregants in advanced generations (Arunachalam *et al*., 1984). Several investigators have reported estimates of heterosis for peanuts. According to the available evidence, heterosis in groundnut like heterosis in other crop species such as wheat (Fonesca and Patterson, 1968; Sun *et al*., 1972; Widner and Lebsock, 1973), alfalfa (Sriwatanapongise and Wilsie, 1968); Cotton (Marani, 1963, 1968), Corn (Moll *et al*., 1962), and tobacco (Matzinger and Wernsman, 1968) is related to the parental genetic diversity. According Wynne and Gregory (1981), heterosis in peanuts is most often observed in crosses between sub-specific groups, viz., *Virginia* x *Spanish* and *Virginia* x *Valencia*. These results imply that gene action differs in crosses made within and crosses made between botanical varieties.

The manifestation of heterosis in different economic traits of groundnut was first observed by Stokes and Hull (1930) in 11 groundnut crosses. Higgins (1938) in a diallel cross of 16 cultivars observed marked heterosis for vegetative traits and pod yield. Individual plant yields were highest for *Spanish* x *Virginia* crosses. Katayama and Nagatomo (1963) noticed marked heterosis in some of the hybrids studied by them.

Syakudo and Kawabata (1963) observed marked heterosis for the top weight in *Virginia* x *Spanish* or *Virginia* x *Valencia* combinations. Pod length of F_1 was intermediate between that of the parents. Lin (1966) noted significant hybrid vigour for length of main stem and branches especially in the F_2 by crossing a Spanish type with 'Florispan runner' (a virginia type).

Hassan and Srivastava (1966) observed a marked superiority of the F_1's over their better parents in yield as well as for the number of branches and leaflet length in crosses of 3 groundnut varieties differing in maturity and growth habit. They found greater heterosis for vegetative traits between Virginia x Valencia cultivars.

Studies conducted in a controlled environment by Parker et al. (1970) on the hybrids of diallel crosses of 6 parents collected from 3 centres of diversity in South America, the F_1's exceeded mid-parent means by 20-40% for several seedling characters which included days to flowering. Their conclusions also revealed greater heterotic responses for Valencia x Virginia crosses than for Valencia x Spanish or Virginia x Spanish crosses.

Wynne et al. (1970) reported that F_1 hybrids from Virginia x Valencia parents gave greater heterosis than other crosses for vegetative plant characters by using the same parents as Parker et al. (1970). Crosses of Valencia x Spanish gave greater heterosis for yield and fruit characters. However, the highest cross had Virginia x Spanish parentage. Coffelt and Hammons (1971) recorded 661 pods weighing 1.96 pounds from one F_1

hybrid plant and 1,156 matured seeds from another F_1 plant. On an average more than 700 seeds were obtained per F_1 plant.

Hammons (1973a) reported heterotic responses of inter sub-specific F_1 hybrids for fruit yield. Wynne et al. (1975) observed significant heterosis over the mid-parent in 2 crosses sown with drill, while in space-planted test, 4 crosses were equal to or higher than the mid-parent. Their studies indicated genotype x environment interaction in the expression of heterosis.

Garet (1976) studied heterosis and combining ability in a 5 parent diallel in Senegal. The study revealed a good heterotic response over better parent for 100-pod weight, 100-kernel weight, pod and seed number per plant and shelling percentage. Best heterosis resulted from crosses involving Virginia and Spanish parents.

Raju (1978) recorded heterosis ranging from 20 to 37% over the superior parent with respect to 3 important yield components, viz., mature pods (20.05%), 2 seeded pod (20.8%) and pod yield per plant (37.02%). Raju et al. (1979) in their studies on F_1 hybrids of 5 x 5 diallel set for 7 characters observed greater heterosis for number of mature pods, number of 2-seeded pods, pod yield and 100 kernel weight in a Virginia x Spanish cross and a moderate heterosis for these characters in Virginia x Virginia cross and concluded that the crosses involving the vàrieties adapted for Indian conditions and new exotic genotypes were the best for the expression of heterosis.

Arunachalam *et al*. (1980) classified parents of 2 diallel crosses as high or low based on their general combining abilities as computed for 15 characters. High x low crosses produced greater heterosis than high x high or low x low crosses. In the first 15 x 15 diallel set positive heterosis for 9 characters including pod yield was recorded whereas they could record positive heterosis for as many as 13 characters including pod yield in another 10 x 10 complete diallel set.

Isleib and Wynne (1980) reported positive heterosis for number, size and yield of pods by crossing 28 diverse lines with elite *Virginia* breeding line. Parents from sub sp. *fastigiata* generally had greater heterotic responses than parents from subsp. *hypogaea*. Muralidharan and Raman (1980) recorded positive heterosis for days to flowering, number of 2-seeded pods and pod yield per plant in the hybrids derived by crossing some bunch groundnut varieties with *Arachis monticola*, a wild species.

Hybrid vigour for F_1 hybrids between subspecies was recorded by Gregory *et al*. (1980). Most F_2 hybrid means were equal to midparental values although some F_2 means were exceptionally high or low. Sridharan and Marappan (1980) observed positive heterosis over the mid-parent in F_1's for all the 9 characters studied. They reported positive heterosis over the better parent in all the hybrids for number of mature pods and pod yield per plant. Heterosis for pod yield ranged from 37.44% to 95.33% over mid-parent and from 4.20% to 70.30% over better parent.

Layrisse *et al*. (1980) found that hybrid vigour for fruit yield, seed yield and 100 kernel weight persisted in F_2 progenies of a diallel cross of 10 lines. The parents belonged to 2 each of the 5 centres of genetic diversity in South America. The parents of the crosses with significant heterosis generally came from different centres of diversity.

Durga Prasad (1981) studied 64 F_1's obtained from 8x8 line x tester design crosses. The parents were assigned 'High' (H) and 'Low' (L) status based on the phenotypic values of a number of related component characters spanning the entire growth phase. Forty four crosses were found to be heterotic over better parent. Out of 44, 23 crosses were between parents with high- and low- general combining ability (gca) followed by 13 crosses between parents both of which had high gca. Heterosis was realised on the strength of both high and low specific combining (sca) effects. The distribution of crosses heterotic over better parent showed that the top most rank was obtained by *Virginia* runner x *Spanish* bunch and *Spanish* bunch x *Valencia*. Maximum frequency of heterotic crosses was found in H x L followed by H x H crosses, whether heterosis was measured over mid or better parent.

Wynne and Gregory (1981) arrived at the following conclusion regarding the nature of gene action in a review on heterosis in groundnut. Heterosis in groundnut was most often observed in crosses between the subspecific groups, gene action being different in crosses made within and those made between botanical varieties. Additive genetic variance appeared to be of primary importance in crosses made between parents chosen from a single botanical variety, but both additive and non-additive genetic variance were significant in crosses made between parents from different botanical varieties.

Arunachalam et al. (1982) studied 2 sets of diallel crosses involving 15 and 10 parents respectively at the seedling stage and at flowering and harvest for a total of 15 characters. The first diallel consisted of material selected for high yield, the second of high-yielding material resistant to *Puccinia arachidis* and to leaf spot. Only 1 cross, 'PI259747' x 'PI298115', showed heterosis for as many as 6 characters; 6 crosses in the first diallel showed heterosis for 4 or more characters as did 8 in the second. When the parents were assessed for gca over all the 15 characters, the highest proportion of crosses showing heterosis occurred in between high gca and low gca parents. This overall gca assessment agreed with an assessment based on the seedling characters in 47% of the crosses in the first diallel and in 90% of the crosses in the second diallel (64% of the total). Crosses within variety groups, as well as those between them, had a high proportion of crosses showing heterosis.

Jagannadha Reddy (1982) in crosses involving 3 Valencia and 2 Spanish cultivars observed that the crosses between Spanish x Spanish and Valencia x Valencia were equally good and comparable to the best cross (J11 X EC 21083-A) which involved

Spanish and *Valencia* parents for several characters based on heterosis percentages. Raju (1982) studied heterosis in 20 crosses. The study indicated that heterosis for economic yield may be obtained in both intraspecific and intra-subspecific crosses, unlike most of the previous reports where yield heterosis was thought to be prevalent in inter-subspecific crosses only.

Isleib and Wynne (1983) measured heterosis as a deviation of the F_1 performance from the mean parental value and also observed heterosis for all traits. Heterosis upto 19 per cent above the better parent occurred for pod size and length. They opined that for pod and seed yield and pod length, dominance was the more important source of non-additive genetic variation, while epistasis was more important for pod and seed number. They also found a linear and increasing relationship of heterosis to divergence between parents, for the traits which exhibited more dominance while, for the others a curvilinear relationship was observed.

Arunachalam *et al*. (1984) examined the frequency and magnitude of heterosis in relation to genetic divergence among parents in 2 diallel cross experiments. They concluded that the frequency of heterotic crosses and the magnitude of heterosis for yield and its components were higher in crosses between parents in intermediate divergence classes than the extreme ones. The study thus showed that there was an optimum level of genetic divergence between parents to obtain heterosis in F_1 generation.

Xiang *et al*. (1984) observed significant heterosis for pod weight per plant and sed weight per plant in an incomplete diallel cross of four *Spanish* and four *Valencia* type cultivars.

Deshmukh *et al*. (1985) conducted a study involving 2 *Spanish* types one *Virginia* type and one intermediate type female parents and one *Spanish* type male parent for estimating heterobeltiosis in groundnut. The study indicated that parental genetic diversity was more important for expression of heterosis than its growth habit.

Arunachalam and Bandyopadhyay (1986) postulated that the chances of high frequency and magnitude of heterosis were greater in crosses between parents with high genetic divergence. Basu *et al*. (1986) studied the magnitude of heterosis for 11 vegetative and reproductive characters through a half-diallel analysis. *Spanish* x *Spanish* recorded high desirable negative heterosis for days to 50% flowering and high positive heterosis for number of mature pods and pod yield. They observed 34.7 - 57.3 per cent heterosis over the parental value for pod yield.

Prasad (1987) reported higher degrees of heterosis for pod number and pod yield in F_1's using TAP-5, an aerial podding genotype as male parent in combination with other *Spanish*, *Virginia* and *Valencia* genotypes as female parents. Madhavi (1988) reported that the genotypes R 33-1 (*Virginia* bunch), M13 (*Virginia* runner), TMV2NLM (*Virginia* bunch), JL-24 (*Spanish* bunch), TAP5 (*Valencia* aerial podding) and MH2BC28 (*Valencia*) exhibited a better heterosis in different cross combinations for yield and yield components on one hand physiological traits on the other and concluded that these genotypes could be considered as genetically divergent parents, which could be used to widen the genetic diversity in groundnut breeding.

Nagabhushanam (1989) studied the heterosis in F_1 generation of the matings involving different combinations of parents characterised for canopy development. He observed that majority of the crosses belonging to medium compact x medium spreading and medium spreading x medium compact canopy combinations showed significant positive heterosis for canopy development and kernel yield. It was concluded that the optimum levels of parental genetic divergence leading to heterosis in F_1 was provided by the genotypes of intermediate canopy categories, while the other parental combinations involving extreme degrees of divergence were not conducive for heterosis and the combinations of medium compact x medium compact and medium spreading x medium spreading canopy types did not appear to provide adequate levels of genetic divergence conducive for higher heterosis.

Makne and Bhale (1991) estimated heterosis for six characters involving ten parent varieties of groundnut in all possible combinations excluding reciprocals. Small amounts of positive and negative heterosis over better parental value were observed for oil and protein percentage, 100 kernel weight and days to maturity. Relatively higher heterotic effects were noticed for pod yield and harvest index.

In groundnut, however magnificient the heterosis may be, it cannot be exploited for commercial production of hybrid varieties because of the natural restrictions found in the form of peculiar floral structure; but will serve to identify parents with adequate levels of genetic diversity, so that in the later generations wider degrees of variances could be recovered for selecting superior segregants (Arunachalam et al., 1984).

2.4.2 Inheritance of Certain Characters

Hammons (1973a) reviewed the literature on qualitative inheritance in peanuts prior to 1973. Increasing evidence indicated that qualitatively inherited traits were probably controlled by at least duplicate genes. This was largely due to the alloploid nature of the peanut and tends to confirm the theory of 2 genomes in A. hypogaea. Early reports of mono- and digenic models were as likely to be di, tri or tetragenic, but population sizes were too small to distinguish between the simpler and more complex models. The number of genes may vary greatly among the parental lines used in an inheritance study. Obviously fewer genes will be detected to control a trait in closely related parents, while the number of different genes or alleles found controlling a trait will increase among more divergent parents. Cytoplasmic and/or maternal effects further complicate qualitative inheritance studies. The phenotypic expression of nuclear genes may be modified by the presence, absence or interaction of different plasmons.

2.4.2.1 Growth Habit

The habit of the growth of the plant influences considerably the agronomic practices. The optimum spacing and mode of harvest in groundnut largely depend upon the habit of growth. Two distinct diatropic growth habits were recognised in peanuts, known as runner vs bunch, although intermediate growth forms may be found (Gregory et al., 1951). Both have an erect main stem (central axis), usually quite short in runners, which give rise to lateral branches. In bunch plants, the side branches are also erect or ascending, although in later growth stages they may become semidecumbent. In runner plants the laterals are prostrate, always growing peripherally from the main axis, trailing on the ground except for the tips which may be somewhat ascending. The inheritance of growth habit differences has been studied by several investigators.

Badami (1928) stated that the erect habit was recessive to spreading with the bifactorial difference. Hayes (1933) found duplicate factors with a 15 runner : 1 bunch ratio in the F_2 in a cross of runner with bunch.

Patel et al. (1936) made crosses between the bunch and spreading varieties. The F_1 plants in all of them showed complete dominance of the spreading habit. In the F_2 the spreading and the bunch types occurred in the ratio of 9:7. They reported that spreading type was probably the result of two complementary factors, designated S_1 and S_2 and the bunch type was recessive. It was concluded that two dominant factors were necessary to produce the spreading type of habit.

Higgins (1938) stated that the inheritance of growth habit was very complex and "that multiple factors were involved". It was reported by John et al. (1954) that the spreading habit was caused by two semi-spreading factors which were both dominant to the bunch factors. The segregation in the F_2, showed one bunch to every 15 of other dominant types. The classification of the 15 dominant types into distinct 'spreading' and 'semi-spreading' groups, however, presented considerable difficulty due to interaction of various factors.

The crosses were made between four spreading and two erect varieties by Dalal (1962), to study the inheritance of habit of growth in groundnut. He reported that the spreading habit of growth was the result of interaction of two pairs of supplementary factors, one of the factors produced 'erect and bushy' and the other 'erect and open' habit. Thus, the genetical constitution of 'spreading', 'erect and bushy' and 'erect and open' habits of growth were symbolised as S_1 S_2, S_1 s_2s_2 and $s_1s_1S_2$ respectively.

Ashri and Goldin (1963) suggested that at least two nuclear genes and two cytoplasmic factors were involved in the determination of growth habit. The nuclear genes interacted differently with each other and with each plasmon.

In 1964, Ashri made reciprocal crosses between the V_4 variety of peanuts and six other varieties, all bunch (erect). In all crosses, when V_4 was female parent, the F_1 hybrids were runners, while the reciprocal hybrids were bunch. The mode of inheritance of growth habit was tested in reciprocal F_2, F_3, BC_1F_1 and BC_1F_2 populations. It was concluded that there were two plasmon types - one found only in V_4 and another present in the other tested varieties. Also, there were at least two nuclear genes which interacted differently with each other in each plasmon and with each plasmon. In the V_4 plasmon the two genes were complementary while in the second plasmon their dominant alleles or the recessive ones are additive. In most cases, the same genotypes produced in conjunction with the different plasmon opposite growth habits.

Inheritance studies conducted by Tahir (1965) indicated that runner plant habit was dominant to spreading bunch and upright bunch habits and a range of intermediate forms of plant habit appeared in their crosses. It was also stated that the upright bunch habit was recessive to spreading bunch and open plant habit was dominant to compact habit in upright bunch varieties.

Ashri (1968) reported that two plasmons designated V_4 (from Arachis hypogaea 'Virginia Beit Dagan 4') and others (from

Virginia bunch G_2 and other varieties), and two genes, Hb_1 and Hb_2, interact to produce the runner (trailing) or bunch (erect) growth habits, the dominant alleles lead to the development of a runner habit in both plasmons. In V_4 plasmon the genotype Hb_1 Hb_2 produced a runner habit and all other genotypes a bunch habit, while in the others plasmon the dominant alleles were additive and possibly also complementary. $Hb_1Hb_1Hb_2Hb_2$, $Hb_1Hb_1Hbhb_2$ and $Hb_1hb_1Hb_2Hb_2$ gave runner plants in the others plasmon, while all other genotypes gave bunch plants.

The results of the studies involving the varieties K17, Big Japan and early runner indicated the dominance of bunch habit over spreading habit in the F_1 and a monogenic segregation in the F_2 generation (Hassan and Srivastava, 1966).

Halevy et al. (1969) found that the treatment of peanuts with gibberellin changed the orientation of lateral branches of runners to that of erect ones and two growth retardants changed those of the erect type to a more horizontal orientation. They also reported that spreading plants contained a higher concentration of gibberellic acid antagonists and a particular gibberellic acid inhibitor not found in erect plants.

Shchori and Ashri (1970) studied the inheritance of growth habit by crossing three chemically induced mutants affecting growth habit with the original variety. The mutants-open habit-1 (Oh_1), open habit-2 (Oh_2) and spherical (sp) were reported to be recessive and monogenically controlled.

It was reported by Ziv *et al*. (1973) that the spreading habit was light-induced, requiring blue plus far-red light of a certain minimum intensity. They concluded that the genic and cytoplasmic factors interact with light environments for the expression of growth habit. Therefore, differences in light could alter growth habit expression.

A study was undertaken by Coffelt (1974) to investigate the inheritance of growth habit in reciprocal infraspecific crosses between two cultivars which differed at two loci conditioning growth habit. Results showed a complementary-duplicate interaction of the two loci, for which gene symbols Hb_3 and Hb_4 were proposed. Segregation in the F_2 was in accord with the proposed phenotypic ratio of 11 spreading to 5 erect growth habits.

Ashri (1976a) made a series of reciprocal crosses between varieties from different countries including bunch varieties (with V_4 plasmon and the nuclear genotype $Hb_1Hb_1hb_2hb_2$), virginia variety (with the 'O' plasmon type and the nuclear genotype $hb_1hb_1Hb_2Hb_2$) and HG_1 from India possessed a third plasmon type 'G' and a third locus Hb_5 which interacted with (V_4), (O), Hb_1 and Hb_2. In the (G) plasmon Hb_1 and Hb_5 were additive, plants with three or four dominant alleles had a trailing habit while other nuclear genotypes produced erect plants. In (V_4), Hb_1 and Hb_5 were complementary, Hb_1 - Hb_5 - plants being trailing and the others being erect. Hb_2 and Hb_5

were complementary in the (G) plasmon and additive in (O) plasmon.

Sixty eight accessions were studied in crosses with one or another of three testers : V_4, VSM and HG_1 having the V_4, O and G plasmons respectively by Ashri (1976b). He reported that the three plasmons namely V_4, O, and G types interacted differently with three plasmon sensitive nuclear genes, there by determining whether the plants will be erect or trailing.

Ashri and Levy (1977) found that growth habit (erect vs. trailing) in nearly 100 accessions was affected by at least three plasmons and by three major nuclear genes which interacted with each other and with the plasmons. Mutagenic treatment of the trailing line TBR (V_4) resulted in isolation of 137 erect mutants. Twenty-eight mutants which bred true in M_3 were crossed with testers. Fourteen behaved as recessive nuclear mutations and 14 behaved as plasmon mutations.

Balaiah _et al_. (1977) studied the inheritance of growth habit in six crosses of groundnut. In crosses involving the _spanish_ parents, the F_1 was _Virginia_ bunch and in F_2 a segregation ratio of 3 _Virginia_ bunch : 1 _Spanish_ was observed. In crosses, where the _Virginia_ runner types were used as the ovule parents, the F_1 was _Virginia_ bunch while the F_2 gave a segregation of 3 _Virginia_ bunch: 1 _Virginia_ runner. It was concluded that the _Virginia_ bunch habit behaved as simple dominant over both _spanish_ and _virginia_ runner habits.

cross between Poonawhite and Kopergaon No.3. For this study, 23

Resslar and Emery (1978) examined the expression of growth habit (bunch vs. lax bunch) in the F_1, F_2, F_3 and BC_1S_1 from reciprocal crosses of lines with reported differences in cytoplasms and genotypes. Reciprocal differences were noted in the F_1 generation of the cross involving Virginia Beit Dagan (V_4) and NC_2. The F_2, F_3 and BC_1S_1 of the cross NC_2 x V_4 also fitted the expectations of a model based on cytoplasmic differences. Late generation progenies of V_4 x NC_2 did not fit expectations, however, and the reciprocal could not be differentiated in the F_3. It was proposed that maternal rather than cytoplasmic inheritance per se accounted for the reciprocal cross differences.

Jadhav and Shinde (1979) studied the inheritance of growth habit in the segregating population obtained from the cross between Poonawhite and Kopergaon No.3. For this study, 23 F_3 families derived from F_2 were raised and observed, out of which 15 families were semi spreading and 8 were bunch type. The F_1 phenotype was semi spreading and F_2 population segregated into the ratio of 3 semi spreading and 1 bunch type of plants. It was, therefore, evident that semi spreading habit was dominant over bunch habit.

Balaiah et al. (1984) made crosses by using Gujarat narrow leaf mutant as pollen parent with three spanish type varieties. None of the joint segregation ratios for any pair of the six characters fitted values expected for independent segregation. It was concluded that all six, namely growth habit, branching, number of primary and secondary branches, shoot pigmentation and leaflet shape were linked.

Varan et al. (1986) reported the inheritance of growth habit in groundnut by crossing TMV10 a semi-spreading variety as male parent with 5 bunch cultivars. All the F_1 plants were semi-spreading. In the F_2, four crosses exhibited a 3 semi spreading : 1 bunch segregation, while POL2 x TMV10 gave a 9 : 7 ratio indicating that 2 complementary factors affected growth habit in this cross.

Desale (1987) made a cross between a mutant with 'spear-shaped' leaflets with Kopergaon1. Analysis of F_2 segregation data revealed that spreading vs semi spreading habit was controlled by complementary genes (9 spreading : 7 semi spreading).

Results of a study of the F_2 from a complete diallel cross involving A. hypogaea cultivars Argentine and T2442 and A. monticola suggested that growth habit was determined by 4 genes (Essomba et al., 1988). They also reported that epistatic and additive effects existed for growth habit.

2.4.2.2 Leaf Shape

Inheritance studies of leaf shape variations in the cultivated peanut, A. hypogaea L. have been reported rarely.

Badami (1928) noted that the F_1 was intermediate in leaf size and a wide range of sizes occurred in the F_2. It was suggested that the inheritance of the normal leaf sizes observed in the subspecies was complex and may be quantitatively controlled.

Hayes (1933) reported that leaf shape of the runner variety 'Sine' was dominant to leaf shape of the 'Valencia' variety. In the F_2 from a cross between these varieties he obtained 8 plants with 'Crinkled' leaves in contrast to 150 plants with normal leaves. Since neither of the parents nor the F_1 hybrid exhibited the trait, he suggested complementary recessive inheritance despite the absence of further data.

Hammons (1964) found a dominant Krinkle leaf mutant. The krinkle leaf character expressed as a conspicuous reflexed, wrinkled leaf blade was inherited as a simple monogenic dominant and the gene symbols Kr and kr were suggested for the Krinkle leaf allele and normal leaf recessive allele respectively. Extensive segregation data from crosses between krinkle and normal leaf plants demonstrated the application of the marker in peanut qualitative character analysis.

Hassan (1964) concluded that elliptical shape was recessive to elliptical-oblong shape in groundnut. Kansara (1967) reported that narrow leaflet character was partially dominant over the broad leaflet and was controlled by a single factor pair.

Hammons (1968) described a radiation induced change in leaflet shape called 'cup'. The mutant 'cup' differed in several morphological features from the control and was especially characterised by ventrally involute leaflets. The mutation was controlled by a single recessive gene (cu, cu), whose intensity of expression was influenced by modifiers when the gene was in the homozygous condition. The modifiers may be mutations of the residual genotype.

Loesch (1961) and Loesch and Hammons (1968) studied the inheritance of five mutations induced by X-rays by making a diallel cross between the mutants and a control, NC_4. The mutants Flop (drooping leaflets), cup (involute leaflet margins) and ilex were each controlled by a single recessive gene, while the mutants hedera and corduroy (rugose, ribbed leaflets) by duplicate recessive genes, possibly with repulsion phase linkage of one corduory locus with one hedera locus.

Ashri (1970) found a small leaflet mutant. From a study of a cross Pintar Bunch Mani pintar 1 x Pearl, he concluded that the small leaflet trait observed in the F_2 was controlled by two duplicate genes, designated as Sl_1sl_1 and Sl_2sl_2.

Bhide and Desale (1970) isolated a spear-shaped small leaflet mutant with reduced internodal and calyx tube lengths from Kopergaon - 1, a semi-spreading type. Back crossing of the true-breeding mutant to the Kopergaon - 1 parent indicated recessive, monogenic inheritance of the small leaflet character.

Matlock _et al_. (1970) reported partial dominance of narrow leaf mutants, with monogenic inheritance. They proposed gene symbols Nl nl to represent narrow leaf. The heterozygotes can be distinguished from either homozygote with a great degree of accuracy under green-house conditions.

Srivastava (1970) observed a short plant with unhealthy appearance and yellowish mottled leaves in the variety C 501. It resulted in reduced yield (two thin pods with four seeds) and plant size. All four seeds germinated but mosaic mottling was observed in the upper leaves of three seedlings, while the forth was normal. The mottled character was shown to be controlled by a single dominant gene.

Balaiah et al. (1977) reported the inheritance of narrow leaf character by using Gujarat narrow leaf mutant as pollen parent in six crosses of groundnut. The F_1 in all the six crosses possessed narrow leaflet and there by indicated the dominance of this character. In the F_2 generation a segregation ratio of 3:1 for the narrow and broad leaflet was obtained indicating that narrow leaflet was conditioned by a single gene dominant to normal leaflet.

Branch and Hammons (1981) reported a second gene for the flop trait. In intersubspecific crosses between the mutant flop and normal leaf parents, they found digenic inheritance and an F_2 phenotypic ratio of 15 normal : 1 flop. The gene symbols $Fl_1fl_1Fl_2fl_2$ were proposed for the flop genotype.

Chandramouli and Kale (1981) isolated a variant similar to the imparipinnate but with normal leaflet size in one of the

F_3 progenies of a cross, TG16 x TG17. Both parents had paripinnate leaves. The results showed that the imparipinnate leaf trait was governed by a single recessive gene.

The bifurcated leaflet character was observed by Chandramouli et al. (1984) in a cross between Gujarat Dwarf and a recombinant of two induced mutants of Spanish Improved. The bifurcation was controlled by three recessive genes and was only observed in plants of the small-leaf type. It was suggested that two characters were closely linked.

Prasad et al. (1984) recovered a narrow leaf Virginia mutant from EMS treated TMV2 Spanish bunch variety, which was found to be genetically different from Gujarat narrow leaf mutant reported by Gopani and Vaishnani (1970).

Branch (1987) discovered the curly leaf trait in a single plant derived from a cross between the normal-leaf cultivars Chico and Florigiant. Analysis of segregation data from crosses between a true breeding curly-leaf genotype obtained by selfing and normal leaf genotypes representing Arachis hypogaea sub spp. hypogaea and fastigiata indicated that curly-leaf trait was controlled by a single recessive gene, designated as 'Cur'.

Desale (1987) made a cross between a mutant with 'spear-shaped' leaflets and Kopergaon 1. Analysis of F_2 segregation data revealed that normal leaflet was dominant to mutant leaflet shape, shape being controlled by a single gene.

Dwivedi and Nigam (1989) reported a dwarf compact mutant plant (PLM) of cv. OG66-6-1 which had partially crinkled (puckered) leaves with yellow stripes along the margins. Data on leaf phenotype from parental, F_1, F_2 and backcross generations of 2 reciprocal crosses of PLM with the normal leaved cultivars J11 and MK374 indicated that the normal leaf phenotype was controlled by two pairs of genes, Nl_1 and Nl_2. Expression of the mutant leaf phenotype was dependent on the presence of the Nl_1 gene in a recessive homozygous condition and Nl_2 in a dominant homozygous or heterozygous condition.

2.5 USE OF INDUCED MUTANTS IN GROUNDNUT BREEDING

Considering the urgent need to widen the genetic variability for groundnut improvement it appears that induced mutations for wide range of characters can play an important role in groundnut breeding (Prasad and Kaul, 1980).

A brief review of the role of induced mutagenesis in improvement of groundnut crop is presented below.

The idea of producing mutations artificially and using them for breeding was clearly stated as early as 1901 by De Vries. He wrote that, "The knowledge of the laws of mutations will probably lead to the artificial production of mutations at will and thus the creation of completely new properties in plants and animals."

Gregory (1955) was able to develop a new variety NC4X through exploitation of induced micro mutants. He found the genetic variance for yield among irradiated progenies of the 'NC2' to be 4 times that measured in the control progenies. Several high yielding mutants were recovered from the populations studied. It was suggested that the use of ionizing radiations may not only be valuable in the production of specific changes such as disease reaction specificity in plants, but may be of general breeding value in agronomic programmes. It was also suggested that specific changes in already adapted varieties may be induced without affecting the adapted genetic background.

Cooper and Gregory (1960) developed the mutants resistant to Cercospora personata and Cercospora arachidicola by selecting for defoliation resistance in the X_2 and X_3 of X - irradiated plants of a Virginia bunch selection. Resistance was maintained over nine generations and yield and fertility were high.

Emery et al. (1964) studied to separate the mutated background genotype from the deleterious mutant locus and to evaluate the genetic variances and combining abilities of these backgrounds among progenies bearing normal phenotypes. Five morphological mutants were crossed among themselves and with an unirradiated control line. Many of the hybrids had higher genetic variances than the controls and a wide range in means and variances among the hybrids was observed. Selection for both high and low yields of fruit in the F_4 was most effective in hybrids with the highest genetic variances and selection responses were generally greater among the hybrids than among the control progenies. They found that each of the backgrounds interacted with the others in a characteristic way. There was evidence that background mutations may influence the quantitative expression of several plant characters simultaneously.

Loesch (1964) reported the effect of mutated background genotype of mutant expression in peanuts. He stated that progress in breeding may be achieved through the use of induced mutations having small effects, even with backgrounds associated with deleterious mutants.

Emery et al. (1965) concluded that even though induced macromutations were generally deleterious, the diversified genetic background created by irradiation could be a valuable source of germplasm that could be stabilized in normal appearing phenotypes.

By seed treatment with diethyl sulphate in TMV_2, Avadhani and Ramana Rao (1968) observed increase in the number of flowers produced per plant and the number of gynophores in basal nodes of primary branches. There were also increases in the shelling percentage, oil content and weight of kernels.

Martin (1968) reported that irradiation of the late variety 28.206 led to an increase in variability in oil content and pod size in the M_2, but selection for these two characters in the following generations did not led to improvement. Irradiation of the early variety 28.204, which was lower in oil content gave rise to six lines differing in various characters, but all early and rich in oil and higher in 100 seed weight than the initial variety although slightly lower in shelling percentage; one was superior also in yield.

Stucker et al. (1968) studied the polygenic variation in six characters induced by x-rays in A. hypogaea L. 'NC 2'. They found that the components of variance from irradiated populations were larger for leaflet width, length, the ratio of width to length, seed number and fruit yield than those of control populations.

Gopani and Vaishnani (1970) reported two mutants viz., dwarf and narrow leaf isolated respectively from Kopergaon-3 (Bunch) and Punjab-1 (spreading). The height of the main axis of Gujarat Dwarf Mutant was only 6.75 cm and the percentage of fertilization from flowers to pods was 72.5. Owing to its dwarf habit, earliness re-structured flowering and higher pod realization, the mutant may be used as a plant type suited for intercropping as well as a donor parent for compact plant habit. The Gujarat Narrow leaf mutant was observed to possess hard, thick cuticle on the leaf and less number of stomata per unit area in addition to narrow leaves. It had the potentiality for resistance to drought and cercospora leaf spot disease. These mutants crossed freely with other varieties.

Emery et al. (1972) observed a wide range of hybrid means and variances when macro-mutants were involved in the parentage. Differential responses of specific cup hybrids to changes in location and season were indicative of the diverse nature of the mutated backgrounds. The interpretations of the genetic backgrounds of macro-mutants had important implications to the plant breeder who would use macro-mutants for indirect sources of genetic variability. The backgrounds of all macro-mutants would be valuable as new and verified sources of mutant genes.

Ashri and Levy (1973) reported that treatment of young embryos with chemical mutagens could be valuable in crops whose ovaries contain many ovules, because of the large M_1 seed populations obtainable from each fruit. They found differences in sensitivity between the stages of development of peanut embryos to chemical mutagens, with the earlier stages being most effective.

Emery and Wynne (1976) reported that the mean yields of F_1 lines derived from the irradiated populations were considerably below that of the control population when selection began but reached 99% of the control mean in the F_6 generation. Selection gains in the irradiated populations appeared to result from the removal of low yielding sublines, since greatest progress was made by raising the lower extremities of the mean ranges of sublines derived from the F_2 rather than by extending the upper extremities of the ranges. The three highest-yielding lines in the F_6 generation occurred in irradiated populations while the three highest yielding sublines were found in the control population.

Yadava and Hari Singh (1977) developed a variety 'MH_2' from Gujarat Dwarf Mutant (GDM). It was an extremely dwarf bunch type, early in maturity and uniform in pod bearing with 49 per cent oil content and resistance to tikka disease. Owing to its extremely short stature it was speculated that it would respond to population increase. It was found that this newly developed genotype was reported to be very much responsive to population increase.

Reddy et al. (1977) using gamma-ray irradiated seeds of the cultivars belonging to Spanish, Valencia and Virginia groups had demonstrated that variability in the desired direction could be generated in respect of 13 morphological attributes.

Patil (1977) envisaged the advantage of cross breeding among the induced mutants. X ray induced large pod groundnut mutants showed certain undesirable qualitative characters. In order to select useful recombinants with large seeds, the mutant was crossed to a Spanish parent and Virescent mutant having a chlorophyll marker. A few selections having large kernels, improved oil content and increased shelling per cent were isolated in the cross between the two mutants indicating the advantages of cross breeding among the induced mutants.

Patil and Mouli (1978) reported that modifications of growth pattern leading to reduced vegetative growth and improved productivity was desirable in groundnut. A small mutant of groundnut with only 4-5 primary branches but all with flowering nodes including those on the stem, was isolated from a cross between two radiation induced mutants, 'TG-1' and 'Darker Green'. Though the overall vegetative growth was less because of its shorter stature and fewer nodes, the number of pegs and pods/plant in the mutant were not different from those in the unirradiated 'Spanish Improved', indicating better productive efficiency. This mutant produced 14-90% more pod yield than the local varieties and had wider adaptability.

Dorairaj (1979) studied the relative effects of gamma irradiaiton on homozygous and heterozygous genotypes of groundnut and concluded that irradiation of heterozygous genotypes created greater variability. He also reported that irradiation of varieties increased the frequency of new character associations while irradiation of hybrid seeds brought about more instances of alteration in the strength of existing correlations.

Patil and Mouli (1979) reported that mutants affecting height, number and growth of branches, leaf size and colour, pod size and number were induced by irradiation in Arachis hypogaea. Although beneficial mutants for direct use were rare, more than 20 cultivars having improved yield, oil content and kernel quality were developed from inter-crosses between the available mutants. Trombay groundnut varieties had consistently produced improved yields and kernels of export quality at different locations.

Rao (1979) obtained two bushy mutants and leaf mutants which resembled Arachis monticola by x-ray irradiation of two semi-spreading varieties C501 and 'Asiriya'. The mutants with spreading habit or with dwarf bunch habit were obtained on x-ray irradiation of 'Asiriya'. It was considered that the results supported the hypothesis of a common ancestor for bunch and Virginia types.

Mutants BP_1 and BP_2 of Arachis hypogaea which had a compact habit, large kernels and large pods and show early and mid-early maturity respectively, were derived from the late maturing 41C, which had a spreading habit and kernels and pods of medium size, on treatment with gamma rays. These mutants out yielded the early, compact variety AK 12-24, which was a predominant variety in Bihar (Sinha and Rahman, 1979).

The mutation experiments conducted by Mouli et al. (1979) resulted in the development of cultures of Arachis hypogaea combining sequential flowering, early maturity and large kernels. Hybridization among induced mutants and re-irradiation of selected cultures had resulted in the development of useful types such as TG13, TG16, TG18A, TG19A and LV3.

Habib et al. (1979) reported alterations in height, leaf size, internodal length and pod yield following treatment of the bunch variety Dh3-30, SB-11, and US4 with gamma-rays and EMS. Differences in stem girth were also observed following EMS treatment. Ratnaswamy (1980) recovered superior segregants from double crosses coupled with mutagenesis compared with normal double crosses.

Marghitu *et al*. (1982) obtained favourable mutations after gamma-ray irradiation of seeds of a breeding line and 3 Romanian groundnut varieties. The mutant progenies had greater yield (upto 15%), earliness and disease resistance.

Qiu (1982) after gamma-ray irradiation of 6 varieties observed varying frequencies for different categories of mutations. Leaf, fruit and height mutations were more frequent than fertility, maturity, pigmentation and quality mutations. The frequency of mutations affecting disease resistance was very low. Dose and method of irradiation, variety used and developmental stage at which irradiation took place, all affected the frequency and spectrum of mutation.

Gadgil and Mitra (1983) achieved 2-3% increase in oil and 2-4.4% increase in sucrose through X- and gamma-ray irradiation of 'Spanish Improved' groundnut variety.

The effect of mutagenic treatments on character association in the M_3 generation of two varieties of groundnut was reported by Ramanathan and Rathinam (1983). The possibility of selection for yield with improved plant architecture from mutagen treated population was indicated by the altered character association. They also reported that the spectrum of chlorophyll mutations showed differential response of the two varieties to mutagenic treatments. Two mutants having semi-spreading growth habit possessed desirable features of short stature, higher pod and kernel yield, bold kernels and increased shelling percentage compared to that of control.

Sharma *et al*. (1983) obtained four mutants of Spanish Improved by gamma irradiation. These mutants had higher oleic acid contents than Spanish Improved but lower linoleic acid content. The essential amino acid content per seed was higher in the mutants than in Spanish Improved.

Ramanathan (1984) reported that EMS had a greater effect on seedling height than gamma rays in Ah 7911 while, the reverse was true in the case of variety TMV-9. The occurrence of 40 mutant plants from single treatment of gamma irradiation of 30 krad and EMS at 40 mM in TMV-9 and a combination (20 krad + 40 mM) treatment in Ah 7911 was reported by Ramanathan (1984). Mutant plants recovered in M_2 showed superior yield and morphological similarity to parents. When they were tested in M_3 generation, five out of forty lines gave significantly higher yield than their respective parents, with mature pods contributing to higher yield.

The studies on induced mutants carried out by Prasad *et al*. (1984) indicated that genetic restructuring of groundnut plant towards compact canopy and higher pod yield was possible in the case of *Virginia* genotypes. The *Spanish* genotypes did not tolerate reduction of the vegetative growth which reflected in lower pod number because they attained a critical genetic balance for canopy attributes. All the *Spanish* mutants with higher pod number showed enhanced branch number and dry weight of vegetative parts. The narrow leaf *Virginia* Mutant (TMV2 NLM) of TMV2 reported in the study showed several desirable characters such as higher dry matter production, higher pod number and resistance to leaf spot disease. These studies had resulted in the development of a wide range of gene-mutants for different degrees of canopy compaction and pod number in the same genetic background thus paving the way for a systematic analysis of the mutant characters.

Prasad (1985) isolated aerial pod bearing groundnut mutants from a population of Brazilian Valencia groundnut variety 'Tatu'. The mutant plants bred true to the character selected for and differed significantly from the parent exhibiting a larger number of aerial pods with seeds. This novel mutant should be useful in gaining more insight into the possible structural alterations that can be developed in groundnut plant as suggested by Wynne and Gregory (1981).

Prasad et al. (1985) initiated a study to improve the peanut variety 'Tatu' through induction of mutations for increased pod number per plant and better pod filling, using a chemical mutagen NaN_3. Sodium azide at a concentration of 3mM was found to be the most efficient as well as effective for induction of desirable mutants. Among the ten productive mutants selected, three of them Dwarf, Sd-HP and V_3 consistantly maintained their superiority in yield at significant levels over a period of three seasons including conditions of low rainfall. The mutants Dwarf and Sd-HP demonstrated improvement in pod number per plant, seed number per pod, shelling percentage and harvest index in the M_4 generation in addition to superior yield levels.

The details of the origin and characteristics of the groundnut mutant variety 'Co2' were reported by Sivaram et al. (1985). It was derived from Arachis hypogaea POL-1, which had been treated with EMS. Due to increased secondary branching and thus more pods per plant, it had a higher pod yield than POL-1 with a higher shelling out turn and higher 100 seed weight than the parent.

The varieties viz., Roxo, Red beuty (RB) and 534 were irradiated with 1500 rad fast neutrans or 20 krad gamma-rays by Busolo-Bulacu (1987) in Uganda. The pedigree selection method was used on the resulting material until M_9. Seven mutant selections of RB and one Roxo selection were tested in yield trials. Yields ranged from 1029.5 to 1372.1 kg/ha vs. 1024.6 kg/ha in RB and 1645.9 kg/ha in Roxo.

Chandra Mouli et al. (1987) in order to improve the yield potential Arachis hypogaea cultivar Phule Pragathi (JL24) treated the dry seeds with various doses of gamma radiation. Screening of over 10,000 plants resulted in the identification of 5 mutants. These mutants gave superior yields over JL24 in both kharif and summer seasons at 2 locations, with JL24 M1 giving a pod yield of 4083 kg/ha at Trombay and also a greater oil content than JL24.

Dutta *et al.* (1987) irradiated the seeds of F_3 lines from 3 genetically broad based crosses in groundnut with 30 kR gamma-rays. They observed that the performance of some F_3 lines for pod yield, shelling percentage and 100 kernel weight improved from medium to high in the F_5 generation showing the beneficial effects of irradiation which could have promoted desirable recombination.

Jiang and Zhou (1987) obtained "Fushi", an *A. hypogaea* variety with rapid emergence, short internodes, many plump pods with thin shells and many branches but low yields from Shitougi by means of beta-irradiation in the 1960's. Since then many cultivars were developed from it. It was crossed with Fuasheng which resulted in development of 13 varieties.

Prasad (1988) reported the induced mutations for compact canopy development in a wide range of groundnut varieties. It was observed that the frequencies of mutants for canopy character were much higher in the case of *Virginia* varieties than in the case of *Spanish* varieties. The mutants with enhanced canopy development isolated from a dwarf and compact *Valencia* variety MH2, exhibited increased pod number than the parent. The aerial pod bearing mutant developed from a Brazilian *Valencia* variety 'Tatu' exhibiting a large proportion of well developed aerial pods was crossed with other varieties used as female parents and the recombinants with the aerial pod bearing attribute and other desirable attributes of the female parents were recovered.

Singh *et al*. (1988) treated the seeds of T28 and Chandra with gamma-ray doses of 35, 50, 65 and 75 krad and were sown and grown to maturity. The M_2 was also irradiated and selection conducted for 8 yield components. Germination percentage decreased with increasing dose. Most mutants showed a change from spreading to semi-compact habit and increases in yield component values. Mutants were grouped into early and late maturing and of 90 only six were superior to controls over 4 years.

Dormant seeds of *Arachis hypogaea* were irradiated with 10-40 kR of gamma rays, with pre and post irradiation treatments by Soriano (1988). The M_2 seedlings were inoculated thrice with spores of *C. arachidicola* and *C. personatum*, 9 plants showed complete resistance. However, after recurrent selection, only three M_5 lines were found to be completely resistant while the others showed intermediate level of resistance. The disease resistant lines yielded almost twice as much as several commercial varieties owing to severe defoliation in the latter.

Chandra Mouli and Kale (1989) observed that after gamma-radiation treatment of cv. Phule Pragati, also known as JL24, screening of the M_2 and succeeding generations revealed mutations affecting maturity, seed size, shelling percentage and oil content. Three mutants matured early (in 85-90 days). JL24M7 had larger seeds than JL24 and JL24M6 and JL24M8 had smaller leaflets and seeds. All three gave greater pod yield at 90 days than JL24.

Nagabhushanam (1989) reported that the induced mutants viz., TMV2NLM, MH2 BC28 and PGN2 representing a shift towards enhanced canopy development from the sequential branching parental systems viz., TMV2, MH2 and GAUG-1 respectively and the mutants compact mutant of M13 and 32-2-5 representing a relatively compact canopy development from the respective parental varieties viz., M13 and MK374 exhibited much higher degree of stability for yield than the parents themselves. It was found that when the above canopy mutants were employed as parents in crosses exhibited much larger degree of variances for several agronomic attributes in F_2 generation as compared to the F_2's derived from the crosses involving their respective parents. He also isolated certain agronomically useful mutants viz., CCM1 and CCM2 of M13, ABM-2, ABM-1, DCM-4, DCM-2, DCM-1 and SPM-1 of NCAC 17090 and ABM-6 of GAUG-1 which showed promising yield potential as compared to the respective parents, by treating the seeds of groundnut genotypes belonging to different botanical groups with sodium azide.

Din 'Van Luen and Lysikov (1990) treated the seeds of three varieties with ethyleneimine, ethyl methanesulfonate, N-ethyl-N-nitrosourea, N-methyl-N-nitrosourea and diethylsulfate at concentrations of 0.02, 0.04 and 0.06 % for 2-4 h. In the M_3-M_4, three mutants were selected with high yield, early ripening, large seeds and good resistance to pests and lodging. They were recommended for use in breeding.

Manoharan and Thangavelu (1990) treated the dry seeds of cv. chico with 20-50 kR gamma-rays. Among 1730 M_2 plants evaluated, 7 with bold seeds were identified, having 100-seed weights ranging from 22.2 to 40.4g compared to 21.1g in the control.

Nagabhushanam et al. (1990) reported the occurrence of aerial pod bearing variant in the F_2 population involving an induced mutant MH2BC28, a mutant of MH2 for enhanced canopy development and ICG(C)8 an inter-specific derivative.

Luhua 6 was derived by gamma-irradiation (24 kR) of seeds of Baisha 1016 with subsequent selection upto the M_7 for early maturity by Qiu et al. (1990). It had a 100-seed weight of 50-75g, and erect habit, sequential flowering and matured ten days before Baisha 1016. It produced 9-13 pods/plant and had a shelling percentage of 64-74%. Seed yield of Luhua 6 was 13.6 percent higher than Baisha 1016. It was suitable for planting in spring, summer and autumn.

Qui et al. (1990) crossed two groundnut cultivars and two stable gamma-ray induced mutants derived from them and heritability of 10 yield components determined. High levels of heritability and genetic advance were noted for many components, with higher levels in progeny of mutants than in those of the original cultivars.

From the fore-going it appears that induced mutants for canopy development and reproductive attributes can be of immense importance in not only widening the available genetic variability, but also in restructuring the groundnut plant type in a manner conducive for higher levels of productivity.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

The present investigations were carried out with a view to study the breeding potential of certain induced groundnut mutants for canopy and reproductive characters. The field work was carried out during the post rainy (rabi) seasons of 1987-88 and 1988-89 as well as in the rainy (kharif) seasons of 1988 and 1989 at the Agricultural College Farm, Rajendranagar, Hyderabad, which is situated at an altitude of 542.6m above mean sea level. Geographically it lies at a latitude of 80.5°N and a longitude of 77.53°E.

3.1 MATERIAL

The material for the present study consisted of 18 genotypes, of which four were induced mutants such as 32-2-5 (compact canopy mutant of MK 374), Compact Mutant of M13, TMV2NLM (Narrow leaf virginia type mutant of TMV2) and MH2BC28 (Mutant of MH2 for enhanced canopy development), three already available spontaneous mutants such as TAP5 (Aerial pod bearing mutant of TATU, a Brazilian variety), GNLM (A spontaneous mutant of Punjab-1 for narrow leaf) and G201 (A mutant of T 28 for canopy) and other groundnut varieties viz., MH2, TMV2, PGN1, JL24, J11, PI 259747, PI 350680, MK374, Kadiri-3, M13 and ICG2271. The details of the genotypes and salient features are given in Table 1. These genotypes were categorised for canopy development at 60 days by arriving at a score based on canopy diameter, canopy circumference and leaf area at 60 days. Three different experiments were

Table 1 : Experimental material of present study

Sl. No.	Name of the genotype	Botanical group	Canopy category	Salient features
1.	TMV2NLM (Narrow leaf mutant of TMV 2)	Virginia semi spreading	3	EMS induced mutant of TMV 2. It has narrow leaves, which start expressing after first five normal leaves, alternate branching, vegetative main axis and higher root nodule number and mass. It matures 10-15 days later than the parent. Developed at IARI Regional Station, Hyderabad. Prasad *et al.* (1984).
2.	32-2-5	Virginia semi spreading	3	Gamma ray induced mutant of Virginia variety MK 374. It has a compact canopy and matures a few days earlier than the parent. Developed at IARI Regional Station, Hyderabad. Prasad *et al.* (1984).
3.	Compact Mutant of M13	Virginia semi spreading	3	EMS induced mutant of M13 for more compact canopy and synchronus pod bearing. Earlier in maturity by 5-7 days as compared to the parent. Developed at IARI Regional Station, Hyderabad. Prasad (1988).
4.	MH2BC28 (Better canopy mutant of MH2)	Valencia	2	NMU induced mutant of MH 2 possessing better canopy development and higher yield potential than the parent. Developed at IARI Regional Station, Hyderabad. Prasad (1988).
5.	TAP5 (Aerial pod bearing mutant)	Valencia	3	Spontaneous mutant of a Brazilian Valencia vaiety 'Tatu'. It produces well developed aerial pods. Prasad (1985).
6.	G-201 (Kaushal)	Virginia semi spreading	2	Natural mutant of T-28 (Manipuri). Medium duration of 120 days. Anonymous (1985).
7.	GNLM (Gujarat narrow leaf mutant)	Virginia semi spreading	3	Spontaneous narrow leaf mutant from 'Punjab 1'. It possess hard, thick cuticle on the leaf and less number of stomata per unit area. It has the potentiality for resistance to drought and *Cercospora* leaf spot disease. Gopani and Vaishnani (1970).
8.	TMV2	Spanish bunch	2	Mass selection from 'Gudiyatham bunch'. It is widely adopted and released in 1940. Developed at A.R.S., Tindivanam. Anonymous (1985).

Contd..

Sl. No.	Name of the genotype	Botanical group	Canopy category	Salient features
9.	PGN 1	Spanish bunch	2	Cross derivative of Manfredi x Robut 33-1. AICORPO Groundnut Annual Report (1985).
10.	JL 24	Spanish bunch	2	Selection from EC 94943. Dark green foliage and short duration (< 105 days). A popular cultivar from Maharashtra. Anonymous (1985).
11.	J 11	Spanish bunch	2	Derivative of Ah 4218 x Ah 4354 Cross, developed at Junagadh. Pale green foliage, short duration (105 days) and oil per cent 49.6. A popular cultivar from Gujarat. Anonymous (1985).
12.	MH 2	Valencia	1	Selection from Gujarat dwarf mutant. It is an extremely dwarf variety possessing one to four seeded pods with red testa and short duration (90 days). Developed at HAU, Hissar. Anonymous (1985).
13.	PI 259747 (ICG 4747)	Valencia	2	Selection from a peruvian line. Resistant to late leaf spot and rust. Subrahmanyam et al. (1980).
14.	PI 350680 (ICG 6340)	Valencia	2	Selection from a peruvian line. Resistant to rust and late leaf spot. Subrahmanyam et al. (1980).
15.	MK 374	Virginia semi spreading	3	Selection from Nigerian cultivar MK 374 released in 1978. Developed at A.R.S., Kadiri of A.P.A.U., Hyderabad. Anonymous (1985)
16.	Kadiri-3	Virginia semi spreading	3	Selection from Robut 33-1 (Israel). It possess medium spreading, clustered pod bearing, early maturity and wider adaptability. Developed at A.R.S., Kadiri of A.P.A.U., Hyderabad. Anonymous (1985).
17.	M 13	Virginia runner	4	Selection from 'NC 13'. It has more spreading habit, large sized pods, Bold seeds, long duration (> 135 days) and moderately resistant to leaf spot. Developed at P.A.U., Ludhiana. Anonymous (1985).
18.	ICG 2271 (NCAC 343)	Virginia runner	4	Introduced from U.S.A. Resistant to termites, jassids, thrips and leaf minor. ICRISAT Annual Report 1982 (1983).

conducted. The details of each experiment, methodology followed and statistical treatment of the data are presented below.

3.2 METHODS

3.2.1 Experiment I : Evaluation of genotypes differing in canopy under different population densities and nitrogen levels

The seven groundnut genotypes for different degrees of canopy development including three mutants viz., TMV2NLM (category 3), TAP5 (category 3), Compact Mutant of M13 (category 3), Kadiri-3 (category 3), M13 (category 4), MH2 (category 1) and JL24 (category 2) were studied for agronomic and physiologic attributes. This experiment was carried out during kharif (1988), rabi (1988-89) and kharif (1989) under three different spacings viz., 30 cm, 60 cm and 90 cm between the rows and two levels of nitrogen viz., 20 kg N ha^{-1} as basal dose and 40 kg N ha^{-1} which includes 20 kg N ha^{-1} as basal dose and 20 kg N ha^{-1} as top dressing at peak flowering in a Randomized Block Design with two replications with a plot size of 3 m x 3 m.

The doses of P_2O_5 and K_2O applied basally were kept constant at 40 kg and 20 kg per hectare respectively. In addition gypsum at the rate of 500 kg ha^{-1} was top dressed at the time of peak flowering. All necessary cultural operations pertaining to irrigation, weeding and plant protection were undertaken to maintain good crop growth.

Thus the diverse genotypes were evaluated under three plant population densities, two levels of nitrogen and three different seasons. In the entire text the seasons 1, 2, 3 indicate the <u>kharif</u> 1988, <u>rabi</u> 1988-89 and <u>kharif</u>, 1989 respectively. The micro-environments I, II, III, IV, V and VI in the complete text indicate N_1-30, N_2-30, N_1-60, N_2-60, N_1-90 and N_2-90 respectively.

N_1-30 : 30 cm inter-row spacing with basal dressing of 20kg nitrogen

N_2-30 : 30 cm inter-row spacing with 20 kg basal + 20 kg top dressing of nitrogen

N_1-60 : 60 cm inter-row spacing with basal dressing of 20 kg nitrogen

N_2-60 : 60 cm inter-row spacing with 20 kg basal + 20 kg top dressing of nitrogen

N_1-90 : 90 cm inter-row spacing with basal dressing of 20 kg nitrogen

N_2-90 : 90 cm inter-row spacing with 20 kg basal + 20 kg top dressing of nitrogen.

3.2.1.1 Observations recorded

The data were recorded on five randomly selected plants in the net plot in each plot on the following characters.

Days to initial flowering: The number of days taken from the date of sowing to the date of first flowering.

Days to 50 per cent flowering: Number of days taken for 50 per cent of the plants to flower from the date of sowing.

Days to 100 per cent flowering : Number of days taken for 100 per cent of the plants to flower from the date of sowing.

Days to peg initiation : Number of days taken for the first initiation of peg from the date of sowing.

Canopy circumference : Canopy circumference at 60 days after emergence was measured in cm with the help of a measuring tape by placing around the plant spread.

Canopy diameter : Canopy diameter at 60 days after emergence was measured in cm in two different directions at ground level and the mean was taken.

Plant height : The height of the plant at maturity was measured in cm from the first cotyledonary node to the tip of the main axis.

Number of primaries : Number of branches originated from the main axis (n+1) were counted at the time of harvest.

Number of secondaries : Number of branches developed on primary branches (n+2) per plant were counted at the time of harvest.

Number of aerial pegs : The total number of aerial pegs which did not have access to penetrate into the soil.

Number of mature pods : Well filled pods were counted at harvest.

Mature pod weight: Weight of mature pods in grams.

Number of mature kernels : Well developed kernels were counted after shelling of air dried pods.

Mature kernel weight : Weight of mature kernels in grams.

Total dry matter at harvest : Dry weight of the plant including root system in grams at the time of harvest.

100 kernel weight : Weight of 100 kernels in grams.

Oil per cent : Oil per cent in uncrushed seed was determined by using Nuclear Magnetic Resonance (NMR) spectrometer at Directorate of Oilseeds Research (DOR), Rajendranagar.

Shelling per cent : The ratio of kernel weight to pod weight expressed in percentage.

Harvest Index : The ratio of kernel yield to total dry matter expressed in percentage.

3.2.2 Experiment II : Hybridization

3.2.2.1 Crossing programme

The crossing programme involving the traditional genotypes on one hand and the mutant genotypes on the other was carried out in rabi 1987-88. The cross involving TMV2NLM and GNLM was however made in rabi 1989-90.

The crossing was started with the initiation of flowering. The flower buds of the plants to be used as females were emasculated and a bright coloured nylon thread was tied as a ring around the emasculated bud for identification. Emasculations were done between 4.30 PM to 6.00 PM and the emasculated buds were pollinated in the next morning before anthesis, between 6.00 AM and 8.00 AM (Kale and Mouli, 1984). Emasculation was done for about 4 to 5 consecutive buds arising from each axil and the others arising later, were removed carefully. Only those pods whose pegs had the nylon ring around the node were harvested as crosses.

3.2.2.2 Evaluation of F_1 generations

The F_1 hybrids along with parents were grown during *kharif* 1988, in a Randomised Block Design with two replications. Seeds were sown on ridges by hand dibbling with a spacing of 60 cm between the rows and 15 cm within a row. The data were collected on each F_1 plant. Seeds harvested separately from each F_1 plant. The F_1 generation of GNLM and TMV2NLM could not be included with the rest as the cross was made in *rabi* 1989-90.

3.2.2.3 Evaluation of F_2 generations

In the F_2 generations, single plant progenies of each cross along with the parents were grown during *rabi* 1988-89 in two replications. Another set of F_2 generations obtained from the F_1 hybrids studied by Madhavi (1988) were, however, grown in *kharif* 1988 and the relevant data collected. The inter and intra row spacings adopted were 60 cm x 20 cm respectively. Segregants were identified and tagged at the time of flowering. At the time of collection of data, utmost care was taken to include all the segregants without fail. In addition five plants at random were also selected from among phenotypically non-recombinant population of each cross for collecting the necessary data. These plants selected for data recording were harvested separately. The progenies of agronomically superior recombinants selected in F_2 generation were evaluated in F_3 generation during *kharif* 1989.

Through out the study the crop was fertilized at the rate of 20 kg ha^{-1} N, 40 kg ha^{-1} P_2O_5 and 20 kg ha^{-1} K_2O as basal dose. Another dose of nitrogen 20 kg ha^{-1} was applied at peak flowering stage as top dressing. Gypsum was applied at the rate of 500 kg ha^{-1} as top dressing when the crop was in peak flowering. All appropriate cultural operations and prophylactic measures against pests and diseases were undertaken to maintain good crop growth.

3.2.2.4 Observations recorded

The data were recorded in each replication for the following characters in F_1 and F_2 generations. The description of characters was same as in Experiment I.

Before harvesting, the data were recorded on

Days to flower

Canopy circumference

Canopy diameter

Leaf area at 60 days

To calculate the leaf area of the standing crop without destroying the plant, the procedure suggested by Madhavi (1988) has been adopted for the present study. The total number of leaves of each plant was counted in the field and fourth leaf from each of the primary branches of the plant was taken. The leaf area of the freshly collected leaves from each plant was measured with the leaf area meter. The total leaf area of the plant was calculated using the following formula :

$$\text{Total leaf area} = \frac{\text{Leaf area in cm2 of the sample leaves}}{\text{Number of primary branches}} \times \text{Number of leaves of the plant}$$

At the time of harvest, the following observations were recorded.

Plant height

Number of primaries

Number of secondaries

Number of aerial pegs

Number of mature pods

Mature pod weight

Number of mature kernels

Mature kernel weight

Total dry matter at harvest

Shelling per cent

Harvest Index

3.2.3 Experiment III : Induction of mutations for canopy characters in the Aerial pod bearing genotype TAP5

Four hundred well developed dry seeds of the aerial podding genotype TAP5 per treatment were presoaked in water for 23 hours and treated with two chemical mutagens viz., Sodium azide and Ethyl Methane Sulphonate as given below.

3.2.3.1 Sodium azide (NaN_3)

The Sodium azide solution of 3 mM concentration was prepared by dissolving 0.195 g of chemical in 1000 ml of 0.1 M citric acid-sodium phosphate buffer solution and it was used for treating the presoaked seed for 3 hours at room temperature (24 $\pm$ 1^{o}C) with intermittent shaking as described by Prasad *et al.* (1985).

3.2.3.2 Ethyl Methane Sulphonate (EMS)

The seeds presoaked in water for 23 hours were treated in an aquious solution of EMS of the concentration of 0.3% for 3 hours with intermittent shaking at room temperature (24 $\pm$ 1^{o}C) (Prasad, 1972). Seeds soaked in water were maintained as control.

After the mutagenic treatment, the seeds were thoroughly washed in running tap water for 30 minutes to remove the excess amount of mutagen. The seeds were then sown immediately together with the appropriate control on ridges by hand dibbling with a spacing of 60cm between the rows and 20 cm between the seeds within a row to raise M_1 generations during kharif 1988. The same spacing was adopted through out the study.

All the seeds obtained separately from each M_1 plant were sown in M_2 generation along with the control in rabi 1988-89. In M_2 generation each plant was thoroughly examined and different mutants were identified. The data were collected from the mutants and also from a sample of 10 randomly selected plants. Seeds from each mutant and randomly selected plants were harvested separately in M_2 generation. Single plant progenies were grown in M_3 generation during kharif 1989 and their breeding behaviour was studied. Data were collected from 20 randomly selected plants in each progeny (Prasad et al., 1985).

Appropriate cultural operations and plant protection measures were carried out whenever necessary.

3.2.3.3 Observations recorded

Observations were recorded on the following characters for calculation of means and variances in M_1, M_2 and M_3 generations.

Canopy circumference

Canopy diameter

Leaf area at 60 days

Plant height

Number of primaries

Number of secondaries

Number of aerial pegs

Number of mature pods

Mature pod weight

Number of mature kernels

Mature kernel weight

Total dry matter at harvest

In addition to the above characters, chlorophyll content at 60 days after emergence was estimated in selected mutants and control in M_2 generation by using the method suggested by Witham et al. (1971). Fresh green leaves of mutants were collected in separate polythene covers. One gram of fresh leaf material was taken in a clean mortar to which 40 ml of 80 per cent acetone and a pinch of calcium carbonate were added and made into a fine pulp. This pulp was filtered into a 100 ml volumetric flask to obtain the chlorophyll extract. The filter paper was cleaned thoroughly with 80 ml of 80 per cent acetone in order to extract the entire chlorophyll. The final volume was adjusted to 100 ml by adding 80 per cent acetone. The optical density of the chlorophyll extract was read in Spectronic-1001 at the wave lengths of 644 , 652 and 663 nm.

The amount of chlorophyll 'a', chlorophyll 'b' and total chlorophyll of the tissue were calculated by using following formulae :

Chlorophyll 'a' = 1.07 (D 663) - 0.094 (D 644) mg/g tissue

Chlorophyll 'b' = 1.77 (D 644) - 0.280 (D 663) mg/g tissue

$$\text{Total chlorophyll} = \frac{(D652) \times V}{34.5 \times W} \text{ mg/g tissue}$$

Where,

D = optical density at the corresponding wave length

V = Volume of the aliquot

W = Weight of the plant material

3.2.4 Statistical Analysis

3.2.4.1 Categorisation of Groundnut Genotypes for Canopy Development

The genotypes were categorised for the canopy development employing canopy category 1 to 4 based on the factors believed to influence canopy ratings such as canopy diameter, canopy circumference and leaf area at 60 days (Metz et al., 1984). While considering the characters jointly to make decisions, in order to categorise the canopy types, a method proposed by Arunachalam and Bandyopadhyay (1984) was used. A score was allotted for each genotype. The scores were added across the characters to provide a final score, based on which the genotypes were thereby categorised for the canopy development.

Duncan's multiple range test (DMRT) was used (SAS, 1985), instead of t'test suggested by Arunachalam and Bandyopadhyay (1984) to find out the differences in the mean performance of the genotypes for canopy diameter, canopy circumference and leaf area at 60 days. The genotypic means for the above traits over three seasons (pooled analysis) were arranged in groups based on

DMRT. The top most group containing genotypes with the highest mean was given rank 1, the next highest rank 2 and so on. If 'K' was the number of groups for a particular character, the genotypes of rank 1 were given a score = 1/k, those of rank 2 a score = 2/K and so on to obtain standardised scores across the characters later on. When overlapping of groups occur, it is possible that a genotype could be of rank 1 and also of rank 2. The score for that genotype was taken to be the average which would thus be equal to (1+2)/2K = 3/2K. The genotypes occuring of more than 2 ranks would be treated in a like manner for allotment of scores (Arunachalam and Bandyopadhyay, 1984). The individual scores for each trait were added up to provide a total score for each genotype. The genotypes were then ranked in ascending order based on their total score. By observing the clear trend of total score, the genotypes were classified for different canopy types. The rating of 1 indicated a compact canopy with a total score of >2.5, 2 a medium compact canopy with a total score range of 1.6 - 2.4, 3 a medium spreading (0.8 - 1.6), and 4 a spreading canopy (0 - 0.8) (Table 3).

3.2.4.2 Experiment I

Stability Analysis: Stability analysis was carried out for 7 genotypes with 2 treatment factors i.e., 3 spacings and 2 fertilizer doses over 3 seasons considering as Randomized Block Design (Murari Singh, 1991). Three parameters viz., (1) overall mean of each genotype over the range of environments (2) The regression of each genotype on the environmental index and (3) a function of the squared deviation from this regression were estimated by following the methodology of Eberhart and Russell (1966). The model proposed by them is as follows:

$$Y_{ij} = \mu + B_i I_j + \delta_{ij}$$

where,

i varies from 1 to 7

j varies from 1 to 18

Y_{ij} = mean of i^{th} genotype in j^{th} environment

μ = mean of all the genotypes over all the environments.

B_i = the regression coefficient of the i^{th} genotype on the environmental index which measures the response of this genotype to varying environments.

I_j = the environmental index which is defined as the deviation of the mean of all the genotypes at a given location from the overall mean.

δ_{ij} = the deviation from regression of the i^{th} genotype at j^{th} environment.

Analysis of variance for stability

Analysis of variance to estimate stability parameters is given below.

Source	d.f.	S.S.	M.S.
Total (treatment combining)	ge-1	$\sum_i \sum_j Y_{ij}^2 - CF$	
Genotype (cultivar)	g-1	$1/e \sum_i Y_i^2 - CF$	M_1

Source	d.f.	S.S.	M.S.
Environment + (Genotype x Environment)	g(e-1)	$\sum_{i}\sum_{j} Y_{ij}^2 - \sum Y_{i}^2 . /e$	
Environment (linear)	1	$1/g(\sum_{j} Y._{j}I_{j})^2/\sum I_j^2$	
Genotype x Environment (linear)	g-1	$[(\sum_{j} Y_{ij}I_{j})^2/\sum_{j} I_j^2]-$ Environment (linear)S.S.	MS_2
Pooled deviations	g(e-2)	$\sum_{i}\sum_{j} \delta^2 ij$	MS_3
Deviations due to genotype I	e-2	$[\sum_{j} Y_{ij}^2 - (Y_I)^2]$	MS_3-I
: :		$(\sum_{j} YI_{j}I_{j})^2/\sum_{j} I_j^2 =$	
: :		$= \sum_{j} \sigma^2 I_j$	
genotype....g	e-2	$\sum_{j} Y_{gj}^2 - (Y_i^2)/e -$	MS_3-g
		$(\sum_{j} Y_{gj}I_j)^2/\sum_{j} I_j^2 =$	
		$= \delta^2$ gi	
Pooled error	e(r-1)(g-1)		

g = genotype (cultivar); e = environment; r = repliction

Estimation of stability parameters

The regression coefficient (bi) and mean square deviations (S^2d) from linear regression were estimated as follows:

a) Regression coefficient

$$b_i = \sum_{j} Y_{ij}I_j/\sum_{j} I_j^2$$

where,

$\sum_j Y_{ij}I_j$ = the sum of products of environmental index (I_j) with corresponding mean of that genotype at each environment (Y_{ij})

$\sum_j I_j^2$ = the sum of squares of the environmental index I_j.

b) **Mean Square deviations (S^2d) from linear regression**

$$S^2d = \sum_j \hat{\delta}_{ij}^2/(e-2)]-S^2e/r$$

where,

$$\sum_j \hat{\delta}_{ij}^2 = \sum_j Y_{ij}^2-Y_i^2/g - (\sum_j Y_{ij}I_j)^2/\sum_j I_j^2$$

= variance due to deviation from regression for a genotype

$\sum_j Y_{ij}^2-Y_i^2/g$ = variance due to dependent variable and

$(\sum_j Y_{ij}I_j)^2/(\sum_j I_j^2)$ = variance due to regression

S^2e/r = the estimate of pooled error

e = number of environments;

r = number of replications

The various computational steps involved in the estimations are as follows:

Computation of environmental index (I_j):

$$I_j = \sum_j Y_{ij}/g - \sum_{ij}\sum Y_{ij}/ge$$

= Total of all the genotypes at the j^{th} environ-ment/number of genotypes - grand total/total number of observations.

Computation of regression coefficient (b_i) for each genotype:

a) for each value of regression coefficient, $\sum_j I^2 j$ is common.

b) $\sum_j Y_{ij} I_j$ for each genotype is the sum of products of environmental index (I_j) with the corresponding mean ($\bar{X}$) of that genotype in each environment.

These values may be obtained in the following manner.

$$(\bar{X})(I_j) = (\sum_j Y_{ij} I_j) = (S)$$

where,

$(\bar{X})$ = matrix of means

(I_j) = vector for environmental index, and

(S) = vector for sum of products,

i.e., $\sum_j Y_{ij} I_j$

Computation of S^2d:

In a regression analysis, it is possible to partition the variance of the dependent variable (Y) into two parts, the one which explains the linearity between dependent and independent variables (Variance due to regression) and the other which explains the variance due to deviations from linearity.

$\sigma^2 Y = \sigma^2$ regression + σ^2 deviation from the regression

The variance of mean over different locations with regard to individual genotype may be obtained in the following way:

$$\sigma^2_{gi} = \sum_j Y^2_{ij} - (Y^2_i/g)$$

The variance due to deviations from regression ($\sum_j \delta^2_{ij}$) for a genotype being

$$\sum_j \delta^2_{ij} = [(\sum_j Y^2_{ij}) - Y^2_i/g] - (\sum_j Y_{ij} I_j)^2 / \sum_j I^2_j$$

where,

$\sum_j Y^2_{ij} - Y^2_i/g$ = the variance due to dependent variable

and ($\sum_j Y_{ij} I_j)^2/(\sum_j I^2_j)$ = the variance due to regression

because,

$(\sum_j Y_{ij} I^2_j)/\sum_j I^2_j = (\sum_j Y_{ij} I_j)(\sum_j Y_{ij} I_j)/\sum_j I^2_j = b_i \sum_j Y_{ij} I_j$

From $\sum_j \delta^2_{ij}$ values, the stability parameters S^2d for each variety is computed as follows:

$$S^{-2}d = [\sum_j \delta^2_{ij}/(e-2)] - (S^2e/r)$$

Mean square deviation = (Deviation from regression/d.f. for environment) - pooled error/No. of replications)

The variance due to genotypes, environments and the pooled error were the same as those calculated in the pooled analysis of the data, except that the total sum of squares was mainly partitioned into three main components namely (1) sum of squares due to genotypes, (2) sum of squares due to environments + (genotype x environment) and (3) pooled error. Again SS due to

GxE was further partitioned into two parts i.e., (a) SS due to GxE (linear) which is in fact SS due to regression and (b) SS due to deviations from linearity of response (i.e., SS due to deviations).

i) SS due to environment + (GxE) $= \sum_i \sum_j Y_{ij}^2 - (\sum_i Y_i^2/e)$

ii) SS due to environment (linear) $= (1/g)[\sum_j Y_j I_j)^2/\sum_j I_j^2)$

iii) SS due to genotype x environment (linear) =

$\sum_j [(\sum_j Y_{ij} I_j)^2/\sum_j I_j^2)]$-SS environment (linear)

where,

$(\sum_j Y_{ij} I_j)^2/\sum_j I_j^2) = b_i \sum_j Y_{ij} I_j$ for each variety.

Tests of significance

The following tests of significance were carried out.

(1) To test the significance of the differences among genotype means i.e., Ho $= \mu_1 = \mu_2 \ldots \mu_{14}$ the 'F' test used was,

$$F = \frac{\text{Mean square due to genotype}}{\text{Mean square due to pooled deviation}} = MS_1/MS_3$$

(2) To ascertain that the genotypes did not differ due to regression on environmental index i.e., Ho $= b_1 = b_2 = b_3 \ldots b_{14}$, the 'F' test used was:

$$F = \frac{\text{MS due to genotype x environment (linear)}}{\text{MS due to pooled deviation}} = MS_2/MS_3$$

(3) Individual deviation from linear regression was tested as follows:

$$F = [(\sum_j \delta^2_{ij})/(e-2)]/\text{pooled error}$$

$$P = 0.05 \text{ at } (g-2) \text{ d.f.}$$

(4) The hypothesis that any regression coefficient does not differ from unity or from zero was tested by the appropriate 't' test i.e., for (b-0) (b-0) / (S b_i) = 't' (P = <0.05 for (e-2) d.f.)

$$\text{for } (1-b) \quad \frac{1-b}{SEb_i} = \text{'t'} \text{ (P = <0.05 for (e-2) d.f.)}$$

$$SE\ b_i = \sqrt{\sum_j \delta^2_{ij}/(e-2) \Big/ \sum_j I^2_j}$$

Stability parameters

A genotype with unit regression coefficient (b=1) and the deviation not significantly differing from zero (s^2d = 0) was taken to be stable genotype with unit response. Mean and standard error of 'b' are

$$\text{Mean of b} = b = \sum_i bi/g$$

$$SE\ b = \sqrt{\text{M.S. due to pooled deviation}/ \sum_j I^2_j}$$

Population mean (u) and standard error were calculated as

$$\text{Population mean (u)} = \frac{\text{Grand Total}}{\text{Number of observations}}$$

$$\text{SE (mean)} = \sqrt{\frac{\text{MS due to pooled deviation}}{\text{No. of environments} - 1}}$$

3.2.4.3 Experiment II

Estimation of Means and Variances

Means and variances were estimated for quantitative characters in F_2 generation. In F_1 generation, only means were calculated. The mean values for 17 parents were also calculated in each generation. Following formulae were used.

$$\text{Mean } (\bar{x}) = A + \left[\frac{\Sigma fd}{\Sigma f} \times C \right]$$

$$\text{Variance } (\sigma^2) = \frac{1}{N} \left[\Sigma fd^2 - \frac{(\Sigma fd)^2}{N} \right] \times C^2$$

where,

A = assumed mean

f = frequency

d = (X-A)/C, where 'X' is the mid value of the class interval

N = Total number of observations

C = Length of the class interval

Estimation of Heterosis

The heterosis was considered as the deviation of the F_1 from the better parent. It was calculated as per cent increase or decrease of F_1 over the better parent by using the formula given by Liang _et al_. (1972).

$$\% \text{ Heterosis} = \frac{\overline{F}_1 - \overline{B.P.}}{\overline{B.P.}} \times 100$$

where,

$\overline{F}_1$ = Mean of F_1

$\overline{B.P.}$ = Mean of better parent

To test the significance of heterosis, the following formula suggested by Arunachalam et al. (1980) was utilized.

$$t = \frac{\overline{F}_1 - \overline{B.P.}}{\sqrt{2 \text{ EMS } (F_1)/r}}$$

where,

r = number of replications

The calculated 't' value is compared with 't' table value at error d.f.

Selection criteria for Means and Variances of different characters

In F_2 generation, 20 per cent selection criteria was adopted in order to group the means and variances of different characters viz., Days to initial flowering, days to 50 per cent flowering, days to 100 per cent flowering, canopy diameter, canopy circumference and leaf area at 60 days, plant height, number of primaries, number of secondaries, number of aerial pegs, number of mature pods and its weight, number of mature kernels and its weight, shelling per cent and harvest index.

By adopting 20 per cent selection criteria, the F_2 generation for the above characters was grouped into high variance with high mean, high variance with medium mean, high variance with low mean, medium variance with high mean, medium variance with medium mean, medium variance with low mean, low variance with high mean, low variance with medium mean and low variance with low mean.

Cluster analysis

In order to group the crosses involving TAP5, cluster analysis (SAS, 1985) was carried out based on means and variances in F_2 generation. The crosses were grouped for the characters viz., canopy diameter, canopy circumference, leaf area at 60 days, number of primaries, secondaries and aerial pegs, number of mature pods and kernels, mature pod weight and kernel weight, total dry matter at harvest, shelling percent and harvest index into high variance with high mean, high variance with medium mean, high variance with low mean, medium variance with high mean, medium variance with medium mean, medium variance with low mean, low variance with high mean, low variance with medium mean and low variance with low mean.

Chi-square test

The nature of inheritance of branching pattern, canopy compaction, leaf shape and aerial podding were determined by fitting the F_2 populations into the relevant monohybrid, dihybrid and trihybrid Mendelian ratios and tested for goodness of fit. X^2 test was computed as follows.

$$\chi^2 = \sum_{i=1}^{p} \frac{(\text{observed}_i - \text{expected}_i)^2}{\text{expected}_i}$$

where, p is the total number of phenotypic classes, observed_i is the observed value and expected_i is the expected value of the i^{th} class (Gomez and Gomez, 1976).

3.2.4.4 Experiment III

Estimation of Means and Variances

In M_1, M_2 and M_3 generations of the present study, the means and variances were calculated for various canopy and reproductive attributes same as in the case of Experiment II. The increase in variance in the progenies of mutagen treated material over the control was estimated in terms of percentage for all the characters.

Estimation of viable mutation frequencies

The frequencies of viable mutations were estimated in the M_2 generation of the mutagenic treatments based on M_2 families and M_2 plants.

Viable mutation frequency (on M_2 family basis)

$$= \frac{\text{Number of } M_2 \text{ families segregating for viable mutations}}{\text{Number of } M_2 \text{ families scored}} \times 100$$

Viable mutation frequency (on M_2 plant basis)

$$= \frac{\text{Number of viable mutants recovered}}{\text{Number of } M_2 \text{ plants scored}} \times 100$$

Estimation of mutagenic effectiveness and efficiency

Mutagenic effectiveness and efficiency were calculated by using the modified formulae of Konzak *et al*. (1965) as adopted by Prasad (1972).

Mutagenic effectiveness is the ratio between the percentage of M_2 families segregating for mutations and the product of time of mutagenic treatment and the concentration of mutagen.

$$\text{Mutagenic effectiveness} = \frac{Me}{tc}$$

where,

Me = Percentage of M_2 families segregating for mutants

t = duration of mutagenic treatment

c = concentration of the mutagen

Mutagenic efficiency is the proportion of M_2 families segregating in relation to the percentage sterility induced by the mutagen.

$$\text{Mutagenic efficiency} = \frac{Me}{S}$$

where,

S = Percentage seed sterility in M_1 generation (seed sterility was estimated as percentage reduction of seed number in relation to control).

RESULTS

CHAPTER IV

RESULTS

4.1 CATEGORISATION OF GROUNDNUT GENOTYPES FOR CANOPY DEVELOPMENT

The genotypes were categorised for the canopy development employing canopy category 1 to 4 based on the factors believed to influence canopy ratings such as canopy diameter, canopy circumference and leaf area at 60 days. Mean performance of the genotypes for canopy diameter, canopy circumference and leaf area at 60 days in different seasons and pooled, DMRT between means of genotypes for canopy circumference, diameter and leaf area at 60 days and allocation and classification of scores for eighteen genotypes for different canopy categories are presented in Tables 2, 3 and 4 respectively.

As per the canopy categorisation adopted in the present study (Tables 2, 3 and 4) MH2 (Valencia) alone falls under canopy category of 1 (Compact>2.5) which exhibited the lowest mean canopy development and leaf area at 60 days in all the seasons. The genotypes JL24 (Spanish), J11 (Spanish), PGN1 (Spanish), MH2BC28 (Valencia) a mutant of MH2 for enhanced canopy development, TMV2 (Spanish), PI350680 (Valencia), PI259747 (Valencia) and G201 (Virginia bunch) a mutant of T-28 come under canopy category 2 (medium compact, 1.6 - 2.4) with enhanced canopy development and slightly higher leaf area at 60 days when compared with canopy category 1. The genotypes MK374 (Virginia bunch), TAP5 (Valencia) an aerial podding mutant of 'Tatu', TMV2NLM (Virginia bunch) a narrow leaf mutant of TMV2, Kadiri-3 (Virginia bunch), 32-2-5 (Virginia bunch) a compact canopy mutant

Table 2 : Mean performance of the groundnut genotypes for canopy diameter, canopy circumference and leaf area at 60 days (for categorisation of varieties for canopy development)

Varieties	Rainy 1988			Post rainy 1988-89			Rainy 1989			Pooled over seasons		
	Canopy diameter (cm)	Canopy circumference (cm)	Leaf area at 60 days (sq. cm)	Canopy diameter (cm)	Canopy circumference (cm)	Leaf area at 60 days (sq. cm)	Canopy diameter (cm)	Canopy circumference (cm)	Leaf area at 60 days (sq. cm)	Canopy diameter (cm)	Canopy circumference (cm)	Leaf area at 60 days (sq. cm)
MH2	28.75	87.50	879.00	22.00	50.80	916.72	17.25	48.87	359.10	22.67g	62.39f	718.27o
J11	47.00	156.00	1502.00	45.80	145.10	2601.70	35.46	133.40	714.30	42.75ef	144.83e	1606.00jk
JL24	45.75	155.50	1587.00	46.00	149.20	2558.36	34.60	134.80	690.73	42.12f	146.50e	1612.03j
TMV2	49.25	158.50	1393.00	45.60	148.30	2481.25	39.90	137.80	638.82	44.92def	148.20e	1504.36l
PGN1	47.30	153.50	1055.00	47.50	150.10	2019.01	40.56	139.60	657.30	45.12de	147.13e	1243.77n
TAP5	60.50	171.50	2073.00	60.00	180.60	2664.87	46.90	148.40	1032.57	55.80b	166.83c	1916.81h
PI259747	47.75	157.50	1533.00	49.00	149.40	2082.24	40.80	138.00	928.32	45.85d	148.30e	1514.52l
PI350680	45.75	152.50	1635.00	48.50	147.25	2117.25	39.70	138.60	992.63	44.65def	146.12e	1581.63k
G201	46.00	154.50	1846.00	48.50	150.50	2643.16	35.13	136.25	929.80	43.21def	147.08e	1806.32i
MK374	57.50	169.50	2052.00	54.70	169.18	3004.57	46.10	146.60	1079.26	52.77c	161.76d	2045.28g
GNLM	60.25	170.50	1979.00	60.15	180.25	4014.77	49.38	151.25	1233.92	56.59b	167.33c	2409.16e
TMV2NLM	57.30	165.00	2122.00	58.20	176.15	3950.51	47.90	148.80	1234.25	54.47bc	163.32d	2435.59e
Kadiri-3	58.00	168.00	2335.00	55.00	170.80	3032.41	50.40	154.60	1159.42	54.47bc	164.47cd	2175.61f
32-2-5	54.00	166.00	2303.00	55.90	170.20	4134.29	48.80	148.50	1655.73	52.90c	161.57d	2697.67d
M13	62.75	185.50	2661.00	75.80	211.20	4918.36	57.26	173.00	2054.13	65.27a	190.07b	3211.16b
ICG2271	65.00	200.00	3163.00	76.50	215.50	4819.29	57.38	177.50	2121.50	66.29a	197.67a	3367.93a
MH2BC28	46.75	155.60	1554.00	44.20	147.75	2003.91	39.50	136.50	729.31	43.48def	146.62e	1429.07m
Compact Mutant of M13	53.84	166.15	2701.63	54.26	168.18	4019.93	53.59	160.16	1839.82	53.88bc	164.83cd	2853.79c

Note : Means followed by the same letter are not different at the 0.05 probability level according to DMRT in each column.

Table 3: Duncan's multiple range test (DMRT) between means of genotypes (pooled over seasons) for canopy diameter, canopy circumference and leaf area at 60 days.

Genotypes	CD (cm)	Rank	Genotypes	CC (cm)	Rank	Genotypes	LA (sq.cm)	Rank
ICG2271	66.29a	1	ICG2271	197.67a	1	ICG2271	3367.93a	1
M13	65.27a		M13	190.07b	2	M13	3211.16b	2
						Compact mutant	2853.79c	3
GNLM	56.59b		GNLM	167.33c		of M13		
TAP5	55.80b		TAP5	166.83c	3	32-2-5	2697.67d	4
TMV2NLM	54.47bc	2	Compact mutant	164.83cd				
KADIRI-3	54.47bc		of M13			TMV2-NLM	2435.59e	5
Compact mutant	53.88bc		KADIRI-3	164.47cd		GNLM	2409.16e	
of M13			TMV2NLM	163.32d	4	KADIRI-3	2175.61f	6
32-2-5	52.90c		MK374	161.76d		MK374	2045.28g	7
MK374	52.77c		32-2-5	161.57d		TAP5	1916.81h	8
						G201	1806.32i	9
PI259747	45.85d	3	PI259747	148.30e				
PGN1	45.12de		TMV2	148.20e		JL24	1612.03j	
TMV2	44.92def	4	PGN1	147.13e		J11	1606.00jk	10
PI350680	44.65def		G201	147.08e	5	PI350680	1581.63k	
MH2BC28	43.48def		MH2BC28	146.62e		PI259747	1541.52l	11
G201	43.21def		JL24	146.50e		TMV2	1504.36l	
J11	42.75ef	5	PI350680	146.12e		MH2BC28	1429.07m	12
JL24	42.12f		J11	144.83e		PGN1	1243.77n	13
						MH2	718.27o	14
MH2	22.67g	6	MH2	62.39f	6			

Note : CD = Canopy diameter, CC = Canopy circumference, LA = Leaf area at 60 days

Means followed by the same letter are not different at 0.05 probability level according to DMRT in each column.

Table 4 : Allocation and classification of scores for eighteen genotypes for canopy diameter, canopy circumference and leaf area at 60 days for different canopy categories.

Genotypes	CD	CC	LA	Total Score	Score range class	Canopy category assigned
ICG2271	1/6	1/6	1/14	0.405	(0.0-0.8)	(4)
M13	1/6	2/6	2/14	0.643		
Compact Mutant of M13	2/6	3/6	3/14	1.047	(0.8-1.6)	(3)
GNLM	2/6	3/6	5/14	1.190		
32-2-5	2/6	7/12	4/14	1.202		
KADIRI-3	2/6	3/6	6/14	1.262		
TMV2NLM	2/6	7/12	5/14	1.273		
TAP5	2/6	3/6	8/14	1.404		
MK374	2/6	7/12	7/14	1.416		
G201	7/12	5/6	9/14	2.059	(1.6-2.4)	(2)
PI259747	3/6	5/6	11/14	2.119		
PI350680	7/12	5/6	10/14	2.130		
TMV2	7/12	5/6	11/14	2.202		
MH2BC28	7/12	5/6	12/14	2.273		
PGN1	7/12	5/6	13/14	2.345		
J11	5/6	5/6	10/14	2.380		
JL24	5/6	5/6	10/14	2.380		
MH2	6/6	6/6	14/14	3.000	(>2.5)	(1)

Note : CD = Canopy diameter, CC = Canopy circumference,
LA = Leaf area at 60 days

of MK374, GNLM (*Virginia* bunch) a narrow leaf mutant of Punjab-1, Compact Mutant of M13 (*Virginia* bunch) fall under canopy category 3 (medium spreading, 0.8 - 1.6) with higher canopy development and leaf area at 60 days. While the genotypes M13 (*Virginia* runner) and ICG 2271 (*Virginia* runner) fall under canopy category 4 (spreading, 0 - 0.8) with the highest levels of canopy development and leaf area at 60 days.

4.2 RESPONSE OF GROUNDNUT GENOTYPES TO THREE DIFFERENT SPACINGS AND TOP DRESSING OF NITROGEN

The response of 7 genotypes viz., MH2, JL24, TAP5 (aerial podding mutant of Tatu), Kadiri-3, TMV2NLM (narrow leaf mutant of TMV2), Compact Mutant of M13 and M13 to three different spacings and top dressing of nitrogen was studied and the results are presented below (Tables 5, 6, 7, 8, 9, 10 and 11).

4.2.1 MH2

4.2.1.1 Days to Initial Flowering

The data (Table 5) indicate that the number of days taken for initial flowering were less in *kharif* season as compared to *rabi* season. There were no significant differences among the treatments N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm for this character in both *kharif* and *rabi* seasons.

4.2.1.2 Days to 50% Flowering

The days taken for 50 per cent of the plants to flower were more in *rabi* season than in *kharif* season. With regard to this character, significant differences were not observed among the treatments N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm in both <u>kharif</u> and <u>Rabi</u> seasons.

4.2.1.3 Days to 100% Flowering

It was observed that in <u>kharif</u> season the number of days taken for 100% flowering were much less than in <u>rabi</u> season (Table 5). In both <u>kharif</u> and <u>rabi</u> seasons there were no significant differences among the treatments N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm for this trait.

4.2.1.4 Days to Peg Initiation

The days taken for the initiation of the first peg were less in <u>kharif</u> season than in <u>rabi</u> season. The differences observed for this trait among the treatments viz., N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm were not significant in both <u>kharif</u> and <u>rabi</u> seasons.

4.2.1.5 Canopy Diameter

The canopy diameter was slightly high in <u>kharif</u> season than in <u>rabi</u> season. The canopy diameter recorded in N_2-90 cm (32.90 cm), N_2-60 cm (32.75 cm), N_1-60 cm (31.63 cm), N_2-30 cm (30.80 cm) and N_1-90 cm (30.60 cm) treatments was at par and the differences among them were not significant in <u>kharif</u> season. Whereas in <u>rabi</u> season, N_2-60 cm (30.75 cm) resulted in high canopy diameter which was significantly different from N_1-60 cm (27.50 cm), N_1-30 cm (26.85 cm) and N_1-90 cm (26.50 cm). But it

Table 5 : Mean performance of MH2 for 19 characters in six micro-environments in *Kharif* and *Rabi* seasons.

Micro-environment / Treatment	Days to initial flowering		Days to 50% flowering		Days to 100% flowering		Days to peg initiation		Canopy diameter (cm)		Canopy circumference (cm)		Plant height (cm)	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	26.750	47.000	28.750	52.000	31.750	54.000	32.750	53.000	29.800	26.850	48.380	50.000	8.150	4.400
N2-30	27.250	48.000	29.250	53.000	32.000	55.500	33.750	53.500	30.800	27.650	59.850	51.250	8.180	4.600
N1-60	26.750	46.000	29.500	52.000	32.500	55.000	33.500	52.500	31.630	27.500	57.100	71.900	11.250	4.450
N2-60	26.250	45.500	29.750	52.500	31.500	56.000	34.000	53.500	32.750	30.750	61.670	72.700	7.380	4.750
N1-90	26.500	46.000	29.250	52.000	32.000	55.000	33.000	52.000	30.600	26.500	68.950	46.500	10.750	4.400
N2-90	26.500	44.500	29.250	52.000	32.250	54.500	33.750	54.000	32.900	28.500	69.400	65.000	9.750	4.700
SE	0.483	1.983	0.960	1.133	1.197	0.966	0.609	1.041	0.944	1.532	1.160	1.856	0.736	0.447
CD at 5%	1.242	5.098	2.468	2.913	3.077	2.484	1.566	2.676	2.430	3.940	2.982	4.772	1.892	1.149

Micro-environment / Treatment	Number of primaries		Number of secondaries		Number of aerial pegs		Number of mature pods		Mature pod weight (g)		Number of mature kernels		Mature kernel weight (g)	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	4.600	5.100	0.000	1.600	9.450	3.900	10.750	13.750	6.430	9.100	19.130	31.250	5.500	7.500
N2-30	4.600	5.500	0.150	1.100	7.650	8.500	12.200	16.700	7.900	13.050	32.170	30.500	6.550	9.000
N1-60	4.680	5.700	0.150	1.600	10.400	7.200	11.500	17.150	7.030	13.300	23.150	27.000	6.450	9.100
N2-60	5.080	5.800	0.050	2.500	5.320	16.100	14.630	17.000	10.430	13.650	24.050	31.500	7.850	9.500
N1-90	5.100	5.600	0.050	1.400	16.200	5.300	11.800	17.500	7.500	13.700	34.450	24.500	6.050	9.400
N2-90	5.230	5.750	0.000	1.850	13.550	8.500	14.000	18.000	9.700	14.500	47.250	35.000	7.450	10.000
SE	0.346	0.348	0.097	0.536	1.732	2.147	0.599	1.623	0.495	1.790	2.195	1.059	0.478	1.171
CD at 5%	0.889	0.895	0.249	1.378	4.453	5.520	1.540	4.170	1.270	4.600	5.643	2.723	1.230	3.010

Micro-environment / Treatment	Total dry matter at harvest (g)		100 kernel weight (g)		Oil percent		Shelling percent		Harvest Index	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	20.120	12.950	21.730	37.580	45.300	47.250	85.030	70.200	24.590	37.110
N2-30	17.110	15.450	24.940	39.950	45.750	48.250	88.980	85.400	30.860	37.260
N1-60	16.920	15.190	24.250	34.020	47.800	48.300	78.500	70.300	26.620	36.860
N2-60	22.440	16.770	26.910	34.490	47.670	48.200	90.990	71.900	32.400	37.940
N1-90	14.460	15.050	19.880	35.180	46.100	47.150	80.250	70.200	21.460	31.540
N2-90	24.350	22.310	23.620	37.090	46.580	47.700	85.880	70.900	40.380	39.130
SE	1.268	1.240	1.491	0.857	1.337	1.359	2.886	3.720	3.170	2.106
CD at 5%	3.260	3.203	3.833	2.203	3.437	3.494	7.420	9.560	8.150	5.410

was not significantly different from N_2-90 cm (28.50 cm) and N_2-30 cm (27.65 cm).

4.2.1.6 Canopy Circumference

There was not much difference in canopy circumference in <u>kharif</u> and <u>rabi</u> seasons. In <u>kharif</u> season significantly high canopy circumference was observed in N_2-90 cm (69.40 cm) and N_1-90 cm (68.95 cm) than in the rest of the treatments between which the difference was not significant. While in <u>rabi</u> season, the canopy circumference recorded in N_2-60 cm (72.70 cm) and N_1-60 cm (71.90 cm) were at par and these two values were significantly higher than those observed in the rest of the treatments.

4.2.1.7 Plant Height

The plant height observed in <u>kharif</u> season was much higher than in <u>rabi</u> season. In <u>kharif</u> season, significantly high value was found in N_1-60 cm (11.25 cm) as compared to that in rest of the treatments except N_1-90 cm (10.75 cm) and N_2-90 cm (9.75 cm), among which the differences were not significant. While in <u>rabi</u> season significant differences were not observed among all the treatments.

4.2.1.8 Number of Primaries

The number of primaries recorded were slightly high in <u>Rabi</u> season than in <u>kharif</u> season. From <u>Kharif</u> data it was observed that the N_2-90 cm (5.23) resulted in more number of primaries which was significantly different from N_1-60 cm (4.68),

N_1-30 cm (4.60) and N_2-30 cm (4.60). But the value found in N_2-90 cm was at par with the values recorded in N_1-90 cm (5.10) and N_2-60 cm (5.08). In rabi season there were no significannt differences among the treatments.

4.2.1.9 Number of Secondaries

The data (Table 5) revealed that secondary branches were more in rabi season as compared to kharif season. There were no significant differences among the treatments N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm for number of secondaries in both kharif and rabi seasons.

4.2.1.10 Number of Aerial Pegs

The data on number of aerial pegs indicate that the mean values were higher in kharif season than in rabi season. In kharif season, significantly more number of aerial pegs were observed in N_1-90 cm (16.20) as compared to all other treatments except N_2-90 cm (13.55) between which the difference was non-significant. In rabi season, N_2-60 cm (16.10) recorded significantly higher number of aerial pegs than that observed in rest of the treatments.

4.2.1.11 Number of Mature Pods

In rabi season, the number of mature pods were more as compared to kharif season. In kharif season, the highest number of mature pods was recorded by N_2-60 cm (14.63) and it was significantly different from the rest of the treatments except N_2-90 cm (14.00), which was at par. While in rabi season more number of mature pods were obtained in N_2-90 cm (18.00) which was not significantly different from the rest of the treatments except from N_1-30 cm (13.75).

4.2.1.12 Mature Pod Weight

The mature pod weight was high in rabi season as compared to that in kharif season. The data indicate that high mature pod weight was found in N_2-60 cm (10.43 g) and it was significantly different from all other treatments except that recorded in N_2-90 cm (9.70 g) in kharif season. In rabi season, there were no significant differences among the treatments viz., N_2-90 cm (14.50 g), N_2-60 cm (13.65 g), N_2-30 cm (13.05 g), N_1-90 cm (13.70 g) and N_1-60 cm (13.30 g) for this trait.

4.2.1.13 Number of Mature Kernels

With regard to number of mature kernels there was not much difference between kharif and rabi seasons. In both kharif and rabi seasons the number of mature kernels was significantly high in N_2-90 cm 47.25 g and 35.00 g respectively than that recorded in rest of the treatments.

4.2.1.14 Mature Kernel Weight

The data (Table 5) on mature kernel weight revealed that in rabi season the kernel weight was higher than that in kharif season. In kharif season, the N_2-60 cm (7.85 g) resulted in significantly high mature kernel weight than the rest of the treatments except the N_2-90 cm (7.45 g). Whereas in rabi season, significant differences were not observed for this character among the treatments.

4.2.1.15 Total Dry Matter at Harvest

In *kharif* season, there was slightly high total dry matter production at harvest than in *rabi* season. The results indicate that significantly high total dry matter at harvest was obtained in N_2-90 cm (24.35 g) followed by N_2-60 cm (22.44 g) than in the rest of the treatments, while the difference between these two is non significant. In *rabi* season, significantly high total dry matter at harvest was observed in N_2-90 cm (22.31 g) than in the rest of the treatments.

4.2.1.16 100 Kernel Weight

The 100 kernel weight was high in *rabi* season than in *kharif* season. In *kharif* season, the highest 100 kernel weight was observed in N_2-60 cm (26.91 g) which was significantly different from N_1-30 cm (21.73 g) and N_1-90 cm (19.88 g). But it was not significantly different from that recorded in N_2-30 cm (24.94 g), N_2-90 cm (23.62 g) and N_1-60 cm (24.25 g). In *rabi* season, significantly higher value was observed in N_2-30 cm (39.95 g) than that found in rest of the treatments.

4.2.1.17 Oil Per cent

The results revealed that there was not much difference in oil per cent between *kharif* and *rabi* seasons. For this trait there were no significant differences among N_1-30 cm, N_2-30 cm,

N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm in both kharif and rabi seasons.

4.2.1.18 Shelling Per cent

High shelling per cent was recorded in kharif season than in rabi season. In kharif season, high shelling per cent was found in N_2-60 cm (90.99%) and it was significantly different from that in N_1-60 cm (78.50%) but not significantly different from the remaining treatments. In rabi season significantly high shelling per cent was observed in N_2-30 cm (85.40%) than that recorded in rest of the treatments (Table 5).

4.2.1.19 Harvest Index

It was observed that the harvest index values were high in rabi season than in kharif season. The treatment N_2-90 cm (40.38) recorded significantly high value than the rest of the treatments except N_2-60 cm (32.40) in kharif seasonn. In rabi season, high harvest index was found in N_2-90 cm (39.13) which was not significantly different from all other treatments except from N_1-90 cm (31.54) between which the difference was significant.

4.2.2 JL-24

4.2.2.1 Days to Initial Flowering

In kharif season the number of days taken for the initiation of first flower were less as compared to rabi season. There were no significant differences among N_1-30 cm, N_2-30 cm,

N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm for this trait in both kharif and rabi seasons (Table 6).

4.2.2.2 Days to 50% Flowering

The results indicate that the number of days to 50% flowering were much less than that in rabi season. In kharif season, the treatments viz., N_1-60 cm (29.75) and N_2-60 cm (29.75) recorded significantly less number of days to 50% flowering than the rest of the treatments except than the treatment N_1-30 cm (30.30). While in rabi season there were no significant differences among the treatments.

4.2.2.3 Days to 100% Flowering

The number of days to 100 per cent flowering were less in kharif season than in rabi season. The N_2-60 cm (31.75) recorded significantly less number of days than N_1-90 cm (33.25) but it was not significantly different from the rest of the treatments in kharif season. In rabi season, significant differences were not observed for this trait among the treatments.

4.2.2.4 Days to Peg Initiation

The days taken for the initiation of peg were much less in kharif season than in rabi season. In kharif season, the N_1-60 cm (33.00) recorded less number of days to peg initiation which was at par with the values found in N_2-60 cm (33.25), N_2-90 cm (33.50) and N_1-30 cm (33.25). There were no significant differences among the treatments for this trait in rabi season.

Table 6 : Mean performance of JL24 for 19 characters in six micro-environments in *Kharif* and *Rabi* seasons.

Micro-environment / Treatment	Days to initial flowering		Days to 50% flowering		Days to 100% flowering		Days to peg initiation		Canopy diameter (cm)		Canopy circumference (cm)		Plant height (cm)	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	27.250	47.500	30.000	52.000	32.500	54.500	33.250	57.000	57.580	57.500	125.940	131.000	41.600	26.750
N2-30	27.500	44.000	30.750	51.000	32.500	54.000	34.000	57.500	58.330	66.700	148.400	147.000	41.880	26.000
N1-60	27.250	43.500	29.750	51.500	32.500	53.500	33.000	56.500	61.380	57.000	149.750	149.000	38.450	27.500
N2-60	27.250	46.000	29.750	52.000	31.750	54.000	33.250	57.000	61.750	59.500	178.260	152.500	35.500	30.000
N1-90	27.000	46.500	31.250	52.000	33.250	55.000	33.750	57.000	57.420	57.500	180.550	160.500	35.600	25.500
N2-90	27.250	47.000	30.500	51.000	32.000	53.500	33.500	56.000	59.250	60.700	197.550	163.500	40.080	31.000
SE	0.387	2.398	0.289	0.695	0.532	1.041	0.266	0.775	1.009	1.266	2.137	2.398	1.367	1.903
CD at 5%	0.995	6.170	0.742	1.790	1.368	2.680	0.684	1.990	2.590	3.250	5.490	6.615	3.514	4.893

Micro-environment / Treatment	Number of primaries		Number of secondaries		Number of aerial pegs		Number of mature pods		Mature pod weight (g)		Number of mature kernels		Mature kernel weight (g)	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	5.000	6.600	0.400	2.550	17.700	24.000	21.000	29.500	17.130	25.550	33.500	42.000	11.750	16.000
N2-30	5.180	6.500	0.500	2.000	17.900	9.100	24.200	32.250	19.600	28.900	39.750	44.500	13.300	16.900
N1-60	6.680	5.250	1.600	3.000	31.900	32.000	26.580	30.000	22.770	25.600	48.750	48.500	14.450	16.100
N2-60	6.800	5.750	1.600	4.000	30.000	32.500	27.700	43.250	23.730	41.950	55.250	54.500	15.050	22.600
N1-90	6.080	5.900	1.030	2.300	32.300	24.500	22.530	35.000	18.300	31.600	44.750	41.000	12.700	18.000
N2-90	6.200	6.500	0.950	6.500	37.500	27.500	28.750	36.500	24.550	32.500	49.500	51.000	15.300	18.500
SE	0.296	0.289	0.294	0.963	9.440	5.510	1.363	0.885	1.069	0.990	1.511	4.710	0.515	0.319
CD at 5%	0.761	0.742	0.756	2.476	24.270	14.166	3.504	2.280	2.750	2.550	3.885	12.109	1.320	0.820

Micro-environment / Treatment	Total dry matter at harvest (g)		100 kernel weight (g)		Oil percent		Shelling percent		Harvest Index	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	23.610	47.600	29.390	43.600	42.250	47.600	70.440	61.400	35.020	25.940
N2-30	25.130	50.800	30.790	45.300	44.100	46.500	72.890	65.170	38.250	26.250
N1-60	33.470	45.800	31.750	42.500	44.950	46.650	65.630	54.900	32.230	27.550
N2-60	33.930	51.900	35.000	46.500	47.200	46.950	67.620	68.060	37.420	30.700
N1-90	36.310	45.600	31.830	43.300	45.400	46.150	64.990	58.060	27.830	21.350
N2-90	40.810	70.000	36.500	44.500	47.700	48.050	71.390	59.400	31.800	29.170
SE	1.906	6.780	1.276	3.920	1.297	1.711	1.401	1.540	2.652	2.267
CD at 5%	4.900	17.431	3.280	10.078	3.334	4.399	3.600	3.960	6.820	5.830

4.2.2.5 Canopy Diameter

There was not much difference in canopy diameter between *kharif* and *rabi* seasons. The canopy diameter was significantly high in N_2-60 cm (61.75 cm) than that observed in rest of the treatments except from that found in N_1-60 cm (61.38 cm) and N_2-90 cm (59.25 cm) in *kharif* season. Whereas in *rabi* season, significantly high canopy diameter was recorded in N_2-30 cm (66.70 cm) when compared to all other treatments.

4.2.2.6 Canopy Circumference

The results (Table 6) showed that the canopy circumference was high in *kharif* season than in *rabi* season. The canopy circumference observed in N_2-90 cm (197.55 cm) was significantly higher than that found in other treatments in *kharif* season. In *rabi* season, the N_2-90 cm (163.50 cm) recorded significantly high canopy circumference when compared to all other treatments except N_1-90 cm (160.50 cm).

4.2.2.7 Plant Height

The plant height was more in *kharif* season than in *rabi* season. In *kharif* season, the highest plant height was found in N_2-30 cm (41.88 cm) which was significantly different from that observed in N_2-60 cm (35.50 cm) and N_1-90 cm (35.60 cm) and it was not significantly different from the rest of the treatments. In *rabi* season, the N_2-90 cm (31.00 cm) resulted in significantly high plant height than N_2-30 cm (26.00 cm) and N_1-90 cm (25.50 cm), but it did not differ significantly from the remaining treatments.

4.2.2.8 Number of Primaries

Between kharif and rabi seasons there was not much difference with regard to number of primaries. In kharif season, the number of primaries recorded in N_2-60 cm (6.80), N_1-60 cm (6.68), N_2-90 cm (6.20) and N_1-90 cm (6.08) were at par and these were significantly different from that found in N_2-30 cm (5.18) and N_1-30 cm (5.00). While in rabi season, there were no significant differences among N_1-30 cm (6.60), N_2-30 cm (6.50), N_2-90 cm (6.50) and N_1-90 cm (5.90) for number of primaries. While the treatments N_1-60 cm (5.25) and N_2-60 cm (5.75) recorded lower number of primaries.

4.2.2.9 Number of Secondaries

More number of secondaries were observed in rabi season than in kharif season. In kharif season, more number of secondaries were recorded in N_2-60 cm (1.60) and N_1-60 cm (1.60) which were significantly different from that found in N_2-30 cm (0.50) and N_1-30 cm (0.40). But they were not significantly different from N_2-90 cm (0.95) and N_1-90 cm (1.03). While in rabi season, the N_2-90 cm (6.50) recorded significantly high number of secondaries than the remaining treatments (Table 6).

4.2.2.10 Number of Aerial Pegs

In kharif season slightly more number of aerial pegs were observed as compared to rabi season (Table 6). The data revealed that there were no significant differences among N_2-90 cm (37.50), N_1-90 cm (32.30), N_1-60 cm (31.90) and N_2-60 cm (30.00) in kharif season and these were significantly different from N_1-30 cm (17.70) and N_2-30 cm (17.90). In rabi season significant differences were not observed among N_2-60 cm (32.50), N_1-60 cm (32.00), N_2-90 cm (27.50), N_1-90 cm (24.50) and N_1-30 cm (24.00), for number of aerial pegs.

4.2.2.11 Number of Mature Pods

From the data (Table 6) it was observed that the number of mature pods was high in rabi season than in kharif season. In kharif season, significantly high number of pods was obtained in N_2-90 cm (28.75) than that in N_2-30 cm (24.20) and N_1-30 cm (21.00). But it was not significantly different from that recorded in N_2-60 cm (27.70) and N_1-60 cm (26.58). Whereas in rabi season, significantly higher number of mature pods was found in N_2-60 cm (43.25) than in the rest of the treatments.

4.2.2.12 Mature Pod Weight

The data on mature pod weight indicate that in rabi season the weight was more than in kharif season. In kharif season, the N_2-90 cm (24.55 g) recorded significantly high mature pod weight than N_2-30 cm (19.60 g) and N_1-30 cm (17.13 g), but it was not significantly different from N_2-60 cm (23.73 g) and N_1-60 cm (22.77 g). Significantly high pod weight was observed in N_2-60 cm (41.95 g) than the rest of the treatments in rabi season.

4.2.2.13 Number of Mature Kernels

The number of mature kernels was slightly high in rabi season than in kharif season. The treatment N_2-60 cm (55.25) recorded significantly higher number of mature kernels than the rest of the treatments in *kharif* season. While in *rabi* season, the N_2-60 cm (54.50) recorded significantly more number of kernels than N_1-30 cm (42.00) and N_1-90 cm (41.00). But it was not significantly different from the rest of the treatments viz., N_2-90 cm (51.00), N_2-30 cm (44.50) and N_1-60 cm (48.50).

4.2.2.14 Mature Kernel Weight

The weight of mature kernels was high in *rabi* season than in *kharif* season. In *kharif* season, the mature kernel weight recorded in N_2-90 cm (15.30 g) was significantly higher than that in the rest of the treatments except that in N_2-60 cm (15.05 g) and N_1-60 cm (14.45 g), among which the differences were not-significant. In *rabi* season, compared to all other treatments, the treatment N_2-60 cm (22.60 g) showed significantly high kernel weight.

4.2.2.15 Total Dry Matter at Harvest

The results (Table 6) indicate that the total dry matter at harvest was high in *rabi* season than in *kharif* season. In *kharif* season, the treatment N_2-90 cm (40.81 g) followed by N_1-90 cm (36.31 g) recorded significantly higher total dry matter at harvest than the remaining treatments, between which the difference was not significant. The N_2-90 cm (70.00 g) showed significantly high value for this trait in *rabi* season as compared to the rest of the treatments.

4.2.2.16 100 Kernel Weight

The weight of 100 kernels was high in Rabi season than in kharif season. In kharif season, significantly high 100 kernel weight was recorded by N_2-90 cm (36.50 g) than the rest of the treatments except N_2-60 cm (35.00 g) between which the difference was not significant. While in rabi season, there were no significant differences among the teatments for this trait. However, the treatment N_2-60 cm (46.50 g) recorded the highest mean value.

4.2.2.17 Oil Per cent

There was not much difference in oil per cent between kharif and rabi seasons (Table 6). The oil per cent recorded in N_2-90 cm (47.70%) was significantly higher than that in N_2-30 cm (44.10%) and N_1-30 cm (42.25%), but it was not significantly different from that in N_2-60 cm (47.20%), N_1-60 cm (44.95%) and N_1-90 cm (45.40%) in kharif season. In rabi season significant differences were not observed among the treatments, however high mean oil per cent was found in N_2-90 cm (48.05%).

4.2.2.18 Shelling Per cent

Slightly high shelling per cent was observed in kharif season than in rabi season. In kharif season, high shelling per cent recorded in N_2-30 cm (72.89%) was significantly different from that observed in all other treatments except that in N_2-90 cm (71.39%) and N_1-30 cm (70.44%). In rabi season, the N_2-60 cm (68.06%) resulted in high shelling per cent which was significantly higher than that in the rest of the treatments except that in N_2-30 cm (65.17%).

4.2.2.19 Harvest Index

The data on harvest index revealed that in kharif season the values were higher than in rabi season. In both kharif and rabi seasons, significant differences were not observed among N_2-60 cm, N_1-60 cm, N_2-90 cm, N_2-30 cm and N_1-30 cm for harvest index. However, high mean harvest index values were observed in N_2-60 cm (37.42 and 30.70) in both kharif and rabi seasons respectively.

4.2.3 TAP5

4.2.3.1 Days to Initial Flowering

It was observed that (Table 7) the days taken for the initiation of the first flower were much less in kharif season than in rabi season. In both kharif and rabi seasons, there were no significant differences among the treatments viz., N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm for this trait.

4.2.3.2 Days to 50% Flowering

In kharif season, days to 50 per cent flowering were more as compared to rabi season. Significant differences were not observed among the treatments viz., N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm for days to 50 per cent flowering in both kharif and rabi seasons.

4.2.3.3 Days to 100% Flowering

The data (Table 7) indicate that in *kharif* season the number of days to 100 per cent flowering were less than in *rabi* season. In *kharif* season, the treatments N_1-30 cm (28.75) and N_2-30 cm (28.75) recorded less number of days which were significantly different from N_1-60 cm (30.50) but they were not significantly different from the rest of the treatments. In *rabi* season, the number of days to 100% flowering recorded in N_2-60 cm (51.50), N_1-90 cm (51.50), N_2-30 cm (52.00) and N_1-60 cm (52.50) were at par and among these the differences were not significant.

4.2.3.4 Days to Peg Initiation

The days taken for the initiation of the first peg were high in *rabi* season than in *kharif* season. With regard to this character significant differences were not observed among N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm in both *kharif* and *rabi* seasons.

4.2.3.5 Canopy Diameter

High canopy diameter was recorded (Table 7) in *kharif* season than in *rabi* season. In both *kharif* (73.25 cm) and rabi (72.75 cm) seasons maximum diameter was found in N_2-90 cm and it was significantly different from that in N_1-30 cm (70.65 cm and 66.00 cm) respectively. But they were not significantly different from the rest of the treatments in both *kharif* and *rabi* seasons.

Table 7 : Mean performance of TAP5 (aerial podding mutant) for 19 characters in six micro-environments in *Kharif* and *Rabi* seasons.

Micro-environment / Treatment	Days to initial flowering		Days to 50% flowering		Days to 100% flowering		Days to peg initiation		Canopy diameter (cm)		Canopy circumference (cm)		Plant height (cm)	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	24.750	40.000	26.750	47.500	28.750	52.000	30.250	53.500	70.650	66.000	192.500	153.000	62.250	33.000
N2-30	24.500	40.500	27.000	49.500	28.750	53.000	31.500	52.500	71.850	69.300	200.250	152.500	63.150	44.000
N1-60	25.000	41.000	27.500	49.500	30.500	52.500	31.750	52.000	72.130	68.500	221.920	155.500	65.750	31.000
N2-60	25.000	40.500	27.500	49.000	29.750	51.500	30.750	53.500	73.150	70.500	226.400	164.500	64.550	45.500
N1-90	25.000	41.500	27.250	47.500	29.250	51.500	30.500	52.500	72.700	68.000	233.500	172.500	64.880	40.500
N2-90	24.750	40.500	27.500	49.500	29.750	53.000	30.250	52.500	73.250	72.750	243.630	174.500	65.680	49.000
SE	0.289	0.730	0.483	2.179	0.470	0.532	0.592	0.940	0.786	1.898	3.786	2.546	1.248	2.033
CD at 5%	0.740	1.880	1.240	5.600	1.210	1.370	1.520	2.420	2.020	4.880	8.191	6.546	3.209	5.227

Micro-environment / Treatment	Number of primaries		Number of secondaries		Number of aerial pegs		Number of mature pods		Number of aerial pods		Mature pod weight (g)		Number of mature kernels	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	4.180	4.000	0.400	0.300	25.500	11.000	19.380	34.800	2.700	3.050	15.620	31.200	36.500	44.500
N2-30	4.200	4.100	0.250	2.200	22.100	16.000	20.500	36.200	3.100	3.450	16.450	32.700	39.750	49.000
N1-60	4.700	4.500	0.300	0.800	29.400	13.500	25.500	33.250	4.900	5.150	21.330	29.550	41.000	44.500
N2-60	5.250	4.750	0.450	1.700	34.800	26.000	28.750	38.000	5.350	6.550	24.400	34.400	51.000	68.000
N1-90	4.530	5.700	0.550	3.700	32.200	24.000	25.250	34.000	5.050	5.800	21.550	30.400	46.500	64.000
N2-90	4.500	4.500	0.980	1.050	37.300	29.000	29.000	37.000	6.450	7.250	24.920	33.750	57.000	63.500
SE	0.212	0.448	0.323	1.630	5.090	6.510	1.968	2.894	0.040	0.219	1.840	3.295	2.514	2.855
CD at 5%	0.545	1.152	0.830	4.191	13.090	16.737	5.060	7.440	0.103	0.563	4.130	8.470	6.463	7.340

Micro-environment / Treatment	Mature kernel weight (g)		Total dry matter at harvest (g)		100 kernel weight (g)		Oil percent		Shelling percent		Harvest Index	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	10.850	17.700	28.520	29.700	30.930	46.650	49.630	49.500	72.500	56.350	29.240	37.560
N2-30	11.450	18.300	29.540	28.900	36.760	51.230	47.800	49.400	72.860	62.260	35.650	39.520
N1-60	14.000	17.200	33.580	26.200	31.550	46.930	49.920	47.900	66.610	59.580	30.310	27.820
N2-60	15.050	19.400	41.380	51.700	35.610	53.090	49.800	49.200	71.110	57.960	35.740	40.260
N1-90	13.400	17.600	39.920	41.900	27.690	50.040	49.580	49.100	65.440	56.780	26.520	24.420
N2-90	15.250	18.800	45.720	59.200	32.380	51.060	50.020	49.800	69.140	59.830	31.120	29.670
SE	0.731	1.332	1.982	4.020	1.592	2.195	1.209	1.280	2.488	2.616	1.708	2.978
CD at 5%	1.880	3.420	5.096	10.335	4.093	5.643	3.108	3.291	6.400	6.730	4.390	7.660

4.2.3.6 Canopy Circumference

The canopy circumference was high in *kharif* season than in *rabi* season. Significantly high canopy circumference was obtained in N_2-90 cm (243.63 cm) in *kharif* season than in the rest of the treatments. While in *rabi* season, the treatment N_2-90 cm (174.50 cm) followed by N_1-90 cm (172.50 cm) recorded significantly high canopy circumference than the rest of the treatments, betweenn which the difference was not significant.

4.2.3.7 Plant Height

The data (Table 7) indicate that in *kharif* season the plant height was high than in *rabi* season. Significant differences were not observed among N_1-60 cm (65.75 cm), N_2-90 cm (65.68 cm), N_1-90 cm (64.88 cm), N_2-60 cm (64.55 cm) annd N_2-30 cm (63.15 cm) except N_1-30 cm (62.25) which differed significantly from N_1-60 cm annd N_2-90 cm in *kharif* season. In *rabi* season significantly high plant height was observed in N_2-90 cm (49.00 cm) than in all other treatments except that in N_2-60 cm (45.50 cm) and N_2-30 cm (44.00 cm).

4.2.3.8 Number of Primaries

There was no difference in number of primaries between *kharif* and *rabi* seasons. The number of primaries was significantly high in N_2-60 cm (5.25) than that in rest of the treatments in *kharif* season. In *rabi* season, more number of primaries was observed in N_1-90 cm (5.70) which was not significantly different from most of the treatments except that in N_2-30 cm (4.10) and N_1-30 cm (4.00).

4.2.3.9 Number of Secondaries

The secondary branches were slightly more in <u>rabi</u> season than in <u>kharif</u> season. It was observed from the data (Table 7) that there were no significant differences among N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm in both <u>kharif</u> and <u>rabi</u> seasons.

4.2.3.10 Number of Aerial Pegs

The data indicate (Table 7) that aerial peg production was more in <u>kharif</u> season than in <u>rabi</u> season. Significantly more number of aerial pegs was found in N_2-90 cm (37.30) in <u>kharif</u> season than that in N_2-30 cm (22.10). But it was not *significantly different from that in the remaining treatments.* In <u>rabi</u> season, the N_2-90 cm (29.00) resulted in more number of aerial pegs which differed significantly from N_1-30 cm (11.00). But it was not significantly higher than that recorded in N_2-60 cm (26.00), N_1-90 cm (24.00), N_2-30 cm (16.00) and N_1-60 cm (13.50).

4.2.3.11 Number of Mature Pods

In <u>rabi</u> season, the number of mature pods was high than in <u>kharif</u> season. In <u>kharif</u> season, significantly more number of mature pods was recorded by N_2-90 cm (29.00) than that found in N_2-30 cm (20.50) and N_1-30 cm (19.38), but it was not significantly different from that recorded in N_2-60 cm (28.75), N_1-60 cm (25.50) and N_1-90 cm (25.25). Whereas, in <u>rabi</u> season, there were no significant differences among the treatments, however,

N_2-60 cm (38.00) followed by N_2-90 cm (37.00) recorded more number of mature pods.

4.2.3.12 Mature Pod Weight

The results (Table 7) revealed that the weight of mature pods was high in rabi season than in kharif season. In kharif season, the N_2-90 cm (24.92 g) recorded significantly high mature pod weight than N_2-30 cm (16.45) and N_1-30 cm (15.62), but it was not significantly different from N_2-60 cm (24.40 g), N_1-60 cm (21.33 g) and N_1-90 cm (21.55 g). In Rabi season, significant differences were not recorded among the treatments, however, the pod weight was high in N_2-60 cm (34.40 g) and N_2-90 cm (33.75 g).

4.2.3.13 Number of Mature Kernels

The number of mature kernels was high in kharif season than in rabi season. It was found that in N_2-90 cm (57.00) the number of mature kernels was significantly higher than those in the remaining treatments except that observed in N_2-60 cm (51.00) in kharif season. In rabi season, N_2-60 cm (68.00) recorded significantly higher number of kernels than the N_2-30 cm (49.00), N_1-30 cm (44.50) and N_1-60 cm (44.50), but it was not significantly different from that recorded in N_1-90 cm (64.00) and N_2-90 cm (63.50).

4.2.3.14 Mature Kernel Weight

It was observed from the data that the weight of mature kernels was slightly high in rabi season as compared to kharif season. Significant differences were not observed among the treatments viz., N_2-90 cm (15.25 g), N_2-60 cm (15.05 g), N_1-60 cm (14.00 g) and N_1-90 cm (13.40 g) for mature kernel weight in *kharif* season. However, all these values were significantly different from those found in N_2-30 cm (11.45 g) and N_1-30 cm (10.85 g). In *rabi* season, significant differences were not observed among the treatments, however, high mature kernel weight was found in N_2-60 cm (19.40 g).

4.2.3.15 Total Dry Matter at Harvest

There was not much difference in total dry matter at harvest between *kharif* and *rabi* seasons. High total dry matter at harvest was obtained in N_2-90 cm in both *kharif* (45.72 g) and *rabi* (59.20 g) seasons which were significantly different from the values recorded in rest of the treatments except those found in N_2-60 (41.38 and 51.70g) in *kharif* and *rabi* seasons respectively.

4.2.3.16 100 Kernel Weight

The weight of 100 kernels was high in *rabi* season than in *kharif* season. Significantly high kernel weight was observed in N_2-30 cm (36.76 g) in *kharif* season when compared to that in rest of the treatments except that in N_2-60 cm (35.61 g), between which the difference was non-significant. In *rabi* season, the N_2-60 cm (53.09 g) recorded significantly high 100 kernel weight than N_1-60 cm (46.93 g) annd N_1-30 cm (46.65 g), but it was not significantly different from the rest of the treatments.

4.2.3.17 Oil Per cent

With regard to oil per cent there was not much difference between *kharif* and *rabi* seasons. The data (Table 7) indicate that there were no significant differences among N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm for this trait.

4.2.3.18 Shelling Per cent

High shelling per cent was recorded in *kharif* season than in *rabi* season. The shelling per cent observed in *kharif* season was high in N_2-30 cm (72.86%) which was not significantly different from most of the treatments except that in N_1-90 cm (65.44%). While in *rabi* season, there were no significant differences among the treatments. Maximum shelling per cent was recorded in N_2-30 (62.26%).

4.2.3.19 Harvest Index

The data on harvest index indicate that there was not much difference between *kharif* and *rabi* seasons. In *kharif* season, the treatment N_2-60 cm (35.74) followed by N_2-30 cm (35.65) recorded significantly high harvest index than the rest of the treatments, between which the difference was not significant. In *rabi* season, significantly high harvest index was recorded by N_2-60 cm (40.26) followed by N_2-30 cm (39.52) and N_1-30 cm (37.56) than the remaining treatments, among which the differences were not significant.

4.2.4 Kadiri-3

4.2.4.1 Days to Initial Flowering

When kharif and rabi seasons were compared, the number of days taken for the initiation of the first flower were high in rabi than in kharif. There were no significant differences among N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm in both kharif and rabi seasons.

4.2.4.2 Days to 50% Flowering

The days taken for the 50 per cent of the plants to flower were less in kharif season than in rabi season (Table 8). In both the seasons significant differences were not observed for this trait among the treatments viz., N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm.

4.2.4.3 Days to 100% Flowering

The data (Table 8) indicate that the days to 100 per cent flowering were less in kharif season than in rabi season. In kharif season, the number of days taken for 100 per cent flowering were less in N_1-60 cm (36.75) which was significantly different from N_2-30 cm (37.75) but did not differ significantly from the remaining treatments. While in rabi season, the differences observed among the treatments were not significant for this trait.

4.2.4.4 Days to Peg Initiation

In kharif season, the initiation of first peg took less number of days as compared to rabi season. In kharif season, all

Table 8 : Mean performance of Kadiri-3 for 19 characters in six micro-environments in <u>Kharif</u> and <u>Rabi</u> seasons.

Micro-environment / Treatment	Days to initial flowering		Days to 50% flowering		Days to 100% flowering		Days to peg initiation		Canopy diameter (cm)		Canopy circumference (cm)		Plant height (cm)	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	29.000	51.000	35.000	56.500	37.000	60.000	35.750	58.000	70.550	64.000	185.900	156.800	31.800	23.500
N2-30	30.250	51.000	35.500	57.000	37.750	61.500	37.250	58.000	73.450	64.500	189.000	160.000	30.850	26.000
N1-60	29.250	51.000	34.500	57.000	36.250	60.000	36.000	57.500	71.000	66.000	201.200	161.000	30.850	27.000
N2-60	29.500	51.000	34.750	58.000	36.750	60.500	36.500	58.000	72.530	67.500	200.500	166.500	29.730	22.000
N1-90	30.000	50.500	35.000	57.500	37.000	61.500	36.500	58.000	72.250	63.500	198.800	163.000	28.600	22.500
N2-90	30.000	48.500	34.500	57.000	37.000	61.000	36.750	56.500	73.380	65.000	198.000	171.000	26.900	28.500
SE	0.577	1.065	0.433	1.549	0.520	1.511	0.413	0.730	1.002	1.597	3.530	3.650	1.658	3.760
CD at 5%	1.480	2.740	1.110	3.980	1.340	3.880	1.060	1.880	2.580	4.110	9.076	9.384	4.263	9.667

Micro-environment / Treatment	Number of primaries		Number of secondaries		Number of aerial pegs		Number of mature pods		Mature pod weight (g)		Number of mature kernels		Mature kernel weight (g)	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	5.450	5.400	3.250	7.500	14.200	5.500	23.900	41.500	19.550	40.400	36.380	47.000	13.250	22.000
N2-30	5.650	6.000	4.570	7.300	15.050	8.000	26.350	44.000	21.800	43.200	37.250	64.000	14.050	23.200
N1-60	5.720	6.500	5.130	13.000	20.950	11.500	29.320	44.500	25.300	43.350	41.000	65.500	15.600	23.100
N2-60	6.150	6.250	5.800	9.200	16.570	6.500	39.600	51.500	36.780	46.550	53.500	69.000	20.500	24.900
N1-90	6.100	5.250	5.470	9.750	23.050	7.000	28.670	38.800	24.880	35.350	56.880	70.500	15.300	20.000
N2-90	6.300	7.500	5.300	7.000	26.400	14.500	33.750	43.800	30.200	42.350	49.130	87.000	17.680	23.000
SE	0.508	0.920	0.357	1.837	3.251	3.406	1.134	3.286	1.051	2.836	1.514	5.150	0.313	1.235
CD at 5%	1.306	2.370	0.918	4.723	8.358	8.757	2.920	8.450	2.700	7.290	3.892	3.241	0.810	3.180

Micro-environment / Treatment	Total dry matter at harvest (g)		100 kernel weight (g)		Oil percent		Shelling percent		Harvest Index	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	22.640	35.950	35.730	53.650	44.880	47.350	65.570	55.010	37.310	38.190
N2-30	27.540	35.030	38.180	55.150	45.720	48.950	68.850	55.170	41.450	40.470
N1-60	27.370	51.090	32.930	54.030	46.750	48.000	56.910	54.050	36.620	31.510
N2-60	28.050	38.740	39.640	54.300	45.100	48.000	65.660	54.280	42.670	39.380
N1-90	37.350	40.820	37.650	56.570	46.970	48.250	59.860	55.400	29.780	33.500
N2-90	32.110	37.420	38.560	59.280	48.200	48.800	66.780	58.140	35.900	38.510
SE	1.556	1.311	1.194	2.521	1.774	1.740	2.083	1.103	1.105	1.156
CD at 5%	4.000	3.371	3.069	6.481	4.561	4.474	5.360	2.840	2.840	2.970

the N -60 cm (201.20 cm)

the treatments recorded less number of days to peg initiation among which the differences were not significant, except N_2-30 cm (37.25) which differed significantly from N_1-30 cm (35.75) and N_1-60 cm (36.00). In rabi season, there were no significant differences among the treatments for days to peg initiation.

4.2.4.5 Canopy Diameter

The data on canopy diameter revealed that in kharif season it was more than in rabi season. The canopy diameter recorded in N_2-30 cm (73.45), N_2-90 cm 73.38 cm), N_2-60 cm (72.53 cm), N_1-90 cm (72.25 cm) and N_1-60 cm (71.00 cm) was at par and there were no significant differences among these treatments in kharif season. In rabi season there were no significant differences among the treatments, however, high mean canopy diameter was found in N_2-60 cm (67.50 cm) (Table 8).

4.2.4.6 Canopy Circumference

High canopy circumference was recorded in kharif season than in rabi season. In kharif season, the N_1-60 cm (201.20 cm) resulted in significantly high canopy circumference than N_2-30 cm (189.00 cm) and N_1-30 cm (185.90 cm), but it was not significantly different from that recorded in N_2-60 cm (200.50 cm), N_2-90 cm (198.00 cm) and N_1-90 cm (198.80 cm). In rabi season, the N_2-90 (171.00 cm) recorded significantly high canopy circumference than N_1-60 cm (161.00 cm), N_2-30 cm (160.00 cm) and N_1-30 cm (156.80 cm). But it did not differ significantly from N_2-60 cm (166.50 cm) and N_1-90 cm (163.00 cm).

4.2.4.7 Plant Height

Slightly high plant height was observed in kharif season than in rabi season. High plant height was observed in N_1-30 cm (31.80 cm) in kharif season which was not significantly different from the rest of the treatments except from N_2-90 cm (26.90 cm). While in rabi season, there were no significant differences among the treatments for plant height.

4.2.4.8 Number of Primaries

There was no difference in number of primaries between kharif and rabi seasons (Table 8). The differences observed among N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm were not significant for number of primaries in both kharif and rabi seasons.

4.2.4.9 Number of Secondaries

It was observed that the number of secondaries was high in rabi season than in kharif season. In kharif season, the number of secondaries recorded was significantly higher in N_2-60 cm (5.80) than that found in N_2-30 cm (4.57) and N_1-30 cm (3.25), but it was at par with those values recorded in N_1-90 cm (5.47), N_2-90 cm (5.30) and N_1-60 cm (5.13). In rabi season, the N_1-60 cm (13.00) showed significantly more number of secondaries than the remaining treatments except those N_1-90 cm (9.75) and N_2-60 cm (9.20).

4.2.4.10 Number of Aerial Pegs

The data in both the seasons indicate that the aerial pegs were more in *kharif* season as compared to *rabi* season. Maximum number of aerial pegs was obtained in N_2-90 cm (26.40) in *kharif* season, which was significantly different from all other treatments except from N_1-90 cm (23.05) and N_1-60 cm (20.95). In *rabi* season, the N_2-90 cm (14.50) recorded more number of aerial pegs which was not significantly different from the rest of the treatments except from N_1-30 cm (5.50).

4.2.4.11 Number of Mature Pods

The number of mature pods obtained was more in *rabi* season than in *kharif* season (Table 8). In *kharif* season significantly high number of mature pods was obtained in N_2-60 cm (39.60) when compared with that in rest of the treatments. In *rabi* season also the N_2-60 cm (51.50) resulted in significantly more number of mature pods than N_1-30 cm (41.50) and N_1-90 cm (38.80), but it was not significantly different from the values recorded in N_1-60 cm (44.50), N_2-30 cm (44.00) and N_2-90 cm (43.80).

4.2.4.12 Mature Pod Weight

In *rabi* season the weight of mature pods was high as compared to that in *kharif* season. Significantly high mature pod weight was observed in N_2-60 cm (36.78 g) than in rest of the treatments in *kharif* season. In *rabi* season, high mature pod weight was found in N_2-60 cm (46.55 g) which was significantly more than that in N_1-60 cm (35.35 g), but it did not differ significantly from the values found in the rest of the treatments.

4.2.4.13 Number of Mature Kernels

It was found that the number of mature kernels was high in *rabi* season than in *kharif* season (Table 8). The data in *kharif* season indicate that the number of mature kernels was high in N_1-90 cm (56.88) which was significantly different from all other treatments except from N_2-60 cm (53.50). The treatment N_2-90 cm (87.00) resulted in significantly high number of mature kernels in *rabi* season than the rest of the treatments.

4.2.4.14 Mature Kernel Weight

In *rabi* season the mature kernel weight was more than that recorded in *kharif* season. In *kharif* season, the N_2-60 cm (20.50 g) resulted in significantly high mature kernel weight than the remaining treatments. In *rabi* season also, high mature kernel weight was observed in N_2-60 cm (24.90 g) but it was not significantly different from most of the treatments except from that in N_1-90 cm (20.00 g).

4.2.4.15 Total Dry Matter at Harvest

At the time of harvest the total dry matter was high in *rabi* season than in *kharif* season (Table 8). Significantly high total dry matter at harvest was obtained in N_1-90 cm (37.35 g) in *kharif* season and N_1-60 cm (51.09 g) in *rabi* season than that recorded in the rest of the treatments respectively.

4.2.4.16 100 Kernel Weight

The weight of 100 kernels was much high in rabi season than in kharif season (Table 8). In kharif season, the N_2-60 cm (39.64 g) showed significantly high 100 kernel weight than N_1-30 cm (35.73 g) and N_1-60 cm (32.93 g), but it was not significantly different from N_2-90 cm (38.56 g), N_2-30 cm (38.18 g) and N_1-90 cm (37.65 g) whereas in rabi season, there were no significant differences among the treatments, however, high 100 kernel weight was obtained in N_2-90 cm (59.28 g).

4.2.4.17 Oil Per cent

There was slight increase in oil per cent in rabi season as compared to that in kharif season. Significant differences were not observed with regard to this character among the treatments viz., N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm and N_2-90 cm.

4.2.4.18 Shelling Per cent

The shelling per cent values were high in kharif season than in rabi season. In kharif season significantly high shelling per cent was observed in N_2-30 cm (68.85%) than that in N_1-90 cm (59.86%) and N_1-60 cm (56.91), but it did not differ significantly from the rest of the treatments. While in rabi season, the N_2-90 cm (58.14%) resulted in high shelling per cent which differed significantly from the rest of the treatments except from N_1-90 cm (55.40%).

4.2.4.19 Harvest Index

Not much difference was observed in harvest index between kharif and rabi seasons. In kharif season the treatment

N_2-60 cm (42.67) followed by N_2-30 cm (41.45) recorded significantly high harvest index than the rest of the treatments, between which the difference was non-significant. The N_2-30 cm (40.47) recorded significantly high harvest index in rabi season than N_1-90 cm (33.50) and N_1-60 cm (31.51), but it was not significantly different from N_2-60 cm (39.38), N_2-90 cm (38.51) and N_1-30 cm (38.19).

4.2.5 TMV2NLM

4.2.5.1 Days to Initial Flowering

In kharif season (Table 9) the days taken for the initiation of the first flower were less as compared to rabi season. Significantly less number of days to initial flowering were recorded in N_1-30 cm (29.50) than that in N_2-30 cm (30.75) and N_1-90 cm (30.25). But N_1-30 cm did not differ significantly from the remaining treatments in kharif season. Whereas in rabi season, there were no significant differences among the treatments.

4.2.5.2 Days to 50% Flowering

The data revealed that in kharif season the number of days to 50 per cent flowering were much less than in rabi season. In kharif season, significant differences were not observed for this trait among N_1-30 cm (34.25), N_1-90 cm (34.75), N_2-90 cm (34.75), N_2-60 cm (34.75) and N_1-60 cm (35.00) which were at par. Significant differences were not observed among the treatments for this trait in rabi season.

4.2.5.3 Days to 100% Flowering

The days taken for 100 per cent flowering were more in *rabi* season than in *kharif* season. In both *kharif* and *rabi* seasons, significant differences were not observed for this trait among N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm.

4.2.5.4 Days to Peg Initiation

It was observed that (Table 9) the number of days to peg initiation were much less in *kharif* season than in *rabi* season. In *kharif* season, the treatments viz., N_1-30 cm (35.25), N_1-60 cm (35.50) and N_1-90 cm (35.75) recorded significantly less number of days than the rest of the treatments, among which the differences were not significant. In *rabi* season, the differences observed among the treatments were not significant for this trait.

4.2.5.5 Canopy Diameter

The canopy diameter was high in *kharif* season than in *rabi* season (Table 9). In *kharif* season, significantly high canopy diameter was observed in N_2-60 cm (75.50 cm) than that in N_1-90 cm (73.25 cm), N_2-30 cm (73.03 cm) and N_1-30 cm (72.13). But it was not significantly different from that recorded in N_2-90 cm (74.50 cm) and N_1-60 cm (73.40 cm). While in *rabi* season significant differences were not observed among the treatments, however, high canopy diameter was found in N_2-60 cm (67.50 cm).

Table 9 : Mean performance of TMV2NLM (narrow leaf mutant of TMV2) for 19 characters in six micro-environments in *Kharif* and *Rabi* seasons.

Micro-environment / Treatment	Days to initial flowering		Days to 50% flowering		Days to 100% flowering		Days to peg initiation		Canopy diameter (cm)		Canopy circumference (cm)		Plant height (cm)	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	29.500	50.500	34.250	58.500	36.750	61.500	35.250	60.000	72.130	68.500	183.580	163.000	35.380	25.500
N2-30	30.750	51.000	35.250	56.500	37.250	60.000	36.500	60.000	73.030	69.250	192.420	174.500	34.500	28.500
N1-60	29.750	51.500	35.000	57.000	36.750	59.500	35.500	59.500	73.400	69.500	197.000	174.500	32.700	22.500
N2-60	30.000	51.000	34.750	57.500	36.750	60.000	36.750	59.000	75.500	71.000	205.750	181.500	34.400	26.500
N1-90	30.250	51.500	34.750	56.500	37.000	59.500	35.750	58.500	73.250	69.500	210.250	176.000	29.750	28.500
N2-90	29.750	50.500	34.750	57.000	37.000	60.000	36.250	59.000	74.500	71.000	212.670	177.500	33.250	19.000
SE	0.289	1.317	0.296	1.000	0.387	1.041	0.365	1.155	0.862	1.471	2.244	4.120	1.373	2.958
CD at 5%	0.740	3.390	0.760	2.571	0.990	2.680	0.940	2.970	2.220	3.780	5.769	10.593	3.529	7.605

Micro-environment / Treatment	Number of primaries		Number of secondaries		Number of aerial pegs		Number of mature pods		Mature pod weight (g)		Number of mature kernels		Mature kernel weight (g)	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	9.320	6.500	12.350	17.000	32.500	10.500	17.400	43.500	13.350	42.850	17.320	57.500	9.550	22.900
N2-30	8.520	7.500	11.330	22.000	25.100	10.000	20.000	44.500	16.000	43.200	25.250	65.000	11.100	23.100
N1-60	8.820	8.000	13.930	18.500	38.000	10.500	21.150	45.000	16.550	43.750	28.500	59.000	11.000	23.500
N2-60	8.150	7.750	17.250	18.500	35.000	8.500	25.130	57.500	21.400	47.400	33.000	65.500	13.350	25.600
N1-90	8.550	7.000	18.750	20.500	38.700	8.100	20.200	39.800	15.680	37.350	31.000	61.000	10.650	20.800
N2-90	8.100	8.000	19.700	17.500	25.700	14.000	22.500	54.500	18.680	46.850	36.500	62.500	12.200	25.100
SE	0.519	0.470	1.683	2.033	11.030	2.800	0.571	5.290	0.674	1.544	2.619	4.370	0.392	1.003
CD at 5%	1.334	1.208	4.327	5.227	28.360	7.199	1.470	13.600	1.730	3.970	6.733	11.235	1.010	2.580

Micro-environment / Treatment	Total dry matter at harvest (g)		100 kernel weight (g)		Oil percent		Shelling percent		Harvest Index	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	32.590	43.900	35.210	49.300	43.800	50.300	71.830	54.680	26.000	37.200
N2-30	32.130	51.100	36.130	52.400	41.300	50.050	75.800	55.870	29.550	38.800
N1-60	36.150	47.800	30.930	51.200	42.700	49.550	67.020	54.480	26.730	42.910
N2-60	35.570	48.600	35.050	54.700	43.820	49.150	73.520	56.100	32.610	45.370
N1-90	38.950	54.800	33.110	54.900	44.720	49.900	68.650	54.470	25.360	31.820
N2-90	40.920	54.400	38.520	51.100	44.420	49.550	72.760	57.380	27.840	31.930
SE	3.231	4.710	1.833	5.170	1.591	0.501	1.286	1.590	2.067	1.670
CD at 5%	8.307	12.109	4.713	13.292	4.090	1.288	3.310	4.090	5.310	4.290

4.2.5.6 Canopy Circumference

In *kharif* season, the canopy circumference was more than that observed in *rabi* season. In *kharif* season, the canopy circumference recorded in N_2-90 cm (212.67cm) was significantly higher than that observed in all other treatments except that found in N_1-90 cm (210.25 cm). In *rabi* season, the N_2-60 cm (181.50 cm) exhibited high canopy circumference, but it was not significantly different from most of the treatments except from N_1-30 cm (163.00 cm).

4.2.5.7 Plant Height

The results on plant height (Table 9) revealed that in *kharif* season it was more than in *rabi* season. In *kharif* season, the plant height observed in N_1-30 cm (35.38 cm) was significantly higher than that in N_1-90 cm (29.75), but it did not differ significantly from that in the remaining treatments. In *rabi* season, the plant height recorded in N_2-30 cm (28.50 cm) and N_1-90 cm (28.50 cm) was at par and differed significantly from N_1-60 cm (22.50 cm) and N_2-90 cm (19.00 cm). T hey did not differ significantly from the rest of the treatments.

4.2.5.8 Number of Primaries

Slightly more number of primaries was recorded in *kharif* season than in *rabi* season. In *kharif* season, there were no significant differences among the treatments viz., N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm for this trait. In *rabi* season, the number of primaries recorded in N_1-60 cm (8.00) and N_2-90 cm (8.00) was at par and these values were not significantly different from that observed in rest of the treatments except from that in N_1-30 cm (6.50).

4.2.5.9 Number of Secondaries

The secondary branches were slightly more in rabi season than in kharif season. In kharif season, the N_2-90 cm (19.70) recorded significantly more number of secondaries than N_1-60 cm (13.93), N_1-30 cm (12.35) and N_2-30 cm (11.33), but it did not differ significantly from N_1-90 cm (18.75) and N_2-60 cm (17.25). Significant differences were not observed among the treatments in rabi season, however, the highest number of secondaries was observed in N_2-30 cm (22.00).

4.2.5.10 Number of Aerial Pegs

The aerial pegs were more in kharif season than in rabi season. The results indicate that there were no significant differences among N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm for number of aerial pegs in both kharif and rabi seasons.

4.2.5.11 Number of Mature Pods

It was observed that the number of mature pods were high in rabi season than in kharif season (Table 9). Significantly more number of mature pods were obtained in N_2-60 cm (25.13) than in the rest of the treatments in kharif season. In rabi season, the N_2-60 cm (57.50) recorded significantly more pods than N_1-30 cm (43.50) and N_1-90 cm (39.80), but it was not significantly different from N_2-90 cm (54.50), N_1-60 cm (45.00) and N_2-30 cm (44.50).

4.2.5.12 Mature Pod Weight

In rabi season, the mature pod weight was high as compared to that in kharif season. The treatment N_2-60 cm (21.40 g) recorded significantly high mature pod weight than the remaining treatments in kharif season. In rabi season, high mature pod weight was obtained in N_2-60 cm (47.40 g) which differed significantly from all other treatments except from N_2-90 cm (46.85 g) and N_1-60 cm (43.75 g).

4.2.5.13 Number of Mature Kernels

More number of mature kernels were observed in rabi season than in kharif season (Table 9). The data in kharif season indicate that the N_2-90 cm (36.50) resulted in significantly more number of kernels than N_1-60 cm (28.50), N_2-30 cm (25.25) and N_1-30 cm (17.32), but it was not significantly different from N_2-60 cm (33.00) and N_1-90 cm (31.00). While in rabi season, there were no significant differences among the treatments, however, the highest number of kernels was found in N_2-60 cm (65.50).

4.2.5.14 Mature Kernel Weight

The data indicate that in rabi season the weight of mature kernels was higher than that in kharif season. The mature kernel weight was significantly high in N_2-60 cm (13.35 g) in kharif season than in the rest of the treatments. In rabi season, the mature kernel weight recorded in N_2-60 cm (25.60 g) and N_2-90 cm (25.10 g) was at par and significantly different from N_1-30 cm (22.90 g) and N_1-90 cm (20.80 g). But they did not differ significantly from N_1-60 cm (23.50g) and N_2-30 cm (23.10g).

4.2.5.15 Total Dry Matter at Harvest

The total dry matter at harvest was high in <u>rabi</u> season than in <u>kharif</u> season. The N_2-90 cm (40.92 g) recorded significantly high dry matter than N_2-30 cm (32.13 g) and N_1-30 cm (32.59 g), but it did not differ significantly from the rest of the treatments. Whereas in <u>rabi</u> season, the differences observed among the treatments were not significant for this trait.

4.2.5.16 100 Kernel Weight

In <u>rabi</u> season, the 100 kernel weight was higher than that recorded in <u>kharif</u> season (Table 9). In <u>kharif</u> season, it was observed that the N_2-90 cm (38.52 g) resulted in high 100 kernel weight which was significantly different from N_1-90 cm (33.11 g) and N_1-60 cm (30.93 g) but it did not differ significantly from N_2-30 cm (36.13 g), N_1-30 cm (35.21 g) and N_2-60 cm (35.05 g). While in <u>rabi</u> season, the differences recorded among the treatments were not significant, however high 100 kernel weight was observed in N_1-90 cm (54.90 g) followed by N_2-60 cm (54.70 g).

4.2.5.17 Oil Per cent

The oil content was high in <u>rabi</u> season than in <u>kharif</u> season. Significant differences were not observed with regard to this character among N_1–30 cm, N_2–30 cm, N_1–60 cm, N_2–60 cm, N_1–90 cm and N_2–90 cm in both kharif and rabi seasons.

4.2.5.18 Shelling Per cent

The values of shelling per cent were high in kharif season than in rabi season. In kharif season, significantly higher shelling per cent was recorded by N_2–30 cm (75.80%) than N_1–90 cm (68.65%) and N_1–60 cm (67.02%), but it did not differ significantly from N_2–60 cm (73.52%), N_2–90 cm (72.76%) and N_1 30 cm (71.83%) while in rabi season, the differences observed among the treatments were not significant, however, the treatment N_2–90 cm (57.30%) recorded high shelling per cent.

4.2.5.19 Harvest Index

It was observed from the data that the harvest index values were high in rabi season than those in kharif season (Table 9). In kharif season, high harvest index was obtained in N_2 60 cm (32.61) which differed significantly from that in N_1–60 cm (26.73), $N_1$30 cm (26.00) and N_1–90 cm (25.36). But it was not significantly different from N_2 30 cm (29.55) and N_2–90 cm (27.84). In rabi season, the N_2–60 cm (45.37) recorded significantly high harvest index than the rest of the treatments except the N_1 60 cm (42.91).

4.2.6 Compact mutant of M13

4.2.6.1 Days to Initial Flowering

The initiation of first flower took more number of days in rabi season than in kharif season (Table 10). In kharif season. significantly less number of days to initial flowering was recorded by N_2—30 cm (29.75) than N_1—60 cm (30.75) and N_2—60 cm (30.75). But it was not significantly different from N_1—30 cm (30.50). N_1—90 cm (30.50) and N_2—30 cm (30.50). While in <u>rabi</u> season, significant differences were not recorded among the treatments for this trait.

4.2.6.2 Days to 50% flowering

It was observed that in <u>kharif</u> season the days taken for 50% flowering were less than that in <u>rabi</u> season. The N_1—90 cm (34.25) recorded less number of days which was significantly different from all other treatments except from N_2—60 cm (35.50) in <u>kharif</u> season, whereas in <u>rabi</u> season, the differences observed among the treatments were not significnt for days to 50% flowering.

4.2.6.3 Days to 100% Flowering

When both the seasons were compared, the days taken for 100% flowering were less in <u>kharif</u> season than in <u>rabi</u> season. The differences observed among N_1—30 cm. N_2—30 cm, N_1—60 cm, N_2 60 cm. N_1 90 cm with and without top dressing of nitrogen were not significant in both the seasons for this trait.

4.2.6.4 Days to Peg Initiation

In <u>kharif</u> season the days taken for peg initiation were much less than that in <u>rabi</u> season. Significantly less number of days were recorded in N_2—30 cm (35.25) for initiation of first peg as compared to the rest of the treatments in <u>kharif</u> season.

Table 10: Mean performance of Compact Mutant of M13 for 19 characters in six micro-environments in *Kharif* and *Rabi* seasons.

Micro-environment / Treatment	Days to initial flowering		Days to 50% flowering		Days to 100% flowering		Days to peg initiation		Canopy diameter (cm)		Canopy circumference (cm)		Plant height (cm)	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	30.500	52.000	35.000	58.000	36.750	62.000	37.000	60.000	70.550	65.500	175.380	156.500	38.150	28.000
N2-30	29.750	52.000	35.000	58.500	37.500	63.500	35.250	62.000	71.150	66.500	182.250	164.000	37.980	29.000
N1-60	30.750	51.500	35.250	57.500	37.000	63.000	37.750	61.000	70.450	67.000	183.070	161.500	32.400	23.500
N2-60	30.750	51.000	35.500	58.500	37.500	63.500	37.000	61.000	72.130	67.500	188.840	165.000	37.600	31.500
N1-90	30.500	51.000	34.250	56.500	37.000	61.000	37.250	62.000	70.470	64.000	189.900	177.000	34.550	19.500
N2-90	30.500	52.500	35.000	58.500	37.500	64.000	37.250	63.500	71.500	66.500	206.650	175.500	36.250	28.000
SE	0.371	1.095	0.428	1.919	0.348	1.390	0.365	1.072	1.081	0.991	1.917	3.207	2.584	1.971
CD at 5%	0.950	2.820	1.100	4.930	0.890	3.570	0.940	2.760	2.780	2.550	4.929	8.245	6.643	5.067

Micro-environment / Treatment	Number of primaries		Number of secondaries		Number of aerial pegs		Number of mature pods		Mature pod weight (g)		Number of mature kernels		Mature kernel weight (g)	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	8.730	9.000	11.380	9.500	29.900	21.000	26.300	40.650	21.700	37.800	34.980	51.500	14.050	21.000
N2-30	8.320	7.750	11.200	17.250	33.100	8.000	26.750	41.150	22.430	39.750	31.000	64.500	14.400	21.700
N1-60	10.000	8.500	11.950	20.500	32.800	10.500	27.500	43.500	23.800	43.000	39.880	70.000	15.050	23.000
N2-60	11.550	7.500	9.700	21.000	32.100	15.000	33.000	48.500	28.780	45.950	56.500	82.500	16.900	24.500
N1-90	9.300	8.000	18.800	16.500	31.000	11.000	26.680	40.000	22.150	37.450	48.650	69.000	14.350	20.800
N2-90	10.520	7.500	15.900	25.500	47.600	11.000	30.200	41.000	26.180	38.700	55.000	77.500	15.850	21.000
SE	0.436	1.059	0.717	3.166	9.850	3.112	2.553	1.891	2.790	2.336	2.444	4.840	1.047	1.262
CD at 5%	1.121	2.723	1.843	8.140	25.320	8.001	6.560	4.860	7.170	6.010	6.283	12.444	2.690	3.240

Micro-environment / Treatment	Total dry matter at harvest (g)		100 kernel weight (g)		Oil percent		Shelling percent		Harvest Index	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	44.990	65.800	33.950	50.750	44.830	50.900	67.390	63.620	27.460	31.390
N2-30	43.230	55.100	40.030	53.110	44.800	50.950	72.070	66.410	32.460	35.310
N1-60	36.130	64.700	35.140	45.980	47.850	50.800	63.650	64.600	32.150	36.100
N2-60	51.600	70.800	41.720	52.920	42.750	50.450	69.120	68.670	37.830	36.700
N1-90	62.840	71.300	35.740	46.160	46.600	49.600	65.730	63.380	21.080	32.530
N2-90	59.620	63.200	42.660	51.720	48.350	47.700	69.740	66.120	29.580	35.590
SE	2.429	8.580	1.395	3.350	1.812	0.475	2.852	3.055	2.112	2.462
CD at 5%	6.245	22.059	3.586	8.613	4.659	1.221	7.330	7.850	5.430	6.330

rabi season. Among

In *rabi* season, the N_1-30 cm (60.00) recorded significantly less number of days to peg initiation than N_2-90 cm (63.50) but it did not differ significantly from the rest of the treatments.

4.2.6.5 Canopy Diameter

It was observed from the data that in *kharif* season the canopy diameter was more than that in *rabi* season. In *kharif* season significant differences were not observed among the treatments however, the canopy diameter was more in N_2-60 cm (72.13 cm). Significantly high canopy diameter was found in N_2-60 cm (67.50 cm) than that in N_1-90 cm (64.00 cm), but it did not differ significantly from the rest of the treatments in *rabi* season (Table 10).

4.2.6.6 Canopy Circumference

The canopy circumference was more in *kharif* season than in *rabi* season. The N_2-90 cm (206.65 cm) showed significantly high canopy circumference than the remaining treatments in *kharif* season. In *rabi* season, significantly high canopy circumference was observed in N_1-90 cm (177.00 cm) followed by N_2-90 cm (175.50 cm) than in the rest of the treatments, between which the difference was not significant.

4.2.6.7 Plant Height

In *kharif* season more plant height was observed than in *rabi* season. Among the treatments there were no significant differences for the plant height in *kharif* season. In *rabi* season, the N_2-60 cm (31.50 cm) recorded significantly high plant height than N_1–60 cm (23.50 cm) and N_1–90 cm (19.50 cm) but it did not differ significantly from the rest of the treatments.

4.2.6.8 Number of Primaries

With regard to number of primaries not much difference was observed between *kharif* and *rabi* seasons (Table 10). More number of primaries were observed in N_2–60 cm (11.55) which differed significantly from the rest of the treatments except from N_2–90 cm (10.52). In *rabi* season, there were no significant differences among the treatments, however more primaries were found in N_1–30 cm (9.00).

4.2.6.9 Number of Secondaries

Secondary branches were more in *rabi* season than in *kharif* season. The N_1–90 cm (18.80) showed significantly higher number of secondaries than the rest of the treatments in *kharif* season. In *rabi* season significantly more number of secondaries were found in N_2–90 cm (25.50) than that in N_1–90 cm (16.50) and N_1–30 cm (9.50) but it did not differ significantly from the remaining treatments.

4.2.6.10 Number of Aerial Pegs

It was found that the aerial pegs were more in *kharif* season than in *rabi* season. In *kharif* season the differences observed among the treatments were not significant for this character. In *rabi* season, the N_1–30 cm (21.00) recorded signifi cantly more number of aerial pegs than all other treatments except N_2–60 cm (15.00).

4.2.6.11 Number of mature Pods

The number of mature pods obtained in *rabi* season was more than in *kharif* season In *kharif* season, significantly more number of mature pods was obtained in N_2-60 cm (33.00) than that in N_1-30 cm but it was not significantly different from N_2-90 cm (30.20). N_1-60 cm (27.50), N_2-30 cm (26.75) and N_1-90 cm (26.68). Significantly more number of mature pods were recorded in N_2-60 cm (48.50) than in the remaining treatments in *rabi* season (Table 10).

4.2.6.12 Mature Pod Weight

The data indicated that the weight of mature pods was high in *rabi* season than in *kharif* season. For mature pod weight significant differences were not observed among the treatments in *kharif* season, however maximum weight was observed in N_2-60 cm (28.78 g). In *rabi* season, significantly higher pod weight was recorded in N_2 60 cm (45.95 g) than in N_2-30 cm (39.75 g), N_2-90 cm (38.70 g). N_1-30 cm (37.80 g) and N_1-90 cm (37.45 g), it did not differ significantly from N_1-60 cm (43.00 g).

4.2.6.13 Number of Mature Kernels

More number of mature kernels were recorded in *rabi* season than in *kharif* season. In *kharif* season, the N_2-60 cm (56.50) followed by N_2-90 cm (55.00) resulted in significantly more number of mature kernels than in the rest of the treatments between which the difference was not significant. The number of mature kernels found in N_2-60 cm (82.50) was significantly higher than that in all other treatments except that in N_2–90 cm (77.50) in *rabi* season.

4.2.6.14 Mature Kernel Weight

The mature kernel weight was high in *rabi* season than in *kharif* season (Table 10). In *kharif* season, high mature kernel weight was observed in N_2–60 cm (16.90 g) but it was not signifi cantly different from most of the treatments except that in N_1 30 cm (14 05 g). While in *rabi* season, the N_2–60 cm (24.50 g) recorded significantly high kernel weight than N_2–90 cm (21.00g), N_1–30 cm (21.00 g) and N_1–90 cm (20.90 g). But it was not significantly different from N_1–60 cm (23.00 g) and N_2–30 cm (21.70 g).

4.2.6.15 Total Dry Matter at Harvest

At the time of harvest the total dry matter was high in *rabi* season as compared to that in *kharif* season. Significantly high total dry matter was observed in N_1 90 cm (62.84 g) followed by N_2–90 cm (59.62 g) than in the rest of the treatments in *kharif* season, between which the difference was not significant. While in *rabi* season, there were no significant differences among the treatments for this character.

4.2.6.16 100 Kernel Weight

The 100 kernel weight was high in *rabi* season than in *kharif* season In *kharif* season, the N_2–90 cm (42.66 g) followed

cant. However, these values were significantly higher than the rest of the treatments. In *rabi* season, the differences observed among the treatments were not significant, however, high 100 cent. However, these values were significantly higher than the rest of the treatments. In *rabi* season, the differences observed among the treatments were not significant, however, high 100 kernel weight was found in N_2-30 cm (53.11 g).

4.2.6.17 Oil Per cent

The oil per cent was high in *rabi* season than in *kharif* season. The oil per cent was high in N_2-90 cm (48.35%) but it was not significantly different from all other treatments except from N_2-60 cm (42.75%). While in *rabi* season significant differences were not observed for oil per cent among N_2-30 cm (50.95%) N_1-30 cm (50.90%), N_1-60 cm (50.80%) and N_2-60 cm (50.45%). However all these treatments differed significantly from N_2-90 cm (47.70%).

4.2.6.18 Shelling Per cent

Not much difference was observed for shelling per cent between *kharif* and *rabi* seasons. In *kharif* season, the N_2-30 cm (72.07%) recorded significantly high shelling per cent than N_I-60 cm (64.60%), but it was not significantly different from the rest of the treatments whereas in *rabi* season, significant differences were not observed among the treatments, however, high shelling per cent was found in N_2-60 cm (68.67%) (Table 10).

4.2.6.19 Harvest Index

The harvest index values were slightly high in *rabi* season than in *kharif* season. In *kharif* season, significantly high harvest index was obtained in N_2-60 cm (37.83) than in the remaining treatments except that in N_2-30 cm (32.46). Among the treatments there were no significant differences in *rabi* season, however high harvest index was recorded by N_2-60 cm (36.70).

4.2.7 M13

4.2.7.1 Days to initial flowering

In *kharif* season, the number of days to initial flowering was less as compared to that in *rabi* season. With regard to this character significant differences were not recorded among the treatments for this trait in *kharif* season. While in *rabi* season, significantly less number of days to initial flowering was observed in N_1-30 cm (49.50) as compared to the rest of the treatments except that in N_2-90 cm (50.50).

4.2.7.2 Days to 50% Flowering

The data (Table 11) indicate that the number of days taken for 50% flowering were less in *kharif* than in *rabi* season. In both *kharif* and *rabi* seasons, it was observed that there were no significant differences among N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm.

4.2.7.3 Days to 100% Flowering

The number of days taken for 100% flowering were less in *kharif* season than in *rabi* season. In *kharif* season, significantly less number of days to 100% flowering were recorded in N_1-90 cm (37.25) than in N_2-30 cm (38.50) and N_2-90 cm (38.50), but it did not differ significantly from the remaining treat-

Table 11: Mean performance of M13 for 19 characters in six micro-environments in *Kharif* and *Rabi* seasons.

Micro-environment / Treatment	Days to initial flowering		Days to 50% flowering		Days to 100% flowering		Days to peg initiation		Canopy diameter (cm)		Canopy circumference (cm)		Plant height (cm)	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	31.250	49.500	36.000	58.500	38.000	62.500	38.500	60.000	71.330	69.000	207.100	161.500	32.550	19.900
N2-30	31.500	52.500	36.500	58.500	38.500	62.000	37.750	61.000	71.750	70.400	210.100	174.000	34.050	22.600
N1-60	30.750	51.000	36.000	59.000	38.000	63.000	38.500	60.500	72.600	69.200	210.300	159.500	30.150	25.700
N2-60	31.250	51.000	36.000	58.500	38.000	63.000	38.000	62.000	73.250	71.200	212.200	180.100	35.150	20.900
N1-90	30.750	52.000	35.750	57.000	37.250	62.500	37.500	62.000	72.130	68.250	204.900	181.000	29.180	22.000
N2-90	31.250	50.500	35.750	57.000	38.500	62.500	37.750	61.000	73.000	70.500	199.300	180.500	28.770	24.500
SE	0.566	0.532	0.289	0.827	0.433	0.975	0.707	1.133	0.960	0.630	12.770	1.789	1.887	4.060
CD at 5%	1.460	1.370	7.420	2.130	1.110	2.510	1.820	2.910	2.470	1.620	32.832	4.600	4.851	10.438

Micro-environment / Treatment	Number of primaries		Number of secondaries		Number of aerial pegs		Number of mature pods		Mature pod weight (g)		Number of mature kernels		Mature kernel weight (g)	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	6.300	10.000	11.000	23.850	32.200	14.900	19.250	40.000	15.480	37.300	18.000	70.500	11.000	20.500
N2-30	8.500	7.600	10.200	17.600	34.400	13.000	20.750	42.500	16.730	40.200	25.250	77.000	11.850	21.600
N1-60	8.180	8.100	12.900	19.600	37.000	10.800	21.250	46.000	17.380	44.100	30.650	58.000	11.850	23.700
N2-60	9.980	10.000	10.500	22.650	35.900	13.300	25.130	49.900	20.750	44.900	27.250	73.300	13.750	24.600
N1-90	9.450	8.500	12.050	19.500	70.000	9.900	18.920	38.800	15.400	35.600	27.750	42.500	10.550	20.000
N2-90	9.700	9.500	10.850	17.000	41.500	11.700	25.630	49.500	21.430	43.600	31.750	64.500	13.600	24.000
SE	0.769	0.874	2.085	2.727	7.940	3.660	1.298	5.970	1.159	3.480	1.504	9.160	0.900	1.843
CD at 5%	1.977	2.247	5.361	7.011	20.414	9.410	3.340	15.350	2.980	8.950	3.867	23.550	2.310	4.740

Micro-environment / Treatment	Total dry matter at harvest (g)		100 kernel weight (g)		Oil percent		Shelling percent		Harvest Index	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
N1-30	35.900	59.800	46.400	54.900	43.470	48.050	73.400	54.560	26.440	25.580
N2-30	43.400	63.600	46.900	47.800	42.200	46.650	74.130	56.000	24.400	25.890
N1-60	42.900	69.900	44.160	72.500	43.250	50.500	69.130	55.400	22.440	25.780
N2-60	43.500	73.900	46.810	72.900	43.670	49.350	71.540	55.870	25.880	25.900
N1-90	39.100	73.100	44.390	59.000	46.100	48.850	66.610	55.980	20.170	22.250
N2-90	46.500	64.000	50.730	68.000	44.550	48.150	71.530	58.750	21.960	27.690
SE	5.140	7.580	2.629	10.750	2.644	1.327	2.946	0.491	1.867	3.336
CD at 5%	13.215	19.488	6.759	27.638	6.798	3.412	7.570	1.260	4.800	8.580

ments. While in *rabi* season, significant differences were not observed among the treatments for this trait.

4.2.7.4 Days to Peg Initiation

The results on days to peg initiation revealed that in *kharif* season the days taken were less than in *rabi* season. In both the seasons it was found that there were no significant differences among N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm.

4.2.7.5 Canopy Diameter

The canopy diameter was slightly high in *kharif* season than in *rabi* season. With regard to this character significant differences were not observed among the treatments in *kharif* season, however high canopy diameter was observed in N_2-60 cm (73.25 cm). In *rabi* season high canopy diameter was observed in N_2-60 cm (71.20 cm) which was at par with that in N_2-90 cm (70.50 cm) and N_2-30 cm (70.40 cm) and they differed significantly from the rest of the treatments (Table 11).

4.2.7.6 Canopy Circumference

In *kharif* season, the canopy circumference was higher than that recorded in *rabi* season. There were no significant differences among N_1-30, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm in *kharif* season for this trait, however high canopy circumference was found in N_2-60 cm (212.20 cm). In *rabi* season, high canopy circumference was observed in N_1-90 cm (181.00 cm) which differed significantly from N_2-30 cm (174.10 cm), N_1-30 cm

(161.50 cm) and N_1-60 cm (159.50 cm). But it was not significantly different from that found in N_2-90 cm (180.50 cm) and N_2-60 cm (180.10 cm).

4.2.7.7 Plant Height

It was observed that the plant height in *kharif* season was more than that in *rabi* season. In *kharif* season, significantly high plant height was recorded by N_2-60 cm (35.15 cm) than N_1-60 cm (30.15 cm) N_1-90 cm (29.18 cm) and N_2-90 cm (28.17 cm), but it did not differ significantly from N_2-30 cm (34.05 cm) and N_1-30 cm (32.55 cm). While in *rabi* season, significant differences were not observed among the treatments for plant height.

4.2.7.8 Number of Primaries

Between *kharif* and *rabi* seasons there was not much difference in number of primaries (Table 11). The results in *kharif* season revealed that the number of primaries was high in N_2-60 cm (9.98) but it did not differ significantly from all other treatments except N_1-30 cm (6.30). In *rabi* season more number of primaries was observed in N_1-30 cm (10.00) and N_1-60 cm (10.00) which differed significantly from N_2-30 cm (7.60). But they were not significantly different from the rest of the treatments.

4.2.7.9 Number of Secondaries

The number of secondary branches was high in *rabi* season than in *kharif* season. From the results (Table 11), it was observed that there were no significant differences among N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N_2-90 cm in both kharif and rabi seasons for this trait.

4.2.7.10 Number of Aerial Pegs

More number of aerial pegs was recorded in kharif season than in rabi season. In kharif season, significantly more aerial pegs were found in N_1-90 cm (70.00) than in the rest of the treatments. Whereas in rabi season, there were no significant differences among the treatments for number of aerial pegs.

4.2.7.11 Number of Mature Pods

The data indicate that (Table 11) in rabi season the mature pod number was higher than in kharif season. The number of mature pods was high in N_2-90 cm (25.63) followed by N_2-60 cm (25.13) and they differed significantly from the rest of the treatments in kharif season. In rabi season, the differences observed among the treatments for this character were not significant, however more number of mature pods was found in N_2-60 cm (49.90).

4.2.7.12 Mature Pod Weight

The weight of mature pods was much high in rabi season than in kharif season. High mature pod weight was recorded by N_2-90 cm (21.43 g) followed by N_2-60 cm (20.75 g), between which the difference was non-significant, but they were significantly different from the rest of the treatments. In rabi season, significantly high mature pod weight was observed in N_2-60 cm (44.90 g) than that in N_1-90 cm (35.60 g), but it was not significantly different from N_1-60 cm (44.10 g), N_2-90 cm (43.60 g), N_2-30 cm (40.20 g) and N_1-30 cm (37.30 g).

4.2.7.13 Number of Mature Kernels

In rabi season the mature kernel number was much higher than that observed in kharif season. The N_2-90 cm (31.75) resulted in significantly higher number of mature kernels in kharif season than the rest of the treatments except the N_1-60 cm (30.65), between which the difference was not significant. In rabi season, the highest number of mature kernels was found in N_2-30 cm (77.00) which was not significantly different from the rest of the treatments except that in N_1-90 cm (42.50).

4.2.7.14 Mature Kernel weight

It was found that in rabi season the weight of mature kernels was more than that in kharif season (Table 11). In kharif season, significantly high mature kernel weight was recorded by N_2-60 cm (13.75 g) than N_1-30 cm (11.00 g) and N_1-90 cm (10.55 g), but it was not significantly different from N_2-90 cm (13.60 g), N_2-30 cm (11.85 g) and N_1-60 cm (11.85 g). While in rabi season, significant differences were not observed among the treatments, however high mature kernel weight was recorded by N_2-60 cm (24.60 g).

4.2.7.15 Total Dry Matter at Harvest

In rabi season at the time of harvest the total dry matter was higher than that in kharif season. In both kharif and rabi seasons, significant differences were not found for this trait among N_1-30 cm, N_2-30 cm, N_1-60 cm, N_2-60 cm, N_1-90 cm and N2-90 cm.

4.2.7.16 100 Kernel Weight

In <u>rabi</u> season the 100 kernel weight was more than that observed in <u>kharif</u> season. The results (Table 11) revealed that significant differences were not observed among N1-30 cm, N2-30 cm, N1-60 cm, N1-60 cm, N2-60 cm, N1-90 cm and N2-90 cm in both <u>kharif</u> and <u>rabi</u> seasons for this trait. However, the 100 kernel weight was maximum in N_2-90 cm (50.73 g) in <u>kharif</u> season and N2-60 cm (72.90 g) in <u>rabi</u> season.

4.2.7.17 Oil Per cent

An increase in oil per cent was found in <u>rabi</u> season as compared to <u>kharif</u> season. In <u>kharif</u> season there were no significant differences for oil per cent among the treatments, while in <u>rabi</u> season, the N2-60 cm (49.35%) recorded significantly high oil per cent than N2-30 cm (46.65%) but it did not differ significantly from the rest of the treatments.

4.2.7.18 Shelling Per cent

In <u>kharif</u> season the shelling per cent was higher than in <u>rabi</u> season. For shelling per cent significant differences were not observed in <u>kharif</u> season among the treatments, however, high shelling per cent was found in N2-30 cm (74.13%). Whereas in <u>rabi</u> season, the N2-90 cm exhibited significantly high shelling per cent than the rest of the treatments (Table 11).

4.2.7.19 Harvest Index

There was not much difference between *kharif* and *rabi* seasons for harvest index (Table 11). In *kharif* season, high harvest index was observed in N_1—30 cm (26.44) but it was not significantly different from most of the treatments except from that in N_1—90 cm (20.17). While in *rabi* season, the differences observed among the treatments were not significant, however, high harvest index was recorded by N_2-90 cm (27.69).

4.3 STABILITY ANALYSIS

The genotypes viz., MH2 (canopy category 1), JL24 (canopy category 2), TAP5 (canopy category 3), Kadiri-3 (canopy category 3), TMV2NLM (canopy category 3), Compact Mutant of M13 (canopy category 3) and M13 (canopy category 4) were subjected to stability analysis for 19 characters and the results are presented in Tables 12, 13 and 14.

4.3.1 Days to Initial Flowering

Analysis of variance (Table 12) revealed that the variances due to genotype, environment (linear), genotype x environment (linear) were significant when tested against pooled deviation. It indicates that the number of days to initiation of first flower varied significantly in different environments as well as the genotypes differed among themselves in average performance over all environments. When individual variances of genotypes tested against pooled error, it was found that most of the genotypes exhibited significant differences over environments except TMV2NLM, Kadiri-3 and Compact Mutant of M13, indicating their stability for this trait.

Based on environmental index (Table 13) there were no differences among the micro-environments in both season 1 and season 3 for this trait. In season 2, the micro-environment VI (N_2-90) followed by IV (N_1-60) and IV (N_2-60) were found to be favourable for the expression of this trait. The most stable variety for this character was TAP5 with an environmental standard deviation of 7.72. While, the strain Compact Mutant of M13 showed maximum variation with an environmental standard deviation of 10.38. The genotype TAP5 recorded the lowest mean value (30.11) followed by MH2 (33.17) and JL24 (33.42) with environmental standard deviations of 7.72, 9.50 and 9.02 respectively. Genotypes M13 (37.78), Compact Mutant of M13 (37.53), TMV2NLM (37.00) and Kadiri-3 (36.61) recorded high mean values with standard deviations of 9.93, 10.38, 10.24 and 10.22 respectively.

Based on stability parameters (Table 14) the mean of individual genotypes ranged from 30.11 (TAP5) to 37.78 (M13) with a general mean of 35.09. The regression coefficients (bi) of days to initial flowering on environmental index were in the range of 0.941 to 1.088. The deviations from regression (S^2di) ranged from -0.389 to 1.651. The regression coefficients of all genotypes significantly deviated from unity (b=1) except that of MH2 and M13. Most of the genotypes showed significant deviations from regression except TMV2NLM, Kadiri-3 and Compact Mutant of

Table 12 : Analysis of variance for 19 characters in 7 varieties over 18 environments (Stability Analysis).

Source	DF	Days to initial flowering	Days to 50% flowering	Days to 100% flowering	Days to peg initiation	Canopy diameter (cm)	Canopy circumference (cm)	Plant height (cm)
Varieties	6	151.25 **	227.28 **	241.61 **	140.07 **	4194.62 **	43873.82 **	3672.49 **
ENV+ (VAR X ENVS)	119	92.39 **	117.11 **	131.53 **	120.39 **	7.42 **	1017.49 **	59.23 **
Environment (Linear)	1	10767.15 **	13874.72 **	15554.51 **	14161.49 **	469.76 **	89118.48 **	3900.21 **
VAR X ENV (Linear)	6	16.13 **	1.70 **	6.35 **	11.19 **	11.39 **	2818.78 **	304.21 **
Pooled deviation	112	1.17 **	0.46	0.53 **	0.87 **	3.08 **	134.37 **	11.81 **
Varieties								
MH2	16	1.09 *	0.36	0.61	0.41	0.90	70.79 **	3.44
JL24	16	1.31 *	0.79	0.61	0.64	12.28 **	480.01 **	5.42 *
TAP5	16	1.74 **	0.47	0.65	1.14 **	1.22	94.03 **	36.05 **
Kadiri-3	16	0.74	0.27	0.41	0.78	4.08 **	87.21 **	5.60 **
TMV2NLM	16	0.22	0.33	0.28	0.43	0.83	10.94 **	12.23 **
Compact Mutant of M13	16	0.80	0.54	0.38	1.22 **	1.36	39.75 **	11.50 **
M13	16	2.26 **	0.43	0.78 *	1.49 **	0.89	157.85 **	8.41 **
Pooled Error	108	0.61	0.52	0.40	0.45	1.03	4.72	2.51

Source	DF	Number of primaries	Number of secondaries	Number of aerial pegs	Number of mature pods	Mature pod weight (g)	Number of mature kernels	Mature kernel weight (g)
Varieties	6	60.83 **	939.05 **	1039.49 **	832.04 **	890.15 **	1231.26 **	221.28 **
ENV+ (VAR X ENVS)	119	1.31 *	11.27 **	138.45 **	84.20 **	89.89 **	226.09 **	18.06 **
Environment (Linear)	1	33.77 **	630.11 **	8309.94 **	7670.06 **	8346.51 **	16946.48 **	1661.36 **
VAR X ENV (Linear)	6	3.15 **	43.58 **	385.08 **	257.63 **	241.90 **	450.44 **	18.85 **
Pooled deviation	112	0.92 **	4.01 **	52.27 **	7.18 **	8.03 **	64.79 **	1.66 **
Varieties								
MH2	16	0.43	0.32	17.06	4.37	5.09 *	81.42 **	1.39 **
JL24	16	0.73 **	1.38	71.84 *	6.80	10.33 **	50.28 **	1.69 **
TAP5	16	0.18	0.64	32.52	7.87 *	7.85 **	48.01 **	1.92 **
Kadiri-3	16	0.35	2.52 *	17.69	11.00 **	12.70 **	51.59 **	2.18 **
TMV2NLM	16	2.14 **	6.83 **	52.85	6.75	6.36 **	46.81 **	1.46 **
Compact Mutant of M13	16	1.05 **	9.32 **	85.44 **	2.43	2.40	35.63 **	0.53
M13	16	1.58 **	7.08 **	88.53 **	11.03 **	11.50 **	139.75 **	2.43 **
Pooled Error	108	0.29	1.24	36.99	4.12	2.72	8.34	0.61

Source	DF	Total dry matter at harvest (g)	100 kernel weight (g)	Oil percent	Shelling per cent	Harvest Index
Varieties	6	2652.19 **	966.79 **	33.26 **	693.42 **	256.91 **
ENV+ (VAR X ENVS)	119	167.31 **	67.93 **	4.73 **	50.42 **	31.05 **
Environment (Linear)	1	12803.33 **	6879.21 **	305.08 **	4161.90 **	1569.77 **
VAR X ENV (Linear)	6	489.97 **	29.63 **	18.72 **	65.17 **	23.61
Pooled deviation	112	37.20 **	9.17 *	1.30	12.92 **	17.71 **
Varieties						
MH2	16	22.83 **	7.19	0.97	42.69 **	26.89 **
JL24	16	32.90 **	2.98	1.75	8.22	30.04 **
TAP5	16	60.35 **	7.22	0.64	5.17	13.17 **
Kadiri-3	16	23.86 **	5.46	0.53	12.43 *	7.78 *
TMV2NLM	16	12.28	3.93	1.79	7.43	24.87 **
Compact Mutant of M13	16	42.66 **	6.75	2.03	7.06	11.60 **
M13	16	65.54 **	30.67 **	1.38	7.42	9.63 **
Pooled Error	108	8.37	6.55	1.70	6.57	3.74

* Significant at 5% level.

** Significant at 1% level.

Table 13 : Mean performance of seven varieties over 18 environments (Stability Analysis)

Days to initial flowering

Varieties	*Kharif* 1988						*Rabi* 1988-89					
	Env I	Env II	Env III	Env IV	Env V	Env VI	Env I	Env II	Env III	Env IV	Env V	Env VI
	N1-30	N2-30	N1-60	N2-60	N1-90	N2-90	N1-30	N2-30	N1-60	N2-60	N1-90	N2-90
MH2	27.000	26.500	27.000	26.000	27.500	26.500	47.000	48.000	46.000	45.500	46.000	44.500
JL24	27.000	27.000	27.000	27.000	27.500	27.500	47.500	44.000	43.500	46.000	46.500	47.000
TAP5	25.000	25.500	26.000	25.500	26.000	25.500	40.000	40.500	41.000	40.500	41.500	40.500
Kadiri-3	27.500	28.000	28.000	28.000	29.000	28.000	51.000	51.000	51.000	51.000	50.500	48.500
TMV2NLM	28.500	29.000	29.000	29.000	29.000	29.000	50.500	51.000	51.500	51.000	51.500	50.500
Com.Mut.M13	29.000	28.500	29.000	29.000	28.500	29.500	52.000	52.000	51.500	51.000	51.000	52.500
M13	29.000	28.500	28.000	28.500	29.000	29.000	49.500	52.500	51.000	51.000	52.000	50.500
Gr. Mean	27.570	27.570	27.710	27.570	28.070	27.860	48.210	48.430	47.930	48.000	48.430	47.710
EI	-7.516	-7.516	-7.373	-7.516	-7.016	-7.230	13.127	13.341	12.841	12.913	13.341	12.627

Varieties	*Kharif* 1989						Mean	Env. SD
	Env I	Env II	Env III	Env IV	Env V	Env VI		
	N1-30	N2-30	N1-60	N2-60	N1-90	N2-90		
MH2	26.500	28.000	26.500	26.500	25.500	26.500	33.170	9.500
JL24	27.500	28.000	27.500	27.500	26.500	27.000	33.420	9.020
TAP5	24.500	23.500	24.000	24.500	24.000	24.000	30.110	7.720
Kadiri-3	30.500	32.500	30.500	31.000	31.000	32.000	36.610	10.220
TMV2NLM	30.500	32.500	30.500	31.000	31.500	30.500	37.000	10.240
Com.Mut.M13	32.000	31.000	32.500	32.500	32.500	31.500	37.530	10.380
M13	33.500	34.500	33.500	34.000	32.500	33.500	37.780	9.930
Gr. Mean	29.290	30.000	29.290	29.570	29.070	29.290		
EI	-5.802	-5.087	-5.802	-5.516	-5.516	-5.802		

Days to 50% flowering

Varieties	*Kharif* 1988						*Rabi* 1988-89					
	Env I	Env II	Env III	Env IV	Env V	Env VI	Env I	Env II	Env III	Env IV	Env V	Env VI
	N1-30	N2-30	N1-60	N2-60	N1-90	N2-90	N1-30	N2-30	N1-60	N2-60	N1-90	N2-90
MH2	29.500	29.500	31.500	30.000	31.000	30.000	52.000	53.000	52.000	52.500	52.000	52.000
JL24	29.500	31.000	30.000	30.000	33.000	32.500	52.000	51.000	51.500	52.000	52.000	51.000
TAP5	28.000	28.500	28.500	28.500	29.000	28.500	47.500	49.500	49.500	49.000	47.500	49.500
Kadiri-3	36.000	36.500	35.500	36.000	34.500	36.000	56.500	57.000	57.000	58.000	57.500	57.000
TMV2NLM	36.000	36.000	36.000	36.000	36.000	36.000	58.500	56.500	57.000	57.500	56.500	57.000
Com.Mut.M13	36.000	36.000	36.000	37.000	34.000	36.500	58.000	58.500	57.500	58.500	56.500	58.500
M13	36.000	37.000	37.000	36.000	36.500	36.000	58.500	58.500	59.000	58.500	57.000	57.000
Gr. Mean	33.000	33.500	33.500	33.360	33.570	33.640	54.710	54.860	54.790	55.140	54.140	54.570
EI	-6.905	-6.405	-6.400	-6.550	-6.330	-6.260	14.810	14.950	14.880	15.240	14.240	14.670

Varieties	*Kharif* 1989						Mean	Env. SD
	Env I	Env II	Env III	Env IV	Env V	Env VI		
	N1-30	N2-30	N1-60	N2-60	N1-90	N2-90		
MH2	28.000	29.000	27.500	29.500	27.500	28.500	36.940	11.190
JL24	30.500	30.500	29.500	29.500	29.500	28.500	37.420	10.360
TAP5	25.500	25.500	26.500	26.500	25.500	26.500	34.420	10.500
Kadiri-3	34.000	34.500	33.500	33.500	34.500	33.000	42.310	10.860
TMV2NLM	32.500	34.500	34.000	33.500	33.500	33.500	42.250	10.910
Com.Mut.M13	34.000	34.000	34.500	34.000	34.500	33.500	42.640	11.170
M13	36.000	36.000	35.000	36.000	35.000	35.500	43.360	10.730
Gr. Mean	31.500	32.000	31.500	31.790	31.430	31.290		
EI	-8.400	-7.900	-8.400	-8.120	-8.480	-8.620		

Table 13 : Continued..

Days to 100% flowering

Varieties	Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90
	Kharif 1988						Rabi 1988-89					
MH2	33.000	31.500	34.500	33.000	33.000	34.000	54.000	55.500	55.000	56.000	55.000	54.500
JL24	33.500	34.000	33.000	33.000	35.000	33.500	54.500	54.000	53.500	54.000	55.000	53.500
TAP5	30.000	30.500	31.500	31.000	31.000	30.500	52.000	53.000	52.500	51.500	51.500	53.000
Kadiri-3	38.000	37.500	37.500	38.000	37.500	38.000	60.000	61.500	60.000	60.500	61.500	61.000
TMV2NLM	38.000	38.000	38.000	37.500	37.500	37.500	61.500	60.000	59.500	60.000	59.500	60.000
Com.Mut.M13	38.000	38.500	37.500	38.500	38.000	38.500	62.000	63.500	63.000	63.500	61.000	64.000
M13	38.500	38.500	38.000	38.000	38.000	38.000	62.500	62.000	63.000	63.000	62.500	62.500
Gr. Mean	35.570	35.500	35.710	35.570	35.710	35.710	58.070	58.500	58.070	58.360	58.000	58.360
EI	-6.980	-7.052	-6.837	-6.980	-6.837	-6.837	15.520	15.948	15.520	15.806	15.448	15.806

Varieties	Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Mean	Env. SD
	Kharif 1989							
MH2	30.500	32.500	30.500	30.000	31.000	30.500	39.670	11.230
JL24	31.500	31.000	32.000	30.500	31.500	30.500	39.640	10.580
TAP5	27.500	27.000	29.500	28.500	27.500	29.000	37.060	11.130
Kadiri-3	36.000	38.000	35.000	35.500	36.500	36.000	44.890	11.580
TMV2NLM	35.500	36.500	35.500	36.000	36.500	36.500	44.640	11.270
Com.Mut.M13	35.500	36.500	36.500	36.500	36.000	36.500	45.750	12.470
M13	37.500	38.500	38.000	38.000	36.500	39.000	46.220	11.920
Gr. Mean	33.430	34.290	33.860	33.570	33.640	34.000		
EI	-9.123	-8.266	-8.694	-8.980	-8.909	-8.552		

Days to peg initiation

Varieties	Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90
	Kharif 1988						Rabi 1988-89					
MH2	33.50	32.50	33.50	33.50	32.50	33.50	53.00	53.50	52.50	53.50	52.00	54.00
JL24	34.00	34.00	32.00	33.50	34.00	33.50	57.00	57.50	56.50	57.00	57.00	56.00
TAP5	31.00	31.00	31.00	31.50	31.50	31.00	53.50	52.50	52.00	53.50	52.50	52.50
Kadiri-3	35.00	35.50	36.50	35.50	35.00	35.50	58.00	58.00	57.50	58.00	58.00	56.50
TMV2NLM	34.00	35.00	34.50	36.00	35.00	36.00	60.00	60.00	59.50	59.00	58.50	59.00
Com.Mut.M13	36.50	35.50	36.50	36.50	36.00	37.00	60.00	62.00	61.00	61.00	62.00	63.50
M13	36.50	36.00	36.50	36.00	36.00	36.00	60.00	61.00	60.50	62.00	62.00	61.00
Gr. Mean	34.36	34.21	34.36	34.64	34.29	34.64	57.36	57.79	57.07	57.71	57.43	57.50
EI	-8.15	-8.29	-8.15	-7.86	-8.22	-7.86	14.85	15.28	14.57	15.21	14.92	14.99

Varieties	Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Mean	Env. SD
	Kharif 1989							
MH2	32.00	35.00	33.50	34.50	33.50	34.00	40.00	9.55
JL24	32.50	34.00	34.00	33.00	33.50	33.50	41.25	11.35
TAP5	29.50	32.00	32.50	30.00	29.50	29.50	38.14	10.67
Kadiri-3	36.50	39.00	35.50	37.50	38.00	38.00	43.53	10.35
TMV2NLM	36.50	38.00	36.50	37.50	36.50	36.50	43.78	11.36
Com.Mut.M13	37.50	35.00	39.00	37.50	38.50	37.50	45.14	12.02
M13	40.50	39.00	40.50	40.00	39.00	39.50	45.69	11.32
Gr. Mean	35.00	36.07	35.93	35.71	35.50	35.50		
EI	-7.50	-6.43	-6.57	-6.79	-7.00	-7.00		

Table 13 : Continued..

Canopy diameter

Varieties	Kharif 1988 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Rabi 1988-89 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90
MH2	28.60	29.10	31.75	32.00	29.70	33.30	26.85	27.65	27.50	30.75	26.50	28.50
JL24	59.15	60.15	64.75	63.50	61.85	62.50	57.50	66.70	57.00	59.50	57.50	60.70
TAP5	71.80	72.70	72.75	73.30	72.65	73.00	66.00	69.30	68.50	70.50	68.00	72.75
Kadiri-3	70.10	70.90	69.00	71.05	71.00	72.75	64.00	64.50	66.00	67.50	63.50	65.00
TMV2NLM	71.75	72.55	74.80	76.00	74.50	75.50	68.50	69.25	69.50	71.00	69.50	71.00
Com.Mut.M13	70.35	70.80	69.40	71.25	69.45	70.50	65.50	66.50	67.00	67.50	64.00	66.50
M13	71.15	71.50	71.70	72.00	70.50	72.00	69.00	70.40	69.20	71.20	68.25	70.50
Gr. Mean	63.27	63.96	64.88	65.59	64.24	65.65	59.62	62.04	60.67	62.56	59.61	62.14
EI	-0.16	0.52	1.44	2.15	0.80	2.22	-3.81	-1.39	-2.76	-0.87	-3.83	-1.29

Varieties	Kharif 1989 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Mean	Env. SD
MH2	31.00	32.50	31.50	33.50	31.50	32.50	30.26	2.26
JL24	36.00	56.50	58.00	60.00	53.00	56.00	59.46	3.47
TAP5	69.50	71.00	71.50	73.00	72.75	73.50	71.25	2.17
Kadiri-3	71.00	76.00	73.00	74.00	73.50	74.00	69.82	3.89
TMV2NLM	72.50	73.50	72.00	75.00	72.00	73.50	72.35	2.28
Com.Mut.M13	70.75	71.50	71.50	73.00	71.50	72.50	69.42	2.61
M13	71.50	72.00	73.50	74.50	73.75	74.00	71.48	1.73
Gr. Mean	63.18	64.71	64.43	66.14	64.00	65.14		
EI	-0.26	1.28	0.99	2.71	0.56	1.71		

Canopy circumference

Varieties	Kharif 1988 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Rabi 1988-89 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90
MH2	52.75	65.20	65.70	71.85	82.40	83.30	50.00	51.25	71.90	72.70	46.50	65.00
JL24	121.38	136.80	138.00	188.50	196.60	231.10	131.00	147.00	149.00	152.50	160.50	163.50
TAP5	232.50	236.25	273.84	271.82	274.00	291.00	153.00	152.50	155.50	164.50	172.50	174.50
Kadiri-3	221.35	216.50	234.65	232.99	233.15	230.49	156.75	160.00	161.00	166.50	163.00	171.00
TMV2NLM	205.65	210.83	213.50	230.99	238.50	241.34	163.00	174.50	174.50	181.50	176.00	177.50
Com.Mut.M13	201.25	211.50	205.15	216.17	211.80	245.80	156.50	164.00	161.50	165.00	177.00	175.50
M13	248.17	251.50	246.50	249.99	236.33	265.65	161.50	174.00	159.50	180.10	181.00	180.50
Gr. Mean	183.29	189.80	196.76	208.90	210.40	226.95	138.82	146.18	147.56	154.69	153.79	158.21
EI	15.36	21.87	28.83	40.97	42.47	59.03	-29.11	-21.75	-20.37	-13.24	-14.14	-9.71

Varieties	Kharif 1989 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Mean	Env. SD
MH2	44.00	54.50	48.50	51.50	55.50	55.50	60.45	12.15
JL24	130.50	160.00	161.50	168.00	164.50	164.00	159.13	26.44
TAP5	152.50	164.25	170.00	181.00	193.00	196.25	200.49	48.93
Kadiri-3	150.50	161.50	167.75	168.00	164.50	165.50	184.73	32.19
TMV2NLM	161.50	174.00	180.50	180.50	182.00	184.00	191.68	25.24
Com.Mut.M13	149.50	153.00	161.00	161.50	168.00	167.50	180.65	27.42
M13	166.00	168.75	174.00	174.50	173.50	179.00	198.36	38.16
Gr. Mean	136.36	148.00	151.89	155.00	157.29	158.82		
EI	-31.57	-19.93	-16.03	-12.93	-10.64	-9.11		

Table 13 : Continued..

Plant height

Varieties	Kharif 1988 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Rabi 1988-89 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90
MH2	9.60	10.60	10.00	8.60	10.50	9.50	4.40	4.60	4.45	4.75	4.40	4.70
JL24	48.20	46.25	41.90	40.00	38.70	45.15	26.75	26.00	27.50	30.00	25.50	31.00
TAP5	72.00	73.80	80.50	75.10	77.25	78.85	33.00	44.00	31.00	45.50	40.50	49.00
Kadiri-3	36.10	35.70	31.70	33.45	30.70	27.30	23.50	26.00	27.00	22.00	22.50	28.50
TMV2NLM	37.25	36.00	31.40	32.80	31.00	30.50	25.50	28.50	22.50	26.50	28.50	19.00
Com.Mut.M13	40.80	40.95	32.30	38.70	31.10	36.00	28.00	29.00	23.50	31.50	19.50	28.00
M13	37.60	33.60	33.30	36.30	29.60	27.40	19.85	22.60	25.70	20.85	22.00	24.50
Gr. Mean	40.22	39.56	37.60	37.85	35.55	36.39	23.00	25.81	23.09	25.87	23.27	26.39
EI	8.85	8.19	5.93	6.48	4.18	5.02	-8.37	-5.55	-8.27	-5.50	-8.10	-4.98

Varieties	Kharif 1989 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Mean	Env. SD
MH2	6.70	5.75	12.50	6.15	11.00	10.00	7.68	2.82
JL24	35.00	37.50	35.00	31.00	32.50	35.00	35.16	7.09
TAP5	52.50	52.50	51.00	54.00	52.50	52.50	56.42	15.87
Kadiri-3	27.50	26.00	30.00	26.00	26.50	26.50	28.16	4.09
TMV2NLM	33.50	33.00	34.00	36.00	28.50	36.00	30.58	4.97
Com.Mut.M13	35.50	35.00	32.50	36.50	38.00	36.50	32.96	5.79
M13	27.50	34.50	27.00	34.00	28.75	29.75	28.60	5.42
Gr. Mean	31.17	32.04	31.71	31.95	31.11	32.32		
EI	-0.19	0.67	0.35	0.58	-0.26	0.95		

Number of primaries

Varieties	Kharif 1988 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Rabi 1988-89 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90
MH2	5.20	5.00	5.10	5.90	5.70	6.20	5.10	6.50	5.70	5.80	5.60	5.75
JL24	5.90	6.70	8.10	7.60	6.90	7.30	6.60	6.50	5.25	5.75	5.90	6.50
TAP5	4.10	4.40	5.00	5.30	4.70	5.00	4.00	4.10	4.50	4.75	5.70	4.50
Kadiri-3	5.90	5.80	6.20	6.80	7.20	6.60	5.40	6.00	6.50	6.25	5.25	7.50
TMV2NLM	6.65	6.80	7.90	7.30	9.60	8.20	6.50	7.50	8.00	7.75	7.00	8.00
Com.Mut.M13	8.20	6.90	12.00	13.60	10.70	11.30	9.00	7.75	8.50	7.50	8.00	7.50
M13	6.10	8.00	7.60	10.20	8.90	7.40	10.00	7.60	8.10	10.00	8.50	9.50
Gr. Mean	6.01	6.74	7.41	8.10	7.59	7.43	6.66	6.42	6.65	6.83	6.56	7.04
EI	-0.81	-0.68	0.59	1.28	0.76	0.61	-0.16	-0.40	-0.17	0.01	-0.26	0.21

Varieties	Kharif 1989 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Mean	Env. SD
MH2	4.00	4.20	4.25	4.25	4.50	4.25	5.11	0.71
JL24	4.10	4.25	5.25	6.00	5.25	5.10	6.02	1.07
TAP5	4.25	4.00	4.40	5.20	4.35	4.00	4.57	0.50
Kadiri-3	5.00	5.50	5.25	5.50	5.00	6.00	5.98	0.73
TMV2NLM	12.00	10.25	9.75	9.00	7.50	8.00	8.21	1.43
Com.Mut.M13	9.25	9.75	8.00	9.50	8.50	9.75	9.17	1.74
M13	6.50	9.00	8.75	9.75	10.00	10.50	8.69	1.31
Gr. Mean	6.44	6.71	6.52	7.03	6.44	6.80		
EI	-0.38	-0.11	-0.30	0.21	-0.38	-0.02		

Table 13 : Continued..

Number of secondaries

Varieties	Kharif 1988 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Rabi 1988-89 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90
MH2	0.00	0.00	0.00	0.00	0.00	0.00	1.60	1.10	1.60	2.50	1.40	1.85
JL24	0.26	0.60	1.10	1.20	0.80	1.40	2.55	2.00	3.00	4.00	2.30	6.50
TAP5	0.80	0.30	0.10	0.20	0.10	1.20	0.30	2.20	0.80	1.70	3.70	1.05
Kadiri-3	4.00	5.90	7.25	7.60	8.20	8.10	7.50	7.30	13.00	9.20	9.75	7.00
TMV2NLM	10.70	12.40	13.60	17.50	24.50	21.40	17.00	22.00	18.50	18.50	20.50	17.50
Com.Mut.M13	12.85	11.80	14.40	12.40	22.10	17.80	9.50	17.25	20.50	21.00	16.50	25.50
M13	9.50	11.90	14.80	11.00	14.10	19.80	23.85	17.60	19.60	22.65	19.50	17.00
Gr. Mean	5.44	6.13	7.32	7.13	9.97	9.96	8.90	9.92	11.00	11.36	10.52	10.91
EI	-2.52	-1.83	-0.63	-0.83	2.02	2.00	0.95	1.97	3.05	3.41	2.57	2.96

Varieties	Kharif 1989 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Mean	Env. SD
MH2	0.00	0.30	0.30	0.10	0.10	0.00	0.60	0.83
JL24	0.60	0.40	2.10	2.00	1.25	0.50	1.81	1.55
TAP5	0.00	0.20	0.50	0.70	1.00	0.75	0.87	0.92
Kadiri-3	2.50	3.25	3.00	4.00	2.75	2.50	6.27	2.97
TMV2NLM	14.00	10.25	14.25	17.00	13.00	18.00	16.70	3.97
Com.Mut.M13	9.90	10.60	9.50	7.00	15.50	14.00	14.89	5.06
M13	12.50	8.50	11.00	10.00	10.00	8.50	14.54	4.98
Gr. Mean	5.64	4.79	5.81	5.83	6.23	6.32		
EI	-2.31	-3.17	-2.15	-2.13	-1.73	-1.63		

Number of aerial pegs

Varieties	Kharif 1988 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Rabi 1988-89 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90
MH2	8.90	9.10	5.80	7.65	14.40	9.60	3.90	8.50	7.20	16.10	5.30	8.50
JL24	10.40	13.80	19.30	22.00	27.00	37.50	24.00	9.10	32.00	32.50	24.50	27.50
TAP5	21.40	16.20	25.80	28.60	22.90	44.00	11.00	16.00	13.50	26.00	24.00	29.00
Kadiri-3	13.90	15.10	23.40	17.13	26.10	29.80	5.50	8.00	11.50	6.50	7.00	14.50
TMV2NLM	31.48	14.30	43.40	33.90	32.90	20.80	10.50	10.00	10.50	8.50	8.10	14.00
Com.Mut.M13	33.80	31.80	34.10	39.70	27.10	61.30	21.00	8.00	10.50	15.00	11.00	11.00
M13	24.90	23.70	31.60	29.20	55.40	26.10	14.90	13.00	10.80	13.30	9.95	11.70
Gr. Mean	20.61	17.71	26.20	25.45	29.40	32.73	12.97	10.37	13.71	16.84	12.84	16.60
EI	2.64	-5.53	2.95	2.20	6.15	9.48	-10.28	-12.88	-9.53	-6.40	-10.41	-6.65

Varieties	Kharif 1989 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Mean	Env. SD
MH2	10.00	6.20	15.00	3.00	18.00	17.50	9.70	4.61
JL24	25.00	22.00	44.50	38.00	37.50	37.50	26.89	10.04
TAP5	29.50	28.00	33.00	41.00	41.50	30.50	26.77	9.37
Kadiri-3	14.50	15.00	18.50	16.00	20.00	23.00	15.86	6.84
TMV2NLM	33.50	36.00	32.50	36.00	44.50	30.50	25.08	12.74
Com.Mut.M13	26.50	34.50	31.50	24.50	35.00	34.00	27.21	13.22
M13	39.50	45.00	42.50	42.50	84.50	43.50	31.23	19.38
Gr. Mean	25.50	26.67	31.07	28.71	40.14	30.93		
EI	2.25	3.42	7.82	5.47	16.89	7.68		

Table 13 : Continued.. Number of mature pods

Varieties	Kharif 1988 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Rabi 1988-89 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90
MH2	9.00	10.40	11.50	14.20	10.00	12.00	13.75	16.70	17.15	17.00	17.50	18.00
JL24	24.00	25.50	31.50	31.40	23.75	29.50	29.50	32.25	30.00	43.25	35.00	36.50
TAP5	22.50	23.00	30.50	31.50	32.00	34.50	34.80	36.20	33.25	38.00	34.00	37.00
Kadiri-3	25.50	27.00	36.15	45.70	37.70	39.00	41.50	44.00	44.50	51.50	38.80	43.80
TMV2NLM	19.30	21.65	28.00	31.75	25.90	28.00	43.50	44.50	45.00	57.50	39.85	54.50
Com.Mut.M13	26.60	26.50	31.50	37.50	28.00	33.90	40.65	41.15	43.50	48.50	40.00	41.00
M13	19.50	21.00	23.00	25.75	20.35	31.75	40.00	42.50	46.00	49.90	38.85	49.50
Gr. Mean	20.91	22.15	27.45	31.11	25.39	29.81	34.81	36.76	37.06	43.66	34.86	40.04
EI	-7.32	-6.08	-0.78	2.88	-2.84	1.58	6.58	8.53	8.83	15.43	6.63	11.81

Varieties	Kharif 1989 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Mean	Env. SD
MH2	12.50	14.00	11.50	15.05	13.60	16.00	13.88	2.79
JL24	18.00	22.90	21.65	24.00	21.30	28.00	28.22	6.28
TAP5	16.25	18.00	20.50	26.00	18.50	23.50	28.33	7.26
Kadiri-3	22.30	25.70	22.50	33.50	19.65	28.50	34.85	9.56
TMV2NLM	15.50	18.35	14.30	18.50	14.50	17.00	29.87	14.18
Com.Mut.M13	26.00	27.00	23.50	28.50	25.35	26.50	33.09	7.73
M13	19.00	20.50	19.50	24.50	17.50	19.50	29.37	11.71
Gr. Mean	18.51	20.92	19.06	24.29	18.63	22.71		
EI	-9.72	-7.31	-9.17	-3.94	-9.60	-5.52		

Mature pod weight

Varieties	Kharif 1988 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Rabi 1988-89 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90
MH2	5.00	6.25	6.80	10.05	5.65	7.20	9.10	13.05	13.30	13.65	13.70	14.50
JL24	19.60	20.85	27.95	27.65	19.40	25.20	25.50	28.90	25.60	41.95	31.60	32.50
TAP5	18.45	18.45	26.25	27.55	28.35	31.00	31.20	32.70	29.55	34.40	30.40	33.75
Kadiri-3	21.20	22.65	32.40	44.00	33.90	35.60	40.40	43.20	43.35	46.55	35.35	42.35
TMV2NLM	15.50	17.40	23.60	28.20	21.45	23.50	42.85	43.20	43.75	47.40	37.35	46.85
Com.Mut.M13	22.10	22.30	28.40	33.45	23.35	29.95	37.80	39.75	43.00	45.95	37.45	38.70
M13	15.55	16.90	19.10	21.35	16.50	27.45	37.30	40.20	44.15	44.90	35.60	43.60
Gr. Mean	16.77	17.83	23.50	27.46	21.23	25.70	32.03	34.43	34.67	39.26	31.64	36.04
EI	-7.67	-6.61	-0.94	3.02	-3.21	1.26	7.59	9.99	10.23	14.82	7.19	11.59

Varieties	Kharif 1989 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Mean	Env. SD
MH2	7.85	9.55	7.25	10.80	9.35	12.20	9.74	3.08
JL24	14.65	18.35	17.60	19.80	17.20	23.90	28.35	6.79
TAP5	12.80	14.45	16.40	21.25	14.75	18.85	24.48	7.43
Kadiri-3	17.90	20.95	18.20	29.55	15.85	24.80	31.57	10.42
TMV2NLM	11.20	14.60	9.50	14.60	9.90	13.85	25.82	13.92
Com.Mut.M13	21.30	22.55	19.20	24.10	20.95	22.40	29.59	8.78
M13	15.40	16.55	15.65	20.15	14.30	15.40	25.56	11.78
Gr. Mean	14.44	16.71	14.83	20.04	14.61	18.77		
EI	-10.00	-7.73	-9.61	-4.41	-9.83	-5.67		

Table 13 : Continued..

Number of mature kernels

Varieties	Kharif 1988 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Rabi 1988-89 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90
MH2	22.75	38.85	25.30	23.10	42.40	59.50	31.25	30.50	27.00	31.50	24.50	35.00
JL24	33.00	39.00	60.50	64.00	48.00	56.50	42.00	44.50	48.50	54.50	41.00	51.00
TAP5	38.50	44.50	53.00	61.50	58.00	69.50	44.50	49.00	44.50	68.00	64.00	63.50
Kadiri-3	36.75	37.50	43.00	60.00	72.25	53.75	47.00	64.00	65.50	69.00	70.50	87.00
TMV2NLM	22.65	31.00	34.50	37.00	38.00	38.00	57.50	65.00	59.00	65.50	61.00	62.50
Com.Mut.M13	43.96	35.00	43.25	62.50	64.80	58.00	51.50	64.50	70.00	82.50	69.00	77.50
M13	17.00	23.50	43.30	26.50	28.00	39.50	70.50	77.00	58.00	73.35	42.50	64.50
Gr. Mean	30.66	35.62	43.26	47.80	50.21	53.54	49.18	56.36	53.21	63.48	53.21	63.00
EI	-13.54	-8.58	-0.94	3.60	6.01	9.33	4.98	12.16	9.01	19.28	9.01	18.80

Varieties	Kharif 1989 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Mean	Env. SD
MH2	15.50	25.50	21.00	25.00	26.50	35.00	30.01	9.90
JL24	34.00	40.50	37.00	46.50	41.50	42.50	45.81	8.75
TAP5	34.50	35.00	29.00	40.50	35.00	44.50	48.72	12.68
Kadiri-3	36.00	37.00	39.00	47.00	41.50	44.50	52.85	15.41
TMV2NLM	12.00	19.50	22.50	29.00	24.00	35.00	39.65	17.54
Com.Mut.M13	26.00	27.00	36.50	50.50	32.50	52.00	52.61	17.16
M13	19.00	27.00	18.00	28.00	27.50	32.50	39.76	20.19
Gr. Mean	25.29	30.21	29.00	38.07	32.64	40.86		
EI	-18.91	-13.99	-15.20	-6.13	-11.56	-3.34		

Mature kernel weight

Varieties	Kharif 1988 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Rabi 1988-89 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90
MH2	4.40	5.60	6.40	7.70	5.00	6.40	7.50	9.00	9.10	9.50	9.40	10.00
JL24	13.30	13.80	16.60	16.80	13.10	15.80	16.00	16.90	16.10	22.60	18.00	18.50
TAP5	12.80	13.00	16.10	16.20	16.80	17.60	17.70	18.30	17.20	19.40	17.60	18.80
Kadiri-3	13.80	14.30	18.40	23.70	19.20	20.05	22.00	23.20	23.10	24.90	20.00	23.00
TMV2NLM	11.00	12.40	14.70	16.80	13.90	15.00	22.90	23.10	23.50	25.60	20.80	25.10
Com.Mut.M13	14.20	14.50	16.80	18.90	15.00	17.50	21.00	21.70	23.00	24.50	20.80	21.00
M13	11.10	12.10	12.40	13.90	11.30	16.40	20.50	21.60	23.70	24.60	20.00	24.00
Gr. Mean	11.51	12.24	14.49	16.29	13.47	15.54	18.23	19.11	19.39	21.59	18.09	20.06
EI	-3.37	-2.64	-0.39	1.41	-1.41	0.66	3.35	4.24	4.51	6.71	3.21	5.18

Varieties	Kharif 1989 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Mean	Env. SD
MH2	6.60	7.50	6.50	8.00	7.10	8.50	7.46	1.60
JL24	10.20	12.80	12.30	13.30	12.30	14.80	15.18	2.91
TAP5	8.90	9.90	11.90	13.90	10.00	12.90	14.94	3.33
Kadiri-3	12.70	13.80	12.80	17.30	11.40	15.30	18.28	4.46
TMV2NLM	8.10	9.80	7.30	9.90	7.40	9.40	15.37	6.52
Com.Mut.M13	13.90	14.30	13.30	14.90	13.70	14.20	17.40	3.71
M13	10.90	11.60	11.30	13.60	9.80	10.80	15.53	5.31
Gr. Mean	10.19	11.39	10.77	12.99	10.24	12.27		
EI	-4.69	-3.49	-4.11	-1.89	-4.64	-2.61		

Table 13 : Continued..

Total dry matter at harvest

Varieties	Kharif 1988 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Rabi 1988-89 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90
MH2	21.94	16.15	16.39	20.90	19.95	18.59	12.95	15.45	15.19	16.77	15.05	22.31
JL24	28.40	31.26	44.64	45.67	48.00	52.42	47.56	50.83	45.81	51.89	45.57	69.91
TAP5	37.01	41.23	45.79	53.93	46.28	54.93	29.71	28.87	26.20	51.69	41.91	59.36
Kadiri-3	28.93	35.63	29.17	32.90	46.08	37.89	35.95	35.03	51.10	38.74	40.82	37.43
TMV2NLM	42.97	41.39	45.34	45.17	51.71	55.82	43.90	51.05	47.80	48.59	54.85	54.41
Com.Mut.M13	62.92	54.55	45.44	64.69	80.29	74.03	65.83	55.06	64.71	70.82	71.32	63.19
M13	44.83	60.81	56.19	47.14	41.89	74.61	59.78	63.60	69.89	73.91	73.10	63.99
Gr. Mean	38.14	40.15	40.42	44.34	47.74	52.61	42.24	42.84	45.81	50.34	48.94	52.93
EI	-1.06	0.94	1.22	5.14	8.54	13.41	3.04	3.64	6.61	11.14	9.74	13.73

Varieties	Kharif 1989 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Mean	Env. SD
MH2	18.30	18.08	17.45	23.98	8.96	30.18	18.25	4.64
JL24	18.82	19.00	22.31	22.20	24.63	29.21	38.79	14.57
TAP5	20.03	17.85	21.37	28.83	33.57	36.51	37.49	12.68
Kadiri-3	16.34	19.45	25.57	23.20	28.61	26.35	32.73	8.95
TMV2NLM	22.22	22.86	26.97	25.98	26.19	26.03	40.73	12.14
Com.Mut.M13	27.06	31.92	26.84	38.49	45.37	45.19	54.87	16.47
M13	27.01	26.03	29.68	39.79	36.38	39.07	51.54	16.66
Gr. Mean	21.39	22.17	24.31	28.92	29.10	33.21		
EI	-17.81	-17.03	-14.89	-10.28	-10.10	-5.99		

100 kernel weight

Varieties	Kharif 1988 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Rabi 1988-89 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90
MH2	23.53	28.70	24.70	28.74	20.73	26.50	37.58	39.95	34.02	34.49	35.18	37.09
JL24	30.61	31.15	32.90	35.26	31.12	36.49	43.63	45.33	42.49	46.48	43.31	44.53
TAP5	30.29	36.75	30.99	32.67	27.92	30.42	46.65	51.23	46.92	53.09	50.04	51.06
Kadiri-3	36.88	40.00	32.17	41.40	40.25	40.69	53.65	55.15	54.03	54.30	56.57	59.28
TMV2NLM	37.65	38.40	30.89	34.96	31.17	39.17	49.28	52.41	51.19	54.73	54.86	51.10
Com.Mut.M13	33.74	43.52	33.20	43.91	35.72	42.92	50.75	53.11	45.98	52.92	46.16	51.72
M13	45.44	46.45	43.23	45.38	39.77	53.32	54.91	47.81	72.49	72.92	59.00	68.04
Gr. Mean	34.02	37.85	32.58	37.48	32.38	38.50	48.06	49.28	49.59	52.70	49.30	51.83
EI	-6.06	-2.23	-7.50	-2.61	-7.70	-1.58	7.98	9.20	9.51	12.62	9.22	11.75

Varieties	Kharif 1989 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Mean	Env. SD
MH2	19.91	21.18	23.79	25.07	19.03	20.73	27.83	6.88
JL24	28.18	30.43	30.59	34.73	32.55	36.51	36.46	6.14
TAP5	31.56	36.77	32.11	38.55	27.46	34.33	38.27	8.93
Kadiri-3	34.58	36.35	33.69	37.88	35.06	36.42	43.24	9.31
TMV2NLM	32.76	33.86	30.97	35.12	35.04	37.88	40.64	8.87
Com.Mut.M13	34.16	36.53	37.07	39.53	35.77	42.39	42.17	6.86
M13	47.34	47.36	45.10	48.24	49.00	49.41	51.96	9.87
Gr. Mean	32.64	34.64	33.33	37.02	33.42	36.81		
EI	-7.44	-5.44	-6.75	-3.06	-6.66	-3.27		

Table 13 : Continued..

Oil per cent

Varieties	Kharif 1988 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Rabi 1988-89 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90
MH2	45.50	45.85	47.45	47.80	46.60	48.45	47.25	48.25	48.30	48.20	47.15	47.70
JL24	42.40	44.60	45.45	47.35	45.65	47.70	47.60	46.50	46.65	46.95	46.15	48.05
TAP5	49.15	47.80	49.75	50.25	49.50	50.00	49.50	49.40	47.90	49.20	49.10	49.80
Kadiri-3	45.15	45.80	47.00	45.70	47.05	48.45	47.35	48.95	48.00	48.00	48.25	48.80
TMV2NLM	44.30	43.95	42.80	44.05	44.80	45.85	50.30	50.05	49.55	49.15	49.90	49.55
Com.Mut.M13	45.15	45.35	47.60	43.55	46.55	48.45	50.90	50.95	50.80	50.45	49.60	47.70
M13	43.25	42.50	43.65	43.95	46.10	44.70	48.05	46.65	50.50	49.36	48.85	48.15
Gr. Mean	44.99	45.12	46.24	46.09	46.61	47.66	48.71	48.68	48.81	48.76	48.43	48.54
EI	-1.78	-1.64	-0.52	-0.67	-0.16	0.89	1.94	1.92	2.05	1.99	1.67	1.77

Varieties	Kharif 1989 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Mean	Env. SD
MH2	45.10	45.65	48.15	47.55	45.60	44.70	46.96	1.24
JL24	42.10	43.60	44.45	47.05	45.15	47.70	45.84	1.82
TAP5	50.10	47.80	50.10	49.35	49.65	50.50	49.36	0.78
Kadiri-3	44.60	45.65	46.50	44.50	46.90	47.95	46.92	1.42
TMV2NLM	43.30	38.65	42.60	43.60	44.65	43.00	45.56	3.38
Com.Mut.M13	44.50	44.25	48.10	41.95	46.65	48.25	47.26	2.72
M13	43.70	41.90	42.85	43.40	46.10	44.30	45.44	2.61
Gr. Mean	44.77	43.93	46.11	45.34	46.39	46.56		
EI	-1.99	-2.83	-0.66	-1.42	-0.38	-0.20		

Shelling per cent

Varieties	Kharif 1988 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Rabi 1988-89 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90
MH2	89.67	93.01	81.19	94.33	90.10	93.48	70.18	85.35	70.31	71.89	70.24	70.93
JL24	69.62	73.61	62.10	62.65	64.28	69.86	61.41	65.17	54.90	68.06	58.06	59.40
TAP5	73.76	74.46	65.31	66.85	60.06	66.14	56.35	62.26	59.58	57.96	56.78	59.83
Kadiri-3	64.25	66.47	54.59	60.06	57.29	59.47	55.01	55.17	54.05	54.28	55.40	58.14
TMV2NLM	73.93	77.42	62.24	66.48	66.66	67.08	54.68	55.87	54.48	56.11	54.47	57.38
Com.Mut.M13	69.92	77.45	64.61	67.49	66.10	70.20	63.61	66.41	64.60	68.67	63.38	66.12
M13	75.81	76.27	69.16	69.55	62.81	71.22	54.56	56.00	55.40	55.87	55.99	58.75
Gr. Mean	73.85	76.96	65.60	69.63	66.76	71.06	59.40	63.75	59.04	61.83	59.19	61.51
EI	6.17	9.27	-2.09	1.95	-0.92	3.38	-8.28	-3.93	-8.64	-5.85	-8.50	-6.18

Varieties	Kharif 1989 Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Mean	Env. SD
MH2	80.40	84.96	75.81	87.64	70.41	78.28	81.01	9.05
JL24	71.25	72.18	69.16	72.60	65.69	72.92	66.27	5.62
TAP5	71.25	71.25	67.93	75.36	70.89	72.14	66.00	6.47
Kadiri-3	66.89	71.24	59.24	71.26	62.43	74.10	61.07	6.52
TMV2NLM	69.73	74.18	71.80	80.56	70.64	78.43	66.23	9.01
Com.Mut.M13	64.86	66.69	62.67	70.74	65.36	69.27	67.12	3.55
M13	70.99	72.00	69.14	73.56	70.40	71.84	66.07	7.83
Gr. Mean	70.77	73.21	67.96	75.96	67.96	73.85		
EI	3.08	5.53	0.28	8.28	0.28	6.17		

Table 13 : Continued..   Harvest Index

	Kharif 1988						Rabi 1988-89					
Varieties	Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90
MH2	22.28	31.28	28.10	37.40	20.75	35.89	37.11	37.26	36.86	37.94	31.52	39.13
JL24	33.58	35.73	28.14	36.84	21.88	28.61	25.94	26.24	27.55	30.70	21.34	29.17
TAP5	26.93	34.74	27.25	34.83	28.99	35.54	37.56	39.52	27.82	40.26	24.42	29.67
Kadiri-3	32.71	39.01	39.41	42.31	30.46	34.98	38.19	40.47	31.50	39.38	33.50	38.51
TMV2NLM	24.81	28.24	31.21	36.49	27.77	27.92	37.20	38.80	42.91	45.37	31.81	31.92
Com.Mut.M13	23.52	30.05	36.10	41.67	18.06	34.73	31.39	35.31	36.10	36.70	32.53	35.59
M13	23.81	17.49	18.98	23.64	18.71	21.74	25.58	25.89	25.78	25.90	32.25	27.69
Gr. Mean	26.80	30.93	29.88	36.17	23.80	21.35	23.28	34.78	32.65	36.61	28.20	33.10
EI	-4.57	-0.43	-1.49	4.80	-7.57	-0.02	1.92	3.42	1.28	5.24	-3.17	1.73

	Kharif 1989							
Varieties	Env I N1-30	Env II N2-30	Env III N1-60	Env IV N2-60	Env V N1-90	Env VI N2-90	Mean	Env. SD
MH2	26.90	30.44	25.13	27.39	22.16	44.86	31.80	6.87
JL24	36.46	40.77	36.33	38.01	33.78	34.99	31.45	5.64
TAP5	31.54	36.57	33.37	36.65	24.07	26.69	32.02	5.18
Kadiri-3	41.92	43.89	33.84	43.03	39.11	36.83	37.17	4.52
TMV2NLM	27.17	30.86	22.24	28.73	22.93	27.75	31.34	6.48
Com.Mut.M13	31.40	34.86	28.19	33.99	24.10	24.42	31.59	5.92
M13	29.08	31.30	25.91	28.12	21.62	22.17	24.20	3.74
Gr. Mean	32.07	35.53	29.28	33.70	25.40	31.10		
EI	0.70	4.16	-2.08	2.33	-5.97	-0.26		

Table 14 : Stability parameters for 19 characters in seven varieties over 18 environments (stability analysis).

Varieties	Days to initial flowering			Days to 50% flowering			Days to 100% flowering		
	Mean	bi	S^2d	Mean	bi	S^2d	Mean	bi	S^2d
MH2	33.17	0.993	0.479 **	36.94	1.034 *	-0.160	39.67	0.980	0.209 *
JL24	33.42	0.941 *	0.694 **	37.42	0.957 **	0.275 *	39.64	0.923 **	0.209 *
TAP5	30.11	0.800 **	1.128 **	34.42	0.971	-0.045	37.06	0.971	0.244 **
Kadiri-3	36.61	1.071 *	0.129	42.31	1.005	-0.250	44.89	1.011	0.012
TMV2NLM	37.00	1.075 **	-0.389	42.25	1.009	-0.185	44.64	0.985	-0.125
Compact Mutant of M13	37.53	1.088 **	0.185	42.64	1.032 *	0.026	45.75	1.090 **	-0.019
M13	37.78	1.032	1.651 **	43.36	0.992	-0.085	46.22	1.040 *	0.381 **
Grand mean	35.09			39.90			42.55		

Varieties	Days to peg initiation			Canopy diameter (cm)			Canopy circumference (cm)		
	Mean	bi	S^2d	Mean	bi	S^2d	Mean	bi	S^2d
MH2	40.00	0.874 **	-0.042	30.26	1.038	-0.127	60.45	0.329 **	66.072 **
JL24	41.25	1.038	0.186 *	59.46	0.343 **	11.255 **	159.13	0.574 **	475.291 **
TAP5	38.14	0.973	0.683 **	71.25	0.948	0.196	200.49	1.755 **	89.314 **
Kadiri-3	43.53	0.946 **	0.329 **	69.82	1.691 **	3.052 **	184.73	1.129	82.496 **
TMV2NLM	43.78	1.040	-0.027	72.35	1.060	-0.198	191.68	0.915	6.225 *
Compact Mutant of M13	45.14	1.097 **	0.765 **	69.42	1.183	0.337	180.65	0.977	35.035 **
M13	45.69	1.032	1.037 **	71.48	0.738	-0.141	198.36	1.321 **	153.130 **
Grand mean	42.50			63.43			167.93		

Varieties	Plant height (cm)			Number of primaries			Number of secondaries		
	Mean	bi	S^2d	Mean	bi	S^2d	Mean	bi	S^2d
MH2	7.68	0.379 **	0.930	5.11	0.566	0.138 *	0.60	0.268 **	-0.922
JL24	35.16	1.174	2.906 **	6.02	1.283	0.434 **	1.81	0.456 **	0.137
TAP5	56.42	2.579 **	33.535 **	4.57	0.518	-0.109	0.87	0.212 **	-0.602
Kadiri-3	28.16	0.591 **	3.091 **	5.98	0.851	0.055	6.27	1.104	1.275 **
TMV2NLM	30.58	0.634 *	9.714 **	8.21	0.229	1.849 **	16.70	1.327	5.590 **
Compact Mutant of M13	32.96	0.833	8.991 **	9.17	2.670 **	0.754 **	14.89	1.782 **	8.080 **
M13	28.60	0.810	5.901 **	8.69	0.882	1.286 **	14.54	1.851 **	5.841 **
Grand mean	31.37			6.82			7.95		

Table 14: Continued..

Varieties	Number of aerial pegs			Number of mature pods			Mature pod weight (g)		
	Mean	bi	S^2d	Mean	bi	S^2d	Mean	bi	S^2d
MH2	9.70	0.272 **	-19.941	13.88	0.238 **	0.257	9.74	0.259 **	2.367 **
JL24	26.89	0.688	34.846 **	28.22	0.716 **	2.688 **	24.35	0.720 **	7.607 **
TAP5	26.77	0.905	-4.480	28.33	0.839 *	3.754 **	24.48	0.826 *	5.132 **
Kadiri-3	15.86	0.657	-19.312	34.85	1.122	6.887 **	31.57	1.174 *	9.980 **
TMV2NLM	25.08	1.270	15.850 *	29.87	1.738 **	2.635 **	25.82	1.637 **	3.637 **
Compact Mutant of M13	27.21	1.163	48.443 **	33.09	0.944	-1.690	29.59	1.033	-0.321
M13	31.23	2.046 **	51.530 **	29.37	1.403 **	6.914 **	25.56	1.351 **	8.783 **
Grand mean	23.25			28.23			24.44		

Varieties	Number of mature kernels			Mature kernel weight (g)			Total dry matter at harvest (g)		
	Mean	bi	S^2d	Mean	bi	S^2d	Mean	bi	S^2d
MH2	30.01	0.388 **	73.078 **	7.46	0.302 **	0.774 **	18.25	-0.020 **	14.453 **
JL24	45.81	0.453 **	41.940 **	15.18	0.702 **	1.079 **	38.79	1.298 **	24.523 **
TAP5	48.72	0.901	39.668 **	14.94	0.815 *	1.309 **	37.49	0.983	51.974 **
Kadiri-3	52.85	1.152	43.251 **	18.26	1.130	1.565 **	32.73	0.732	15.483 **
TMV2NLM	39.65	1.360 *	38.473 **	15.37	1.716 **	0.850 **	40.74	1.124	3.905 *
Compact Mutant of M13	52.61	1.354 *	27.288 **	17.40	0.974	-0.087	54.87	1.466 **	34.282 **
M13	39.76	1.392 *	131.411 **	15.53	1.361 **	1.820 **	51.54	1.417 **	57.168 **
Grand mean	44.20			14.88			39.20		

Varieties	100 kernel weight (g)			Oil per cent			Shelling per cent		
	Mean	bi	S^2d	Mean	bi	S^2d	Mean	bi	S^2d
MH2	27.83	0.838	0.634	46.96	0.497 **	-0.729	81.01	1.098	36.119 **
JL24	36.46	0.777 **	-3.578	45.84	0.801	0.057	66.27	0.826	1.654
TAP5	38.27	1.130	0.661	49.36	0.053 **	-1.055	66.00	1.028	-1.397
Kadiri-3	43.24	1.187	-1.093	46.92	0.768	-1.164	61.07	0.939	5.861 **
TMV2NLM	40.64	1.139	-2.628	45.56	1.947 **	0.092	66.23	1.456 **	0.859
Compact Mutant of M13	42.17	0.839	0.194	47.26	1.466	0.331	67.12	0.412 **	0.490
M13	51.96	1.089	24.112 **	45.44	1.469	-0.315	66.07	1.246	0.848
Grand mean	40.08			46.76			67.68		

Table 14: Continued..

Varieties	Harvest Index		
	Mean	bi	S^2d
MH2	31.80	1.290	23.151 **
JL24	31.45	0.514	26.307 **
TAP5	32.02	1.048	9.432 **
Kadiri-3	37.17	0.996	4.044 **
TMV2NLM	31.34	1.189	21.134 **
Compact Mutant of M13	31.59	1.351	7.866 **
M13	24.20	0.613	5.896 **
Grand mean	31.37		

Note : * Significant at 5% level
** Significant at 1% level

M13. None of the genotypes recorded unit regressions and non-significant deviations from regression indicating their instability for this character.

4.3.2 Days to 50 Per cent Flowering

Analysis of variance indicated that variances due to genotypes, environment (linear) and genotype x environment (linear) were significant (Table 12). It indicates that the genotypes differed among themselves in average performance over all environments. In all the genotypes considerable stability was observed with regard to this character when individual variances were tested against pooled error.

Based on environmental index, the differences among the micro-environments were not much in season 1 (Table 13). Except the micro-environment IV (N_2-60) all other micro-environments were found to be favourable for this trait in season 2. In season 3 the best micro-environment was VI (N_2-90) with low environmental index. The variety JL24 appeared to be the stable genotype with environmental standard deviation of 10.36. The maximum deviation of 11.19 was observed in MH2 for this trait. The genotypes TAP5 (34.42), MH2 (36.94) and JL24 (37.42) exhibited low mean values with environmental standard deviations of 10.50, 11.19 and 10.36 respectively. High mean values for days to 50 per cent flowering were recorded in M13 (43.36), Compact Mutant of M13 (42.63), Kadiri-3 (42.31) and TMV2NLM (42.25) with standard deviations of 10.73, 11.17, 10.86 and 10.91 respectively.

Days to 50% flowering recorded a general mean of 39.90 and the mean of individual genotypes ranged from 34.42 (TAP5) to 43.36 (M13) (Table 14). The regression coefficients were in the range of 0.957 to 1.034. The deviations from regression ranged from -0.250 to 0.275. The genotypes viz., TAP5, M13, TMV2NLM and Kadiri-3 were considered to be stable based on their unit regression coefficients and non-significant deviations from regression.

4.3.3 Days to 100 Per cent Flowering

The analysis of variance (Table 12) revealed that the variances due to genotypes, environment (linear) and genotype x environment (linear) were significant. It indicates that the genotypes differed among themselves in average performance for this trait over all the environments. When variances of individual genotypes were tested against pooled error, it was found that all the genotypes except M13 recorded non-significant variances. Most of the genotypes were stable for this character.

The environmental index (Table 13) revealed that except the micro-environment II (N_2-30) all other recorded low and almost same values in season 1. Not much difference was observed in season 2 among the six micro-environments. In season 3, all the micro-environments except the micro-environment 1 (N_1-30) were found to be favourable. The genotype JL24 was found to be stable with least standard deviation of 10.58, whereas maximum variation was observed in Compact Mutant of M13 (12.47). The lowest number of days to 100 per cent flowering was found in TAP5

(37.06) with environmental standard deviation of 11.13. The genotype JL24 (39.64) and MH2 (39.67) showed low mean values with standard deviations of 10.58 and 11.23 respectively. High mean values were recorded in M13 (46.22), Compact Mutant of M13 (47.75), Kadiri-3 (44.89) and TMV2NLM (44.64) with standard deviations of 11.92, 12.47, 11.58 and 11.27 respectively.

The mean number of days to 100 per cent flowering ranged from 37.06 (TAP5) to 46.22 (M13) with a general mean of 42.55 (Table 14). The regression on environmental index was in the range of 0.923 to 1.090. The deviations from regression ranged from -0.125 to 0.381. The genotypes TMV2NLM and Kadiri-3 were found to be stable for the expression of this character as was evidenced by their unit regression coefficients and non-significant deviations from regression.

4.3.4 Days to Peg Initiation

A perusal of the analysis of variance (Table 12) revealed that variances due to genotypes, environment (linear) and genotype x environment (linear) were significant, when tested against pooled deviation. The genotypes MH2, JL24, TMV2NLM and Kadiri-3 were found to be stable for this trait as was evidenced by the non-significance of variances when tested against pooled error.

Based on environmental index (Table 13), the micro environment II (N_2-30) was found to be favourable in season 1. In season 2, the favourable micro-environments were III (N_1-60) followed by V (N_1-90) and Vl (N_2-90). The micro-environment I (N_1-30) followed by V (N_1-90) and VI (N_2-90) were favourable for this trait in season 3. MH2 was found to be stable genotype with an environmental standard deviation of 9.55. Maximum deviation was seen in Compact Mutant of M13 (12.02). TAP5 exhibited lowest mean value (38.14) with an environmental standard deviation of 10.67. The highest mean value was recorded in M13 (45.69) followed by Compact Mutant of M13 (45.14) TMV2NLM (43.78), Kadiri-3 (43.53), JL24 (41.25) and MH2 (40.00) with environmental standard deviations of 11.32, 12.02, 11.36, 10.35, 11.35 and 9.55 respectively.

Days to peg initiation recorded (Table 14) a general mean of 42.50 and the mean of individual genotypes ranged from 38.14 (TAP5) to 45.69 (M13). The regression of days to peg initiation on environmental index was in a range of 0.874 to 1.097. Whereas deviations from regression ranged from -0.042 to 1.037. The only genotype TMV2NLM recorded unit regression coefficient and non-significant deviation from regression and as such can be considered stable for this character.

4.3.5 Canopy Diameter

Analysis of variance (Table 12) indicated that variances due to genotypes, environment (linear) and genotype x environment (linear) were significant when tested against pooled deviation. Considerable stability was observed in most of the genotypes for the expression of this trait over environments as was evidenced by their non-significant variances when tested against pooled error. Except JL24, all the genotypes were found to be stable.

The environmental index revealed that the most favourable micro-environment for the expression of this character was V1 (N_2-90) followed by IV (N_2-60) in season 1. In season 2, the micro-environment IV (N_2-60) was found to be the best. The micro-environment IV (N_2-60) was the best for this trait in season 3. Among the three seasons, best expression of this trait was observed in the micro-environment IV (N_2-60) in season 3 with an environmental index of 2.71. The most stable genotype for canopy diameter was found to be M13 with least environmental standard deviation of 1.73. Maximum deviation was observed in Kadiri-3 (3.89) followed by JL24 (3.47) with mean values of 69.82 cm and 59.46 cm respectively. TMV2NLM exhibited high mean value (72.35 cm) for canopy diameter followed by M13 (71.48 cm), TAP5 (71.25 cm), Kadiri-3 (69.82 cm) and Compact Mutant of M13 (69.42 cm) with standard deviations of 2.28, 1.73, 2.17, 3.89 and 2.61. The genotype MH2 showed the lowest mean value over environments with standard deviation of 2.26. By considering the environmental standard deviations alone it could be observed that the genotypes such as M13, TAP5, MH2, TMV2NLM and Compact Mutant of M13 were stable for this trait.

The mean canopy diameter of individual genotypes ranged from 30.26 cm (MH2) to 72.35 cm (TMV2NLM) with a general mean of 63.43 cm (Table 14). The range of regression coefficients was from 0.343 to 1.691, whereas, the deviations from regression were in a range of -0.198 to 11.255. It was found that the genotypes M13, TAP5, MH2, TMV2NLM and Compact Mutant of M13 exhibited unit regression coefficients and non-significant deviations from regressions indicating their stability for canopy diameter.

4.3.6 Canopy Circumference

From the analysis of variance (Table 12) it was found that the variances due to genotypes, environment (linear) and genotype x environment (linear) were significant. All the genotypes were found to be unstable for this trait because of their significant differences over environments when tested against pooled error.

Based on environmental index (Table 13) it was found that the micro environment VI (N_2-90) was the most favourable in all the three seasons for the best expression of this character. Among the three seasons, the micro-environment VI (N_2-90) of season 1 was found to be the best with a high environmental index (59.03), MH2 was considered to be the stable genotype with the lowest environmental standard deviation of 12.15 and the lowest mean value of 60.45 cm. The genotype TAP5 was found to be the most unstable with an environmental standard deviation of 48.93 and a high mean of 200.49 cm. Followed by TAP5, the genotypes, M13 (198.36 cm), TMV2NLM (191.68 cm), Kadiri-3 (184.73 cm) and Compact Mutant of M13 (180.65 cm) also showed high mean values with standard deviations of 38.16, 25.24, 32.19 and 27.42 respectively.

The stability parameters (Table 14) indicated that the canopy circumference had recorded a general mean of 167.93 cm and the mean of individual genotypes ranged from 60.45 cm (MH2) to 200.49 cm (TAP5). The regression coefficients were in a range of 0.329 to 1.755. Deviations from regression ranged from 6.225 to 475.291. None of the genotypes were found to be stable for this trait as was evidenced by their significant differences from unity and deviations from regression.

4.3.7 Plant Height

The variances due to genotypes, environment (linear) and genotype x environment (linear) were found to be significant as indicated by analysis of variance (Table 12). There was considerable differences among the genotypes in average performance for plant height. Individual variances of genotypes when tested against pooled error indicated that most of the genotypes exhibited significant differences over environments except MH2 indicating its stability for this character.

The environmental index indicated that in season 1, the favourable micro-environments for the expression of this trait were I (N_1-30) and II (N_2-30) (Table 13). In season 2, the micro-environment VI (N_2-90) was found to be the most favourable followed by IV (N_2-60) and II (N_2-30). The micro-environment VI (N_2-90) followed by II (N_2-30) were favourable in season 3. Based on environmental standard deviation, the genotype MH2 was found to be the most stable with a deviation of 2.82 and the mean value of 7.68 cm. TAP5 was the most unstable genotype with maximum deviation of 15.87 and recorded high mean value of 56.42 cm. The mean plant height recorded in JL24 (35.16 cm), Compact Mutant of M13 (32.96 cm), TMV2NLM (30.58 cm) M13 (28.60 cm) and Kadiri-3 (28.16 cm) was slightly lower than that found in TAP5, with environmental standard deviations of 7.09, 5.79, 4.97, 5.42 and 4.09 respectively.

The plant height had recorded a general mean of 31.37 cm and the mean of individual genotypes ranged from 7.68 (MH2) to 56.42 cm (TAP5). The regression coefficients ranged from 0.379 to 2.579, whereas deviations from regression were in the range of 0.930 to 33.535 (Table 14). Most of the values differed significantly from unity (b=1) except the values of Compact Mutant of M13, M13 and JL24. The deviations from regression were significant in all varieties except that in MH2. Based on stability parameters viz., bi and S^2di, none of the genotypes were found to be stable for this trait.

4.3.8 Number of Primaries

A perusal of analysis of variance (Table 12) revealed that the variances due to genotypes, environment (linear) and genotype x environment (linear) were significant. It indicates that the genotypes differed among themselves in average performance over all environments. When tested against pooled error, most of the genotypes showed significant variances except TAP5, Kadiri-3 and MH2. These varieties exhibited stability for this trait.

Based on environmental index, the micro-environment IV (N_2-60) was found to be the best for this trait in both season 1 and 3. The expression of this trait was best in the micro-environment VI (N_2-90) in season 2. The mean number of primares were less in TAP5 (4.57), MH2 (5.11) and Kadiri-3 (5.98) which also recorded low environmental standard deviations of 0.50, 0.71 and 0.73 respectively indicating their stability for this character. The Compact Mutant of M13 was found to be the most unstable genotype with a standard deviation of 1.74 and exhibited a high mean value of 9.17. The genotypes M13 (8.69), TMV2NLM (8.21) and JL24 (6.02) recorded slightly low mean number of primaries than that observed in Compact Mutant of M13 with environmental standard deviations of 1.31, 1.43 and 1.07 respectively

The general mean number of primaries was 6.82 and the mean of individual genotypes ranged from 4.57 (TAP5) to 9.17 (Compact Mutant of M13) (Table 14). The regression coefficients on environmental index were in the range of 0.229 to 2.670. The range of deviations from regression was between -0.109 and 1.849. There was no significant deviation from unity in most of the genotypes except Compact Mutant of M13. Non-significant deviations from regression were observed only in TAP5 and Kadiri-3. The genotypes TAP5 and Kadiri-3 were considered as stable for the expression of this trait because of thier unit regression coefficients and non-significant deviations from regression.

4.3.9 Number of Secondaries

The analysis of variance (Table 12) revealed that the variances due to genotypes, environment (linear) and genotype x environment (linear) were significant when tested against pooled deviation. It indicates that the number of secondaries varied significantly in different environments as well as the genotypes differed among themselves in average performance over all environments. The individual genotype variances, when tested against pooled error, the genotypes MH2, TAP5 and JL24 exhibited non-significant variances indicating their stability for this trait.

The micro-environments V (N_1-90) and VI (N_2-90) were found to be favourable in the seasons 1 and 3 based on environmental index (Table 13). In season 2, the most favourable micro-environment was IV (N_2-60) followed by III (N_1-60) for the expression of this trait. The genotypes MH2, TAP5 and JL24 were considered to be stable for this trait with environmental standard deviations of 0.83, 0.92 and 1.55 respectively and recorded low mean values of 0.60, 0.87 and 1.81 respectively. Maximum variation was observed in Compact Mutant of M13 with an environmental standard deviation of 5.06. The number of secondaries were more in TMV2NLM (16.70) followed by Compact Mutant of M13 (14.89), M13 (14.54) and Kadiri-3 (6.27) with environmental standard deviations of 3.97, 5.06, 4.98 and 2.97 respectively.

A range of 0.60 (MH2) to 16.70 (TMV2NLM) for mean of individual genotypes and a general mean of 7.95 were recorded for number of secondaries (Table 14). The regression on environmental index ranged from 0.212 to 1.851, whereas deviations from regression were in the range of -0.922 to 8.080. Only two genotypes such as TMV2NLM and Kadiri-3 exhibited unit regression coefficients. While the genotypes TAP5, MH2 and JL24 recorded non-significant deviations from regression. It was observed that the combination of these two parameters was not found, indicating the instability of genotypes for the expression of this trait.

4.3.10 Number of Aerial Pegs

Analysis of variance (Table 12) indicated that the variances due to genotypes, environment (linear) and genotype x environment (linear) were significant when tested against pooled deviation. Considerable differences were observed among the genotypes in average performance over all environments. Most of the genotypes recorded non-significant variances when tested against pooled error indicating their stability for this trait.

The environmental index revealed that in season 1, the best micro-environment for the expression of this character was VI (N_2-90) (Table 13). Whereas in season 2, the micro-environments IV (N_2-60) followed by VI (N_2-90) were found to be favourable. In season 3, the micro-environment V (N_1-90) was the best for this trait. The most stable genotype in respect of this trait was MH2 with an environmental standard deviation of 4.61 and a mean value of 9.70. The genotype M13 exhibited maximum deviation of 19.38 and recorded the highest mean of 31.23. The genotypes Compact Mutant of M13 (27.21), JL24 (26.89). TAP5 (26.77) and TMV2NLM (25.08) showed the mean values which were nearer to the highest mean value of M13 with environmental standard deviations of 13.22, 10.04, 9.37 and 12.74 respectively. While, Kadiri-3 recorded the mean value of 15.86 with environmental standard deviation of 6.84.

Number of aerial pegs recorded a general mean of 23.25 and the mean of individual genotypes was in a range of 9.70 (MH2) to 31.23 (M13). The range of regression coefficients was between 0.272 to 2.046 (Table 14). Deviations from regression were in a range of -19.941 to 48.443. The genotypes TAP5 and Kadiri-3 were observed to be stable for the expression of this trait as was evidenced by their unit regression coefficients and non-significant deviations from regression.

4.3.11 Number of Mature Pods

From the analysis of variance (Table 12), it was observed that the variances due to genotypes, environment (linear) and genotype x environment (linear) were significant when tested against pooled deviation. It indicates that the average performance of genotypes significantly differed among themselves over all environments. Non significant variances were recorded in Compact Mutant of M13, MH2, TMV2NLM and JL24 when individual variances were tested against pooled error indicating their stability for this character.

Based on environmental index it was found that the most favourable micro-environment for the expression of this trait was IV (N_2-60) in all the three seasons. Among the three seasons the best micro-environment was IV (N_2-60) of season 2 with high environmental index (15.43) (Table 13). MH2 recorded less number of mature pods with the least environmental standard deviation and considered as stable genotype for this trait. The environmental standard deviation was the highest in TMV2NLM (14.18) and considered as the most unstable genotype. Maximum number of mature pods were recorded in Kadiri-3 (34.85) followed by Compact Mutant of M13 (33.09), TMV2NLM (29.87), M13 (29.37), TAP5 (28.33) and JL24 (28.22) with environmental standard deviations of 9.56, 7.73, 14.18, 11.71, 7.26 and 6.28 respectively.

A general mean of 28.23 was recorded for number of mature pods and the mean of individual genotypes ranged from 13.88 (MH2) to 34.85 (Kadiri-3) (Table 14). A range of 0.238 to 1.738 was observed for regression coefficients on environmental index. Deviations from regression were in a range of -1.690 to 6.914. Unit regression coefficients (bi = 1) were found in only Compact Mutant of M13 and Kadiri-3 while, non-significant deviations from regression were seen in Compact Mutant of M13 and MH2. The genotype Compact Mutant of M13 was found to be the stable genotype as evidenced by its unit regression coefficient and non-significant deviation from regression.

4.3.12 Mature Pod Weight

A perusal of analysis of variance (Table 12) indicated

4.3.12 Mature Pod Weight

A perusal of analysis of variance (Table 12) indicated that the variances due to genotypes, environment (linear) and genotype x environment (linear) were significant, indicating that the genotypes differed significantly among themselves in average performance over all environments. When individual variances of genotypes tested against pooled error it was found that most of the genotypes exhibited significant variances except Compact Mutant of M13 indicating its stability for mature pod weight.

In all the three seasons, the micro-environment IV (N_2-60) was found to be the most favourable based on environmental index (Table 13) for the expression of this character. Among the three seasons, the micro environment IV (N_2-60) of season 2 was the most favourable with high environmental index (14.82). Based on environmental standard deviation, the genotype MH2 was considered as stable genotype with the least standard deviation of 3.08 and a low mean of 9.74g. TMV2NLM was found to be an unstable genotype with maximum deviation of 13.92. The highest mature pod weight was observed in Kadiri-3 (31.57) followed by Compact Mutant of M13 (29.59 g), JL24 (28.35 g), TMV2NLM (25.82 g), M13 (25.56 g) and TAP5 (24.48 g) with environmental standard deviations of 10.42, 8.78, 6.79, 13.92 and 7.43 respectively.

The mature pod weight recorded a general mean of 24.44g and the mean of individual genotypes ranged from 9.74 g (MH2) to

31.57 g (Kadiri-3) (Table 14). Regression of mature pod weight on environmental index was in the range of 0.259 to 1.637. The range of deviations from regression was between -0.321 to 9.980. Except Compact Mutant of M13 all other genotypes exhibited significant deviations from unity and deviations from regression. The genotype Compact Mutant of M13 was regarded as stable for this trait because of its unit regression coefficient and non-significant deviation from regression.

4.3.13 Number of Mature Kernels

The variances due to genotypes, environment (linear) and genotype x environment (linear) were found to be significant from analysis of variance (Table 12), when tested against pooled deviation. It indicates that the average performance of genotypes differed significantly among themselves over the environments. None of the genotypes were found to be stable for this trait as was evidenced by their significant variances.

From the environmental index (Table 13) it was observed that the most favourable micro-environment for the expression of this trait was VI (N_2-90) in season 1. The micro-environment IV (N_2-60) followed by VI (N_2-90) were found to be favourable in season 2. In season 3, the best micro-environment was VI (N_2-90) for this trait. Among the three seasons, the micro-environment IV (N_2-60) of season 2 recorded high environmental index (19.28). Low environmental standard deviation was observed in JL24 (8.75) followed by MH2 (9.90) indicating their stability for this trait.

M13 was found to be the most unstable genotype with standard deviation of 20.19. High mean number of mature kernels was recorded in Kadiri-3 (52.85) followed by Compact Mutant of M13 (52.61), TAP5 (48.72) and JL24 (45.81) with environmental standard deviations of 15.41, 17.16, 12.68 and 8.75 respectively. Whereas, low mean values were recorded in MH2 (30.01), TMV2NLM (39.65) and M13 (39.76) with standard deviations of 9.90, 17.54 and 20.19 respectively.

Among the individual genotypes, the mean number of mature kernels ranged from 30.01 (MH_2) to 52.85 (Karidi-3) and the general mean was 44.20 (Table 14). The regression coefficients on environmental index were in a range of 0.388 to 1.392. Deviations from regression ranged from 27.288 to 131.411. The genotypes TAP5 and Kadiri-3 recorded unit regression coefficients, while all the genotypes exhibited significant deviations from regression. It indicates that none of the genotypes were stable for number of mature kernels.

4.3.14 Mature Kernel Weight

Analysis of variance (Table 12) revealed that the variances due to genotypes, environment (linear) and genotype x environment (linear) were significant. The average performance of genotypes for mature kernel weight differed significantly among themselves over the environments. All the genotypes exhibited significant differences over environments when individual variances were tested against pooled error, except the genotype Compact Mutant of M13 indicating its stability for this trait.

The environmental Index (Table-13) revealed that the most favourable micro-environment for the expression of this trait was IV (N_2-60) followed by the micro-environment VI (N_2-90) in all the three seasons. The micro-environment IV (N_2-60) of season 2 was found to be the best among the three seasons for this trait. The genotype MH2 was found to be the most stable with the least environmental standard deviation of 1.60 and the lowest mean of 7.46 g. Maximum deviation was observed in TMV2NLM (6.52). Kadiri-3 exhibited the highest mean value (18.28g) followed by Compact Mutant of M13 (17.40g), M13 (15.53g), TMV2NLM (15.37g), JL24 (15.18 g) and TAP5 (14.94 g) with environmental standard deviations of 4.46, 3.71, 5.31, 6.52, 2.91 and 3.33 respectively.

Based on stability parameters, the mean mature kernel weight ranged from 7.46 g (MH2) to 18.26 g (Kadiri-3) with a general mean of 14.88 g (Table 14). A range of 0.302 to 1.716 was found for regression coefficients on environmental index. Deviations from regression ranged from -0.087 to 1.820. Out of all genotypes only two genotypes viz., Compact Mutant of M13 and Kadiri-3 recorded unit regression coefficients. Deviations from regression were significant in all genotypes except in Compact Mutant of M13. Stability for kernel yield was observed in Compact Mutant of M13 as was evidenced by its unit regression coefficient and non-significant deviation from regression.

4.3.15 Total Dry Matter at Harvest

The analysis of variance (Table 12) indicated that the variances due to genotypes, environment (linear) and genotype x environment (linear) were significant. Significant differences were observed among the genotypes for total dry matter at harvest over the environments. The variances of most of the genotypes were found to be significant, when individual variances were tested against pooled error, except that of TMV2NLM. This genotype was stable for this trait.

It was found from the environmental index (Table 13), that the most favourable micro-environment for the expression of this trait was VI (N_2-90) in all the three seasons. The environmental standard deviation (4.64) and the mean dry matter at harvest (18.25 g) were the least in MH2 which was found to be stable. Maximum deviation was recorded in M13 (16.66) followed by Compact Mutant of M13 (16.47) which exhibited high mean total dry matter of 51.54 g and 54.87 g respectively at harvest. The genotypes viz., TMV2NLM (40.73 g), JL24 (38.79g), TAP5 (37.49 g) and Kadiri-3 (32.73 g) recorded considerable mean dry matter with environmental standard deviations of 12.14, 14.57, 12.68 and 8.95 respectively.

The total dry matter at harvest recorded a general mean of 39.20g and the individual genotype means ranged from 18.25g (MH2) to 54.87 g (Compact Mutant of M13). Regression coefficients ranged from -0.020 to 1.466, whereas deviations from regression were in a range of 3.905 to 57.168 (Table 14). The genotypes TAP5, Kadiri-3 and TMV2NLM recorded unit regression coefficients, but none of the genotypes exhibited non-significant deviation from regression. This indicates that stable genotypes were not observed for this trait.

4.3.16 100 Kernel Weight

A perusal of analysis of variance (Table 12) indicated that the variances due to genotypes, environment (linear) and genotype x environment (linear) were significant when tested against pooled deviation. It indicates that there were significant differences among genotypes for 100 kernel weight over the environments. The testing of individual variances against pooled error indicated that most of the genotypes exhibited non-significant variances indicating their stability for this trait.

Based on environmental index (Table 13), the micro-environments II (N_2-30) and IV (N_2-60) were found to be favourable in season 1. In both the seasons 2 and 3, the most favourable micro-environment for the expression of this trait was IV (N_2-60) followed by VI (N_2-90). Among the three seasons, the micro-environment IV (N_2-60) of season 2 recorded high environmental index (12.62). The genotype JL-24 was found to be stable for this trait with an environmental standard deviation of 6.14 followed by MH2 (6.88). The genotypes M13 (9.87) and Kadiri-3 (9.31) showed maximum environmental standard deviations and recorded high mean 100 kernel weights of 51.96 g and 43.24g respectively. The lowest mean value was found in MH2 (27.83 g). The mean values observed in Compact Mutant of M13 (42.17g), TMV2NLM (40.64g), TAP5 (38.27g) and JL24 (36.46g) were slightly lower than the high values recorded in M13 and Kadiri-3 with standard deviations of 6.86, 8.87, 8.93 and 6.14 respectively.

The mean 100 kernel weight of individual genotypes ranged from 27.83 g (MH2) to 51.96 g (M13) with a general mean of 40.08g (Table 14). Regression coefficients on environmental index ranged from 0.838 to 1.187. The range of deviations from regression was between -3.578 to 24.112. Most of the genotypes viz., Compact Mutant of M13, TAP5, TMV2NLM, Kadiri-3, MH2 exhibited unit regression coefficients and non-significant deviations from regression indicating their stability for 100 kernel weight.

4.3.17 Oil%

The variances due to genotypes, environment (linear) and genotype x environment (linear) were found to be significant when tested against pooled deviation (Table 12). Among the genotypes there were significant differences in average performance for oil per cent over the environments. When individual variances of genotypes were tested against pooled error, all the genotypes recorded non-significant variances over environments for this trait. It indicates that all the genotypes were stable for this trait.

Based on environmental Index, the micro-environment VI (N_2-90) was found to be favourable in season 1. In season 2 not much difference was observed among the six micro-environments. The micro-environments VI (N_2-90) followed by V (N_1-90) and III (N_1-60) were found to be favourable in season 3 (Table 13). The genotype TAP5 appeared to be the most stable genotype with low environmental standard deviation (0.78) and high mean oil per cent of (49.36%). TMV2NLM was considered to be unstable with high environmental standard deviation of 3.38 and mean of 45.56%. The rest of the genotypes viz., Compact Mutant of M13, MH2, Kadiri-3, JL24 and M13 recorded the mean oil per cent of 47.26%, 46.26%, 46.96%, 46.92%, 45.84% and 45.44% respectively and environmental standard deviations of 2.72, 1.24, 1.42, 1.82 annd 2.61 respectively.

The oil per cent recorded a general mean of 46.76 per cent and the mean of individual genotypes ranged from 45.44 per cent (M13) to 49.36 per cent (TAP5). The regression values on environmental index ranged from 0.053 to 1.947, while the range of deviations from regression was between -1.164 to 0.331 (Table 14). The genotypes such as Compact Mutant of M-13, JL24, Kadiri-3 and M13 exhibited unit regression coefficients and non-significant deviations from regression indicating their stability for this trait.

4.3.18 Shelling Per cent

It was observed from the analysis of variance that the variances due to genotypes, environment (linear) and genotype x environment (linear) were significant when tested against pooled deviation (Table 12). Most of the genotypes exhibited non-significant variances when tested against pooled error and were found to be stable for oil per cent.

The environmental index revealed that in seasons 1 and 2, the micro-environment II (N_2-30) was the best for the expression of this trait. In season 3, the micro-environment IV (N_2-60) was found to be the most favourable (Table 13). Based on environmental standard deviation it was found that Compact Mutant of M13 as stable genotype with low standard deviation of 3.55. Maximum deviations of 9.05 and 9.01 were observed in MH2 and TMV2NLM respectively indicating their instability for this trait. MH2 recorded the highest mean shelling per cent of 81.01 per cent. The mean values found in other genotypes viz., Compact Mutant of M13 (67.12%), JL24 (66.27%), TMV2NLM (66.23%), M13 (66.07%) and TAP5 (66.00%) were at par with the environmental standard deviations of 3.55, 5.62, 9.01, 7.83 and 6.47 respectively. While, Kadiri-3 recorded low mean of 61.07 per cent with standard deviation of 6.52.

The general mean of 67.68 per cent was recorded by shelling per cent. The mean of individual genotypes ranged between 61.07 per cent (Kadiri-3) to 81.07 per cent (MH2). The ranges of regression coefficients and deviations from regression were from 0.412 to 1.456 and -1.397 to 36.119 respectively. By considering the unit regression coefficients and non-significant deviations from regression, the genotypes viz., TAP5, JL24 and M13 were found to be stable for shelling per cent.

4.3.19 Harvest Index

The perusal of analysis of variance (Table 12) revealed that the variances due to genotypes and environment (linear) were significant when tested against pooled deviation. Individual variances of genotypes when tested against pooled error indicated that all the genotypes exhibited significant differences over environments indicating their unstability for harvest index.

The micro-environment IV (N_2-60) was found to be favourable in season 1 and 2 based on environmental index for the expression of this trait. Whereas in season 3, the micro environment II (N_2-30) was found to be the most favourable. With regard to this trait, M13 followed by Kadiri-3 were found to be stable with low environmental standard deviations of 3.74 and 4.52 respectively. The genotypes MH2 and TMV2NLM were considered as unstable with high standard deviations of 6.87 and 6.48 respectively. High harvest index was recorded by Kadiri-3 (37.17). M13 showed the lowest value of harvest index (24.20). The mean harvest index values recorded by TAP5 (32.02), MH2 (31.80), Compact Mutant of M13 (31.59), JL24 (31.45) and TMV2NLM (31.34) were at par and the standard deviations observed in these varieties were 6.87, 5.64, 6.48, 5.92 and 5.18 respectively.

The mean of individual genotypes ranged from 24.20 (M13) to 37.17 (Kadiri-3). The general mean for harvest index was 31.37 (Table 14). A range of 0.514 to 1.351 was observed for regression coefficients, whereas deviations from regression ranged from 4.044 to 26.307. All the genotypes exhibited unit regressions but the deviations from regression were significant. None of the genotypes were found to be stable for harvest index.

4.4 MEAN PERFORMANCE OF PARENTS AND F_1 CROSSES AND HETEROSIS OF F1 CROSSES FOR CANOPY AND REPRODUCTIVE CHARACTERS

The results of analysis of variance for the parents, crosses and parents vs crosses in F_1 generation are presented in Table 15. The data with regard to the mean performance of parents and F_1 crosses for 17 characters studied are presented in Table 16 and 17 respectively. The heterosis exhibited by F_1 crosses over the better parent for important canopy and reproductive attributes are presented in Table 18.

The analysis of variance revealed highly significant differences among parents and hybrids for all the 17 characters studied viz., days to initial flowering, days to 50% flowering, days to 100% flowering, canopy diameter, canopy circumference, leaf area at 60 days, plant height, number of primaries, number of secondaries, number of aerial pegs, number of mature pods, mature pod weight, number of mature kernels, mature kernel weight, total dry matter at harvest, shelling per cent and harvest index which indicated high degree of genetic differences in the parental material. Significant differences were also observed when parents were compared with F_1 hybrids (parents vs hybrids) for canopy diameter, canopy circumference, leaf area at

Table 15 : Analysis of variance for parents and F_1's in groundnut.

	D.F.	Days to initial flowering	Days to 50% flowering	Days to 100% flowering	Canopy diameter (cm)	Canopy circumference (cm)	Leaf area at 60 days (sq.cm)	Plant height (cm)	Number of primaries	Number of secondaries
Replications	1	3.885 *	0.028	1.805	1.206	18.531 **	1990	6.750	1.250	28.880
Parents vs Crosses	1	1.779	0.018	1.805	1266.661 **	2029.606 **	5608541 **	18.250	12.415 *	54.620 *
Parents	15	11.125 **	30.198 **	15.281 **	208.780 **	1199.348 **	708871 **	141.060 **	15.925 **	102.400 **
Crosses	35	2.713 **	6.341 **	6.532 **	206.162 **	997.825 **	796415 **	66.660 **	4.077 **	56.990 **
Error	51	0.659	1.048	1.567	2.040	2.390	1520	18.120	1.898	10.460

	D.F.	Number of aerial pegs	Number of mature pods	Mature pod weight (g)	Number of mature kernels	Mature kernel weight (g)	Total dry matter at harvest (g)	Shelling per cent	Harvest Index
Replications	1	191.430	30.370	6.184 **	39.750	1.097	61.970	0.180	0.140
Parents vs Crosses	1	42.440	65.180 *	4.369 *	468.780 *	11.035 **	2.030	797.270 **	186.880 **
Parents	15	166.030 *	102.390 **	65.958 **	337.990 **	28.369 **	448.000 **	340.050 **	123.160 **
Crosses	35	213.000 **	121.090 **	98.845 **	304.360 **	48.360 **	172.920 **	213.000 **	129.450 **
Error	51	69.630	13.260	0.777	65.680	0.688	70.270	52.020	13.980

* Significant at 5% level.

** Significant at 1% level.

60 days, number of primaries, number of secondaries, number of mature pods, mature pod weight, number of mature kernels, mature kernel weight, shelling per cent and harvest index.

A perusal of data on heterosis indicated that out of 36 crosses, seven crosses were in first order of superiority which had registered significantly higher degrees of heterosis in desirable direction for more number of character combinations such as TMV2 x 32-2-5 (days to initial flowering, days to 50% flowering, canopy diameter, leaf area at 60 days, mature pod weight, mature kernel weight and harvest index), Kadiri-3 x 32-2-5 (canopy diameter, canopy circumference, leaf area at 60 days, number of mature pods, mature pod weight, mature kernel weight and harvest index), Kadiri-3 x TAP5 (days to initial flowering, canopy diameter, canopy circumference, leaf area at 60 days, number of mature pods, mature pod weight and mature kernel weight), TMV2 x TMV2NLM (days to initial flowering, days to 50% flowering, canopy diameter, canopy circumference, leaf area at 60 days, mature pod weight and mature kernel weight), J11 x TMV2NLM (days to initial flowering, days to 50% flowering, days to 100% flowering, canopy diameter, canopy circumference, leaf area at 60 days and mature pod weight), PGN1 x TAP5 (canopy diameter, canopy circumference, leaf area at 60 days, number of mature pods, mature pod weight and mature kernel weight) and TMV2 x MH2 (canopy diameter, canopy circumference, leaf area at 60 days, number of mature pods, mature pod weight and mature kernel weight). Seven crosses were in second order of superiority showing higher degrees of heterosis for slightly less number of character combinations such as TMV2NLM x 32-2-5 (canopy diameter, canopy circumference, leaf area at 60 days, mature pod weight and mature kernel weight), JL24 x 32-2-5 (days to initial flowering, days to 50% flowering, canopy diameter, canopy circumference and leaf area at 60 days), PGN1 x TMV2NLM (days to initial flowering, canopy diameter, leaf area at 60 days, mature pod weight and mature kernel weight), JL-24 x TMV2NLM (days to initial flowering, days to 50% flowering, days to 100% flowering, canopy diameter and canopy circumference), GNLM x TAP5 (days to initial flowering, canopy diameter, canopy circumference and leaf area at 60 days), M13 x TAP5 (days to initial flowering, days to 50% flowering, canopy diameter and canopy circumference) and PGN1 x MH2 (canopy diameter, canopy circumference, leaf area at 60 days and mature pod weight). In the remaining crosses, three crosses exhibited high degree of heterosis in desirable direction for three characters, eight crosses for two character combinations and five crosses for a single character. Six crosses did not show heterosis for any character.

4.4.1 Days to Initial Flowering

The parents recorded a range of mean values for days to initial flowering between 25.00 days and 35.50 days. The parent TAP5 (25.00 days) followed by MH2 (26.50 days) recorded less number of days, while ICG 2271 (35.50 days) recorded more number of days to initial flowering. For the 36 F_1's the range of means was between 28.50 days and 33.00 days. The least number of days

Table 16: Mean performance of 16 parents (grown along with F_1 hybrids) for 17 characters.

Parents	Canopy Category	Days to initial flowering	Days to 50% flowering	Days to 100% flowering	Canopy diameter (cm)	Canopy circumference (cm)	Leaf area at 60 days (sq cm)	Plant height (cm)	Number of primaries	Number of secondaries
MH2	1	26.500	29.000	33.000	28.750	87.50	879.00	8.500	4.000	0.500
J11	2	29.000	31.000	32.500	47.000	156.00	1502.00	27.500	5.000	0.500
JL24	2	30.000	32.500	33.500	45.750	155.50	1587.00	39.000	4.500	7.000
TMV2	2	29.500	32.500	34.500	49.250	158.50	1393.00	26.500	6.500	0.000
PGN1	2	28.000	31.500	34.500	47.300	153.50	1055.00	25.000	4.000	1.000
PI259747	2	31.000	32.500	33.500	47.750	157.50	1533.00	42.500	4.500	0.500
PI350680	2	30.000	31.000	32.500	45.750	152.50	1635.00	36.000	4.000	0.000
G201	2	32.500	35.500	38.500	46.000	154.50	1846.00	24.500	9.500	14.000
TAP5	3	25.000	28.000	30.500	60.500	171.50	2073.00	37.500	4.500	0.000
MK374	3	33.000	37.500	39.500	57.500	169.50	2052.00	26.000	7.000	11.500
GNLM	3	32.000	35.000	36.500	60.250	170.50	1979.00	27.000	8.000	18.000
TMV2NLM	3	32.000	35.000	36.500	57.300	165.00	2122.00	25.500	8.500	21.500
Kadiri-3	3	31.500	33.500	36.500	58.000	168.00	2335.00	33.000	7.500	8.000
32-2-5	3	32.000	35.500	36.500	54.000	166.00	2303.00	24.500	6.000	12.000
M13	4	31.500	37.500	38.500	62.750	185.50	2661.00	21.000	14.500	8.500
ICG2271	4	35.500	41.000	43.500	65.000	200.00	3163.00	19.500	9.000	12.500
CD at 5%		1.591	2.007	2.454	2.799	3.03	76.42	8.344	2.701	6.339

Parents	Canopy Category	Number of aerial pegs	Number of mature pods	Mature pod weight (g)	Number of mature kernels	Mature kernel weight (g)	Total dry matter at harvest (g)	Shelling per cent	Harvest index
MH2	1	8.500	14.500	8.940	26.000	6.070	17.030	73.690	27.520
J11	2	20.000	22.500	12.040	29.500	5.490	24.070	56.250	17.850
JL24	2	8.500	34.000	24.390	55.500	14.800	32.570	64.240	31.450
TMV2	2	6.000	12.000	10.000	41.500	6.020	25.970	70.300	18.630
PGN1	2	28.000	22.500	14.310	31.000	9.440	18.380	69.710	34.460
PI259747	2	10.000	10.500	9.190	17.000	3.560	45.850	42.830	7.700
PI350680	2	16.000	16.000	12.470	29.000	7.530	32.670	64.610	19.180
G201	2	15.000	32.000	21.990	43.000	14.610	50.060	69.640	22.350
TAP5	3	26.500	21.500	15.220	40.000	10.300	22.610	71.870	30.880
MK374	3	32.500	26.000	22.350	41.500	11.260	33.350	56.320	24.540
GNLM	3	24.000	24.500	23.630	32.500	11.130	43.980	50.110	20.060
TMV2NLM	3	25.000	15.000	10.090	21.000	6.900	49.850	81.980	12.970
Kadiri-3	3	22.500	32.000	20.500	46.000	17.050	56.970	90.610	22.900
32-2-5	3	18.000	20.000	13.320	21.000	6.990	57.890	56.790	11.350
M13	4	36.500	17.500	19.020	29.000	7.720	63.810	45.550	10.650
ICG2271	4	26.500	24.500	23.490	36.500	10.120	47.440	53.590	16.930
CD at 5%		16.354	7.136	1.728	15.884	1.625	16.431	14.137	7.328

Table 17: Mean performance of 36 F_1 hybrids for 17 characters.

Crosses	Canopy combi-nation	Days to initial flower-ing	Days to 50% flower-ing	Days to 100% flower-ing	Canopy dia-meter (cm)	Canopy circum-ference (cm)	Leaf area at 60 days (sq cm)	Plant height (cm)	Number of prima-ries	Number of secon-daries
M13 X MH2	(4 x 1)	31.300	36.250	38.100	64.100	171.70	2650.41	29.150	7.950	11.100
MK374 X MH2	(3 x 1)	33.000	36.300	37.900	53.900	155.30	2050.86	29.900	7.100	14.600
Kadiri-3 X MH2	(3 x 1)	30.200	33.950	36.700	62.600	164.70	2325.91	25.200	7.300	6.050
G201 X MH2	(2 x 1)	32.400	33.900	36.400	37.100	116.00	1835.00	19.900	10.000	13.400
TMV2 X MH2	(2 x 1)	29.200	31.000	34.200	60.800	181.60	2188.00	28.500	5.300	2.000
PGN1 X MH2	(2 x 1)	29.500	31.600	33.500	58.300	176.00	1575.06	33.100	6.000	1.200
JL24 X MH2	(2 x 1)	29.050	32.150	34.500	50.850	150.60	2063.70	28.750	5.250	1.300
TMV2NLM X MH2	(3 x 1)	30.500	34.500	36.000	54.000	170.00	2204.60	29.500	8.900	12.500
GNLM X MH2	(3 x 1)	31.400	34.300	36.400	55.850	173.00	2101.60	28.300	8.300	11.700
M13 X TMV2NLM	(4 x 3)	30.400	36.000	37.800	54.450	166.60	1778.11	22.100	8.400	13.400
MK374 X TMV2NLM	(3 x 3)	30.600	36.200	38.000	64.950	204.80	2090.88	25.300	8.600	14.200
Kadiri-3 X TMV2NLM	(3 x 3)	31.200	36.300	37.900	61.600	148.50	2604.99	23.400	8.300	10.500
G201 X TMV2NLM	(2 x 3)	31.600	35.200	37.800	41.700	134.50	1265.88	23.000	7.100	13.700
TMV2 X TMV2NLM	(2 x 3)	30.000	32.400	34.700	68.200	179.30	3290.60	30.900	7.600	9.200
PGN1 X TMV2NLM	(2 x 3)	29.700	33.300	36.500	64.000	157.10	2571.98	30.700	7.800	11.900
JL24 X TMV2NLM	(2 x 3)	30.000	31.800	33.700	66.100	186.60	1884.35	33.600	6.200	6.400
J11 X TMV2NLM	(2 x 3)	29.600	31.550	33.650	63.450	178.90	3019.43	31.000	6.900	11.050
PI259747 X 32-2-5	(2 x 3)	30.000	32.500	30.500	31.250	114.50	1889.14	21.000	7.000	5.000
TMV2NLM X 32-2-5	(3 x 3)	31.500	36.000	38.100	64.800	174.50	2528.29	20.700	8.900	16.900
GNLM X 32-2-5	(3 x 3)	30.700	33.900	36.900	64.050	166.40	1655.68	23.600	9.650	15.750
JL24 X 32-2-5	(2 x 3)	30.100	32.250	35.350	67.500	171.40	3573.45	36.000	7.000	6.650
TMV2 X 32-2-5	(2 x 3)	28.700	31.400	34.100	62.200	168.90	3823.92	28.600	7.500	6.900
Kadiri-3 X 32-2-5	(3 x 3)	31.100	34.700	37.200	69.500	187.30	3174.75	24.200	7.900	9.600
M13 X TAP5	(4 x 3)	29.700	33.800	36.200	79.200	201.50	1584.93	30.700	8.000	7.800
MK374 X TAP5	(3 x 3)	32.150	35.250	37.000	57.300	165.80	2262.86	23.350	7.350	10.500
Kadiri-3 X TAP5	(3 x 3)	29.400	32.600	34.900	76.500	198.40	2547.49	24.200	6.700	6.900
G201 X TAP5	(2 x 3)	31.850	35.150	36.850	52.000	169.90	1899.26	35.400	7.900	3.400
PGN1 X TAP5	(2 x 3)	29.500	31.300	34.70	65.300	182.40	2395.35	37.600	6.600	1.900
TMV2 X TAP5	(2 x 3)	28.500	31.600	33.500	53.450	168.10	1602.12	41.800	4.700	0.300
JL24 X TAP5	(2 x 3)	28.600	31.200	34.000	64.650	171.70	2193.04	31.100	5.100	1.100
J11 X TAP5	(2 x 3)	29.100	32.400	34.900	46.350	147.40	2417.26	31.600	4.700	0.600
PI350680 X TAP5	(2 x 3)	29.700	32.100	34.800	59.150	177.10	2817.47	44.400	5.600	1.100
ICG2271 X TAP5	(4 x 3)	32.700	36.500	38.500	64.450	178.70	2474.12	21.300	10.000	11.100
GNLM X TAP5	(3 x 3)	30.000	34.700	37.100	76.650	230.70	2345.29	29.700	8.900	11.500
TMV2NLM X TAP5	(3 x 3)	30.700	33.900	36.100	68.500	188.60	3867.23	27.900	9.000	16.500
TMV2NLM X G201	(3 x 2)	30.900	34.900	37.200	57.750	183.50	3104.61	25.100	8.200	18.700
CD at 5%		1.591	2.007	2.454	2.799	3.03	76.42	8.344	2.701	6.339

Table 17 : Continued...

Crosses	Canopy combination	Number of aerial pegs	Number of mature pods	Mature pod weight (g)	Number of mature kernels	Mature kernel weight (g)	Total dry matter at harvest (g)	Shelling per cent	Harvest index
M13 X MH2	(4 x 1)	17.700	19.800	20.490	33.600	8.420	64.940	46.850	11.290
MK374 X MH2	(3 x 1)	14.900	18.500	15.810	28.400	8.070	49.990	56.650	13.710
Kadiri-3 X MH2	(3 x 1)	19.350	19.700	16.530	30.000	8.300	40.350	53.390	16.950
G201 X MH2	(2 x 1)	9.100	17.900	15.940	32.100	7.230	37.800	51.430	15.750
TMV2 X MH2	(2 x 1)	12.600	23.000	17.170	47.600	10.500	27.060	59.830	29.390
PGN1 X MH2	(2 x 1)	42.300	29.100	20.590	36.500	8.760	29.940	50.140	21.770
JL24 X MH2	(2 x 1)	4.300	18.800	14.300	30.250	6.510	23.550	49.960	21.880
TMV2NLM X MH2	(3 x 1)	14.000	16.500	8.950	20.100	6.050	40.200	74.530	12.920
GNLM X MH2	(3 x 1)	13.500	16.800	10.570	24.600	6.400	39.690	67.410	13.850
M13 X TMV2NLM	(4 x 3)	18.400	8.500	6.140	16.600	4.230	47.850	77.070	8.120
MK374 X TMV2NLM	(3 x 3)	30.300	20.600	16.250	31.500	7.750	53.200	55.670	12.520
Kadiri-3 X TMV2NLM	(3 x 3)	14.100	23.400	19.150	40.100	10.640	34.560	58.060	23.290
G201 X TMV2NLM	(2 x 3)	13.300	14.300	9.910	20.400	4.990	35.160	56.550	12.160
TMV2 X TMV2NLM	(2 x 3)	13.700	17.500	13.960	46.000	9.520	39.540	72.290	19.270
PGN1 X TMV2NLM	(2 x 3)	33.700	29.000	24.230	44.200	11.270	41.700	51.430	21.320
JL24 X TMV2NLM	(2 x 3)	15.900	16.500	13.750	22.400	6.830	44.600	52.180	13.220
J11 X TMV2NLM	(2 x 3)	17.250	15.400	14.340	29.800	8.230	50.080	62.770	13.960
PI259747 X 32-2-5	(2 x 3)	0.000	14.000	9.540	11.500	2.790	28.590	30.770	8.800
TMV2NLM X 32-2-5	(3 x 3)	35.000	25.000	17.580	34.200	10.460	47.000	64.110	18.070
GNLM X 32-2-5	(3 x 3)	27.550	20.050	13.130	26.500	6.980	36.510	57.680	16.200
JL24 X 32-2-5	(2 x 3)	7.500	12.400	8.320	16.650	4.770	39.570	62.170	10.610
TMV2 X 32-2-5	(2 x 3)	13.600	23.200	24.350	41.600	12.450	27.330	53.960	30.750
Kadiri-3 X 32-2-5	(3 x 3)	23.600	40.500	35.110	61.700	24.000	42.100	71.440	36.020
M13 X TAP5	(4 x 3)	28.300	13.300	11.610	22.400	7.330	50.900	69.820	13.500
MK374 X TAP5	(3 x 3)	22.000	24.650	21.210	33.600	10.600	36.550	52.840	22.380
Kadiri-3 X TAP5	(3 x 3)	34.700	40.000	33.930	53.600	23.050	44.820	69.890	34.090
G201 X TAP5	(2 x 3)	6.400	6.100	3.800	8.250	1.450	33.220	42.110	4.220
PGN1 X TAP5	(2 x 3)	31.500	36.800	26.670	55.500	19.470	37.490	77.290	33.800
TMV2 X TAP5	(2 x 3)	33.000	23.100	17.610	32.400	9.890	29.090	59.280	24.970
JL24 X TAP5	(2 x 3)	4.300	16.500	15.790	27.800	8.570	25.380	57.290	25.220
J11 X TAP5	(2 x 3)	5.600	14.400	9.410	24.200	4.820	20.690	60.900	18.160
PI350680 X TAP5	(2 x 3)	24.000	12.500	11.460	26.700	5.840	36.510	51.770	13.950
ICG2271 X TAP5	(4 x 3)	36.600	7.700	6.040	10.100	2.130	42.330	42.830	4.760
GNLM X TAP5	(3 x 3)	26.800	16.000	11.370	23.900	5.030	48.280	49.380	9.380
TMV2NLM X TAP5	(3 x 3)	18.200	23.900	16.070	30.700	11.800	42.760	48.340	13.490
TMV2NLM X G201	(3 x 2)	18.200	19.700	17.070	25.700	8.690	42.240	56.630	16.880
CD at 5%		16.354	7.136	1.728	15.884	1.625	16.431	14.137	7.328

Table 18 : Heterosis (over the better parent) recorded for 17 characters in 36 F_1 hybrids of groundnut.

Crosses	Canopy combination	Days to initial flowering	Days to 50% flowering	Days to 100% flowering	Canopy diameter (cm)	Canopy circumference (cm)	Leaf area at 60 days (sq cm)
M13 X MH2	(4 x 1)	-0.635	-3.333	-1.039	2.151	-7.439 **	-0.397
MK374 X MH2	(3 x 1)	0.000	-3.200	-4.051	-6.261 *	-8.378 **	-0.097
Kadiri-3 X MH2	(3 x 1)	-4.127	3.343	0.548	7.931 **	-1.964 *	-0.389
G201 X MH2	(2 x 1)	-0.308	-4.500	-5.455	-19.348 **	-24.919 **	-0.596
TMV2 X MH2	(2 x 1)	-1.017	-4.615	-0.870	23.452 **	14.574 **	57.071 **
PGN1 X MH2	(2 x 1)	5.357	0.317	-2.899	23.256 **	14.658 **	49.295 **
JL24 X MH2	(2 x 1)	-3.167	-1.077	2.985	11.148 **	-3.151 **	30.038 **
TMV2NLM X MH2	(3 x 1)	-4.688	-1.429	-1.370	-5.759 *	3.030 **	3.864 *
GNLM X MH2	(3 x 1)	-1.875	-2.000	-0.274	-7.303 **	1.466	6.195 **
M13 X TMV2NLM	(4 x 3)	-5.000	-4.000	-1.818	-13.227 **	-10.189 **	-33.179 **
MK374 X TMV2NLM	(3 x 3)	-7.273 **	-3.467	-3.797	12.957 **	20.826 **	-1.467
Kadiri-3 X TMV2NLM	(3 x 3)	-2.500	3.714	3.836	6.207 *	-11.607 **	11.563 **
G201 X TMV2NLM	(2 x 3)	-2.769	-0.845	-1.818	-27.225 **	-18.485 **	-40.345 **
TMV2 X TMV2NLM	(2 x 3)	-6.250 *	-7.429 *	-4.932	19.023 **	8.667 **	55.071 **
PGN1 X TMV2NLM	(2 x 3)	-7.187 **	-4.857	0.000	11.693 **	-4.788 **	21.205 **
JL24 X TMV2NLM	(2 x 3)	-6.250 *	-9.143 **	-7.671 *	15.358 **	13.091 **	-11.199 **
J11 X TMV2NLM	(2 x 3)	-7.500 **	-9.857 **	-7.808 *	10.733 **	8.424 **	42.292 **
PI259747 X 32-2-5	(2 x 3)	-6.250 *	-8.451 **	-16.438 **	-42.130 **	-31.024 **	-17.970 **
TMV2NLM X 32-2-5	(3 x 3)	-1.563	1.408	4.384	13.089 **	5.120 **	9.782 **
GNLM X 32-2-5	(3 x 3)	-4.062	-4.507	1.096	6.307 *	-2.405 *	-28.108 **
JL24 X 32-2-5	(2 x 3)	-5.937 *	-9.155 **	-3.151	25.000 **	3.253 **	55.165 **
TMV2 X 32-2-5	(2 x 3)	-10.312 **	-11.549 **	-6.575	15.185 **	1.747	66.041 **
Kadiri-3 X 32-2-5	(3 x 3)	-2.812	-2.254	1.918	19.828 **	11.488 **	35.964 **
M13 X TAP5	(4 x 3)	-5.714 *	-9.867 **	-5.974	26.215 **	8.625 **	-40.439 **
MK374 X TAP5	(3 x 3)	-2.576	-6.000 *	-6.329	-5.289 *	-3.324 **	9.159 **
Kadiri-3 X TAP5	(3 x 3)	-6.667 *	-2.687	-4.384	26.446 **	15.685 **	9.100 **
G201 X TAP5	(2 x 3)	-2.000	-0.986	-4.286	-14.050 **	-0.933	-8.381 **
PGN1 X TAP5	(2 x 3)	5.357	-0.635	0.580	7.934 **	6.356 **	15.550 **
TMV2 X TAP5	(2 x 3)	-3.390	-2.769	-2.899	-11.653 **	-1.983 *	-22.715 **
JL24 X TAP5	(2 x 3)	-4.667	-4.000	1.493	6.860 **	0.117	5.791 **
J11 X TAP5	(2 x 3)	0.345	4.516	7.385	-23.388 **	-14.052 **	16.606 **
PI350680 X TAP5	(2 x 3)	-1.000	3.548	7.077	-2.231	3.265 **	20.663 **
ICG2271 X TAP5	(4 x 3)	-7.887 **	-10.976 **	-11.494 **	-0.846	-10.650 **	-21.779 **
GNLM X TAP5	(3 x 3)	-6.250 *	-8.570	1.644	26.694 **	34.519 **	13.135 **
TMV2NLM X TAP5	(3 x 3)	-4.062	-3.143	-1.096	13.233 **	9.970 **	82.245 **
TMV2NLM X G201	(3 x 2)	-4.923	-1.690	-3.377	0.785	11.212 **	46.306 **

Table 18 : Continued...

Crosses	Canopy combi-nation	Plant height (cm)	Number of prima-ries	Number of secon-daries	Number of aerial pegs	Number of mature pods	Mature pod weight (g)
M13 X MH2	(4 x 1)	38.810	-45.172 **	30.588	-51.507 *	13.143	7.729
MK374 X MH2	(3 x 1)	15.000	1.429	26.957	-54.154 *	-28.846 *	-29.262 **
Kadiri-3 X MH2	(3 x 1)	-23.636	-2.667	-24.375	-14.000	-38.437 **	-19.366 **
G201 X MH2	(2 x 1)	-18.776	5.263	-4.286	-39.333	-44.063 **	-27.513 **
TMV2 X MH2	(2 x 1)	7.547	-18.462	300.000	48.235	58.621 *	71.700 **
PGN1 X MH2	(2 x 1)	32.400	50.000	20.000	51.071	29.333	43.885 **
JL24 X MH2	(2 x 1)	-26.282 *	16.667	-81.429	-49.412	-44.706 **	-41.369 **
TMV2NLM X MH2	(3 x 1)	15.686	4.706	-41.860 **	-44.000	10.000	-11.298
GNLM X MH2	(3 x 1)	4.815	3.750	-35.000	-43.750	-31.429 *	-55.269 **
M13 X TMV2NLM	(4 x 3)	-13.333	-42.069 **	-37.674 **	-49.589 *	-51.429 *	-67.718 **
MK374 X TMV2NLM	(3 x 3)	-2.692	1.176	-33.953 *	-6.790	-20.769	-27.293 **
Kadiri-3 X TMV2NLM	(3 x 3)	-29.091 *	-2.353	-51.163 **	-43.600	-26.875 *	-6.585
G201 X TMV2NLM	(2 x 3)	-9.804	-25.263	-36.279 *	-46.800	-55.313 **	-54.934 **
TMV2 X TMV2NLM	(2 x 3)	16.604	-10.588	-57.209 **	-45.200	16.667	38.355 **
PGN1 X TMV2NLM	(2 x 3)	20.392	-8.235	-44.651 **	19.643	28.889	69.322 **
JL24 X TMV2NLM	(2 x 3)	-13.846	-27.059	-70.233 **	-36.400	-51.471 **	-43.624 **
J11 X TMV2NLM	(2 x 3)	12.727	-18.824	-48.605 **	-31.000	-31.556	19.103 *
PI259747 X 32-2-5	(2 x 3)	-50.588 **	16.667	-58.333 *	-100.000 *	-30.000	-28.378 **
TMV2NLM X 32-2-5	(3 x 3)	-18.824	4.706	-21.395	40.000	25.000	31.982 **
GNLM X 32-2-5	(3 x 3)	-12.593	20.625	-12.500	14.792	-18.163	-44.435 **
JL24 X 32-2-5	(2 x 3)	-7.692	16.667	-44.583	-58.333	-63.529 **	-65.888 **
TMV2 X 32-2-5	(2 x 3)	7.925	15.385	-42.500	-24.444	16.000	82.808 **
Kadiri-3 X 32-2-5	(3 x 3)	-26.667 *	5.333	-20.000	4.889	26.563 *	71.268 **
M13 X TAP5	(4 x 3)	-18.133	-44.828 **	-8.235	-22.466	-38.140 *	-38.959 **
MK374 X TAP5	(3 x 3)	-37.733 **	5.000	-8.696	-32.308	-5.192	-5.101
Kadiri-3 X TAP5	(3 x 3)	-35.467 **	-10.667	-13.750	30.943	25.000 *	65.512 **
G201 X TAP5	(2 x 3)	-5.600	-16.842	-75.714 **	-75.849 *	-80.938 **	-82.719 **
PGN1 X TAP5	(2 x 3)	0.267	46.667	90.000	12.500	63.556 **	75.230 **
TMV2 X TAP5	(2 x 3)	11.467	-27.692	0.000	24.528	7.442	15.703 **
JL24 X TAP5	(2 x 3)	-20.256	13.333	-84.286	-83.774 *	-51.471 **	-35.260 **
J11 X TAP5	(2 x 3)	-15.733	-6.000	20.000	-78.868 *	-36.000 *	-38.173 **
PI350680 X TAP5	(2 x 3)	18.400	24.444	0.000	-9.434	-41.860 *	-24.704 **
ICG2271 X TAP5	(4 x 3)	-43.200 **	11.111	-11.200	38.113	-68.571 **	-74.287 **
GNLM X TAP5	(3 x 3)	-20.800	11.250	-36.111 *	1.132	-34.694 *	-51.883 **
TMV2NLM X TAP5	(3 x 3)	-25.600 *	5.882	-23.256	-31.321	11.163	5.585
TMV2NLM X G201	(3 x 2)	-1.569	-13.684	-13.023	-27.200	-38.437 *	-22.374 **

Table 18 : Continued...

Crosses	Canopy combi-nation	Number of mature kernels	Mature kernel weight (g)	Total dry matter at harvest (g)	Shelling per cent	Harvest index
M13 X MH2	(4 x 1)	15.862	9.067	1.771	-36.423 **	-58.975 **
MK374 X MH2	(3 x 1)	-31.566	-28.330 **	49.985	-23.124 *	-50.182 **
Kadiri-3 X MH2	(3 x 1)	-34.783	-51.320 **	-29.173	-41.077 **	-38.408 **
G201 X MH2	(2 x 1)	-25.349	-50.513 **	-24.491	-30.208 **	-42.769 **
TMV2 X MH2	(2 x 1)	14.699	74.419 **	4.197	-18.809	6.795
PGN1 X MH2	(2 x 1)	17.742	-7.203	62.894	-31.958 **	-36.825 **
JL24 X MH2	(2 x 1)	-45.495 **	-56.014 **	-27.694	-32.202 **	-30.429 *
TMV2NLM X MH2	(3 x 1)	-22.692	-12.319	-19.358	-9.088	-53.052 **
GNLM X MH2	(3 x 1)	-24.308	-42.498 **	-9.754	-8.522	-49.673 **
M13 X TMV2NLM	(4 x 3)	-42.759	-45.207 **	-25.012	-5.989	-37.394
MK374 X TMV2NLM	(3 x 3)	-24.096	-31.172 **	6.720	-32.093 **	-48.981 **
Kadiri-3 X TMV2NLM	(3 x 3)	-12.826	-37.595 **	-39.336 *	-35.923 **	1.703
G201 X TMV2NLM	(2 x 3)	-52.558 **	-65.845 **	-29.764	-31.020 **	-45.593 **
TMV2 X TMV2NLM	(2 x 3)	10.843	37.971 **	-20.682	-11.820	3.435
PGN1 X TMV2NLM	(2 x 3)	42.581	19.386 *	-16.349	-37.265 **	-38.131 **
JL24 X TMV2NLM	(2 x 3)	-59.640 **	-53.851 **	-10.532	-36.350 **	-57.965 **
J11 X TMV2NLM	(2 x 3)	1.017	19.275	0.461	-23.433 *	21.793
PI259747 X 32-2-5	(2 x 3)	-45.238	-60.086 **	-50.613 **	-45.818 **	-22.467
TMV2NLM X 32-2-5	(3 x 3)	62.857	49.642 **	-18.812	-21.798 *	39.322
GNLM X 32-2-5	(3 x 3)	-18.462	-37.287 **	-36.932 *	1.567	-19.242
JL24 X 32-2-5	(2 x 3)	-70.000 **	-67.770 **	-31.646 *	-3.222	-66.264 **
TMV2 X 32-2-5	(2 x 3)	0.241	78.112 **	-52.790 **	-23.243 *	65.056 **
Kadiri-3 X 32-2-5	(3 x 3)	34.130	40.762 **	-27.276	-21.157	57.293 **
M13 X TAP5	(4 x 3)	-44.000 *	-28.835 **	-20.232	-2.852	-56.282 **
MK374 X TAP5	(3 x 3)	-19.036	-5.861	9.595	-26.478 *	-27.526 *
Kadiri-3 X TAP5	(3 x 3)	16.522	35.191 **	-21.327	-22.867 **	10.395
G201 X TAP5	(2 x 3)	-80.698 **	-90.075 **	-33.640 *	-41.408 **	-86.334 **
PGN1 X TAP5	(2 x 3)	38.750	89.029 **	65.812	7.541	-1.915
TMV2 X TAP5	(2 x 3)	-21.928	-3.981	12.014	-17.518	-19.139
JL24 X TAP5	(2 x 3)	-49.910 **	-42.095 **	-22.076	-20.287 *	-19.809
J11 X TAP5	(2 x 3)	-39.500	-53.204 **	-14.042	-15.264	-41.192 **
PI350680 X TAP5	(2 x 3)	-33.250	-43.301 **	11.754	-27.967 **	-54.825 **
ICG2271 X TAP5	(4 x 3)	-74.750 **	-79.320 **	-10.771	-40.406 **	-84.585 **
GNLM X TAP5	(3 x 3)	-40.250	-54.807 **	9.777	-31.293 **	-69.624 **
TMV2NLM X TAP5	(3 x 3)	-23.250	14.563	-14.223	-41.034 **	-56.315 **
TMV2NLM X G201	(3 x 2)	-40.235 *	-40.520 **	-15.621	-30.922 **	-24.474

* Significant at 5% level
** Significant at 1% level

was taken by TMV2 x TAP5 (28.50 days) followed by JL24 x TAP5 (28.60 days) and TMV2 x 32-2-5 (28.70 days) in which TAP5 was involved in two crosses. The cross MK374 x MH2 showed the highest mean value (33.00 days) followed by ICG 2271 x TAP5 (32.70 days), G201 x MH2 (32.40 days) and MK374 x TAP5 (32.15 days).

The heterosis for this trait ranged from - 10.312% to 5.357%. Among the 36 F_1's significant negative heterosis was observed in twelve crosses. Highly significant negative heterosis was recorded by five crosses viz., TMV2 x 32-2-5 (-10.312%), ICG 2271 x TAP5 (-7.887%), J11 x TMV2NLM (-7.500%), MK374 x TMV2NLM (-7.273%) and PGN 1 x TMV2NLM (-7.187%). None of the crosses exhibited significant positive heterosis. Two crosses viz., PGN1 x MH2 (5.357%) and PGN1 x TAP5 (5.357%) recorded high positive heterosis.

4.4.2 Days to 50% Flowering

The range of mean values for days to 50 per cent flowering was between 28.00 days and 41.00 days in the parents. The least number of days was observed in TAP5 (28.00 days) followed by MH2 (29.00 days). The parents viz., ICG 2271 (41.00 days), Mi3 (37.50 days) and MK374 (37.50 days) recorded high mean values. The crosses showed a range of 31.00 days to 36.50 days. Low mean values were recorded in TMV2 x MH2 (31.00 days), JL24 x TAP5 (31.20 days), PGN1 x TAP5 (31.30 days), TMV2 x 32-2-5 (31.40 days), J11 x TMV2NLM (31.55 days), PGN1 x MH2 (31.60 days) and TMV2 x TAP5 (31.60 days), of which TAP5 was involved in three crosses. The highest mean value was found in ICG 2271 x TAP5 (36.50 days).

The range of heterosis for days to 50 per cent flowering was from -11.549% to 4.516%. Nine crosses exhibited significant negative heterosis, of which two crosses viz., ICG 2271 x TAP5 (-10.976%) and TMV2 x 32-2-5 (-11.549%) recorded highly significant negative heterosis. Significant positive heterosis was not observed among the 36 crosses. High positive heterosis was found in J11 x TAP 5 (4.516%), Kadiri-3 x TMV2NLM (3.714%) and PI350680 x TAP5 (3.548%).

4.4.3 Days to 100% Flowering

Among the parents the mean values ranged from 30.50 days to 43.50 days for this trait. TAP5 (30.50 days) recorded the lowest mean value, while the highest mean value was found in ICG 2271 (43.50 days) followed by MK374 (39.50 days), M13 (38.50 days) and G201 (38.50 days). The mean days to 100 per cent flowering ranged from 30.50 days to 38.50 days in crosses. The cross, PI 259747 x 32-2-5 (30.50 days) showed the lowest mean value. High mean values were recorded in ICG 2271 x TAP5 (38.50 days), M13 x MH2 (38.10 days), TMV2NLM x 32-2-5 (38.10 days) and MK 374 x TMV2NLM (38.00 days).

For this character, the heterosis ranged from -16.438% to 7.385%. Out of 36 crosses, only four crosses exhibited significant negative heterosis viz., PI 259747 x 32-2-5 (-16.438%), ICG 2271 x TAP5 (-11.494%), J11 x TMV2NLM (-7.808%) and JL24 x

TMV2NLM (-7.671%). None of the crosses showed significant positive heterosis for this trait. Two crosses viz., J11 x TAP5 (7.385%) and PI350680 x TAP5 (7.077%) recorded high positive heterosis.

4.4.4 Canopy Diameter

In respect of parents, the mean canopy diameter ranged from 28.75 cm to 65.00 cm. The highest mean canopy diameter was observed in ICG 2271 (65.00 cm) followed by M13 (62.75 cm), TAP5 (60.50 cm) and GNLM (60.25 cm). The variety MH2 (28.75 cm) recorded the lowest mean. Among the crosses the mean canopy diameter ranged from 31.25 cm to 79.20 cm. The cross M13 x TAP5 exhibited high mean value followed by GNLM x TAP5 (76.65 cm) and Kadiri-3 x TAP5 (76.50 cm) in which TAP5 was involved in all the three crosses. The crosses viz., PI 259747 x 32-2-5 (31.25 cm), G 201 x MH2 (37.10 cm), G 201 x TMV2NLM (41.70 cm) and J11 x TAP5 (46.35 cm) recorded low mean values for this trait.

The crosses exhibited both positive and negative heterosis for canopy diameter. The range of heterosis for this trait was between -42.130% and 26.694%. Twenty one crosses exhibited significant positive heterosis. Six crosses exhibited highly significant positive heterosis viz., GNLM x TAP5 (26.694%), Kadiri-3 x TAP5 (26.446%), M13 x TAP5 (26.215%), JL24 x 32-2-5 (25.00%), TMV2 x MH2 (23.452%) and PGN1 x MH2 (23.256%) in which TAP5 was involved in three crosses. Significant negative heterosis was observed in eleven crosses. Three crosses

values for the crosses was from 114.50 cm to 230.70 cm. The showed highly significant negative heterosis viz., PI 259747 x 32-2-5 (-42.130%), G 201 x TMV2NLM (-27.225%) and J11 x TAP5 (-23.388%).

4.4.5 Canopy Circumference

The mean canopy circumference in parents ranged from 87.50 cm to 200.00 cm. The highest mean value for canopy circumference was observed in ICG 2271 (200.00 cm) followed by M13 (185.50 cm), TAP5 (171.50 cm) and GNLM (170.50 cm). The parent MH2 showed the lowest mean value (87.50 cm). The range of mean values for the crosses was from 114.50 cm to 230.70 cm. The crosses viz., GNLM x TAP5 (230.70 cm), MK374 x TMV2NLM (204.80 cm) and M13 x TAP5 (201.50 cm) recorded high mean values for this trait. The lowest mean value was found in PI 259747 x 32-2-5 (114.50 cm) followed by G201 x MH2 (116.00 cm).

It was observed that the range of heterosis for this trait was between -31.024% annd 34.519%. Both positive and negative heterosis was found in the crosses for this trait. Significant positive heterosis was recorded by seventeen crosses, of which the cross, GNLM x TAP5 (34.519%) registered highly significant positive heterosis followed by MK374 x TMV2NLM (20.826%), Kadiri-3 x TAP5 (15.685%), PGN1 x MH2 (14.658%) and TMV2 x MH2 (14.574%). Negative significant heterosis was observed in 15 crosses. Highly significant negative heterosis was recorded by PI259747 x 32-2-5 (-31.024%) and G201 x MH2 (-24.919%).

4.4.6 Leaf Area at 60 Days

The mean values ranged from 879.00 cm^2 to 3163.00cm^2 for leaf area at 60 days in the parents. The parent ICG 2271 (3163.00 cm^2) recorded the highest mean value followed by M13 (2661.00 cm^2), Kadiri-3 (2335.00 cm^2) and 32-2-5 (2303.00 cm^2). The lowest mean value was found in MH2 (879.00 cm^2) followed by PGN1 (1055.00 cm^2) and TMV2 (1393.00 cm^2). The crosses showed a range of mean values between 1265.88 cm^2 to 3867.23 cm^2. The cross TMV2NLM x TAP5(3867.23 cm^2 exhibited the highest mean value followed by TMV2 x 32-2-5 (3823.92 cm^2) JL24 x 32-2-5 (3573.45 cm^2). TMV2 x TMV2NLM (3290.60 cm^2), Kadiri-3 x 32-2-5 (3174.75 cm^2), TMV2NLM x G201 (3104.61 cm^2) and J11 x TMV2NLM (3019.43 cm^2), in which TMV2NLM was involved in four crosses and 32-2-5 in three crosses. The cross G201 x TMV2NLM (1265.88 cm^2) recorded the lowest mean leaf area at 60 days.

The heterosis for this character ranged between -40.439% and 82.245%. Among 36 crosses, twenty two crosses exhibited significant positive heterosis and nine crosses recorded significant negative heterosis. Five crosses viz., TMV2NLM x TAP5 (82.235%), TMV2 x 32-2-5 (66.041%), TMV2 x MH2 (57.071%), JL24 x 32-2-5 (55.165%) and TMV2 x TMV2NLM (55.071%) recorded highly significant positive heterosis. Significantly high negative heterosis was observed in three crosses viz., M13 x TAP5 (-40.439%), G201 x TMV2NLM (-40.345%) and M13 x TMV2NLM (-33.179%).

4.4.7 Plant Height

Among the parents, the mean values for plant height ranged from 8.50 cm to 42.50 cm. The genotype PI259747 (42.50 cm) showed the highest mean value followed by JL24 (39.00 cm). TAP5 (37.50 cm) and PI350780 (36.00 cm). The lowest mean value was found in MH2 (8.50 cm) followed by ICG2271 (19.50 cm) and M13 (21.00 cm). For the crosses, the mean values ranged from 19.90 cm to 44.40 cm. PI350680 x TAP5 (44.40 cm) recorded the highest mean value followed by TMV2 x TAP5 (41.80 cm), PGN1 x TAP5 (37.60 cm) and JL24 x 32-2-5 (36.00 cm). The lowest mean value was observed in G201 x MH2 (19.90 cm) followed by TMV2NLM x 32-2-5 (20.70 cm).

The range of heterosis observed for this trait was from -50.588% to 38.810%. Out of 36 crosses, thirteen crosses exhibited positive heterosis for this trait, but none of them recorded significant heterosis. High positive heterosis was found in M13 x MH2 (38.81%) and PGN1 x MH2 (32.400%). Eight crosses expressed significant negative heterosis. Four crosses viz., PI259747 x 32-2-5 (-50.588%), ICG2271 x TAP5 (-43.200%), MK374 x TAP5 (-37.733%) and Kadiri-3 x TAP5 (-35.467%) recorded highly significant negative heterosis.

4.4.8 Number of Primaries

The mean number of primaries ranged from 4.00 to 14.50 in the parents. The genotype M13 (14.50) showed the highest mean value followed by G201 (9.50) and ICG2271 (9.00). Low mean values were found in MH2 (4.00), PGN1 (4.00) and PI350680 (4.00). Among the crosses, the mean values ranged from 4.70 to 10.00. The highest mean number of primaries was recorded by ICG2271 x TAP5 (10.00) and G201 x MH2 (10.00) followed by GNLM x 32-2-5 (9.65) and TMV2NLM x TAP5 (9.00). The crosses viz., TMV2 x TAP5 (4.70) and J11 x TAP5 (4.70) showed the lowest mean number of primaries.

The crosses showed both positive and negative heterosis for this character. The range of heterosis for number of primaries was between -45.172 and 50.00. Twenty crosses registered positive heterosis for this trait which was not significant. High positive heterosis was exhibited by PGN1 x MH2 (50.00%) and PGN1 x TAP5 (46.67%). Out of 36 crosses, significant negative heterosis was observed in M13 x MH2 (-45.172%), M13 x TAP5 (-44.828%) and M13 x TMV2NLM (-42.069%).

4.4.9 Number of Secondaries

The parents recorded a range of mean values between 0.00 to 21.50. Highest mean number of secondaries was found in TMV2NLM (21.50) followed by GNLM (18.00), G201 (14.00), ICG2271 (12.50), 32-2-5 (12.00) and MK374 (11.50). The secondary branches were absent in TMV2. TAP5 and PI350680. Low mean value was found in J11 (0.50). The range of mean values was from 0.30 to 18.70 in the crosses. The cross TMV2NLM x G201 (18.70) exhibited the highest mean value followed by TMV2NLM x 32-2-5 (16.90) and TMV2NLM x TAP5 (16.50). Incidentally TMV2NLM was involved as one of the parents in the above three crosses which showed the highest mean value. Low mean values were recorded by TMV2 x

TAP5 (0.30), J11 x TAP5 (0.60), JL24 x TAP5 (1.10), PI350680 x TAP5 (1.10), PGN1 x MH2 (1.20) and JL24 x MH2 (1.30).

The heterosis for this trait ranged from -84.286% to 300.00%. None of the crosses exhibited significant positive heterosis for number of secondaries. High positive heterosis was observed in TMV2 x MH2 (300.00%) and PGN1 x TAP5 (90.00%). Significant negative heterosis was found in twelve crosses, of which two crosses viz., G201 x TAP5 (-75.714%) and JL24 x TMV2NLM (-70.233%) recorded highly significant negative heterosis.

4.4.10 Number of Aerial Pegs

The range of mean values among the parents was between 6.00 and 36.50 for number of aerial pegs. The parent M13 (36.50) showed the highest mean value followed by MK374 (32.50), PGN1 (28.00), TAP5 (26.50) and ICG2271 (26.50). TMV2 (6.00) recorded the lowest mean value followed by MMH2 (8.50) and JL24 (8.50). In the crosses the mean values ranged from 0.00 to 42.30. The highest mean value was recorded by PGN1 x MH2 (42.30) followed by ICG2271 x TAP5 (36.60) and TMV2NLM x 32-2-5 (35.00). The aerial pegs were absent in PI259747 x 32-2-5. While low mean values were observed in JL24 x MH2 (4.30), JL24 x TAP5 (4.30), J11 x TAP5 (5.60), G201 x TAP5 (6.40), JL24 x 32-2-5 (7.50) and G201 x MH2 (9.10).

The range of heterosis for number of aerial pegs was between -100.00% and 51.071%. Among 36 crosses, none of the crosses showed significant positive heterosis for this trait.

Three crosses viz., PGN1 x MH2 (51.071%), TMV2 x MH2 (48.235%) and TMV2NLM x 32-2-5 (40.000%) recorded high positive heterosis, of which the crosses viz., PI259747 x 32-2-5 (100.00%), JL24 x TAP5 (-83.774%), J11 x TAP5 (-78.868%) and G201 x TAP5 (-75.849%) recorded high degree of significant negative heterosis.

4.4.11 Number of Mature Pods

In parents, the mean values ranged from 10.50 to 34.00 for number of mature pods. The parent JL24 (34.00) recorded highest number of mature pods followed by Kadiri-3 (32.00) and G201 (32.00). The lowest mean value was found in PI259747 (10.50) followed by TMV2 (12.00). Among the crosses the mean number of mature pods ranged from 6.10 to 40.50. The cross, Kadiri-3 x 32-2-5 (40.50) exhibited the highest mean value followed by Kadiri-3 x TAP5 (40.00). Low mean values were recorded by G201 x TAP5 (6.10), ICG2271 x TAP5 (7.70) and M13 x TMV2NLM (8.50).

The crosses exhibited both positive and negative significant heterosis for number of mature pods. The heterosis for this trait ranged between -80.938% and 63.556%. Four crosses expressed significant positive heterosis for number of mature pods, of which one cross viz., PGN1 x TAP5 (63.556%) showed highly significant positive heterosis. Significant negative heterosis was recorded by eighteen crosses. Highly significant negative heterosis was found in G201 x TAP5 (-80.938%), ICG2271 x TAP5 (-68.571%) and JL24 x 32-2-5 (-63.529%).

4.4.12 Mature Pod Weight

Among the parents, the mean values for mature pod weight ranged from 8.94 g to 24.39 g. Maximum mature pod weight was observed in JL24 (24.39g) followed by GNLM (23.63g). ICG2271 (23.49g), MK374 (22.35g) and G201 (21.99g). The parent MH2 (8.94g) recorded the lowest mean value followed by PI259747 (9.19g), TMV2 (10.00g) and TMV2NLM (10.09g). In case of crosses, the mean mature pod weight ranged from 3.80 g to 35.11g. The highest mean value was observed in Kadiri-3 x 32-2-5 (35.11g) followed by Kadiri-3 x TAP5 (33.93 g). The cross, G201 x TAP5 (3.80 g) showed the lowest mean value followed by ICG2271 x TAP5 (6.04 g) and M13 x TMV2NLM (6.14 g).

The range of heterosis for this trait was between -82.719% and 82.808%. Among 36 crosses, positively significant heterosis was recorded in eleven crosses. The crosses viz., TMV2 x 32-2-5 (82.808%), PGN1 x TAP5 (75.230%) TMV2 x MH2 (71.700%), Kadiri-3 x 32-2-5 (71.268%), PGN1 x TMV2NLM (69.322%) and Kadiri-3 x TAP5 (65.512%) exhibited significantly high degree of positive heterosis. Significant negative heterosis was observed in twenty crosses, of which two crosses expressed highly significant negative heterosis viz., G201 x TAP5 (-82.719%) and ICG2271 x TAP5 (-74.287%).

4.4.13 Number of Mature Kernels

The range of mean values for number of mature kernels was between 17.00 and 55.50 in the parents. The parent JL24

(55.50) recorded the highest number of mature kernels followed by Kadiri-3 (46.00), G201 (43.00), TMV2 (41.50), MK374 (41.50) and TAP5 (40.00). While, PI25947 (17.00) showed the lowest number of mature kernels followed by TMV2NLM (21.00) and 32-2-5 (21.00). Among the crosses the range of mean values was from 8.25 to 61.70. The mean number of mature kernels observed in the cross Kadiri-3 x 32-2-5 was the highest (61.70) followed by PGN1 x TAP5 (55.50) and Kadiri-3 x TAP5 (53.60). While, the lowest mean value was found in G201 x TAP5 (8.25) followed by ICG2271 x TAP5 (10.10) and PI 259747 x 32-2-5 (11.50).

Both positive and negative significant heterosis was observed for this trait. The heterosis for number of mature kernels ranged from -80.698% to 62.857%. Out of 36 crosses, none of the crosses exhibited significant positive heterosis. Four crosses viz., TMV2NLM x 32-2-5 (62.857%), PGN1 x TMV2NLM (42.581%), PGN1 x TAP5 (38.750%) and Kadiri-3 x 32-2-5 (34.130%) recorded high positive heterosis. Significant negative heterosis was found in nine crosses. Highly significant negative heterosis was recorded by G201 x TAP5 (-80.698%), ICG2271 x TAP5 (-74.750%) and JL24 x 32-2-5 (-70.000%).

4.4.14 Mature Kernel Weight

The mean values of mature kernel weight ranged from 3.56 g to 17.05 g in parents. The parent, Kadiri-3 (17.05 g) exhibited the highest mature kernel weight followed by JL24 (14.80 g) and G201 (14.61 g). The lowest mean value was found in PI259747 (3.56

g) followed by J11 (5.49 g). In respect of crosses, the mature kernel weight ranged from 1.45 g to 24.00 g. The cross Kadiri-3 x 32-2-5 (24.00 g) recorded the highest mean kernel weight followed by Kadiri-3 x TAP5 (23.05 g). Low mean values were recorded by G201 x TAP5 (1.45 g), ICG2271 x TAP5 (2.13 g) and PI259747 x 32-2-5 (2.79g).

The range of heterosis for mature kernel weight was found to be between -90.075% and 89.029%. Eight crosses exhibited significant positive heterosis for this trait out of 36 crosses. The crosses viz., PGN1 x TAP5 (89.029%), TMV2 x 32-2-5 (78.112%) and TMV2 x MH2 (74.419%) recorded highly significant positive heterosis. Twenty one crosses expressed significant negative heterosis, of which two crosses viz., G201 x TAP5 (-90.075%) and ICG2271 x TAP5 (-79.320%) showed highly significant negative heterosis.

4.4.15 Total Dry Matter at Harvest

The range of mean values for total dry matter at harvest was between 17.03 g and 63.81 g in the parents. The highest mean dry matter at harvest was observed in M13 (63.81 g) followed by 32-2-5 (57.89g), Kadiri-3 (56.97g) and G201 (50.06g). The parent MH2 (17.03g) showed the lowest mean followed by PGN1 (18.38g). The crosses recorded a range of 20.69 g to 64.94 g for this trait. Maximum dry matter at harvest was obtained in the cross M13 x MH2 (64.94 g) followed by MK374 x TMV2NLM (53.20 g), M13 x TAP5 (50.90 g) and J11 x TMV2NLM (50.08 g). The cross J11 x TAP5

(20.69 g) recorded the lowest mean value followed by JL24 x MH2 (23.55 g) and JL24 x TAP5 (25.38 g).

The heterosis for this character ranged between -52.790% and 65.812%. None of the 36 crosses recorded significant positive heterosis for total dry matter at harvest. High positive heterosis was found in PGN1 x TAP5 (65.812%) and PGN1 x MH2 (62.894%). Negative significant heterosis was recorded in six crosses. Highly significant negative heterosis was observed in TMV2 x 32-2-5 (-52.790%) and PI259747 x 32-2-5 (-50.613%).

4.4.16 Shelling Per cent

The parents recorded a range of 42.83% to 90.61% for shelling per cent. The parent Kadiri-3 (90.61%) exhibited the highest shelling per cent followed by TMV2NLM (81.98%). While, the lowest shelling per cent was recorded by PI259747 (42.83%) followed by M13 (45.55%). A range of 30.77% to 77.29% was recorded in the crosses for this trait. Shelling per cent was high in PGN1 x TAP5 (77.29%) followed by M13 x TMV2NLM (77.07%), TMV2NLM x MH2 (74.53%), TMV2 x TMV2NLM (72.29%) and Kadiri-3 x 32-2-5 (71.44%). The lowest shelling per cent was observed in the cross PI259747 x 32-2-5 (30.77%) followed by G201 x TAP5 (42.11%) and ICG2271 x TAP5 (42.83%).

The heterosis ranged between -45.818% and 7.541% for shelling per cent. None of the crosses exhibited significant positive heterosis for this trait. Only two crosses viz., PGN1 x TAP5 (7.541%) and GNLM x 32-2-5 (1.567%) recorded positive heterosis. Twenty four crosses expressed significant negative heterosis, of which five crosses showed highly significant negative heterosis, viz., PI259747 x 32-2-5 (-45.818%), G201 x TAP5 (-41.408%), Kadiri-3 x MH2 (-41.077%), TMV2NLM x TAP5 (-41.034%) and ICG2271 x TAP5 (-40.406%).

4.4.17 Harvest Index

Among the parents, the mean values of harvest index ranged from 7.70 to 34.46. The highest harvest index was found in PGN1 (34.46) followed by JL24 (31.45) and TAP5 (30.88). The parent PI259747 (7.70) exhibited the lowest mean value followed by M13 (10.65), 32-2-5 (11.35) and TMV2NLM (12.97). The harvest index values ranged from 4.22 to 36.02 in the crosses. The cross Kadiri-3 x 32-2-5 recorded the highest mean value (36.02) followed by Kadiri-3 x TAP5 (34.09), PGN1 x TAP5 (33.80) and TMV2 x 32-2-5 (30.75). The lowest mean value was found in G201 x TAP5 (4.22) followed by ICG2271 x TAP5 (4.76).

The range of heterosis for this trait was from -86.334% to 65.056%. Out of 36 crosses, significant positive heterosis was observed in only two crosses viz., TMV2 x 32-2-5 (65.056%) and Kadiri-3 x 32-2-5 (57.293%). Significant negative heterosis was recorded by twenty one crosses. Two crosses viz., G201 x TAP5 (-86.334%) and ICG2271 x TAP5 (-84.585%) exhibited highly significant negative heterosis.

4.5 MEAN PERFORMANCE OF PARENTS AND MEANS AND VARIANCES EXHIBITED BY CROSSES IN F_2 GENERATION FOR CANOPY AND REPRODUCTIVE ATTRIBUTES

The mean values of parents and means and variances recorded by 36 crosses for 17 characters in F_2 generation (Rabi) are presented in Tables 19 and 20 respectively. The means and variances exhibited by 21 crosses for 17 characters in F_2 generation (Kharif) along with their parental mean values were given in Tables 21 and 22 respectively.

4.5.1 F_2 Generation (Rabi)

4.5.1.1 Days to Initial Flowering

In parents the days to initial flowering ranged between 40.00 days and 59.00 days. The number of days taken for initial flowering were the least in TAP5 (40.00 days). ICG2271 (59.00 days) took maximum number of days to initial flowering followed by M13 (53.00 days).

The ranges of means and variances for this trait were from 42.27 days to 56.50 days and 0.00 to 44.20 respectively. Low mean values were observed in six crosses of which, four crosses viz., TMV2 x TAP5, PGN1 x TAP5, TMV2 x MH2 and TMV2 x TMV2NLM exhibited medium degree of variance and two crosses, PGN1 x MH2 and JL24 x MH2 showed low variance. High degree of variance was found in seven crosses, of which five crosses viz., M13 x MH2, M13 x TMV2NLM, MK374 x MH2, G201 x MH2 and GNLM x 32-2-5 recorded high mean and two crosses M13 x TAP5 and Kadiri-3 x TAP5 showed

Table 19 : Mean performance of the parents (grown along with F_2 progenies in *Rabi*) for 17 characters.

Parents	Canopy Category	Days to initial flowering	Days to 50% flowering	Days to 100% flowering	Canopy diameter (cm)	Canopy circumference (cm)	Leaf area at 60 days (sq cm)	Plant height (cm)	Number of primaries	Number of secondaries
MH2	1	43.00	47.00	49.00	22.00	50.80	916.72	6.80	5.20	1.40
J11	2	43.00	46.00	48.00	45.80	145.10	2601.70	39.40	6.20	2.80
JL24	2	44.00	47.00	48.00	46.00	149.20	2558.36	33.63	6.63	3.63
TMV2	2	45.00	48.00	50.00	45.60	148.30	2481.25	31.80	6.30	4.10
PGN1	2	44.00	47.00	49.00	47.50	150.10	2019.01	30.90	6.20	5.20
PI259747	2	43.00	46.00	48.00	49.00	149.40	2082.24	35.63	6.13	1.00
PI350680	2	46.00	47.00	51.00	48.50	147.25	2117.25	44.11	5.22	0.33
G201	2	52.00	54.00	57.00	48.50	150.50	2643.16	25.38	8.25	14.25
TAP5	3	40.00	43.00	45.00	60.00	180.60	2644.87	36.80	4.60	1.50
MK374	3	52.00	57.00	61.00	54.70	169.78	3004.57	26.00	9.11	16.78
GNLM	3	49.00	51.50	56.00	60.15	180.25	4014.77	25.29	6.71	12.14
TMV2NLM	3	48.00	51.00	55.00	58.20	176.15	3950.51	21.50	8.00	24.88
Kadiri-3	3	52.00	57.00	63.00	55.00	170.80	3032.41	22.00	6.50	13.50
32-2-5	3	47.00	53.00	55.00	55.90	170.20	4134.29	31.71	8.29	14.71
M13	4	53.00	57.00	62.00	75.80	211.70	4918.36	21.50	8.40	24.30
ICG2271	4	59.00	62.00	67.00	76.50	215.50	4819.29	22.67	9.67	24.23

Parents	Canopy Category	Number of aerial pegs	Number of mature pods	Mature pod weight (g)	Number of mature kernels	Mature kernel weight (g)	Total dry matter at harvest (g)	Shelling per cent	Harvest index
MH2	1	8.60	14.00	11.27	25.80	8.15	13.96	71.63	36.15
J11	2	29.60	46.20	38.99	70.40	28.72	44.93	74.99	39.21
JL24	2	25.63	19.25	18.42	26.50	12.21	42.37	65.68	25.14
TMV2	2	19.40	35.50	27.34	56.80	20.04	34.03	73.09	36.76
PGN1	2	26.18	31.20	34.16	52.51	23.46	45.20	70.70	35.67
PI259747	2	27.25	29.50	36.11	49.63	18.15	45.30	52.21	29.16
PI350680	2	13.22	17.00	25.80	30.89	16.96	29.26	68.10	35.55
G201	2	29.38	29.13	32.38	52.13	21.72	39.15	69.81	36.26
TAP5	3	32.60	19.10	17.36	32.00	11.92	34.07	70.49	27.59
MK374	3	28.22	27.89	29.72	47.56	19.85	38.21	67.99	35.22
GNLM	3	18.29	29.29	30.00	45.71	20.63	40.91	70.57	34.31
TMV2NLM	3	23.38	31.75	29.92	46.75	18.50	42.39	63.11	31.62
Kadiri-3	3	19.75	55.33	51.10	77.00	37.66	31.54	74.69	54.27
32-2-5	3	19.57	40.57	41.28	58.82	26.50	52.65	68.17	36.71
M13	4	47.80	31.80	35.25	45.70	22.94	47.40	69.20	34.18
ICG2271	4	65.67	32.00	29.73	47.50	16.83	86.04	61.26	17.53

Table 20 : Means and variances of 36 F_2 progenies (grown in rabi) for 17 characters.

Crosses	Canopy Combination	Days to initial flowering	Days to 50% flowering	Days to 100% flowering	Canopy diameter (cm)	Canopy circumference (cm)	Leaf area at 60 days (sq.cm.)	Plant Height (cm)	Number of primaries	Number of secondaries
M13 X MH2	(4 x 1)	52.80	57.75	61.50	48.02	141.20	2049.19	21.70	9.57	18.63
		44.20	6.92	3.00	27.77	62.67	282533.25	32.29	8.12	94.24
MK374 X MH2	(3 x 1)	52.50	60.33	67.00	45.35	139.10	1694.32	26.00	8.56	18.44
		28.30	33.87	49.20	82.12	102.88	302087.50	32.67	5.42	100.92
Kadiri-3 X MH2	(3 x 1)	46.00	50.00	54.00	46.70	145.00	2205.83	25.10	7.59	10.83
		4.92	10.00	14.15	60.06	188.00	780290.00	49.24	5.70	51.70
G201 X MH2	(2 X 1)	55.25	59.63	65.00	37.27	136.23	2538.80	16.88	8.69	18.65
		27.64	23.13	40.00	83.74	170.49	1150861.75	28.27	10.70	57.92
TMV2 X MH2	(2 X 1)	43.29	46.00	48.14	37.93	117.86	2289.28	28.85	5.94	3.35
		3.24	2.00	1.14	100.22	283.50	1228401.75	88.37	2.92	13.05
PGN1 X MH2	(2 X 1)	42.27	45.91	48.36	45.08	132.08	2706.46	25.84	6.35	2.81
		0.62	1.49	0.65	99.96	239.53	1313215.00	35.25	3.57	8.27
JL24 X MH2	(2 X 1)	42.86	46.71	51.86	33.16	78.06	1806.74	24.29	7.54	6.39
		0.48	1.24	17.81	84.20	217.18	601272.13	34.95	4.92	26.77
TMV2NLM X MH2	(3 X 1)	45.26	50.00	52.95	46.75	140.35	2098.99	27.96	9.02	11.83
		14.21	20.35	15.60	110.96	310.88	1672324.36	95.42	6.50	53.34
GNLM X MH2	(3 x 1)	49.38	56.38	59.75	45.02	136.76	1854.02	28.02	8.48	12.62
		11.98	16.84	26.50	90.73	225.62	1911397.38	42.03	6.10	43.16
M13 X TMV2NLM	(4 x 3)	56.50	60.25	64.00	67.63	194.50	7795.92	20.96	8.81	21.42
		35.67	32.25	47.33	64.58	165.05	1142064.25	33.48	6.00	113.53
MK374 X TMV2NLM	(3 X 3)	49.38	56.50	61.88	59.40	158.08	5009.80	21.82	8.60	20.72
		17.70	39.71	49.84	120.27	564.33	1678806.50	36.84	6.12	191.35
Kadiri-3 X TMV2NLM	(3 X 3)	47.17	51.33	54.17	58.36	165.57	4747.59	24.11	7.81	10.81
		2.57	1.87	0.97	123.07	604.39	3872905.13	71.93	4.73	34.96
G201 X TMV2NLM	(2 x 3)	51.75	55.50	59.50	55.33	152.08	4400.74	22.65	8.74	15.65
		10.92	22.33	23.00	182.67	742.60	4922784.00	73.06	4.11	94.33
TMV2 X TMV2NLM	(2 x 3)	44.08	48.25	51.00	59.53	167.85	4974.50	25.98	8.50	16.98
		3.17	2.93	3.27	296.67	1242.67	5043308.00	55.89	6.66	82.43
PGN1 X TMV2NLM	(2 x 3)	44.64	50.36	51.36	56.10	167.82	4635.07	22.60	8.06	16.57
		2.85	17.65	4.45	219.22	1135.55	8698127.00	27.85	5.94	75.21
JL24 X TMV2NLM	(2 x 3)	45.25	48.50	51.00	52.82	162.00	3170.27	34.04	7.78	15.41
		4.92	0.33	0.67	203.01	1142.69	5411340.63	46.11	4.56	53.79
J11 X TMV2NLM	(2 x 3)	44.67	49.00	54.33	51.17	154.07	4437.79	29.60	8.20	13.35
		5.33	12.00	5.33	193.42	987.69	6919523.50	40.25	4.06	89.71
PI259747 X 32-2-5	(2 x 3)	46.00	47.00	49.00	63.90	195.40	4231.88	33.40	6.40	0.80
		0.00	0.00	0.00	135.93	874.80	3372160.19	22.80	4.80	1.20

Table 20 : Continued...

Crosses	Canopy Combi-nation	Days to initial flower-ing	Days to 50% flower-ing	Days to 100% flower-ing	Canopy diame-ter (cm)	Canopy circum-ference (cm)	Leaf area at 60 days (sq.cm.)	Plant Height (cm)	Number of pri-maries	Number of secon-daries
TMV2NLM X 32-2-5	(3 x 3)	49.00	52.71	55.29	58.75	178.50	4753.86	25.26	9.56	27.26
		6.33	4.90	3.90	280.14	1190.19	11562392.00	38.98	10.09	169.09
GNLM X 32-2-5	(3 x 3)	51.80	55.80	59.90	52.88	160.75	3205.83	24.74	8.52	20.71
		19.73	13.51	24.10	128.55	608.17	3276295.75	112.30	3.08	88.65
JL24 X 32-2-5	(2 x 3)	48.00	49.00	51.00	49.33	154.33	3539.44	29.09	7.64	12.64
		0.00	0.00	0.00	266.96	1225.66	5451287.75	71.69	3.45	60.05
TMV2 X 32-2-5	(2 x 3)	44.82	48.91	51.82	59.32	176.07	3896.48	36.15	9.64	16.89
		11.76	5.89	6.96	275.52	1182.84	7573270.00	29.02	6.43	74.03
Kadiri-3 X 32-2-5	(3 x 3)	46.62	47.75	52.63	60.69	168.38	5202.56	26.16	7.39	9.94
		0.55	48.50	3.98	147.14	613.88	4264902.00	45.54	5.18	36.73
M13 X TAP5	(4 x 3)	49.00	53.60	56.60	77.57	209.12	4641.54	23.81	6.69	13.06
		33.50	33.80	31.30	77.19	203.00	1062771.75	66.62	5.53	41.71
MK374 X TAP5	(3 x 3)	49.00	52.50	55.00	75.20	202.39	3947.41	20.07	6.07	10.10
		3.33	3.00	2.67	83.50	427.82	2779146.50	35.78	2.00	44.38
Kadiri-3 X TAP5	(3 x 3)	46.06	51.17	54.28	52.76	161.39	5469.07	26.36	8.28	8.97
		21.00	1.91	6.92	130.10	705.65	10141044.00	56.42	6.39	56.88
G201 X TAP5	(2 x 3)	47.00	53.00	55.00	70.00	191.00	3711.48	22.00	8.33	18.67
		0.00	0.00	0.00	260.75	974.40	3013567.50	28.00	6.33	142.33
PGN1 X TAP5	(2 x 3)	42.86	46.00	47.71	52.46	155.83	3691.15	26.37	6.04	2.19
		1.81	0.67	0.57	156.79	894.72	3799951.56	35.24	3.34	11.08
TMV2 X TAP5	(2 x 3)	43.00	46.17	48.83	62.61	170.27	4053.51	29.79	8.64	4.91
		3.20	1.37	2.57	150.58	867.30	3528729.50	62.86	58.11	18.46
JL24 X TAP5	(2 x 3)	44.29	47.14	49.29	69.79	180.86	3311.94	26.94	6.40	3.91
		0.90	1.14	2.57	153.93	876.92	3867974.00	53.29	5.42	42.20
J11 X TAP5	(2 x 3)	44.17	48.00	49.83	70.47	191.68	4245.77	35.00	7.50	6.32
		3.77	1.20	2.57	234.88	988.49	3226165.50	57.33	1.69	15.18
PI350680 X TAP5	(2 x 3)	45.25	47.75	50.50	68.00	185.67	4117.77	33.77	7.54	1.77
		4.25	1.58	3.00	175.10	900.84	3624729.50	64.19	2.77	7.69
ICG2271 X TAP5	(4 x 3)	52.50	57.00	61.00	80.63	206.50	4740.81	25.92	8.32	13.81
		0.50	8.00	2.00	80.34	210.25	1148721.50	50.08	5.89	78.49
GNLM X TAP5	(3 x 3)	47.75	51.75	54.63	65.41	175.39	2954.44	32.29	8.87	18.29
		3.36	7.07	6.84	160.82	755.14	2819728.28	100.05	15.63	189.40
TMV2NLM X TAP5	(3 x 3)	47.43	52.29	55.57	67.20	180.50	3589.72	24.16	8.54	17.05
		2.95	1.57	2.62	162.96	901.26	3831586.75	46.58	3.98	72.60
TMV2NLM X G201	(3 x 2)	48.40	51.60	54.60	65.36	175.27	3194.56	27.00	9.24	17.12
		4.30	1.80	2.80	125.35	783.42	2247427.25	77.94	3.88	102.23

Table 20 : Continued...

Crosses	Canopy Combi-nation	Number of aerial pegs	Number of mature pods	Mature pod weight (g)	Number of mature kernels	Mature kernel weight (g)	Total dry matter at harvest (g)	Shell-ing per cent	Harvest Index
M13 X MH2	(4 x 1)	41.27	37.07	34.03	59.83	20.54	80.67	70.98	25.63
		1097.86	444.27	119.32	532.63	65.00	1097.69	1037.68	178.38
MK374 X MH2	(3 x 1)	45.72	48.10	36.28	69.72	21.01	70.30	66.81	29.71
		814.71	793.75	125.24	806.21	67.01	446.26	136.37	102.29
Kadiri-3 X MH2	(3 x 1)	36.15	45.63	36.34	55.73	20.37	54.87	69.59	30.99
		515.78	415.29	135.37	855.00	67.01	683.10	462.43	211.29
G201 X MH2	(2 X 1)	24.42	22.88	22.11	37.96	13.39	47.14	66.63	23.33
		411.77	189.07	215.30	472.36	109.00	486.59	470.66	88.66
TMV2 X MH2	(2 X 1)	39.81	45.19	34.88	62.62	23.20	52.20	69.12	31.80
		943.06	600.59	200.00	1365.38	100.94	645.13	108.61	134.34
PGN1 X MH2	(2 X 1)	36.46	43.00	32.41	54.08	21.34	38.53	72.09	36.14
		471.98	766.50	188.24	1062.63	99.32	322.00	530.78	198.07
JL24 X MH2	(2 X 1)	22.96	22.89	20.20	31.75	13.03	45.47	64.95	22.41
		243.67	228.25	215.28	544.64	111.28	461.93	302.05	152.39
TMV2NLM X MH2	(3 X 1)	32.20	39.63	30.72	50.95	18.86	53.38	64.02	28.44
		964.77	753.54	210.24	1396.75	120.85	821.38	501.23	163.75
GNLM X MH2	(3 x 1)	37.25	35.77	25.60	48.21	16.16	57.96	68.77	23.21
		384.19	608.23	200.18	1220.90	101.95	690.44	593.03	119.53
M13 X TMV2NLM	(4 x 3)	41.65	44.35	36.06	67.04	20.88	72.02	64.23	26.62
		922.56	763.52	177.02	1963.32	90.68	992.60	88.08	108.97
MK374 X TMV2NLM	(3 X 3)	41.04	41.45	31.41	56.31	22.22	70.66	66.72	23.38
		944.04	725.75	344.91	1832.76	140.91	1850.99	210.59	102.18
Kadiri-3 X TMV2NLM	(3 X 3)	25.11	37.75	30.96	51.44	25.59	45.35	69.91	31.09
		469.24	773.16	532.88	2125.34	144.44	489.10	143.09	178.72
G201 X TMV2NLM	(2 x 3)	33.65	29.09	32.49	40.83	25.39	58.20	66.46	22.94
		824.06	284.26	390.14	713.24	177.85	1227.65	75.47	85.90
TMV2 X TMV2NLM	(2 x 3)	45.76	50.58	45.44	72.73	29.24	71.95	72.72	27.97
		1583.78	1375.28	1000.62	2805.90	340.14	1587.65	1627.72	199.06
PGN1 X TMV2NLM	(2 x 3)	36.93	43.36	36.00	59.81	28.27	59.30	67.94	28.33
		767.45	666.50	413.37	1625.66	192.94	660.71	1087.40	120.98
JL24 X TMV2NLM	(2 x 3)	28.15	25.85	35.01	36.12	25.20	79.86	66.88	18.51
		310.52	231.42	565.64	487.71	244.86	1399.56	77.40	91.52
J11 X TMV2NLM	(2 x 3)	34.55	37.21	36.94	46.53	29.51	62.42	67.41	19.45
		580.89	878.18	474.59	1192.04	275.71	1429.71	225.37	111.66
PI259747 X 32-2-5	(2 x 3)	18.60	29.25	42.53	46.75	28.52	39.50	67.61	42.24
		43.30	86.25	530.06	103.58	261.09	47.25	9.21	78.40

Table 20 : Continued...

Crosses	Canopy Combination	Number of aerial pegs	Number of mature pods	Mature pod weight (g)	Number of mature kernels	Mature kernel weight (g)	Total dry matter at harvest (g)	Shelling per cent	Harvest Index
TMV2NLM X 32-2-5	(3 x 3)	57.05	50.12	41.60	71.65	27.70	87.64	69.49	25.30
		1177.72	795.75	730.91	1925.87	365.05	1026.57	65.88	101.18
GNLM X 32-2-5	(3 x 3)	46.48	28.98	27.04	44.10	24.32	54.36	72.63	25.17
		834.16	311.92	295.60	815.84	220.23	464.09	613.46	145.36
JL24 X 32-2-5	(2 x 3)	28.82	38.63	31.18	46.63	26.70	82.44	58.69	20.72
		188.36	720.84	504.47	932.84	339.67	1741.76	139.93	171.87
TMV2 X 32-2-5	(2 x 3)	52.91	67.08	57.37	90.91	37.11	101.64	66.12	29.94
		924.66	954.49	726.48	2194.40	363.42	2975.45	72.24	218.93
Kadiri-3 X 32-2-5	(3 x 3)	24.19	65.26	48.65	80.42	32.52	58.19	66.92	34.33
		107.56	898.73	910.09	1525.25	544.07	484.50	79.32	241.79
M13 X TAP5	(4 x 3)	25.97	28.69	21.36	38.94	14.69	59.42	69.39	25.93
		239.06	313.36	211.65	533.08	96.01	844.89	546.03	231.41
MK374 X TAP5	(3 x 3)	17.75	29.28	25.16	43.17	17.32	35.38	73.04	33.93
		314.64	432.35	305.07	1343.00	140.01	231.23	283.94	149.13
Kadiri-3 X TAP5	(3 x 3)	35.72	41.55	29.82	52.58	20.82	64.92	64.89	23.06
		585.90	734.40	408.85	1357.64	206.33	755.15	121.95	162.67
G201 X TAP5	(2 x 3)	34.33	27.00	25.52	39.33	17.27	108.94	59.31	11.14
		472.33	637.00	362.18	1460.33	180.19	1892.35	10.00	11.33
PGN1 X TAP5	(2 x 3)	51.52	37.44	28.12	47.44	20.37	33.11	65.07	34.27
		718.34	388.64	401.87	790.49	227.57	203.39	253.72	284.47
TMV2 X TAP5	(2 x 3)	40.12	32.45	27.52	47.18	19.22	48.24	73.14	29.10
		1416.11	307.94	390.64	785.40	188.18	596.19	1423.37	151.97
JL24 X TAP5	(2 x 3)	24.57	24.11	23.94	33.66	17.05	42.08	65.87	25.03
		754.49	114.93	386.59	249.00	192.96	249.12	83.72	92.14
J11 X TAP5	(2 x 3)	55.59	53.95	39.84	81.95	29.43	61.58	75.94	33.20
		1175.59	493.85	496.87	1125.85	218.27	518.00	75.07	166.83
PI350680 X TAP5	(2 x 3)	35.00	33.23	39.90	61.46	24.15	62.95	60.81	28.29
		480.67	252.03	474.59	872.94	201.68	1139.16	47.42	63.27
ICG2271 X TAP5	(4 x 3)	32.05	24.95	21.73	35.35	13.91	59.34	64.75	20.73
		228.61	257.05	210.30	593.79	107.00	795.65	198.94	193.04
GNLM X TAP5	(3 x 3)	42.92	32.29	26.18	48.29	15.73	68.05	67.54	21.21
		942.24	345.51	344.91	992.10	135.51	885.83	145.04	102.91
TMV2NLM X TAP5	(3 x 3)	40.27	30.46	25.10	42.84	16.98	53.13	69.04	23.52
		1099.65	321.37	396.63	811.14	190.20	601.39	1198.97	85.09
TMV2NLM X G201	(3 x 2)	37.56	41.67	35.16	58.91	21.82	52.12	65.99	30.76
		677.65	621.35	435.97	1582.71	150.79	742.28	62.00	179.63

Note : For each cross above value indicates mean and below value indicates variance of that particular character.

low mean values. Medium degree of variance with medium mean was recorded in sixteen crosses, of which in seven crosses TMV2NLM (narrow leaf mutant) and in five crosses TAP5 (aerial podding mutant) were involved as one of their parents. One cross showed medium variance with high mean G201 x TMV2NLM.

4.5.1.2 Days to 50% Flowering

The range of mean number of days to 50% flowering was between 43.00 days and 62.00 days in parents. The parent TAP5 (43.00) recorded the lowest mean number of days, while the highest number of days was observed in ICG2271 (62.00 days).

For the crosses, the means and variances ranged from 45.91 days to 60.33 days and 0.00 to 48.50 respectively. The crosses, TMV2 x MH2, PGN1 x MH2 and TMV2 x TAP5 recorded low mean values with medium variance. High degree of variance was observed in seven crosses of which four crosses viz., MK374 x TMV2NLM, MK374 x MH2, M13 x TMV2NLM and G201 x MH2 showed high mean and three crosses Kadiri-3 x 32-2-5, M13 x TAP5 and G201 x TMV2NLM recorded medium mean values. Three crosses viz., GNLM x MH2, ICG2271 x TAP5 and M13 x MH2 exhibited medium degree of variance with high mean. Fifteen crosses showed medium mean values with medium degree of variance, of which seven crosses had TMV2NLM (narrow leaf mutant) and five crosses had TAP5 (aerial podding mutant) as one of their parents.

4.5.1.3 Days to 100% Flowering

The mean days to 100% flowering in parents ranged from 45.00 days to 67.00 days. The lowest mean value was found in TAP5

(45.00 days). The parent ICG2271 (67.00 days) recorded the highest number of days to 100 per cent flowering.

In crosses, the means and variances for this trait ranged from 47.71 days to 67.00 days and 0.00 to 49.84 respectively. Five crosses recorded low mean values, of which only one cross TMV2 x TAP5 exhibited medium degree of variance and other four crosses viz., TMV2 x MH2, PGN1 x MH2, PGN1 x TAP5 and PI259747 x 32-2-5 showed low variance. For this trait, high degree of variance was found in seven crosses, of which five crosses recorded high mean and two crosses viz., M13 x TAP5 and GNLM x MH2 showed medium mean values. Medium degree of variance with high mean was observed in M13 x MH2 and ICG2271 x TAP5. Eighteen crosses exhibited medium degree of variance with medium mean, of which in seven crosses TAP5 (aerial podding mutant) and in seven crosses TMV2NLM (narrow leaf mutant) were involved as one of their parents.

4.5.1.4 Canopy Diameter

The parents recorded a range of 22.00 cm to 76.50 cm for mean canopy diameter. Maximum canopy diameter was observed in ICG2271 (76.50cm) followed by M13 (75.80cm). MH2 (22.00cm) showed the lowest canopy diameter.

Among the crosses, the ranges of mean values and variances were from 33.16 cm to 80.63 cm and 27.77 to 296.67 respectively. Out of 36 F_2's, two crosses G201 x TAP5 and J11 x TAP5 (aerial podding mutant) exhibited high degree of variance with high mean for this trait. High degree of variance was also observed in five other crosses viz., TMV2 x TMV2NLM (narrow leaf mutant), TMV2NLM x 32-2-5 (compact canopy mutant), TMV2 x 32-2-5, JL24 x 32-2-5 and PGN1 x TMV2NLM which showed medium mean values. The crosses viz., JL24 x TAP5 and PI350680 x TAP5 exhibited medium degree of variance with high mean canopy diameter. Fifteen crosses recorded medium degree of variance with medium mean, of which in seven crosses TMV2NLM, in five crosses TAP5 and in three crosses 32-2-5 were involved as one of their parents. Medium degree of variance with low mean was observed in TMV2 x MH2, PGN1 x MH2, GNLM x MH2, JL24 x MH2 and G201 x MH2. Three crosses viz., MK374 x TAP5, M13 x TAP5 and ICG2271 x TAP5 showed low variance with high mean. Low degree of variance with medium mean was recorded by M13 x TMV2NLM, Kadiri-3 x MH2 and M13 x MH2. Only one cross MK374 x MH2 exhibited low degree of variance with low mean.

4.5.1.5 Canopy Circumference

Among the parents, the range of mean canopy circumference was between 50.80 cm and 215.50 cm. The canopy circumference observed in ICG2271 (215.50 cm) was the highest followed by M13 (211.70 cm). The lowest canopy diameter was recorded by MH2 (50.80 cm).

The mean values and variances observed in crosses ranged from 78.06 cm to 209.12 cm and 62.67 to 1242.67 respectively. The cross J11 x TAP5 (aerial podding mutant) exhibited high degree of variance with high mean. Seven other crosses also recorded high degree of variance with medium mean values viz., TMV2 x TMV2NLM (narrow leaf mutant), JL24 x 32-2-5 (compact canopy mutant), TMV2NLM x 32-2-5, TMV2 x 32-2-5, JL24 x TMV2NLM, PGN1 x TMV2NLM and J11 x TMV2NLM. None of the crosses showed high degree of variance with low mean. Medium degree of variance with high mean was observed in three crosses viz., G201 x TAP5, PI259747 x 32-2-5 and MK374 x TAP5. Thirteen crosses exhibited medium degree of variance with medium mean values, of which seven crosses had TAP5, four crosses had TMV2NLM and two crosses had 32-2-5 as one of their parents. The crosses viz., TMV2NLM x MH2, TMV2 x MH2, PGN1 x MH2, GNLM x MH2 and JL24 x MH2 recorded medium degree of variance with low mean values. Three crosses viz., ICG2271 x TAP5, M13 x TAP5 and M13 x TMV2NLM showed low degree of variance with high mean. Low degree of variance with medium mean was recorded by two crosses viz., Kadiri-3 x MH2 and M13 x MH2. Two crosses exhibited low degree of variance with low mean viz., G201 x MH2 and Mk374 x MH2.

4.5.1.6 Leaf Area at 60 Days

The mean leaf area at 60 days ranged between 916.72 cm^2 and 4918.36 cm^2 in parents. The parent M13 (4918.36 cm^2) recorded the highest mean leaf area at 60 days followed by ICG2271 (4819.29 cm^2) while the lowest leaf area was found in MH2 (916.72 cm^2).

The mean leaf area and its variance ranged from 1694.32 cm^2 to 7795.92 cm^2 and 282533.13 to 11562392.00 respectively. Among the 36 crosses in F_2 generation, three crosses viz., Kadiri-3 x TAP5 (aerial podding mutant), TMV2NLM x 32-2-5 (compact canopy mutant) and TMV2 x TMV2NLM (narrow leaf mutant) exhibited high degree of variance with high mean. The crosses viz., PGN1 x TMV2NLM, TMV2 x 32-2-5, J11 x TMV2NLM, JL24 x 32-2-5 and JL24 x TMV2NLM recorded high degree of variance with medium mean values. None of the crosses exhibited high variance with low mean. Medium degree of variance with high mean was observed in Kadiri-3 x 32-2-5, Kadiri-3 x TMV2NLM and MK374 x TMV2NLM. Fourteen crosses exhibited medium degree of variance with medium mean, of which in nine crosses TAP5 in two crosses TMV2NLM and in two crosses 32-2-5 were involved as one of their parents. Three crosses viz., GNLM x MH2, TMV2NLM x MH2, TMV2 x MH2 showed medium variance with low mean. One cross, M13 x TMV2NLM showed low degree of variance with high mean value. Low variance with medium mean was found in ICG2271 x TAP5, M13 x TAP5 and G201 x MH2. Four crosses exhibited low variance with low mean viz., Kadiri-3 x MH2, JL24 x MH2, MK374 x MH2 and M13 x MH2.

4.5.1.7 Plant Height

In parents, the range of mean values was between 6.80 cm and 44.11 cm for this trait. PI350680 showed maximum plant height of 44.11 cm and minimum mean plant height was recorded by MH2 (6.80 cm).

The ranges of means and variances in crosses were from 16.88 cm to 36.15 cm and 22.80 to 112.30 respectively. High mean plant height with high degree of variance was recorded by GNLM x TAP5 (aerial podding mutant). High degree of variance was observed in six other crosses viz., (GNLM x 32-2-5) (compact canopy mutant), TMV2NLM (narrow leaf mutant) x MH2, TMV2 x MH2, TMV2NLM x G201, Kadiri-3 x TMV2NLM and G201 x TMV2NLM which recorded medium mean values. None of the crosses showed high variance with low mean. Four crosses viz., PI350680 x TAP5, TMV2 x TAP5, J11 x TAP5 and JL24 x TMV2NLM exhibited medium degree of variance with high mean. Medium degree of variance with medium mean plant height was found in sixteen crosses, of which six crosses had TAP5, three crosses had 32-2-5 and two crosses had TMV2NLM as one of their parents. Three crosses exhibited medium variance with low mean viz., MK374 x TAP5, MK374 x TMV2NLM and M13 x TMV2NLM. Two crosses viz., TMV2 x 32-2-5 and PI259747 x 32-2-5 showed low variance with high mean. One cross exhibited low variance with medium mean and three crosses low variance with low mean.

4.5.1.8 Number of Primaries

For the parents, the mean number of primaries ranged between 4.60 and 9.67. More number of primaries were observed in ICG2271 (9.67) followed by MK374 (9.11). TAP5 (4.60) recorded the lowest number of primaries followed by MH2 (5.20) and PI350680 (5.22).

The crosses recorded the ranges of means and variances from 5.94 and 9.64 and 1.69 to 58.11 respectively. High degree of variance was recorded by four crosses GNLM x TAP5 (aerial podding mutant), TMV2NLM (narrow leaf mutant) x 32-2-5 (compact canopy mutant), M13 x MH2 and TMV2NLM x MH2 which also showed high mean values. The crosses, TMV2 x TAP5, G201 x MH2 and TMV2 x TMV2NLM exhibited high degree of variance with medium mean values. Three crosses viz., TMV2 x 32-2-5, M13 x TMV2NLM and TMV2NLM x G201 recorded medium degree of variance with high mean. Medium degree of variance with medium mean was found in sixteen crosses, of which in six crosses TMV2NLM, in four crosses TAP5 and in two crosses 32-2-5 were involved as one of their parents. Four crosses showed medium variance with low mean viz., M13 x TAP5, JL24 x TAP5, PI259747 x 32-2-5 and PGN1 x MH2. None of the crosses recorded low variance with high mean. The crosses, GNLM x 32-2-5, PI350680 x TAP5 and J11 x TAP5 showed low variance with medium mean. Low variance with low mean was observed in PGN1 x TAP5, TMV2 x MH2 and MK374 x TAP5.

4.5.1.9 Number of Secondaries

The range of mean values for the parents was from 0.33 to 24.88. The parent TMV2NLM (24.88) recorded maximum number of secondaries followed by M13 (24.30) and ICG2271 (24.23). The least number was found in PI350680 (0.33).

In crosses, the means and variances for this trait ranged from 0.80 to 27.26 and 1.20 to 191.35 respectively. Out of 36 F_2's, four crosses viz., MK374 x TMV2NLM (narrow leaf mutant), TMV2NLM x 32-2-5 (compact canopy mutant), G201 x TAP5 (aerial podding mutant) and M13 x TMV2NLM exhibited high degree of variance with high mean. The crosses, GNLM x TAP5 and MK374 x MH2 also showed high degree of variance with medium mean values. None of the crosses recorded high variance with low mean. Medium degree of variance with high mean was found in GNLM x 32-2-5, M13 x MH2 and G201 x MH2. Nineteen crosses exhibited medium variance with medium mean, of which eight crosses had TMV2NLM, five crosses had TAP5 and three crosses had 32-2-5 as one of their parents. The crosses, JL24 x TAP5 and TMV2 x TAP5 recorded medium variance with low mean. One cross J11 x TAP5 showed low variance with medium mean value. Low variance with low mean was observed in five crosses viz., TMV2 x MH2, PGN1 x MH2, PGN1 x TAP5, PI350680 x TAP5 and PI259747 x 32-2-5.

4.5.1.10 Number of Aerial Pegs

In parents, the mean number of aerial pegs ranged between 8.60 and 65.67. The highest mean value was found in ICG 2271 (65.67) followed by M13 (47.80), MH2 (8.60) recorded the lowest mean value.

The ranges of means and variances in crosses were from 17.75 to 57.05 and 43.30 to 1583.78 respectively. High degree of variance with high mean was observed in three crosses viz., TMV2 x TMV2NLM (narrow leaf mutant), J11 x TAP5 (aerial podding mutant) and TMV2NLM x 32-2-5 (compact canopy mutant). Four crosses viz., TMV2 x TAP5, TMV2NLM x TAP5, M13 x MH2 and TMV2NLM x MH2 exhibited high degree of variance with medium mean. Medium degree of variance with high mean was found in four crosses viz., TMV2 x 32-2-5, GNLM x 32-2-5, PGN1 x TAP5 and MK374 x MH2. Fifteen crosses recorded medium degree of variance with medium mean of which seven crosses had TMV2NLM and four crosses had TAP5 as one of their parents. Medium degree of variance with low mean was recorded by JL24 x TAP5, Kadiri-3 x TMV2NLM, G201 x MH2 and MK374 x TAP5. None of the crosses showed low variance with high mean. Three crosses, M13 x TAP5, ICG2271 x TAP5 and JL24 x 32-2-5 exhibited low variance with medium mean. Low degree of variance with low mean was found in three crosses JL24 x MH2, Kadiri-3 x 32-2-5 and PI259747 x 32-2-5.

4.5.1.11 Number of Mature Pods

The parents recorded a range of 14.00 to 55.33 for this trait. The highest mean number of mature pods was found in Kadiri-3 (55.33). MH2 recorded the lowest number (14.00).

In crosses, the means and variances for this trait ranged from 22.88 to 67.08 and 86.25 to 1375.28 respectively. Out of 36 F_2's, five crosses exhibited high degree of variance with high mean viz., TMV2 x TMV2NLM (narrow leaf mutant), TMV2 x 32-2-5 (compact canopy mutant), Kadiri-3 x 32-2-5 and TMV2NLM x 32-2-5 and MK374 x MH2. High degree of variance was also observed in J11 x TMV2NLM and Kadiri-3 x TMV2NLM which recorded medium mean values. Two crosses, J11 x TAP5 and Kadiri-3 x MH2 exhibited medium degree of variance with high mean. Medium degree of variance with medium mean was observed in nineteen crosses. Out of these in seven crosses TAP5, in six crosses TMV2NLM and in two crosses 32-2-5 were involved as one of their parents. The crosses G201 x TAP5 and ICG2271 x TAP5 exhibited medium degree of variance with high mean. None of the crosses recorded low variance with high mean. Two crosses, PI350680 x TAP5 and PI259747 x 32-2-5 showed low variance with medium mean.

Low variance with low mean was recorded in four crosses viz., JL24 x TMV2NLM, JL24 x MH2, G201 x MH2 and JL24 x TAP5.

4.5.1.12 Mature Pod Weight

The mean mature pod weight ranged from 11.27 g to 51.10g in parents. Mature pod weight was the highest in Kadiri-3 (51.10 g) followed by 32-2-5 (41.28 g). The parent MH2 (11.27 g) showed the lowest mean for this trait.

The mean values and variances in crosses ranged from 20.20 g to 57.37 g and 119.32 to 1000.62 respectively. Among the 36 F_2 crosses, high degree of variance with high mean was recorded in five crosses viz., Kadiri-3 x 32-2-5 (compact canopy mutant), TMV2 x TMV2NLM (narrow leaf mutant), TMV2 x 32-2-5, TMV2NLM x 32-2-5 and PI259747 x 32-2-5. High degree of variance was also recorded by JL24 x TMV2NLM and Kadiri-3 x TMV2NLM which showed medium mean values. None of the crosses recorded high variance with low mean. Two crosses viz., J11 x TAP5 (aerial podding mutant) and PI350680 x TAP5 exhibited medium degree of variance with high mean. Medium degree of variance with medium mean was observed in 15 crosses, of which seven crosses had TAP5, six crosses had TMV2NLM and two crosses had 32-2-5 as one of their parents. Five crosses viz., JL24 x TAP5, ICG2271 x TAP5, M13 x TAP5, G201 x MH2 and JL24 x MH2 recorded medium degree of variance with low mean. Low degree of variance with medium mean was found in six crosses viz., TMV2 x MH2, PGN1 x MH2, M13 x TMV2NLM, Kadiri-3 x MH2, MK374 x MH2 and M13 x MH2. None of the crosses exhibited low variance with high mean and low variance with low mean.

4.5.1.13 Number of Mature Kernels

A range of 25.80 to 77.00 was observed in parents for this trait. Maximum number of mature kernels were found in Kadiri-3 (77.00) followed by J11 (70.40). The lowest mean number was recorded by MH2 (25.80).

The mean number of mature kernels and its variance ranged from 31.85 to 90.91 and 103.58 to 2805.90 respectively in crosses. High degree of variance with high mean was recorded in four crosses out of 36 F_2's viz., TMV2 x TMV2NLM (marrow leaf mutant), TMV2 x 32-2-5 (compact canopy mutant), TMV2NLM x 32-2-5 and M13 x TMV2NLM. High degree of variance was also found in three other crosses, Kadiri-3 x TMV2NLM, MK374 x TMV2NLM and PGN1 x TMV2NLM which recorded medium mean values. None of the crosses showed high variance with high mean. Medium degree of variance with high mean was observed in Kadiri-3 x 32-2-5, J11 x TAP5 (aerial podding mutant) and MK374 x MH2. Eighteen crosses expressed medium degree of variance with medium mean. Out of these, in eight crosses TAP5, in four crosses TMV2NLM and in two crosses 32-2-5 were involved as one of their parents. Two crosses recorded medium degree of variance with low mean viz., ICG2271 x TAP5 and JL24 x MH2. None of the crosses expressed low variance with high mean. Two crosses M13 x MH2 and PI259747 x 32-2-5 exhibited low variance with medium mean. Lower degrees of variances and low mean values were seen in M13 x TAP5, JL24 x TMV2NLM, G201 x MH2 and JL24 x TAP5.

4.5.1.14 Mature Kernel Weight

For the parents, the mean mature kernel weight recorded a range of 8.15 g to 37.66 g. Among the parents, the highest kernel weight was recorded by Kadiri-3 (37.66 g) MH2 (8.15 g) showed the lowest mean value.

Among the crosses, the mean values and variances for this trait ranged from 13.03 g to 37.11 g and 65.00 to 544.07 respectively. Five crosses, out of 36 F_2's viz., Kadiri-3 x 32-2-5, TMV2 x 32-2-5 (compact canopy mutant), TMV2 x TMV2NLM (narrow leaf mutant), J11 x TMV2NLM and PI259747 x 32-2-5 exhibitd high degree of variance with high mean mature kernel weight. High degree of variance was observed in two more crosses viz., TMV2NLM x 32-2-5 and JL24 x 32-2-5 which exhibited medium mean values. Two crosses viz., J11 x TAP5 (aerial podding mutant) and PGN1 x TMV2NLM expressed medium degree of variance with high mean values. Medium degree of variance with medium mean values were found in fifteen crosses, of which eight crosses had TAP5, six crosses had TMV2NLM and one cross had 32-2-5 as one of their parents. The crosses viz., GNLM x TAP5, ICG2271 x TAP5, GNLM x MH2, JL24 x MH2 and G201 x MH2 exhibited medium variance with low mean. Low degree of variance with medium mean was found in six crosses viz., TMV2 x MH2, PGN1 x MH2, M13 x TMV2NLM, M13 x MH2, MK374 x MH2 and Kadiri-3 x MH2. One cross M13 x TAP5 showed low variance with low mean. None of the crosses recorded low variance with high mean.

4.5.1.15 Total Dry Matter at Harvest

The parents recorded a range of 13.96 g to 86.04 g for mean dry matter at harvest. The dry matter production at harvest was maximum in ICG2271 (86.04 g). The lowest mean value was found in MH2 (13.96 g).

The ranges of means and variances in crosses were from 33.11 g to 108.94 g and 47.25 to 2975.45 respectively. High degree of variance was exhibited by seven crosses, of which four crosses viz., TMV2 x 32-2-5 (compact canopy mutant), G201 x TAP5 (aerial podding mutant), JL24 x 32-2-5 and JL24 x TMV2NLM (narrow leaf mutant) recorded high mean values and three crosses viz., MK374 x TMV2NLM, TMV2 x TMV2NLM and J11 x TMV2NLM showed medium mean values. None of the crosses expressed high variance with low mean. Medium degree of variance with high mean was observed in TMV2NLM x 32-2-5, M13 x TMV2NLM and M13 x MH2. Eighteen crosses exhibited medium degree of variance with medium mean, of which in eight crosses TAP5, in four crosses TMV2NLM and in two crosses 32-2-5 were involved as one of their parents. The crosses viz., Kadiri-3 X TMV2NLM, MK374 x MH2 and JL24 x MH2 exhibited medium variance with low mean, low variance with high mean and low variance with medium mean respectively. Lower degrees of variances with low mean values were observed in five crosses viz., PGN1 x MH2, JL24 x TAP5, MK374 x TAP5, PGN1 x TAP5 and PI259747 x 32-2-5.

4.5.1.16 Shelling Per cent

Mean shelling per cent ranged between 52.21% and 74.99% in parents. The highest shelling per cent was recorded in J11 (74.99%) followed by Kadiri-3 (74.69%) and TMV2 (73.09%). PI259747 showed the lowest mean value of 52.21%.

In crosses, the means and variances for this trait ranged from 58.69% to 75.94% and 9.21 to 1627.72 respectively. High degree of variance with high mean was found in four crosses viz., TMV2 x TMV2NLM (narrow leaf mutant), TMV2 x TAP5 (aerial podding mutant), GNLM x 32-2-5 (compact canopy mutant) and M13 x MH2. Three more crosses viz., TMV2NLM x TAP5, PGN1 x TMV2NLM and GNLM x MH2 also recorded higher degrees of variances with medium mean values. None of the crosses expressed high variance with low mean. Medium variance with high mean was recorded in PGN1 x MH2, MK374 x TAP5 and J11 x TAP5. Sixteen crosses exhibited medium degree of variance with medium mean values. Out of which, five crosses had TAP5, five crosses had TMV2NLM and one cross had 32-2-5 as one of their parents. Four crosses exhibited medium degree of variance with low mean values viz., TMV2NLM x MH2, ICG2271 x TAP5, JL24 x 32-2-5 and M13 x TMV2NLM. None of the crosses showed low variance with high mean. Low degree of variance with medium mean was expressed by four crosses viz., TMV2NLM x 32-2-5, TMV2 x 32-2-5, TMV2NLM x G201 and PI259747 x 32-2-5. Two crosses, PI350680 x TAP5 and G201 x TAP5 exhibited low degree of variance with low mean values.

4.5.1.17 Harvest Index

Among the parents, the mean harvest index values ranged from 17.53 to 54.27. Kadiri-3 (54.27) recorded the highest harvest index. The parent ICG2271 (17.53) exhibited the lowest mean value.

The means and variances of this trait ranged from 11.14 to 42.24 and 11.33 to 284.47 respectively in crosses. Out of 36 F_2's, *seven crosses exhibited high degree of variance, of which* three crosses viz., PGN1 x TAP5 (aerial podding mutant), Kadiri-3 x 32-2-5 (compact canopy mutant) and PGN1 x MH2 recorded high mean values and four crosses viz., M13 x TAP5, TMV2 x 32-2-5, Kadiri-3 x MH2 and TMV2 x TMV2NLM (narrow leaf mutant) showed medium mean values. The crosses, viz., J11 x TAP5, MK374 x TAP5 and TMV2 x MH2 expressed medium degree of variance with high mean. Medium degree of variances with medium mean values were seen in fifteen crosses, of which in six crosses TMV2NLM, in three crosses TAP5 and in two crosses 32-2-5 were involved as one of their parents. Five crosses viz., ICG2271 x TAP5, JL24 x 32-2-5, J11 x TMV2NLM, GNLM x TAP5 and JL24 x TMV2NLM expressed medium degree of variance with low mean values. Only one cross PI259747 x 32-2-5 exhibited low degree of variance with high mean. Low degree of variances with medium mean values were found in PI350680 x TAP5, TMV2NLM x TAP5, G201 x TMV2NLM and G201 x MH2. The cross G201 x TAP5 expressed low variance with low mean.

4.5.2 F_2 Generation (kharif)

4.5.2.1 Days to Initial Flowering

In parents, the mean days to initial flowering ranged from 28.00 days to 33.00 days. The parent TAP5 (28.00) recorded least number of days to initial flowering. More number of days was observed in M13 (33.00 days) and G201 (33.00 days).

In crosses, the mean values and variances ranged from 28.00 days to 32.47 days and 0.00 to 5.87 respectively. The crosses, TMV2 x TAP5 (aerial podding mutant) and JL24 x MH2BC28 (enhanced canopy mutant) recorded the lowest mean number of days to initial flowering which exhibited medium and low degree of variances respectively. The cross G201 x MH2BC28 showed the highest mean value with medium degree of variance. High degree of variance was found in four crosses, of which M13 x MH2 and M13 x TAP5 exhibited high mean and TMV2NLM (narrow leaf mutant) x MH2BC28 and TMV2NLM x TAP5 recorded medium mean values. Low mean with medium variance was observed in TMV2 x TAP5, JL24 x TAP5 and Kadiri-3 x MH2.

4.5.2.2 Days to 50 Per cent Fowering

The mean number of days to 50 per cent flowering ranged from 29.50 days to 36.00 days. The least number of days was recorded by TAP5 (29.50 days). The parents G201 (36.00), M13 (35.00) and TMV2NLM (35.00) recorded more number of days to 50 per cent flowering.

Among the crosses, the means and variances ranged from 30.00 days to 36.00 days and 0.00 to 4.27 respectively. Low mean

Table 21 : Mean performance of the parents (grown along with F_2 progenies in Kharif) for 17 characters.

Parents	Canopy Category	Days to initial flowering	Days to 50% flowering	Days to 100% flowering	Canopy diameter (cm)	Canopy circumference (cm)	Leaf area at 60 days (sq cm)	Plant height (cm)	Number of primaries	Number of secondaries
MH2	1	29.00	31.50	33.00	20.70	66.40	372.89	6.00	4.00	1.00
JL24	2	29.00	31.00	34.00	48.17	157.89	1073.94	28.00	4.75	1.00
TMV2	2	30.00	31.50	33.00	50.42	160.00	1295.89	37.29	4.57	1.29
MH2BC28	2	29.00	30.50	32.50	52.20	165.00	1103.91	29.00	6.80	5.60
G201	2	33.00	36.00	38.50	46.00	151.25	1351.40	26.86	5.86	8.71
TAP5	3	28.00	29.50	31.50	60.29	184.57	1309.33	48.00	3.50	0.75
Kadiri-3	3	32.00	34.00	36.50	59.44	185.00	1456.83	28.50	5.00	4.17
TMV2NLM	3	32.50	35.00	36.00	60.75	186.25	1359.82	27.20	9.00	18.20
M13	4	33.00	35.00	36.50	66.31	190.88	1442.81	27.75	7.38	10.88

Parents	Canopy Category	Number of aerial pegs	Number of mature pods	Mature pod weight (g)	Number of mature kernels	Mature kernel weight (g)	Total dry matter at harvest (g)	Shelling per cent	Harvest index
MH2	1	6.00	8.50	5.67	16.10	3.01	7.64	53.49	33.31
JL24	2	5.50	14.50	15.74	19.25	11.56	20.69	76.63	38.68
TMV2	2	10.00	15.22	10.53	22.63	6.55	18.10	69.44	28.05
MH2BC28	2	25.40	14.50	10.59	23.00	6.08	19.55	59.78	24.77
G201	2	17.86	22.14	17.48	28.86	7.56	28.05	52.47	24.71
TAP5	3	25.50	20.50	13.56	25.75	6.30	24.54	51.17	21.50
Kadiri-3	3	14.50	33.50	39.34	47.50	21.76	32.05	57.62	38.39
TMV2NLM	3	30.20	13.60	9.79	15.65	4.92	33.62	55.30	15.26
M13	4	39.50	13.56	19.19	19.89	12.12	37.00	62.10	29.60

Table 22 : Means and variances of 21 F_2 progenies (grown in _kharif_) for 17 characters.

Crosses	Canopy Combination	Days to initial flowering	Days to 50% flowering	Days to 100% flowering	Canopy diameter (cm)	Canopy circumference (cm)	Leaf area at 60 days (sq. cm.)	Plant Height (cm)	Number of primaries	Number of secondaries
G201 X MH2	(2 x 1)	31.00	35.25	37.00	46.09	146.00	1276.23	26.33	6.22	9.44
		2.29	1.36	1.14	57.19	530.60	202976.44	105.50	10.69	38.28
G201 X MH2BC28	(2 X 2)	32.47	35.13	36.47	49.54	152.84	2111.34	25.60	9.33	10.07
		0.98	0.41	0.55	230.14	3385.10	862924.75	118.97	20.38	96.50
JL24 X MH2	(2 x 1)	28.25	30.63	33.38	45.22	147.11	926.28	23.50	4.10	1.75
		0.21	1.41	1.70	49.31	377.00	159503.47	53.43	0.57	3.64
JL24 X MH2BC28	(2 X 2)	28.00	30.00	32.50	49.36	151.00	1425.38	30.54	4.38	1.23
		0.00	1.00	1.00	108.88	855.86	310754.91	71.77	0.76	6.53
Kadiri-3 X MH2	(3 x 1)	28.50	33.00	35.75	55.75	178.25	1538.36	22.20	4.50	1.70
		1.00	4.00	0.92	57.79	535.21	103873.60	59.51	1.61	5.12
Kadiri-3 X MH2BC28	(3 x 2)	30.27	34.07	36.20	62.10	197.80	2026.65	31.95	7.00	5.71
		3.35	3.64	3.46	224.32	1100.62	594343.44	98.85	17.60	50.01
TMV2NLM X MH2	(3 x 1)	30.90	35.50	36.60	52.00	145.60	1114.50	25.13	6.42	9.08
		2.99	0.28	0.27	57.63	575.69	127736.63	95.51	4.51	39.42
TMV2NLM X MH2BC28	(3 x 2)	30.50	34.75	36.25	50.17	160.22	1830.57	21.18	7.18	9.98
		3.67	3.58	0.92	130.38	1704.71	713960.75	62.56	9.36	40.16
M13 X MH2	(4 x 1)	31.67	34.67	36.67	40.88	143.88	1030.41	23.00	5.78	7.83
		5.87	4.27	2.27	17.20	290.13	160135.95	153.29	2.65	16.38
MH2BC28 X M13	(2 X 4)	29.38	32.00	34.25	56.50	171.78	1634.97	32.44	4.75	3.13
		0.84	3.43	2.21	111.38	733.44	389020.13	78.53	1.53	10.25
MH2BC28 X TMV2	(2 X 2)	28.67	30.00	32.00	46.83	150.00	1442.25	31.00	4.80	2.14
		0.33	0.00	0.00	120.58	700.00	272420.91	49.50	3.20	3.08

Table 22 : Continued...

Crosses	Canopy Combi- nation	Days to initial flower- ing	Days to 50% flower- ing	Days to 100% flower- ing	Canopy diame- ter (cm)	Canopy circum- ference (cm)	Leaf area at 60 days (sq. cm.)	Plant Height (cm)	Number of pri- maries	Number of secon- daries
TMV2NLM X TMV2	(3 x 2)	30.00	34.75	36.17	50.05	169.27	1456.18	28.68	10.56	12.00
		2.73	0.75	0.88	299.87	1208.82	813182.00	57.31	26.42	57.00
TMV2 X TAP5	(2 x 3)	28.00	30.67	33.83	51.21	148.00	1440.94	35.67	4.42	2.75
		1.60	1.87	2.17	162.82	1366.33	223195.00	167.52	1.17	29.30
TMV2NLM X TAP5	(3 x 3)	30.50	34.00	36.00	58.50	182.17	2015.35	40.29	5.14	1.71
		4.50	0.00	0.00	158.50	4062.17	408927.78	252.24	2.14	3.57
G201 X TAP5	(2 x 3)	30.00	34.33	36.58	56.92	188.92	1560.29	35.95	6.09	9.59
		1.82	2.61	4.99	255.62	1859.24	298414.63	74.14	3.52	65.49
JL24 X TAP5	(2 x 3)	28.50	31.00	33.75	50.90	155.00	1326.11	25.14	5.43	1.57
		1.67	1.33	1.58	240.92	1500.00	317814.92	82.81	2.62	7.95
Kadiri-3 X TAP5	(3 x 3)	30.63	33.50	35.88	65.40	206.00	1447.48	33.53	5.33	4.20
		1.98	2.86	4.41	262.32	1954.44	662147.03	53.12	3.10	37.74
M13 X TAP5	(4 x 3)	31.29	36.00	37.43	55.23	176.00	1409.89	28.89	6.39	8.06
		3.76	1.85	1.49	81.97	657.40	138704.69	83.28	1.90	46.17
G201 X JL24	(2 x 2)	30.90	33.70	35.80	54.72	166.56	2288.72	27.94	5.44	5.06
		1.21	1.79	0.84	116.01	949.78	523182.00	26.86	3.46	25.26
Kadiri-3 X JL24	(3 x 2)	29.56	32.25	34.88	65.21	202.71	1639.15	29.29	6.57	4.29
		0.66	0.73	0.12	260.24	1059.90	589443.06	31.51	2.96	16.81
M13 X JL24	(4 x 2)	29.00	33.00	35.50	54.28	191.33	1341.83	38.62	5.85	4.46
		0.00	0.00	0.50	80.57	500.25	106136.75	131.92	3.64	8.77

Table 22 : Continued...

Crosses	Canopy Combi-nation	Number of aerial pegs	Number of mature pods	Mature pod weight (g)	Number of mature kernels	Mature kernel weight (g)	Total dry matter at harvest (g)	Shell-ing per cent	Harvest Index
G201 X MH2	(2 x 1)	7.11	11.88	7.54	11.67	3.67	31.21	46.98	11.99
		291.86	136.41	58.36	139.55	15.84	298.62	81.77	71.64
G201 X MH2BC28	(2 X 2)	16.47	19.93	15.33	20.47	6.60	30.99	46.42	18.47
		543.27	161.15	134.12	149.75	51.34	516.40	335.77	224.71
JL24 X MH2	(2 x 1)	3.25	13.86	11.76	20.14	5.67	15.41	58.79	30.49
		43.36	57.14	32.64	91.14	11.40	14.55	102.07	205.24
JL24 X MH2BC28	(2 X 2)	6.92	13.15	10.01	17.38	4.92	21.93	63.58	21.13
		56.24	75.81	122.64	112.76	26.70	88.35	372.60	214.56
Kadiri-3 X MH2	(3 x 1)	11.50	13.90	10.03	19.40	4.20	21.02	66.79	24.56
		222.28	14.10	25.62	70.93	13.92	81.07	253.01	91.14
Kadiri-3 X MH2BC28	(3 x 2)	19.52	20.10	15.39	24.90	7.95	31.53	57.05	21.87
		236.66	89.88	209.13	219.89	80.94	157.78	264.01	166.56
TMV2NLM X MH2	(3 x 1)	13.29	8.09	6.21	8.64	2.27	31.66	45.58	10.72
		139.17	15.69	10.21	22.25	14.50	191.64	134.95	30.45
TMV2NLM X MH2BC28	(3 x 2)	16.45	15.43	10.77	18.39	4.55	33.55	53.10	15.64
		178.47	74.98	136.08	133.34	56.35	264.16	266.69	179.84
M13 X MH2	(4 x 1)	16.94	11.00	10.00	19.39	7.06	27.01	77.38	26.45
		263.47	34.11	29.16	127.31	13.50	140.82	151.64	200.11
MH2BC28 X M13	(2 X 4)	10.38	15.00	14.78	21.53	8.13	23.09	67.90	28.37
		89.72	52.94	81.87	209.70	27.33	159.76	302.09	188.26
MH2BC28 X TMV2	(2 X 2)	8.80	10.60	11.74	18.40	4.93	14.60	81.58	32.86
		105.20	23.30	80.03	106.30	22.88	13.01	299.15	252.31

Table 22 : Continued...

Crosses	Canopy Combination	Number of aerial pegs	Number of mature pods	Mature pod weight (g)	Number of mature kernels	Mature kernel weight (g)	Total dry matter at harvest (g)	Shelling per cent	Harvest Index
TMV2NLM X TMV2	(3 x 2)	33.08	16.50	11.16	21.72	6.04	40.66	64.31	15.29
		697.08	88.90	150.53	259.79	53.22	274.76	495.03	68.99
TMV2 X TAP5	(2 x 3)	8.42	19.08	12.22	22.42	6.92	21.22	65.99	28.55
		137.36	117.17	190.11	198.08	38.90	12.16	110.56	260.72
TMV2NLM X TAP5	(3 x 3)	7.57	12.20	10.83	19.00	6.01	23.64	66.47	23.05
		211.95	201.18	158.02	187.90	51.72	233.73	541.17	189.68
G201 X TAP5	(2 x 3)	15.68	14.52	11.45	17.67	5.80	42.36	66.05	14.37
		74.80	56.36	162.19	137.43	34.68	401.86	227.25	113.75
JL24 X TAP5	(2 x 3)	12.14	15.57	10.23	16.71	4.25	27.49	54.17	17.74
		177.81	72.62	121.51	41.24	35.71	165.94	339.98	123.77
Kadiri-3 X TAP5	(3 x 3)	18.00	17.07	11.39	21.00	6.09	38.23	62.37	15.92
		238.86	157.78	166.28	162.86	67.42	309.86	236.37	104.20
M13 X TAP5	(4 x 3)	20.67	17.78	9.90	20.22	4.04	41.05	51.29	16.37
		332.71	59.36	50.28	116.07	16.09	284.97	184.06	54.56
G201 X JL24	(2 x 2)	7.81	12.62	11.38	16.56	6.15	28.67	63.63	22.63
		126.70	21.32	40.14	42.13	13.12	342.81	475.00	202.44
Kadiri-3 X JL24	(3 x 2)	19.62	23.76	20.12	28.81	10.92	35.58	64.49	25.25
		195.75	107.89	140.33	201.26	61.64	192.62	362.73	230.58
M13 X JL24	(4 x 2)	14.08	16.23	15.03	21.23	7.69	41.53	51.60	15.70
		186.08	113.53	58.96	108.86	29.31	197.30	209.39	153.82

Note : For each cross above value indicates mean and below value indicates variance of that particular character values were observed in JL24 x MH2BC28 (enhanced canopy mutant), JL24 x MH2 and TMV2 x TAP5 (aerial podding mutant) which exhibited medium degree of variance. Two crosses viz., M13 x TAP5 and G201 x MH2 showed high mean values and medium degree of variance. The crosses viz., M13 x MH2, Kadiri-3 x MH2, Kadiri-3 x MH2BC28 and TMV2NLM (narrow leaf mutant) x MH2BC28 exhibited high degree of variance with medium mean days to 50 per cent flowering.

4.5.2.3 Days to 100 Per cent Flowering

The range of mean number of days to 100 per cent flowering was between 31.50 days and 38.50 days. The TAP5 (31.50 days) recorded the least number of days to 100 per cent flowering. The highest mean value was found in G201 (38.50 days).

In crosses, the ranges of means and variances were from 32.00 days to 37.43 days and 0.00 to 4.99 respectively. Out of 21 crosses, three crosses recorded low mean number of days, of which JL24 x MH2BC28 (enhanced canopy mutant) and JL24 x MH2 recorded medium degree of variance and MH2BC28 x TMV2 showed low degree of variance. The cross, G201 x TAP5 (aerial podding mutant) exhibited the highest degree of variance with high mean value. Two crosses viz., Kadiri-3 x TAP5 and Kadiri-3 x MH2BC28 also exhibited high degree of variance with medium mean number of days to 100 per cent flowering. The highest mean value was recorded by M13 x TAP5 followed by G201 x MH2, M13 x MH2 and TMV2NLM (narrow leaf mutant) x MH2 which exhibited medium degree of variance.

4.5.2.4 Canopy Diameter

The range of mean values for the parents was from 20.70 cm to 66.31 cm. The canopy diameter was high in M13 (66.31 cm) followed by TMV2NLM (60.75 cm) and TAP5 (60.29 cm). The lowest mean diameter was observed in MH 2 (20.70 cm).

Among the crosses, the mean values and variances ranged from 40.88 cm to 65.40 cm and 17.20 to 311.38. Out of 21 F_2's, two crosses viz., Kadiri-3 x TAP5 (aerial podding mutant) and Kadiri-3 x JL24 recorded high variance with high mean for this trait. High variance with medium mean was found in TMV2NLM x MH2BC28 (enhanced canopy mutant) and TMV2NLM (narrow leaf mutant) x TMV2. The crosses viz., TMV2NLM x TAP5 and Kadiri-3xMH2BC28 exhibited medium variance with high mean. Eleven crosses showed medium variance with medium mean, in which TAP5 was involved in four crosses and MH2BC28 in five crosses. Medium variance with low mean was recorded by only one cross G201 x MH2. Two crosses viz., TMV2NLM x MH2 and Kadiri-3 x MH2 exhibited low variance with medium mean values for this trait. The crosses viz., JL24 x MH2 and M13 x MH2 recorded low variance with low mean.

4.5.2.5 Canopy Circumference

The mean canopy circumference ranged from 66.40 cm to 190.88 cm. The highest canopy circumference was observed in M13 (190.88 cm) followed by TMV2NLM (186.25 cm), Kadiri-3 (185.00 cm) and TAP5 (184.57 cm). The parent MH2 (66.40 cm) showed the lowest canopy circumference.

For the crosses the ranges of mean values and variances were from 143.88 cm to 206.00 cm and 290.13 to 4062.17 respectively. Among the 21 F_2 crosses, one cross Kadiri-3 x TAP5 (aerial podding mutant) exhibited high variance with high mean. Three crosses viz., TMV2NLM (narrow leaf mutant) x TAP5, G201 x MH2BC28 (enhanced canopy mutant) and G201 x TAP5 recorded high variance with medium mean. Medium variance with high mean was observed in Kadiri-3 x MH2BC28 and Kadiri-3 x JL24. Nine crosses viz., TMV2NLM x MH2BC28, JL24 x TAP5, TMV2 x TAP5, TMV2NLM x TMV2, G201 x JL24, JL24 x MH2BC28, MH2BC28 x TMV2, M13 x TAP5 and MH2BC28 x M13 exhibited medium degree of variance with medium mean. One cross, TMV2NLM x MH2 showed medium variance with low mean. The cross M13 x JL24 recorded low variance with high mean and the cross Kadiri-3 x MH2 showed low variance with medium mean. Low degree of variance with low mean was found in G201 x MH2, JL24 x MH2 and M13 x MH2.

4.5.2.6 Leaf Area at 60 Days

The range of mean leaf area at 60 days was between 372.89 cm^2 and 1456.83 cm^2. The parent Kadiri-3 (1456.83 cm^2) showed the highest leaf area followed by M13 (1442.81 cm^2) at 60 days duration. The leaf area observed in MH2 (372.89 cm^2) was the lowest.

In crosses, the ranges of mean values and variances were from 926.88 cm^2 to 2288.72 cm^2 and 100135.95 to 862924.75 respectively. Out of 21 F_2 crosses, only one cross G201 x MH2BC28 (enhanced canopy mutant) exhibited high variance with high mean value. High degree of variances with medium mean values were observed in TMV2NLM (narrow leaf mutant) x MH2BC28, TMV2NLM x TMV2 and Kadiri-3 x TAP 5 (aerial podding mutant). In all the four crosses which exhibited high degree of variance, induced mutants were involved as one of their parents. Three crosses viz., Kadiri-3 x MH2BC28, G201 x JL24 and TMV2NLM x TAP5 showed medium degree of variance with high mean. Seven crosses exhibited medium degree of variance with medium mean viz., JL24 x MH2BC28, MH2BC28 x TMV2, TMV2 x TAP5, G201 x TAP5, JL24 x TAP5, MH2BC28 x M13 and Kadiri-3 x JL24. Three crosses viz., G201 x MH2, M13 x MH2 and JL24 x MH2 recorded medium variance with low mean. Low variance with medium mean was observed in M13 x TAP5, M13 x JL24 and Kadiri-3 x MH2. One cross TMV2NLM x MH2 exhibited low variance with low mean. None of the crosses recorded high variance with low mean and low variance with high mean.

4.5.2.7 Plant Height

For the parents, the mean plant height ranged between 6.00 cm and 48.00 cm. Maximum plant height was observed in TAP5 (48.00 cm). The mean plant height was the lowest in MH2 (6.00cm).

The ranges of means and variances for this trait among crosses were from 21.18 cm to 40.29 cm and 26.86 to 252.24 respectively. High variance with high mean was observed in TMV2NLM (narrow leaf mutant) x TAP5 (aerial podding mutant), TMV2 x TAP5 and M13 x JL24. One cross M13 x MH2 exhibited high degree of variance with low mean plant height. Medium degree of variance was observed in 14 crosses, of which one cross G201 x TAP5 showed high mean, two crosses TMV2NLM x MH2BC28 (enhanced canopy mutant) and Kadiri-3 x MH2 recorded low mean values and remaining crosses exhibited medium mean values for this trait. Low variance with medium mean value was found in three crosses viz., MH2BC28 x TMV2, Kadiri-3 x JL24 and G201 x JL24.

4.5.2.8 Number of Primaries

The range of mean values for number of primaries in parents was between 3.50 and 9.00. TMV2NLM (9.00) recorded the highest number of primaries, while the lowest number was found in TAP5 (3.50) followed by MH2 (4.00).

In crosses, the means and variances for number of primaries ranged from 4.10 to 10.56 and 0.57 to 26.42 respectively. The crosses viz., TMV2NLM (narrow leaf mutant) x TMV2, G201 x MH2BC28 (enhanced canopy mutant) and Kadiri-3 x MH2BC28 recorded high degree of variance with high mean in which the induced mutants were involved as one of the parents. One cross G201 x MH2 showed high variance with medium mean. The cross TMV2NLM x MH2BC28 exhibited medium variance with high mean. Medium degree of variance with medium mean was recorded by thirteen crosses, of which eight crosses had the mutants as one of their parents viz., TMV2NLM x MH2, G201 x TAP 5 (aerial podding mutant), Kadiri-3 x TAP5, JL24 x TAP5, TMV2NLM (narrow leaf mutant) x TAP5, M13 x TAP5, MH2BC28 (enhanced canopy mutant) x TMV2 and MH2BC28 x M13. Low variance with low mean was observed in three crosses viz., TMV2 x TAP5, JL24 x MH2BC28 and JL24 x MH2. None of the crosses exhibited high variance with high mean, medium variance with low mean, low variance with high mean, and low variance with medium mean.

4.5.2.9 Number of Secondaries

The mean values for this trait ranged from 0.75 to 18.20 in parents. The parent TMV2NLM (18.20) recorded the highest number of secondaries. The lowest number was found in TAP5 (0.75) followed by MH2 (1.00), JL 24 (1.00) and TMV2 (1.29).

The means and variances in crosses ranged from 0.00 to 12.00 and 0.00 to 96.50 respectively. Among 21 crosses, three crosses exhibited high degree of variance with high mean viz., G201 x MH2BC28 (enhanced canopy mutant), TMV2NLM (narrow leaf mutant) x TMV 2 and G201 x TAP5 (aerial podding mutant). The cross Kadiri-3 x MH2BC28 recorded high degree of variance with medium mean. The mutants were involved as one of the parents in all the above crosses which showed high degree of variance. Only one cross TMV2NLM x MH2BC28 exhibited medium degree of variance with high mean number of secondaries. Eleven crosses recorded medium degree of variance with medium mean, of which five crosses viz., M13 x TAP5, TMV2NLM x MH2, Kadiri-3 x TAP5, TMV2 x TAP5 and MH2BC28 x M13 had the mutants as one of their parents. Two crosses viz., JL24 x TAP5 and JL24 x MH2BC28 showed medium variance with low mean. The crosses viz., TMV2NLM x TAP5, MH2BC28 x TMV2 and JL24 x MH2 recorded low degree of variance with medium mean. None of the crosses showed high variance with low mean, low variance with high mean and low variance with low mean.

4.5.2.10 Number of Aerial Pegs

In parents, the mean number of aerial pegs ranged between 5.50 to 39.50. More number of aerial pegs was observed in M13 (39.50), TMV2NLM (30.20), TAP5 (25.50) and MH2BC28 (25.40). The parent JL24 (5.50) followed by MH2 (6.00) recorded less number of aerial pegs.

For the crosses, the ranges of means and variances were from 3.25 to 33.08 and 43.36 to 697.08 respectively. High degree of variance was observed in TMV2NLM (narrow leaf mutant) x TMV2 and M13 x TAP5 (aerial podding mutant) which also exhibited high mean values. Two crosses viz., G201 x MH2BC28 (enhanced canopy mutant) and G201 x MH2 recorded high degree of variance with medium mean. Medium degree of variance with high mean was found in Kadiri-3 x MH2BC28 and Kadiri-3 x JL24. Eleven crosses exhibited medium variance with medium mean for this trait, of which in seven crosses the mutants viz., TAP5, MH2BC28 and TMV2NLM were involved. The crrosses viz., TMV2NLM x TAP5 and G201 x TAP5 showed medium variance with low mean and low variance with medium mean respectively. Low variance with low mean was observed in JL24 x MH2BC28 and JL24 x MH2.

4.5.2.11 Number of Mature Pods

Among the parents, the mean number of mature pods ranged from 8.50 to 33.50. Kadiri-3 (33.50) recorded the highest number of mature pods, while the lowest number was found in MH2 (8.50).

The mean values and variances for the crosses ranged from 8.09 to 23.76 and 14.10 to 201.18 respectively. Out of 21 crosses, only one cross G201 x MH2BC28 (enhanced canopy mutant) exhibited high degree of variance with high mean value. Two crosses viz., TMV2NLM (narrow leaf mutant) x TAP5 (aerial podding mutant) and Kadiri-3 x TAP5 recorded high degree of variance with medium mean values. The above crosses which exhibited higher degrees of variances had the mutants as one of their parents. High degree of variance with low mean was found in one cross G201 x MH2. High mean values were observed in three crosses viz., Kadiri-3 x JL24, Kadiri-3 x MH2BC28 and TMV2 x TAP5 which exhibited medium degree of variance. Medium degree of variance with medium mean was found in nine crosses, of which mutants were involved in seven crosses. Out of these seven crosses, MH2BC28 was involved in three crosses viz., TMV2NLM x MH2BC28, JL24 x MH2BC28 and MH2BC28 x M13, TAP5 in three crosses G201 x TAP5, JL24 x TAP5 and M13 x TAP5 and TMV2NLM in one cross TMV2NLM x TMV2. The crosses, M13 x MH2 and MH2BC28 x TMV2 recorded medium variance with low mean. Low degree of variance with medium mean was recorded by Kadiri-3 x MH2 and G201 x JL24. One cross, TMV2NLM x MH2 showed low variance with low mean. None of the crosses exhibited low variance with high mean for this trait.

4.5.2.12 Mature Pod Weight

The mean mature pod weight ranged between 5.67 g and 39.34 g in parents. The mature pod weight found in Kadiri-3 (39.34 g) was the highest among the parents. MH2 (5.67 g) followed by TMV2NLM (9.79 g) recorded the lowest pod weight.

In crosses, the means and variances for this trait ranged from 6.21 g to 20.12 g and 10.21 to 209.13 respectively.

Among the 21 crosses, one cross Kadiri-3 x MH2BC28 (enhanced canopy mutant) exhibited high degree of variance with high mean. High degree of variance was also observed in TMV2 x TAP5 (aerial podding mutant), Kadiri-3 x TAP5 and G201 x TAP5 which recorded medium mean values. None of the crosses showed high variance with low mean. The crosses, G201 x MH2BC28 and Kadiri-3 x JL24 exhibited medium variance with high mean. Nine crosses exhibited medium degree of variance with medium mean, of which in seven crosses mutants were involved as one of their parents viz., JL24 x TAP5, TMV2NLM x TAP5, TMV2NLM x TMV2, MH2BC28 x TMV2, TMV2NLM x MH2BC28, JL24 x MH2BC28 and MH2BC28 x M13. Two crosses, G201xMH2 and M13 x TAP5 showed medium variance with low mean. Low degree of variance with medium mean was found in JL24 x MH2, M13 x MH2 and Kadiri-3 x MH2. The cross TMV2NLM x MH2 showed low variance with low mean. None of the crosses recorded low variance with high mean.

4.5.2.13 Number of Mature Kernels

In parents, the mean number of mature kernels ranged between 15.65 and 47.50. The highest number of mature kernels was observed in Kadiri-3 (47.50). The lowest number was recorded by TMV2NLM (15.65) followed by MH2 (16.10).

For the crosses, the mean values and variances ranged from 8.64 to 28.81 and 22.25 to 259.79 respectively. Out of 21 F_2 crosses, three crosses viz., TMV2NLM (narrow leaf mutant) x TMV2, Kadiri-3 x MH2BC28 (enhanced canopy mutant) and Kadiri-3 x JL24 exhibited high degree of variance with high mean values.

High degree of variance was also recorded in MH2BC28 x M13 which showed medium mean value. None of the crosses showed high variance with low mean. The cross, TMV2 x TAP5 (aerial podding mutant) recorded medium variance with high mean. Medium degree of variance with medium mean was observed in eleven crosses, of which the mutant TAP5 was involved in four crosses viz., TMV2NLM x TAP5, G201 x TAP5, Kadiri-3 x TAP5 and M13 x TAP5 and the mutant MH2BC28 was involved in four crosses viz., G201 x MH2BC28, JL24 x MH2BC28, MH2BC28 x TMV2 and TMV2NLM x MH2BC28. The cross, G201 x MH2 recorded medium variance with low mean. Low degree of variance with medium mean was found in Kadiri-3 x MH2 and JL24 x TAP5. Two crosses viz., G201 x JL24 and TMV2NLM x MH2 showed low variance with low mean. None of the crosses exhibited low variance with high mean.

4.5.2.14 Mature Kernel Weight

The range of mean values for this trait was between 3.01 g and 21.76 g in parents. The parent, Kadiri-3 (21.76 g) recorded the highest mean value for this trait. MH2 (3.01 g) exhibited the lowest mean kernel weight.

The means of mature kernel weight and its variances were ranging from 2.27 g to 10.92 g and 11.40 to 80.94 respectively in crosses. High degree of variance was observed in four crosses, of which two crosses viz., Kadiri-3 x MH2BC28 (enhanced canopy mutant) and Kadiri-3 x JL24 recorded high mean kernel weight and two crosses viz., Kadiri-3 x TAP5 (aerial podding mutant) and TMV2NLM (narrow leaf mutant) x MH2BC28 showed medium mean values.

None of the crosses recorded high variance with low mean. Medium degree of variance with high mean was found in M13 x JL24 and MH2BC28 x M13. Out of eight crosses which exhibited medium degree of variance with medium mean, four crosses viz., JL24 x TAP5, G201 x TAP5, TMV2NLM x TAP5 and TMV2 x TAP5 had TAP5, three crosses viz., G201 x MH2BC28, JL24 x MH2BC28 and MH2BC28 x TMV2 had MH2BC28 and one cross TMV2NLM x TMV2 had TMV2NLM as one of their parents. Three crosses viz., M13 x TAP5, G201 x MH2, TMV2NLM x MH2 expressed medium degree of variance with low mean values. Low degree of variance with medium mean values were found in Kadiri-3 x MH2, M13 x MH2, G201 x JL24 and JL24 x MH2. None of the crosses showed low variance with high mean and low variance with low mean.

4.5.2.15 Total Dry Matter at Harvest

Mean total dry matter at harvest ranged from 7.64 g to 37.00 g in parents. For this trait, the highest mean value was recorded in M13 (37.00 g) followed by TMV2NLM (33.62 g) and Kadiri-3 (32.05 g). The lowest mean value was found in MH2 (7.64 g).

Among the crosses, the means and variances ranged from 14.60 g to 42.36 g and 13.01 to 516.40 respectively. High degree of variance was observed in four crosses, of which one cross, G201 x TAP5 (aerial podding mutant) showed high mean and three crosses viz., G201 x MH2BC28 (enhanced canopy mutant), G201 x JL24 and Kadiri-3 x TAP5 exhibited medium mean values. Medium degree of variance with medium mean was recorded by M13 x TAP5, TMV2NLM (narrow leaf mutant) x TMV2 and M13 x JL24. Ten crosses exhibited medium variance with medium mean, of which in seven crosses the mutants viz., TAP5, MH2BC28 and TMV2NLM were involved as one of their parents. Low degree of variance with medium mean was recorded by JL24 x MH2BC28 and Kadiri-3 x MH2. Two crosses viz., JL24 x MH2 and MH2BC28 x TMV2 exhibited low variance with low mean. None of the crosses exhibited high variance with low mean, medium variance with low mean and low variance with high mean.

4.5.2.16 Shelling Per cent

Mean values for shelling per cent ranged between 51.17 per cent to 76.63 per cent in parents. Maximum shelling per cent was observed in JL24 (76.63%) followed by TMV2 (69.44%) and M13 (62.10%). TAP5 (51.17%) recorded the lowest mean value followed by G201 (52.47%) and MH2 (53.49%).

The means and variances for the crosses ranged from 45.58 per cent to 81.58 per cent and 81.77 to 541.17 respectively. None of the crosses exhibited high degree of variance with high mean for this trait. Four crosses viz., TMV2NLM (narrow leaf mutant) x TAP5 (aerial podding mutant), TMV2NLM x TMV2, G201 x JL24 and JL24 x MH2BC28 (enhanced canopy mutant) recorded high degree of variance with medium mean, of which three crosses had mutants as one of the parents. Medium variance with high mean was observed in MH2BC28 x M13, MH2BC28 x TMV2, M13 x MH2 and Kadiri-3 x MH2. Eight crosses exhibited medium variance with medium mean, of which TAP5 was involved in four crosses and

MH2BC28 in two crosses. Two crosses viz., G201 x MH2BC28 and TMV2NLM x MH2 recorded medium variance with low mean. The crosses viz., TMV2 x TAP5 and JL24 x MH2 showed low variance with medium mean. Only one cross, G201 x MH2 exhibited low variance with low mean. None of the crosses expressed high variance with low mean and low variance with high mean value.

4.5.2.17 Harvest Index

In parents, the mean harvest index ranged from 15.26 to 38.68. The highest harvest index was found in JL24 (38.68) followed by Kadiri-3 (38.39). TMV2NLM (15.26) recorded the lowest mean value.

The ranges of means and variances in crosses were from 10.72 to 32.86 and 30.45 to 260.72 respectively. Out of 21 crosses, four crosses exhibited high degree of variance of which two crosses TMV2 x TAP5 (aerial podding mutant) and MH2BC28 (enhanced canopy mutant) x TMV2 recorded high mean and two crosses Kadiri-3 x JL24 and G201 x MH2BC28 showed medium mean values. Three crosses, out of above four crosses had mutants as one of their parents. The crosses, JL24 x MH2 and MH2BC28 x M13 recorded medium variance with high mean. Ten crosses exhibited medium variance with medium mean, of which three crosses had TAP5 and three crosses had MH2BC28 as one of their parents. Medium variance with low mean was observed in G201 x TAP5 and G201 x MH2. Two crosses viz., TMV2NLM x TMV2 and M13 x TAP5 recorded low variance with medium mean values. One cross TMV2NLM x MH2 exhibited low variance with low mean. None of the crosses recorded high variance with low mean and low variance with high mean.

4.6 COMPARISON OF MEANS AND VARIANCES OF CROSSES INVOLVING PARENTS AND THEIR RESPECTIVE MUTANTS FOR IMPORTANT CHARACTERS

The means and variances of the following 10 crosses involving induced mutants were compared interms of percentage increase or decrease over the parental crosses for the important canopy and reproductive attributes in F_2 generation. The data are furnished in table 23.

4.6.1 G201 x MH2 and G201 x MH2BC28

In F_2 generation increased means and variances were observed for most of the characters in the crossesG201 x MH2BC28 (enhanced canopy mutant of MH2) as compared to the parental cross G201 x MH2. Enhanced mean values were recorded for canopy diameter (7.5%), canopy circumference (4.5%), leaf area at 60 days (65.4%), number of primaries (50.0%), number of secondaries (6.7%), number of mature pods (67.8%), mature pod weight (103.3%), number of mature kernels (75.4%), mature kernel weight (79.8%) and harvest index (68.8%) in the cross G201 x MH2BC28 over parental cross. However, slightly reduced mean values were observed for total dry matter at harvest (-0.7%) and shelling per cent (-1.2%). The cross G201 x MH2BC28 exhibited enhanced variances for all the characters viz., canopy diameter (302.4%), canopy circumference (537.9%), leaf area at 60 days (325.1%),

Table 23 : Comparision of means and variances of crosses involving parents and their respective mutants for important characters.

Crosses	Canopy diameter (cm)		Canopy circum-farence (cm)		Leaf area at 60 days (sq.cm)		Number of prima-ries		Number of secon-daries		Number of mature pods	
G201 X MH2	46.09		146.00		1276.23		6.22		9.44		11.88	
	57.19		530.60		202976.44		10.69		38.28		136.41	
G201 X MH2BC28	49.54	(7.5)	152.54	(4.5)	2111.34	(65.4)	9.33	(50.0)	10.07	(6.7)	19.93	(67.8)
	230.14	(302.4)	3385.10	(537.9)	862924.75	(325.1)	20.38	(90.6)	96.50	(152.1)	161.15	(18.1)
JL24 X MH2	45.22		147.11		926.28		4.10		1.75		13.86	
	49.31		377.00		159503.47		0.57		3.64		57.14	
JL24 X MH2BC28	49.36	(9.2)	151.00	(2.6)	1425.38	(53.9)	4.38	(6.8)	1.23	(-29.7)	13.15	(-5.1)
	108.88	(120.8)	855.86	(127.0)	310754.91	(94.8)	0.76	(46.0)	6.53	(79.4)	75.81	(32.7)
Kadiri-3 X MH2	55.75		178.25		1538.36		4.50		1.70		13.90	
	57.79		535.21		103873.60		1.61		5.12		14.10	
Kadiri-3 X MH2BC28	62.10	(11.4)	197.80	(10.9)	2026.65	(31.7)	7.00	(55.6)	5.71	(235.9)	20.10	(44.6)
	224.32	(288.2)	1100.62	(105.6)	594343.44	(472.2)	17.60	(993.2)	50.01	(876.7)	89.88	(537.4)
TMV2NLM X MH2	52.00		145.60		1114.50		6.42		9.08		8.09	
	57.63		575.69		127736.63		4.51		39.42		15.69	
TMV2NLM X MH2BC28	50.17	(-3.5)	160.22	(10.0)	1630.57	(64.3)	7.18	(11.8)	9.98	(9.9)	15.43	(90.7)
	130.38	(126.2)	1704.71	(196.1)	713960.75	(453.9)	9.36	(107.5)	40.16	(1.9)	74.98	(377.9)
M13 X MH2	40.88		143.88		1030.41		5.78		7.83		11.00	
	17.20		290.13		160135.95		2.65		16.38		34.11	
MH2BC28 X M13	56.50	(38.2)	171.78	(19.4)	1634.97	(58.1)	4.75	(-17.8)	3.13	(-60.0)	15.00	(36.4)
	111.38	(547.6)	733.44	(152.8)	389020.13	(142.9)	1.53	(-42.3)	10.25	(-37.4)	52.94	(55.2)
MH2BC28 X TMV2	46.83		150.00		1142.25		4.80		2.14		10.60	
	120.58		700.00		272420.91		3.20		3.08		23.30	
TMV2NLM X MH2BC28	50.17	(7.1)	160.22	(6.8)	1830.57	(26.9)	7.18	(49.6)	9.98	(366.4)	15.43	(45.6)
	130.38	(8.1)	1704.71	(143.5)	713960.75	(162.1)	9.36	(192.5)	40.16	(1203.9)	74.98	(221.8)
TMV2 X MH2	37.93		117.86		2269.28		5.94		3.35		45.19	
	100.22		283.50		1228401.75		2.92		13.05		600.59	
TMV2NLM X MH2	46.75	(23.3)	140.35	(19.1)	2098.99	(-8.3)	9.02	(51.9)	11.83	(253.1)	39.63	(-12.3)
	110.96	(10.7)	310.68	(9.7)	1672324.36	(36.1)	6.50	(122.6)	53.34	(4.1)	753.54	(25.5)
TMV2 X TAP5	62.61		170.27		4053.51		8.64		4.91		32.45	
	150.56		867.30		3528729.50		58.11		18.46		307.94	
TMV2NLM X TAP5	67.20	(7.3)	180.50	(6.0)	3589.72	(-11.4)	8.54	(-1.2)	17.05	(247.2)	30.46	(-6.1)
	162.96	(8.2)	901.26	(3.9)	3831586.75	(8.6)	3.98	(-93.2)	72.60	(293.3)	321.37	(4.4)
TMV2 X 32-2-5	59.32		176.07		3896.48		9.64		16.89		67.08	
	275.52		1182.84		7573270.00		6.43		74.03		954.49	
TMV2NLM X 32-2-5	58.75	(-1.0)	178.50	(1.4)	4753.86	(22.0)	9.56	(-82.9)	27.26	(61.4)	50.12	(-25.3)
	280.14	(1.7)	1190.19	(0.62)	11562392.00	(52.7)	13.40	(109.4)	169.09	(128.4)	795.75	(-16.6)
MK374 X TMV2NLM	59.40		158.08		5009.80		8.60		20.72		41.45	
	120.27		564.33		1678806.50		6.12		191.35		793.75	
TMV2NLM X 32-2-5	58.75	(-1.1)	168.50	(6.6)	4753.86	(-5.1)	9.56	(11.2)	27.26	(31.6)	50.12	(20.9)
	280.14	(132.9)	1190.19	(110.9)	11562392.00	(588.7)	10.09	(64.9)	169.09	(-11.6)	795.75	(0.25)

Table 23 : Continued...

Crosses	Mature pod weight (g)		Number of mature kernels		Mature kernel weight (g)		Total dry matter at harvest (g)		Shelling percent		Harvest index	
G201 X MH2	7.54		11.67		3.67		31.21		46.98		17.08	
	58.36		139.55		15.84		298.62		81.77		92.64	
G201 X MH2BC28	15.33	(103.3)	20.47	(75.4)	6.60	(79.8)	30.99	(-0.7)	46.42	(-1.2)	28.83	(68.8)
	134.12	(129.8)	149.75	(7.3)	51.34	(227.2)	516.40	(72.9)	335.77	(310.6)	308.15	(232.6)
JL24 X MH2	11.76		20.14		5.67		15.41		58.79		40.84	
	32.64		91.74		11.40		14.55		102.07		328.83	
JL24 X MH2BC28	10.01	(-14.9)	17.38	(-13.7)	4.92	(-13.2)	21.93	(42.3)	63.58	(8.1)	29.17	(-28.6)
	122.64	(275.7)	112.76	(23.7)	26.70	(134.2)	88.35	(507.2)	372.60	(265.0)	338.63	(3.0)
Kadiri-3 X MH2	10.03		19.40		4.20		21.02		66.79		32.95	
	25.62		70.93		13.92		81.07		253.01		105.35	
Kadiri-3 X MH2BC28	15.39	(53.4)	24.90	(28.4)	7.95	(89.3)	31.53	(50.0)	57.05	(-14.6)	30.96	(-6.1)
	209.13	(716.3)	219.89	(210.0)	80.94	(481.5)	157.78	(94.6)	264.01	(4.3)	235.86	(123.9)
TMV2NLM X MH2	6.21		8.64		2.27		31.66		45.58		24.50	
	10.21		22.25		14.50		191.64		134.95		219.44	
TMV2NLM X MH2BC28	10.77	(73.4)	18.39	(112.8)	4.55	(100.4)	33.55	(6.0)	53.10	(16.5)	29.09	(18.7)
	136.08	(1232.8)	133.34	(499.3)	56.35	(288.6)	264.16	(37.8)	266.69	(97.6)	264.50	(20.53)
M13 X MH2	10.00		19.39		7.06		27.01		77.38		34.38	
	29.16		127.31		13.50		140.82		151.64		342.36	
MH2BC28 X M13	14.78	(47.8)	21.53	(11.0)	8.13	(15.2)	23.09	(-14.5)	67.90	(-12.3)	39.64	(15.3)
	81.87	(180.8)	209.70	(64.7)	27.33	(102.4)	159.76	(13.4)	302.09	(99.2)	276.76	(-19.2)
MH2BC28 X TMV2	11.14		18.40		4.93		14.60		81.58		34.56	
	80.03		106.30		22.88		13.01		299.15		270.94	
TMV2NLM X MH2BC28	10.77	(-3.32)	18.39	(-0.1)	4.55	(-8.4)	33.55	(129.8)	53.10	(-34.9)	29.09	(-15.8)
	136.08	(70.0)	133.34	(25.4)	56.35	(146.3)	264.16	(1930.4)	266.69	(-10.9)	264.50	(-2.4)
TMV2 X MH2	34.88		62.62		23.20		52.20		69.12		39.95	
	200.00		1365.38		100.94		645.13		108.61		160.57	
TMV2NLM X MH2	30.72	(-11.9)	50.95	(-18.6)	18.86	(-18.7)	53.38	(2.3)	64.02	(-7.4)	36.76	(-8.0)
	210.24	(5.1)	1396.75	(2.3)	120.85	(19.7)	821.38	(27.3)	501.23	(361.5)	175.75	(9.5)
TMV2 X TAP5	27.52		47.18		19.22		48.24		73.14		36.10	
	390.64		785.40		188.18		596.19		1423.37		144.78	
TMV2NLM X TAP5	25.10	(-8.8)	42.84	(-9.2)	16.98	(-11.7)	53.13	(10.1)	69.04	(-5.6)	31.86	(-11.7)
	396.63	(1.5)	811.14	(3.3)	190.20	(1.1)	601.39	(0.9)	1198.97	(-15.8)	102.59	(-29.1)
TMV2 X 32-2-5	57.37		90.91		37.11		101.64		66.12		38.16	
	726.48		2194.40		363.42		2975.45		72.24		221.74	
TMV2NLM X 32-2-5	41.60	(-27.5)	71.65	(-21.2)	27.70	(-25.4)	87.64	(-13.8)	69.49	(5.1)	33.15	(-13.1)
	730.91	(0.6)	1925.87	(-12.2)	365.05	(0.4)	1026.57	(-65.5)	65.88	(-8.8)	114.71	(-48.3)
NK374 X TMV2NLM	31.41		56.31		22.22		70.66		66.72		31.17	
	344.91		1832.76		140.91		1850.99		210.59		127.99	
TMV2NLM X 32-2-5	41.60	(32.4)	71.65	(27.2)	27.70	(24.7)	87.64	(24.0)	69.49	(4.2)	33.15	(6.4)
	730.91	(111.9)	1925.87	(5.1)	365.05	(159.1)	1026.57	(-44.5)	65.88	(-68.7)	114.71	(-10.4)

Note : 1. For each cross above value indicates mean and below value indicates variance.

2. The values in parenthesis indicate the percentage increase (+) or decrease (-) over the parental cross.

number of primaries (90.6%), number of secondaries (152.1%), number of mature pods (18.1%), mature pod weight (129.8%), number of mature kernels (7.3%), mature kernel weight (227.2%), total dry matter at harvest (72.9%), shelling per cent (310.6%) and harvest index (232.6%) over the parental cross in F_2 generation.

4.6.2 JL24 x MH2 and JL24 x MH2BC28

In F_2 generation, the cross JL24 x MH2BC28 (enhanced canopy mutant of MH2) recorded increased mean values for canopy circumference (2.6%), leaf area at 60 days (53.9%), number of primaries (6.8%), total dry matter at harvest (42.3%) and shelling per cent (8.1%) as compared to the parental cross JL24 x MH2. While decreased mean values were observed for number of secondaries (-29.7%), number of mature pods (-5.1%), mature pod weight (-14.9%), number of mature kernels (-13.7%), mature kernel weight (-13.2%), and harvest index (-28.6%). The cross JL24 x MH2BC28 registered enhanced variances for all the characters viz., canopy diameter (120.8%), canopy circumference (127.0%), leaf area at 60 days (94.8%), number of primaries (46.0%), number of secondaries (79.4%), number of mature pods (32.7%), mature pod weight (275.7%), number of mature kernels (23.7%), mature kernel weight (134.2%), total dry matter at harvest (507.2%), shelling per cent (265.0%) and harvest index (3.0%) over the parental cross in F_2 generation.

4.6.3 Kadiri-3 x MH2 and Kadiri-3 x MH2BC28

The cross Kadiri-3 x MH2BC28 (enhanced canopy mutant of MH2) exhibited increased means and variances for most of the characters in F_2 generation over the parental cross (Kadiri-3 x MH2). Enhanced mean values were observed for canopy diameter (11.4%), canopy circumference (10.9%), leaf area at 60 days (31.7%), number of primaries (55.6%), number of secondaries (235.9%), number of mature pods (44.6%), mature pod weight (53.4%), number of mature kernels (28.4%), mature kernel weight (39.7%) and total dry matter at harvest (50.0%) in the cross Kadiri-3 x MH2BC28 over the parental cross. While, decreased mean values were found for shelling per cent (-14.6%) and harvest index (-6.1%). The cross Kadiri-3 x MH2BC28 exhibited enhanced variances for all the characters in F_2 generation over the parental cross viz., canopy diameter (288.2%), canopy circumference (105.6%), leaf area at 60 days (472.2%), number of primaries (993.2%), number of secondaries (876.7%), number of mature pods (537.4%), mature pod weight (716.3%), number of mature kernels (210.00%) mature kernel weight (481.5%), total dry matter at harvest (94.6%), shelling per cent (4.3%) and harvest index (123.9%).

4.6.4 TMV2NLM x MH2 and TMV2NLM x MH2BC28

The data in F_2 generation revealed that for most of the characters the means and variances were high in the cross TMV2NLM (narrow leaf mutant of TMV2) x MH2BC28 (enhanced canopy mutant of MH2) as compared to the parental cross TMV2NLM x MH2. The cross TMV2NLM x MH2BC28 recorded increased mean values for canopy circumference (10.0%), leaf area at 60 days (64.3%), number of primaries (11.8%), number of secondaries (9.9%), number of mature pods (90.7%), mature pod weight (73.4%), number of mature kernels (112.8%), mature kernel weight (100.4%), total dry matter at harvest (6.0%), shelling per cent (16.5%) and harvest index (18.7%). While slightly reduced mean value was observed for canopy diameter (-3.5%) as compared to parental cross. The variances recorded for all the characters viz., canopy diameter (126.2%), canopy circumference (196.1%), leaf area at 60 days (458.9%), number of primaries (107.5%), number of secondaries (1.9%), number of mature pods (377.9%), mature pod weight (1232.8%), number of mature kernels (499.3%), mature kernel weight (288.6%), total dry matter at harvest (37.8%), shelling per cent (97.6%) and harvest index (20.5%) were high in the cross TMV2NLM x MH2BC28 as compared to TMV2NLM x MH2.

4.6.5 M13 x MH2 and MH2BC28 x M13

The means and variances recorded by the cross MH2BC28 (enhanced canopy mutant of MH2) x M13 for most of the characters were more than that observed in parental cross M13 x MH2 in F_2 generation. Enhanced mean values were recorded for canopy diameter (38.2%), canopy circumference (19.4%), leaf area at 60 days (58.7%), number of mature pods (36.4%), mature pod weight (47.8%), number of mature kernels (11.0%), mature kernel weight (15.2%) and harvest index (15.3%) in the cross MH2BC28 x M13 over the parental cross M13 x MH2. While, decreased mean values were found for number of primaries (-17.8%), number of secondaries (-60.0%), total dry matter at harvest (-14.5%) and shelling per cent (-12.3%). The data in F_2 generation indicated that the cross MH2BC28 x M13 exhibited enhanced variances for canopy diameter (547.6%), canopy circumference (152.8%), leaf area at 60 days (142.9%), number of mature pods (55.2%), mature pod weight (180.8%), number of mature kernels (64.7%), mature kernel weight (102.4%), total dry matter at harvest (13.4%) and shelling per cent (99.2%) over the parental cross. While, reduced variances were observed for number of primaries (-42.3%), number of secondaries (-37.4%) and harvest index (-19.2%) in the cross MH2BC28 x M13.

4.6.6 MH2BC28 x TMV2 and TMV2NLM X MH2BC28

In F_2 generation, enhanced mean values were observed for canopy diameter (7.1%), canopy circumference (6.8%), leaf area at 60 days (26.9%), number of primaries (49.6%), number of secondaries (366.4%), number of mature pods (45.6%), and total dry matter at harvest (129.8%) in the cross TMV2NLM (narrow leaf mutant of TMV2) x MH2BC28 (enhanced canopy mutant of MH2) over the parental cross MH2BC28 x TMV2. As compared to parental cross the mean values were reduced in the cross TMV2NLM x MH2BC28 for mature pod weight (-3.3%), number of mature kernels (-0.1%), mature kernel weight (-8.4%), shelling per cent (-34.9%) and harvest index (-15.8%). The cross TMV2NLM X MH2BC28 exhibited enhanced variances for most of the characters viz., canopy diameter (8.1%), canopy circumference (143.5%), leaf area at 60 days (162.1%), number of primaries (192.5%), number of secondaries (1203.9%), number of mature pods (221.8%), mature pod weight (70.0%), number of mature kernels (25.4%), mature kernel weight

(146.3%) and total dry matter at harvest (1930.4%) over the parental cross. While, reduced variances were observed for shelling per cent (-10.9%) and harvest index (-2.4%) in the cross TMV2NLM x MH2BC28 as compared to parental cross.

4.6.7 TMV2 x MH2 and TMV2NLM x MH2

The data in F_2 generation indicated that the cross TMV2NLM (narrow leaf mutant) x MH2 recorded enhanced mean values for canopy diameter (23.3%), canopy circumference (19.1%), number of primaries (51.9%), number of secondaries (253.1%) and total dry matter at harvest (2.3%) over the parental cross TMV2 x MH2. While, reduced mean values were recorded for leaf area at 60 days (-8.3%), number of mature pods (-12.3%), mature pod weight (-11.9%), number of mature kernels (-18.6%), mature kernel weight (-18.7%), shelling per cent (-7.4%) and harvest index (-8.0%) in the cross TMV2NLM x MH2 as compared to parental cross. The cross TMV2NLM x MH2 exhibited enhanced variances over the parental cross for all the characters viz., canopy diameter (10.7%), canopy circumference (9.7%), leaf area at 60 days (36.1%), number of primaries (122.6%), number of secondaries (4.1%), number of mature pods (25.5%), mature pod weight (5.1%), number of mature kernels (2.3%), mature kernel weight (19.7%), total dry matter at harvest (27.3%), shelling per cent (361.5%) and harvest index (9.5%).

4.6.8 TMV2 x TAP5 and TMV2NLM x TAP5

The cross TMV2NLM (narrow leaf mutant of TMV2) x TAP5 (aerial podding mutant of 'Tatu') showed increased mean values in

F_2 generation for number of secondaries (247.2%), canopy diameter (7.3%), canopy circumference (6.0%) and total dry matter at harvest (10.1%) over the parental cross TMV2 x TAP5. The cross TMV2NLM x TAP5 recorded slightly reduced mean values for leaf area at 60 days (-11.4%), number of primaries (-1.2%), number of mature pods (-6.1%), mature pod weight (-8.8%), number of mature kernels (-9.2%), mature kernel weight (-11.7%), shelling per cent (-5.6%) and harvest index (-11.7%) as compared to parental cross. The data on variances in F_2 generation indicated that increased variances were observed in the cross TMV2NLM x TAP5 over the parental cross for most of the characters viz., canopy diameter (8.2%), canopy circumference (3.9%), leaf area at 60 days (8.6%), number of secondaries (293.3%), number of mature pods (4.4%), mature pod weight (1.5%), number of mature kernels (3.3%), mature kernel weight (1.1%) and total dry matter at harvest (0.9%). Whereas, for number of primaries (-93.2%), shelling per cent (-15.8%) and harvest index (-29.1%) the variances were decreased in the cross TMV2NLM x TAP5.

4.6.9 TMV2 x 32-2-5 and TMV2NLM x 32-2-5

In F_2 generation, the cross TMV2NLM (narrow leaf mutant of TMV2) x 32-2-5 (compact canopy mutant of MK374) recorded enhanced mean values for canopy circumference (1.4%), leaf area at 60 days (22.0%), number of secondaries (61.4%) and shelling per cent (5.1%) over the parental cross. Whereas, the mean values observed for canopy diameter (-1.00%), number of primaries (-82.9%), number of mature pods (-25.3%), matuore pod weight

(-27.5%), number of mature kernels (-21.2%), mature kernel weight (-25.4%), total dry matter at harvest (-13.8%) and harvest index (-13.1%) were less in the cross TMV2NLM x 32-2-5 than TMV2 x 32-2-5. Enhanced variances were found for canopy diameter (1.7%), canopy circumference (0.62%), leaf area at 60 days (52.7%), number of primaries (109.4%), mature pod weight (0.6%), mature kernel weight (0.4%) and number of secondaries (128.4%) in the cross TMV2NLM x 32-2-5 over the parental cross. While, reduced variances were observed for number of mature pods (-16.6%), number of mature kernels (-12.2%), total dry matter at harvest (-65.5%), shelling per cent (-8.8%) and harvest index (-48.3%) as compared to parental cross TMV2 x 32-2-5.

4.6.10 MK374 x TMV2NLM and TMV2NLM x 32-2-5

The cross TMV2NLM (narrow leaf mutant of TMV2) x 32-2-5 (compact canopy mutant of MK374) exhibited increased means and variances for most of the characters in F_2 generation as compared to the parental cross MK374 x TMV2NLM. Increased mean values were observed in the cross TMV2NLM x 32-2-5 for canopy circumference (6.6%), number of primaries (11.2%), number of secondaries (31.6%), number of mature pods (20.9 %), mature pod weight (32.4%), number of mature kernels (27.2%), mature kernel weight (24.7%), total dry matter at harvest (24.0%), shelling per cent (4.2%) and harvest index (6.4%) over the parental cross. While, slightly reduced mean values were observed for canopy diameter (-1.1%) and leaf area at 60 days (-5.1%) over the parental cross. The variances exhibited by TMV2NLM x 32-2-5 were more than the parental cross for canopy diameter (132.9%), canopy circumference (110.9%), leaf area at 60 days (588.7%), number of primaries (64.9%), number of mature pods (0.25%), mature pod weight (111.9%), number of mature kernels (5.1%) and mature kernel weight (159.1%), while the variances recorded for number of secondaries (-11.63%), total dry matter at harvest (-44.5%), shelling per cent (-68.7%) and harvest index (-10.4%) were less in TMV2NLM x 32-2-5 than the parental cross.

4.7 COMPARISON OF MEANS AND VARIANCES OF CROSSES INVOLVING TAP5 (an aerial podding mutant of 'Tatu') IN F_2 GENERATION

In order to compare the crosses involving TAP5 (an aerial podding mutant), clustering was done based on means and variances in F_2 generation. The results pertaining to this are presented in tables 24 and 25.

4.7.1 Canopy Diameter

In F_2 generation cluster 1 indicated medium variance with low mean, cluster 2 low variance with high mean and cluster 3 high variance with medium mean. The crosses viz., PGN1 x TAP5, PI350680 x TAP5, TMV2 x TAP5, JL24 x TAP5, Kadiri-3 x TAP5, GNLM x TAP5 and TMV2NLM x TAP5 were falling in cluster 1. In cluster 2, the crosses viz., MK374 x TAP5, ICG2271 x TAP5 and M13 x TAP5 were falling. Two crosses viz., J11 x TAP5 and G201 x TAP5 were falling in cluster 3 which exhibited medium mean with high degree of variance.

Table 24 : Comparision of means and variances of crosses involving TAP 5 (an aerial podding mutant of 'Tatu') in F_2 generation.

Crosses	Canopy diameter (cm)	Canopy circum-ference (cm)	Leaf area at 60 days (sq.cm)	Number of prima-ries	Number of secon-daries	Number of aerial pegs
PGN1 X TAP5	52.46	155.83	3691.15	6.04	2.19	51.52
	156.79	894.72	3799951.56	3.34	11.08	718.34
TMV2 X TAP5	62.61	170.27	4053.51	8.64	4.91	40.12
	150.58	867.30	3528729.50	58.11	18.46	1416.11
JL24 X TAP5	69.79	180.86	3311.94	6.40	3.91	24.57
	153.93	876.92	3867974.00	5.42	42.20	754.49
J11 X TAP5	70.47	191.68	4245.77	7.50	6.32	55.59
	234.88	988.49	3226165.50	1.69	15.18	1175.59
PI350680 X TAP5	68.00	185.61	4117.77	7.54	1.77	35.00
	175.10	900.84	3624729.50	2.77	7.69	480.67
G201 X TAP5	70.00	191.00	3711.48	8.33	18.67	34.33
	260.75	974.40	3013567.50	6.33	142.33	472.33
MK374 X TAP5	75.20	202.39	3947.41	6.07	10.10	17.75
	83.50	427.82	2779146.50	2.00	44.38	314.64
Kadiri-3 X TAP5	52.76	161.39	5469.07	8.28	8.97	35.72
	130.10	705.65	10141044.00	3.69	56.88	585.90
GNLM X TAP5	65.41	175.39	2954.44	8.87	18.29	42.92
	160.82	755.14	2819728.28	15.63	189.40	942.24
TMV2NLM X TAP5	67.20	180.50	3589.72	8.54	17.05	40.27
	162.96	901.26	3831586.75	3.98	72.60	1099.65
ICG2271 X TAP5	80.63	206.50	4740.81	8.32	13.81	32.05
	80.34	210.25	1148721.50	5.89	78.49	228.61
M13 X TAP5	77.57	209.12	4641.54	6.69	13.06	25.97
	77.19	203.00	1062771.75	5.53	41.71	239.06

Table 24 : Continued...

Crosses	Number of mature pods	Mature pod weight (g)	Number of mature kernels	Mature kernel weight (g)	Total dry matter at harvest (g)	Shelling percent	Harvest index (pods)
PGN1 X TAP5	37.44	28.12	47.44	20.37	33.11	65.07	44.86
	388.64	401.87	790.49	227.50	203.39	253.72	206.53
TMV2 X TAP5	32.45	27.52	47.18	19.22	48.24	73.14	36.10
	307.94	390.64	785.40	188.18	596.19	1423.37	144.78
JL24 X TAP5	24.11	23.94	33.66	17.05	42.08	65.87	33.04
	114.93	386.59	249.00	192.96	249.12	83.72	97.70
J11 X TAP5	53.95	39.84	81.95	29.43	61.58	75.94	39.03
	493.85	496.87	1125.85	218.27	518.00	75.07	183.78
PI350680 X TAP5	33.23	39.90	61.46	24.15	62.95	60.81	39.11
	252.03	474.59	872.94	201.68	1139.16	47.42	95.81
G201 X TAP5	27.00	25.52	39.33	17.27	108.94	59.31	17.87
	637.00	362.18	1460.33	180.19	1892.35	10.00	27.36
MK374 X TAP5	29.28	25.16	43.17	17.32	35.38	73.04	41.13
	432.35	305.07	1343.00	140.01	231.23	283.94	136.76
Kadiri-3 X TAP5	41.55	29.82	52.58	20.82	64.92	64.89	30.58
	734.40	408.85	1357.64	206.33	755.15	121.95	199.32
GNLM X TAP5	32.29	26.18	48.29	15.73	68.05	67.54	28.05
	345.51	344.91	992.10	135.51	885.83	145.04	152.07
TMV2NLM X TAP5	30.46	25.10	42.84	16.98	53.13	69.04	31.86
	321.37	396.63	811.14	190.20	601.39	1198.97	102.59
ICG2271 X TAP5	24.95	21.73	35.35	13.91	59.34	64.75	27.56
	257.05	210.30	593.79	107.00	795.65	198.94	209.88
M13 X TAP5	28.69	21.36	38.94	14.69	59.42	69.39	32.87
	313.36	211.65	533.08	196.01	844.89	546.03	269.66

Note : For each cross above value and below value indicate mean and variance respectively.

Table 25 : Clustering of means and variances of crosses involving TAPS in F_2 generation.

Characters	Clusters	Mean	Variance	Crosses falling in the clusters
Canopy diameter (cm)	1	62.60 (L)	155.75 (M)	PGN1 X TAPS; PI350680 X TAPS; TMV2 X TAPS; JL24 X TAPS; KADIRI-3 X TAPS; GNLM X TAPS; TMV2NLM X TAPS.
	2	77.80 (H)	80.34 (L)	MK374 X TAPS; ICG2271 X TAPS; M13 X TAPS.
	3	70.24 (M)	247.82 (H)	J11 X TAPS; G201 X TAPS.
Canopy circumference (cm)	1	191.34 (M)	981.45 (H)	J11 X TAPS; G201 X TAPS.
	2	172.84 (L)	843.12 (M)	PGN1 X TAPS; TMV2 X TAPS; JL24 X TAPS; PI350680 X TAPS; KADIRI-3 X TAPS; GNLM X TAPS; TMV2NLM X TAPS.
	3	206.00 (H)	280.36 (L)	MK374 X TAPS; M13 X TAPS; ICG2271 X TAPS.
Leaf area at 60 days (sq. cm)	1	4691.18 (M)	1105746.00 (L)	M13 X TAPS; ICG2271 X TAPS.
	2	5469.07 (H)	10141044.00 (H)	KADIRI-3 X TAPS.
	3	3735.91 (L)	3387952.00 (M)	TMV2 X TAPS; JL24 X TAPS; J11 X TAPS; PI350680 X TAPS; MK374 X TAPS; TMV2NLM X TAPS; PGN1 X TAPS; G201 X TAPS; GNLM X TAPS.
Number of primaries	1	7.37 (L)	4.33 (L)	PGN1 X TAPS; JL24 X TAPS; J11 X TAPS; PI350680 X TAPS; G201 X TAPS. MK374 X TAPS; KADIRI-3 X TAPS; TMV2NLM X TAPS; ICG2271 X TAPS; M13 X TAPS.
	2	8.64 (M)	58.11 (H)	TMV2 X TAPS.
	3	8.87 (H)	15.63 (M)	GNLM X TAPS.
Number of secondaries	1	5.36 (L)	22.72 (L)	PGN1 X TAPS; TMV2 X TAPS; JL24 X TAPS; J11 X TAPS; PI350680 X TAPS; M13 X TAPS.
	2	18.48 (H)	165.87 (H)	G201 X TAPS; GNLM X TAPS.
	3	12.48 (M)	63.09 (M)	MK374 X TAPS; KADIRI-3 X TAPS; TMV2NLM X TAPS; ICG2271 X TAPS.
Number of aerial pegs	1	30.14 (L)	386.87 (L)	PI350680 X TAPS; G201 X TAPS; MK374 X TAPS; KADIRI-3 X TAPS; ICG2271 X TAPS; M13 X TAPS.
	2	47.86 (H)	1295.85 (H)	TMV2 X TAPS; J11 X TAPS.
	3	39.82 (M)	878.68 (M)	PGN1 X TAPS; JL24 X TAPS; GNLM X TAPS; TMV2NLM X TAPS.

Table 25 : Continued...

Characters	Clusters	Mean	Variance	Crosses falling in the clusters
Number of mature pods	1	34.28 (M)	685.70 (H)	G201 X TAP5; Kadiri-3 X TAP5.
	2	35.68 (H)	380.28 (M)	PGN1 X TAP5; TMV2 X TAP5; J11 X TAP5; MK374 X TAP5; GNLM X TAP5; TMV2NLM X TAP5; M13 X TAP5.
	3	28.19 (L)	223.85 (L)	JL24 X TAP5; PI350680 X TAP5; ICG2271 X TAP5.
Mature pod weight (g)	1	34.42 (H)	445.55 (H)	J11 X TAP5; PI350680 X TAP5; PGN1 X TAP5; Kadiri-3 X TAP5.
	2	25.57 (M)	364.34 (M)	JL24 X TAP5; TMV2 X TAP5; G201 X TAP5; GNLM X TAP5; TMV2NLM X TAP5; MK374 X TAP5.
	3	21.55 (L)	210.98 (L)	M13 X TAP5; ICG2271 X TAP5.
Number of mature kernels	1	54.26 (H)	1321.71 (H)	J11 X TAP5; G201 X TAP5; MK374 X TAP5; KADIRI-3 X TAP5.
	2	45.93 (M)	739.85 (M)	PGN1 X TAP5; TMV2 X TAP5; PI350680 X TAP5; GNLM X TAP5; TMV2NLM X TAP5; ICG2271 X TAP5; M13 X TAP5.
	3	33.66 (L)	249.00 (L)	JL24 X TAP5.
Mature kernel weight (g)	1	23.69 (H)	213.45 (H)	J11 X TAP5; PI350680 X TAP5; PGN1 X TAP5; KADIRI-3 X TAP5.
	2	17.26 (M)	171.18 (M)	JL24 X TAP5; TMV2 X TAP5; GNLM X TAP5; MK374 X TAP5; TMV2NLM X TAP5; G201 X TAP5.
	3	14.30 (L)	101.51 (L)	M13 X TAP5; ICG2271 X TAP5.
Total dry matter at harvest (g)	1	45.59 (L)	396.55 (L)	PGN1 X TAP5; TMV2 X TAP5; JL24 X TAP5; J11 X TAP5; MK374 X TAP5; TMV2NLM X TAP5.
	2	108.94 (H)	1892.35 (H)	G201 X TAP5.
	3	62.94 (M)	884.14 (M)	PI350680 X TAP5; KADIRI-3 X TAP5; GNLM X TAP5; ICG2271 X TAP5; M13 X TAP5.
Shelling percent	1	71.22 (H)	414.99 (M)	MK374 X TAP5; M13 X TAP5.
	2	71.09 (M)	1311.17 (H)	TMV2 X TAP5; TMV2NLM X TAP5.
	3	65.52 (L)	116.98 (L)	PGN1 X TAP5; JL24 X TAP5; J11 X TAP5; PI350680 X TAP5; G201 X TAP5; Kadiri-3 X TAP5; GNLM X TAP5; ICG2271 X TAP5.
Harvest index	1	34.98 (H)	213.83 (H)	PGN1 X TAP5; J11 X TAP5; KADIRI-3 X TAP5; ICG2271 X TAP5; M13 X TAP5.
	2	17.87 (L)	27.36 (L)	G201 X TAP5.
	3	34.88 (M)	121.62 (M)	TMV2 X TAP5; JL24 X TAP5; PI350680 X TAP5; MK374 X TAP5; GNLM X TAP5; TMV2NLM X TAP5.

H = High, M = Medium, L = Low.

4.7.2 Canopy Circumference

The clusters 1, 2 and 3 indicated high variance with medium mean, medium variance with low mean and low variance with high mean respectively in F_2 generation. High variance with medium mean was found in J11 x TAP5, G201 x TAP5 which were falling in cluster 1. The crosses falling in cluster 2 were PGN1 x TAP5, TMV2 x TAP5, JL24 x TAP5, PI350680 x TAP5, Kadiri-3 x TAP5, GNLM x TAP5 and TMV2NLM x TAP5. Three crosses viz., MK374 x TAP5, M13 x TAP5 and ICG2271 x TAP5 were falling in cluster 3.

4.7.3 Leaf Area at 60 Days

In F_2 generation cluster 1 indicated low variance with medium mean, cluster 2 high variance with high mean and cluster 3 medium variance with low mean. The crosses viz., M13 x TAP5 and ICG2271 x TAP5 were falling in cluster 1. Only one cross Kadiri-3 x TaP5 exhibited high variance with high mean which was falling in cluster 2. Nine crosses were falling in cluster 3 viz., TMV2 x TAP5, JL24 x TAP5, J11 x TAP5, PI350680 x TAP5, MK374 x TAP5, JL24 x TAP5, J11 x TAP5, PI350680 x TAP5, MK374 x TAP5, TMV2NLM x TAP5, PGNI x TAP5, G201 x TAP5 and GNLM x TAP5 which recorded medium variance with low mean.

4.7.4 Number of Primaries

In F_2 generation, the cross TMV2 x TAP5 exhibited high variance with medium mean and was falling in cluster 1. GNLM x TAP5 was falling in cluster 3 which recorded medium variance with high mean. The remaining crosses viz., PGN1 x TAP5, JL24 x TAP5, J11 x TAP5, PI350680 x TAP5, G201 x TAP5, MK374 x TAP5, Kadiri-3 x TAP5, TMV2NLM x TAP5, ICG2271 x TAP5 and M13 x TAP5 recorded low mean with low variance and were falling in cluster 1.

4.7.5 Number of Secondaries

The crosses viz., G201 x TAP5 and GNLM x TAP5 were falling in cluster 2 in F_2 generation, which recorded high variance with high mean. Four crosses viz., MK374 x TAP5, Kadiri-3 x TAP5, TMV2NLM x TAP5 and ICG2271 x TAP5 were falling in cluster 3 which indicated medium variance with medium mean. Cluster 1 indicated low variance with low mean in which seven crosses viz., PGN1 x TAP5, TMV2 x TAP5, JL24 x TAP5, J11 x TAP5, PI350680 x TAP5 and M13 x TAP5 were falling.

4.7.6 Number of Aerial Pegs

In F_2 generation, high variance with high mean was recorded in TMV2 x TAP5 and J11 x TAP5 which were falling in cluster 2. Four crosses viz., PGN1 x TAP5, JL24 x TAP5, GNLM x TAP5 and TMV2NLM x TAP5 were falling in cluster 3 which indicated medium variance with medium mean. The crosses, PI350680 x TAP5, G201 x TAP5, MK374 x TAP5, Kadiri-3 x TAP5, ICG271 x TAP5 and M13 x TAP5 which exhibited low variance with low mean were falling in cluster 1.

4.7.7 Number of Mature Pods

In clusters 1, 2 and 3 in F_2 generation indicated high variance with medium mean, medium variance with high mean and low variance with low mean respectively. Two crosses viz., G201 x

TAP5 and Kadiri-3 x TAP5 were falling in cluster 1 which recorded high variance with medium mean. Medium variance with high mean was found in seven crosses viz., PGN1 x TAP5, TMV2 x TAP5, J11 x TAP5, MK374 x TAP5, GNLM x TAP5, TMV2NLM x TAP5 and M13 x TAP5 which were falling in cluster 2. In cluster 3, three crosses were falling viz., JL24 x TAP5, PI350680 x TAP5 and ICG2271 x TAP5.

4.7.8 Mature Pod Weight

In F_2 generation, cluster 1 indicated high variance with high mean, cluster 2 medium variance with medium mean and cluster 3 low variance with low mean. Four crosses viz., J11 x TAP5, PI350680 x TAP5, PGN1 x TAP5 and Kadiri-3 x TAP5 which exhibited high variance with high mean were falling in cluster 1. The crosses falling in cluster 2 were JL24 x TAP5, TMV2 x TAP5, G201 x TAP5, GNLM x TAP5, TMV2NLM x TAP5 and MK374 x TAP5 which recorded medium variance with medium mean. Two crosses viz., M13 x TAP5 and ICG2271 x TAP5 were falling in cluster 3.

4.7.9 Number of Mature Kernels

The cluster 1 indicated high variance with high mean, cluster 2 medium variance with medium mean and cluster 3 low variance with low mean in F_2 generation. The crosses, J11 x TAP5, G201 x TAP5, MK374 x TAP5 and Kadiri-3 x TAP5 exhibited high variance with high mean and were falling in cluster 1. The crosses falling in cluster 2 were PGN1 x TAP5, TMV2 x TAP5, PI350680 x TAP5, GNLM x TAP5, TMV2NLM x TAP5, ICG2271 x TAP5 and

M13 x TAP5 which recorded medium variance with medium mean. One cross JL24 x TAP5 was falling in cluster 3.

4.7.10 Mature Kernel Weight

In F_2 generation, the clusters 1, 2 and 3 indicated high variance with high mean, medium variance with medium mean and low variance with low mean respectively. The crosses viz., J11 x TAP5, PI350680 x TAP5, PGN1 x TAP5 and Kadiri-3 x TAP5 were falling in cluster 1 which showed high variance with high mean. Cluster 2 had six crosses viz., JL24 x TAP5, TMV2 x TAP5, GNLM x TAP5, MK374 x TAP5, TMV2NLM x TAP5 and G201 x TAP5 which recorded medium variance with medium mean. Two crosses were falling in cluster 3 viz., M13 x TAP5 and ICG2271 x TAP5.

4.7.11 Total Dry Matter at Harvest

The crosses exhibiting low variance with low mean, high variance with high mean and medium variance with medium mean were falling in cluster 1, 2 and 3 respectively in F_2 generation. Only one cross G201 x TAP5 was falling in cluster 2 which recorded high variance with high mean. In cluster 3, five crosses were falling viz., PI350680 x TAP5, Kadiri-3 x TAP5, GNLM x TAP5, ICG2271 x TAP5 and M13 x TAP5 which expressed medium variance with medium mean. Six crosses were falling in cluster 1 viz., PGN1 x TAP5, TMV2 x TAP5, JL24 x TAP5, J11 x TAP5, MK374 x TAP5 and TMV2NLM x TAP5.

4.7.12 Shelling Per cent

In F_2 generation, the crosses exhibiting medium variance with high mean, high variance with medium mean and low variance with low mean were grouped in cluster 1, 2 and 3 respectively. Cluster 1 had two crosses viz., MK374 x TAP5 and M13 x TAP5 which recorded medium variance with high mean. The crosses viz., TMV2 x TAP5 and TMV2NLM x TAP5 recorded high variance with medium mean and were falling in cluster 2. The crosses falling in cluster 3 were PGN1 x TAP5, JL24 x TAP5, J11 x TAP5, PI350680 x TAP5, G201 x TAP5, Kadiri-3 x TAP5, GNLM x TAP5 and ICG2271 x TAP5.

4.7.13 Harvest Index

The cluster 1, 2 and 3 in F_2 generation include the crosses exhibiting high variance with high mean, low variance with low mean and medium variance with medium mean respectively. The crosses, PGN1 x TAP5, J11 x TAP5, Kadiri-3 x TAP5, ICG2271 x TAP5 and M13 x TAP5 exhibiting high variance with high mean were fallen in cluster 1. Six crosses viz., TMV2 x TAP5, JL24 x TAP5, PI350680 x TAP5, MK374 x TAP5, GNLM x TAP5 and TMV2NLM x TAP5 were falling in cluster 3 which showed medium variance with medium mean. Cluster 2 had only one cross G201 x TAP5.

4.8 AGRONOMICALLY SUPERIOR RECOMBINANTS

In the present study several agronomically useful recombinants were isolated from the F_2 generations of different crosses. The data with regard to the mean performance of parents involved in recombinants and the performance of agronomically superior recombinants in F_2 generation along with their F_3 progeny means are presented in tables 26 and 27 respectively.

Table 26 : Mean performance of parents involved in agronomically superior recombinants in F_2 and F_3 generations.

Parents	Branching pattern	Canopy diameter (cm)		Canopy circumference (cm)		Leaf area at 60 days (sq.cm)		Number of primaries		Number of secondaries	
		F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
TMV2	Sequential	45.60	39.90	148.30	137.80	2481.25	638.92	6.30	5.07	4.10	1.29
PGN1	Sequential	47.50	40.56	150.10	139.60	2019.01	657.30	6.20	5.00	5.20	0.90
JL24	Sequential	46.00	34.60	149.20	134.80	2558.36	690.73	6.63	4.75	3.63	1.00
J11	Sequential	45.80	35.46	145.10	133.40	2601.70	714.30	6.20	4.00	2.80	0.85
MH2BC28	Sequential	52.20	39.50	165.00	136.50	1103.91	729.31	6.80	4.20	5.60	0.40
G201	Alternate	46.00	35.13	151.25	136.25	1351.40	929.80	5.86	6.50	8.71	9.70
TAP5	Sequential	60.00	46.90	180.60	148.40	2644.87	1032.57	4.60	4.50	1.50	0.75
MK374	Alternate	54.70	46.10	169.18	146.60	3004.57	1079.26	9.11	7.80	16.78	6.40
KADIRI-3	Alternate	55.00	50.40	170.80	154.60	3032.41	1159.42	6.50	5.80	13.50	5.00
TMV2NLM	Alternate	58.20	47.00	176.15	148.80	3950.51	1234.25	8.00	7.17	24.88	11.85
32-2-5	Alternate	55.90	48.80	170.20	148.50	4134.29	1655.73	8.29	7.18	14.71	10.05

Parents	Branching pattern	Number of mature pods		Mature pod weight (g)		Number of mature kernels		Mature kernel weight (g)	
		F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
TMV2	Sequential	35.50	15.20	27.34	11.23	56.80	25.63	20.04	7.01
PGN1	Sequential	31.20	16.50	34.16	12.75	52.51	21.50	23.46	9.85
JL24	Sequential	19.25	14.75	18.42	15.05	26.50	20.30	12.21	11.58
J11	Sequential	46.20	19.25	38.99	20.00	70.40	22.55	28.72	15.05
MH2BC28	Sequential	14.50	12.50	10.59	10.25	23.00	20.65	6.08	6.20
G201	Alternate	22.14	20.04	17.48	16.08	28.86	29.80	7.56	8.01
TAP5	Sequential	19.10	19.20	17.36	12.35	32.00	26.90	11.92	6.30
MK374	Alternate	27.89	18.70	29.72	17.20	47.56	30.15	19.85	14.09
KADIRI-3	Alternate	55.33	30.00	51.10	29.02	77.00	40.50	37.66	19.50
TMV2NLM	Alternate	31.75	14.20	29.92	11.01	46.75	20.60	18.50	5.40
32-2-5	Alternate	40.57	24.50	41.28	22.20	58.82	32.20	26.50	18.75

Parents	Branching pattern	Total dry matter at harvest (g)		Shelling per cent		Number of aerial pods		Weight of aerial pods (g)	
		F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
TMV2	Sequentia	34.03	18.90	73.09	62.50	--	--	--	--
PGN1	Sequentia	45.20	17.25	70.70	75.20	--	--	--	--
JL24	Sequentia	42.37	20.35	65.68	73.94	--	--	--	--
J11	Sequentia	44.93	19.90	74.99	75.25	--	--	--	--
MH2BC28	Sequentia	19.55	19.60	59.78	60.49	--	--	--	--
G201	Alternate	28.05	29.05	69.81	50.98	--	--	--	--
TAP5	Sequentia	34.07	18.75	70.49	51.01	6.30	5.01	4.20	3.90
MK374	Alternate	38.21	28.15	67.99	80.91	--	--	--	--
KADIRI-3	Alternate	31.54	30.05	74.69	67.20	--	--	--	--
TMV2NLM	Alternate	42.39	34.60	63.11	51.05	--	--	--	--
32-2-5	Alternate	52.65	37.15	68.17	84.05	--	--	--	--

Table 27 : The performance of agronomically superior recombinants in F_2 generation along with their F_3 progeny means.

Pedigree	Segregant	Branching pattern		Canopy diameter (cm)		Canopy circumference (cm)		Leaf area at 60 days (sq.cm)		Number of primaries		Number of secondaries	
		F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
TMV2 X TMV2NLM	ASR-1	Alternate	Segregated	71.50	50.75	180.65	160.50	5178.95	3324.62	18.00	10.20	46.00	25.20
TMV2 X TMV2NLM	ASR-2	Alternate	Segregated	57.50	49.15	160.75	149.35	3578.23	2982.35	12.00	8.40	25.00	15.00
PGN1 X TMV2NLM	ASR-3	Alternate	Segregated	76.50	60.30	191.00	166.25	4654.10	3421.11	14.00	8.90	52.00	20.00
PGN1 X TMV2NLM	ASR-4	Alternate	Segregated	52.50	47.20	159.50	139.40	4572.99	2251.24	10.00	7.25	32.00	16.70
JL24 X TMV2NLM	ASR-5	Alternate	Segregated	61.00	48.25	165.00	146.21	4762.06	3002.59	10.00	7.50	23.00	13.00
J11 X TMV2NLM	ASR-6	Alternate	Segregated	53.50	47.50	160.00	140.00	4924.73	3121.22	11.00	7.90	26.00	12.50
MK374 X TMV2NLM	ASR-7	Alternate	Alternate	73.00	66.45	185.00	170.65	5020.00	4529.85	13.00	12.50	40.00	30.25
TMV2NLM X 32-2-5	ASR-8	Alternate	Alternate	77.50	70.05	198.00	182.30	6843.90	4858.36	12.00	11.00	42.00	27.20
TMV2 X 32-2-5	ASR-9	Alternate	Alternate	66.50	50.55	181.00	159.25	7011.34	3123.33	14.00	10.00	32.00	18.00
TMV2 X 32-2-5	ASR-10	Alternate	Alternate	52.00	48.25	162.00	153.45	5261.80	3013.24	11.00	7.20	24.00	16.50
KADIRI-3 X 32-2-5	ASR-11	Alternate	Alternate	66.00	63.00	187.00	175.00	4856.72	4696.44	9.00	8.00	18.00	15.20
PGN1 X TAP5	ASR-12	Sequential	Sequential	61.50	58.25	170.00	161.20	3077.84	2876.54	7.00	5.25	8.00	7.50
J11 X TAP5	ASR-13	Sequential	Sequential	69.00	62.50	175.00	165.65	3278.56	2938.97	8.00	6.02	12.00	10.50
KADIRI-3 X TAP5	ASR-14	Alternate	Alternate	52.50	50.10	165.00	162.34	3085.23	3000.85	9.00	8.15	16.00	14.00
G201 X MH2BC28	ASR-15	Alternate	Segregated	85.50	54.35	220.00	159.27	6274.60	3129.77	11.00	6.60	35.00	17.90

Table 27 : Continued...

Pedigree	Segregant	Branching pattern		Number of mature pods		Mature pod weight (g)		Number of mature kernels		Mature kernel weight (g)	
		F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
TMV2 X TMV2NLM	ASR-1	Alternate	Segregated	175.00	53.25	120.00	40.30	240.00	100.35	90.58	33.66
TMV2 X TMV2NLM	ASR-2	Alternate	Segregated	125.00	45.30	75.22	38.25	210.00	89.26	60.90	25.32
PGN1 X TMV2NLM	ASR-3	Alternate	Segregated	172.00	60.75	104.56	54.35	280.00	108.35	69.92	29.25
PGN1 X TMV2NLM	ASR-4	Alternate	Segregated	96.00	35.00	82.21	30.14	101.00	60.34	60.77	22.34
JL24 X TMV2NLM	ASR-5	Alternate	Segregated	82.00	32.55	90.01	28.40	115.00	60.02	65.23	23.26
J11 X TMV2NLM	ASR-6	Alternate	Segregated	107.00	35.30	90.50	31.31	120.00	59.35	63.65	23.78
MK374 X TMV2NLM	ASR-7	Alternate	Alternate	115.00	56.15	99.85	48.89	195.00	98.20	70.56	40.35
TMV2NLM X 32-2-5	ASR-8	Alternate	Alternate	95.00	52.30	101.01	45.25	118.00	90.30	72.05	35.54
TMV2 X 32-2-5	ASR-9	Alternate	Alternate	108.00	40.25	110.41	39.30	157.00	65.25	82.92	33.32
TMV2 X 32-2-5	ASR-10	Alternate	Alternate	96.00	38.34	107.06	40.25	140.00	58.30	74.70	32.19
KADIRI-3 X 32-2-5	ASR-11	Alternate	Alternate	108.00	50.68	107.94	52.75	133.00	85.25	81.80	40.75
PGN1 X TAP5	ASR-12	Sequential	Sequential	92.00	65.60	76.87	64.50	122.00	110.35	62.89	50.15
J11 X TAP5	ASR-13	Sequential	Sequential	90.00	69.30	75.97	66.67	140.00	115.40	58.36	53.34
KADIRI-3 X TAP5	ASR-14	Alternate	Alternate	86.00	64.25	94.22	68.30	137.00	108.20	71.17	55.70
G201 X MH2BC28	ASR-15	Alternate	Segregated	85.00	30.35	80.59	28.25	140.00	64.10	61.25	22.95

Table 27 : Continued...

Pedigree	Segregant	Branching pattern		Total dry matter at harvest (g)		Shelling percent		Number of aerial pods		Weight of aerial pods (g)	
		F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
TMV2 X TMV2NLM	ASR-1	Alternate	Segregated	181.60	81.50	75.48	81.52	--	--	--	--
TMV2 X TMV2NLM	ASR-2	Alternate	Segregated	102.35	65.75	80.96	66.25	--	--	--	--
PGN1 X TMV2NLM	ASR-3	Alternate	Segregated	176.00	62.30	66.87	52.82	--	--	--	--
PGN1 X TMV2NLM	ASR-4	Alternate	Segregated	90.26	50.21	73.92	74.12	--	--	--	--
JL24 X TMV2NLM	ASR-5	Alternate	Segregated	99.65	48.75	72.47	80.90	--	--	--	--
J11 X TMV2NLM	ASR-6	Alternate	Segregated	94.26	47.60	70.33	71.95	--	--	--	--
MK374 X TMV2NLM	ASR-7	Alternate	Alternate	152.20	105.95	70.67	82.53	--	--	--	--
TMV2NLM X 32-2-5	ASR-8	Alternate	Alternate	129.09	85.36	71.33	76.54	--	--	--	--
TMV2 X 32-2-5	ASR-9	Alternate	Alternate	148.27	80.70	75.10	81.78	--	--	--	--
TMV2 X 32-2-5	ASR-10	Alternate	Alternate	120.92	75.30	69.73	75.95	--	--	--	--
KADIRI-3 X 32-2-5	ASR-11	Alternate	Alternate	84.19	76.65	75.78	75.25	--	--	--	--
PGN1 X TAP5	ASR-12	Sequential	Sequential	68.02	50.35	81.81	77.75	13.00	11.05	7.50	6.10
J11 X TAP5	ASR-13	Sequential	Sequential	74.36	52.26	76.82	80.01	9.00	8.10	5.42	5.05
KADIRI-3 X TAP5	ASR-14	Alternate	Alternate	96.61	80.15	75.54	80.16	8.00	5.30	6.65	3.99
G201 X NH2BC28	ASR-15	Alternate	Segregated	130.38	50.34	76.00	75.13	--	--	--	--

4.8.1 Recombinants Isolated from F_2 Generation of Crosses Involving TMV2NLM (narrow leaf mutant of TMV2)

ASR 1: A segregant with alternate branching and medium spreading habit was isolated from the cross TMV2 x TMV2NLM. It had thick branches, broad leaves with narrow tip and dark green foliage. It exhibited compact bearing with medium bold pods. It recorded increased values for canopy diameter (71.50 cm), canopy circumference (180.65 cm) and leaf area (5178.95 cm^2) at 60 days, number of primaries (18.00), number of secondaries (46), number of mature pods (175), mature pod weight (120g), number of mature kernels (240), mature kernel weight (90.58g), total dry matter (181.60g) and shelling per cent (75.48%) as compared to both the parents. It exhibited segregation for branching pattern in F_3 generation. The F_3 progeny of this segregant recorded increased mean values for all the above characters as compared to both the parents involved.

ASR 2: Another segregant with alternate branching and medium compact growth habit was observed in the cross TMV2 x TMV2NLM. The branches were thin and the leaves were narrow like TMV2NLM. Pod size was smaller than the parents. It produced more number of primary (12.00) and secondary branches (25.00). It recorded a canopy diameter of 57.50 cm and canopy circumference of 160.75 cm. The number of mature pods (125), mature pod weight (72.22g), number of mature kernels (210), mature kernel weight (60.90 g), total dry matter (102.35 g) and shelling per cent (80.96%) were more in this segregant compared to its parents. Its progeny in

F_3 generation segregated for branching pattern and recorded increased mean values for the above characters as compared to both the parents.

ASR 3: In the cross PGN1 x TMV2NLM, a segregant with alternate branching and medium spreading habit was found. The leaves were narrow like TMV2NLM. It had dark green foliage with thick branches. The pods were bold. The values recorded for canopy diameter (76.50 cm), canopy circumference (191 cm), number of primaries (14), number of secondaries (52), number of mature pods (172), mature pod weight (104.56 g), number of mature kernels (280), mature kernel weight (69.92 g) and total dry matter (176.00 g) were higher than the parents. Segregation for branching pattern was observed in F_3 generation. The progeny means for all the above characters were more than the parents.

ASR 4: Another segregant with alternate branching pattern and medium compact growth habit was observed in PGN1 x TMV2NLM cross. The leaves were broad with narrow tip and dark green in colour. The pods were smooth like PGN1. It recorded a canopy diameter of 52.50 cm and canopy circumference of 159.50 cm. Increased values were observed for leaf area at 60 days (4572.99 cm^2), number of primaries (10.00), number of secondaries (32.00), number of mature pods (96), mature pod weight (82.21 g), number of mature kernels (101.00), mature kernel weight (60.77 g), total dry matter (90.26 g) and shelling per cent (73.92%) in this recombinant as compared to both the parents. The progeny of this recombinant exhibited segregation for branching pattern in F_3 generation. As compared to the parents, the mean values for the above characters were high in F_3 generation.

ASR 5: From the cross JL24 x TMV2NLM, a segregant with alternate branching and medium compact canopy was isolated. It had dark green foliage with broad leaves which were narrow at the tip. The branches were thick and the pods were like JL24. The canopy diameter and circumference of this segregant were 61.00 cm and 165.00 cm respectively. As compared to both the parents, it recorded increased values for number of primaries (10.00), secondaries (23.00), mature pods (82.00) and mature kernels (115.00), mature pod weight (90.01g), mature kernel weight (65.23g), total dry matter at harvest (99.65 g) and shelling per cent (72.47%). It showed segregation for branching pattern in F_3 generation. For all the above characters it recorded increased progeny means than both the parents.

ASR 6: In the cross J11 x TMV2NLM, a segregant with alternate branching and medium compact growth habit was observed. It exhibited variation in leaf size and shape. It produced more number of secondary branches which were thin. The pods were small in size. It showed a canopy diameter of 53.5 cm and canopy circumference of 160.00 cm. The values observed for number of primaries (11.00), number of secondaries (26.00), number of mature pods (107.00), mature pod weight (90.50 g), number of mature kernels (120.00), mature kernel weight (63.65g), total dry matter (94.26g) and shelling per cent (70.33%) were more than the parents. In F_3 generation, its progeny showed segregation for branching pattern and exhibited high mean values for the above characters than both the parents involved.

ASR 7: A segregant with alternate branching and medium spreading habit was isolated from the cross MK374 x TMV2NLM. It had very dark green foliage like MK374. The leaves were narrow at the tip and branches were thin. It produced bold pods which were 2-3 seeded. It recorded higher values for the following characters viz., canopy diameter (73.00), canopy circumference (185.00cm), number of primaries (13.00), secondaries (40.00), mature pods (115) and mature kernels (195), mature pod weight (99.85g), mature kernel weight (70.56g), total dry matter (152.20g) and shelling per cent (70.67%) than both the parents. It bred true in F_3 generation and recorded increased mean values for the above characters than its parents.

4.8.2 Recombinants isolated from F_2 generation of crosses involving 32-2-5 (compact canopy mutant of MK374)

ASR 8: From the cross TMV2NLM x 32-2-5, an alternate branching with medium spreading habit segregant was isolated. The leaves were less narrow compared to TMV2NLM. It exhibited compact bearing and the pods were like 32-2-5. The values recorded for the characters viz., canopy diameter (77.50 cm), canopy circumference (198 cm), number of primaries (12.00), secondaries (42.00), mature pods (95.00) and mature kernels (118), mature pod weight (101.01g), mature kernel weight (72.05g), total dry matter (129.09 g) and shelling per cent (71.33%) were more than both the parents. In F_3 generation, it bred true for branching pattern and showed increased mean values as compared to both the parents.

ASR 9: This segregant was isolated from the cross TMV2 x 32-2-5 which showed alternate branching and medium spreading canopy. It exhibited compact bearing and variation in pod size. Pods were smooth. Higher values were recorded for canopy diameter (66.50 cm), canopy circumference (181.0 cm), number of primaries (14), secondaries (32), mature pods (108) and mature kernels (157.00), mature pod weight (110.41 g), mature kernel weight (82.92 g), total dry matter (148.27 g) and shelling per cent (75.10%) by this segregant as compared to its parents. For the above characters it bred true in F_3 generation and exhibited high mean values compared to its parents.

ASR 10: Another segregant with alternate branching and medium compact canopy was observed in TMV2 x 32-2-5 cross. It showed dark green foliage with thin branches. It produced pods which were similar to TMV2. The canopy diameter and circumference were 52.00 cm and 162.00 cm respectively. The number of primaries (9), secondaries (24), mature pods (96.00) and mature kernels (140.00), mature pod weight (107.06g), mature kernel weight (74.70g) and total dry matter (120.92g) were more in this segregant as compared to its parents. It bred true for branching pattern in F_3 generation and recorded increased values for the above characters as compared to both the parents.

ASR 11: A segregant with alternate branching pattern and erect growth habit was found in the cross Kadiri-3 x 32-2-5. It had light green foliage with thin branches. It showed compact bearing. It exhibited more canopy diameter (66.00cm), canopy circumference (187.0cm), number of primaries (11) and secondaries (18), number of mature pods (108) and kernels (133), mature pod weight (107.94g), mature kernel weight (81.80g), total dry matter (84.19g) and shelling per cent (75.78%) as compared to both the parents. It bred true in F_3 generation. The mean values recorded for the above characters were more than both the parents in F_3 generation.

4.8.3 Recombinants Isolated from F_2 Generation of Crosses Involving TAP5 (aerial podding mutant)

ASR 12: A sequential branching Spanish bunch segregant was isolated from the cross PGN1 x TAP5. Branches were thin with purple pigmentation. Flowering was observed even at the time of harvest. It had dark green foliage. It showed compact bearing with small pods. It exhibited aerial podding expression like TAP5. It recorded a canopy diameter of 61.50 cm. Leaf area observed at 60 days (3077.84 cm^2) was more than both the parents. It produced 13 aerial pods weighing about 7.5g. It also recorded increased values for number of primaries (7), secondaries (8), mature pods (92) and mature kernels (122), mature pod weight (76.87g), mature kernel weight (62.89g), total dry matter (68.02g) and shelling per cent (81.81%). In F_3 generation, it bred true for branching pattern and showed high mean values for the above characters as compared to both the parents.

ASR 13: From the cross J11 x TAP5, a sequential branching segregant with purple pigmentation was isolated. It had thick branches and the foliage was light green in colour. Aerial podding expression was observed. It produced 9 aerial pods weighing 5.42g. It showed a canopy diameter of 69.00 cm. It exhibited more leaf area at 60 days (3278.56 cm^2) than the parents. High values were also observed for number of primaries (8.00), secondaries (12.00), mature pods (90.00) and mature kernels (140.00), mature pod weight (75.97g), mature kernel weight (58.36g) total dry matter (74.36g) and shelling per cent (76.82%). Its breeding behaviour in F_3 generation was found to be true. The mean values recorded for the above characters were more than both the parents.

ASR 14: A purple pigmented, alternate and medium compact segregant was isolated from Kadiri-3 x TAP5. The foliage was dark green with thick branches. The pods were small and smooth with tan colour seeds. It showed aerial podding expression. Number of aerial pods harvested were 8 which weighed 6.65g. Its canopy diameter was 52.50 cm. Leaf area observed at 60 days (3085.23 cm^2) was more than both the parents. The number of primaries (9), secondaries (16), mature pods (86) and mature kernels (137), mature pod weight (94.22g), mature kernel weight (71.17g), total dry matter (96.16g) and shelling per cent (75.54%) were higher than the parents. It was found to be true breeding in F_3 generation. It exhibited increased mean values for the above characters than its parents.

4.8.4 Recombinants Isolated from F_2 Generation of Crosses Involving MH2BC28 (enhanced canopy mutant of MH2)

ASR 15: An alternate branching *Virginia* runner segregant was observed in the cross G201 x MH2BC28. It had deeply dark green foliage and more number of secondary branches. It exhibited variation in leaf size. It produced 2-3 seeded pods with tan colour seeds. Maximum canopy diameter (85.50 cm) and circumference (220 cm) was observed, as compared to both the parents. It also expressed greater values for the characters viz., number of primaries (11), secondaries (35.00), mature pods (85.00) and mature kernels (140.00), mature pod weight (80.5g), mature kernel weight (61.25g), total dry matter (130.38g) and shelling per cent (76.00%). It exhibited segregation for branching pattern in F_3 generation and showed increased mean values for the above characters than both the parents.

4.9 INHERITANCE STUDIES

4.9.1 Inheritance of Branching Pattern

4.9.1.1 Alternate x Sequential (or) Sequential x Alternate

The F_2 population of the crosses involving alternate x sequential or sequential x alternate showed the segregation ratios of 3 alternate : 1 sequential, 15 alternate : 1 sequential and 9 alternate : 7 sequential. The crosses viz., M13 x MH2, G201 x MH2, GNLM x MH2, TMV2NLM x MH2, Kadiri-3 x TAP5, GNLM x TAP5, TMV2NLM x TAP5, M13 x JL24, G201 x JL24, Kadiri-3 x MH2BC28, TMV2 x TMV2NLM, JL24 x TMV2NLM, J11 x TMV2NLM, PI259747 x 32-2-5, JL24 x 32-2-5, TMV2 x 32-2-5 and MH2BC28 x M13 recorded

Table 28 : Inheritance of branching pattern.

Combination of branching pattern in the crosses	Crosses	Branching pattern in F_1	Phenotypic classes in F_2	Ratio	Observed frequency in F_2	Total population in F_2	Chi-square value	Probability value
Alternate x sequential	M13 X MH2	Alternate	Alternate	3	246	333	0.2252	0.50
			Sequential	1	87			
	MK374 X MH2	Alternate	Alternate	15	311	336	0.8127	0.25
OR			Sequential	1	25			
	KADIRI3 X MH2	Alternate	Alternate	15	340	368	1.1595	0.25
Sequential x alternate			Sequential	1	28			
	G201 X MH2	Alternate	Alternate	3	129	167	0.4491	0.25
			Sequential	1	38			
	GNLM X MH2	Alternate	Alternate	3	133	174	0.1916	0.50
			Sequential	1	41			
	TMV2NLM X MH2	Alternate	Alternate	3	193	254	0.1312	0.50
			Sequential	1	61			
	M13 X TAP5	Alternate	Alternate	15	212	223	0.6614	0.25
			Sequential	1	11			
	MK374 X TAP5	Alternate	Alternate	15	166	179	0.3123	0.50
			Sequential	1	13			
	KADIRI-3 X TAP5	Alternate	Alternate	3	177	231	0.3247	0.50
			Sequential	1	54			
	G201 X TAP5	Alternate	Alternate	15	154	167	0.6696	0.25
			Sequential	1	13			
	ICG2271 X TAP5	Alternate	Alternate	15	136	143	0.4491	0.25
			Sequential	1	7			
	GNLM X TAP5	Alternate	Alternate	3	148	194	0.1719	0.50
			Sequential	1	46			
	TMV2NLM X TAP5	Alternate	Alternate	3	172	227	0.0720	0.75
			Sequential	1	55			
	M13 X JL24	Alternate	Alternate	3	175	238	0.2745	0.50
			Sequential	1	63			
	KADIRI-3 X JL24	Alternate	Alternate	9	127	231	0.1520	0.50
			Sequential	7	104			
	G201 X JL24	Alternate	Alternate	3	141	186	0.0645	0.75
			Sequential	1	45			
	G201 X MH2BC28	Alternate	Alternate	15	142	153	0.2314	0.50
			Sequential	1	11			
	Kadiri-3 X MH2BC28	Alternate	Alternate	3	102	133	0.2032	0.50
			Sequential	1	31			
	TMV2NLM X MH2BC28	Alternate	Alternate	15	218	228	1.3520	0.10
			Sequential	1	10			
	TMV2 X TMV2NLM	Alternate	Alternate	3	239	315	0.1280	0.50
			Sequential	1	76			
	PGN1 X TMV2NLM	Alternate	Alternate	15	213	230	0.5095	0.25
			Sequential	1	17			
	JL24 X TMV2NLM	Alternate	Alternate	3	174	222	1.3520	0.10
			Sequential	1	48			
	J11 X TMV2NLM	Alternate	Alternate	3	153	212	0.9056	0.25
			Sequential	1	59			

Table 28 : Continued...

Combination of branching pattern in the crosses	Crosses	Branching pattern	Phenotypic classes in F_2	Ratio	Observed frequency in F_2	Total population in F_2	Chi-square value	Probability value
Alternate x sequential	PI259747 X 32-2-5	Alternate	Alternate	3	112	143	0.8415	0.25
			Sequential	1	31			
	JL24 X 32-2-5	Alternate	Alternate	3	155	211	0.2669	0.50
OR			Sequential	1	56			
	TMV2 X 32-2-5	Alternate	Alternate	3	135	177	0.1525	0.50
Sequential x			Sequential	1	42			
alternate	MH2BC28 X M13	Alternate	Alternate	3	121	159	0.1027	0.50
			Sequential	1	38			
Sequential x Sequential	TMV2 X MH2	Sequential	All Sequential	--	--	190	--	--
	PGN1 X MH2	Sequential	All Sequential	--	--	395	--	--
	JL24 X MH2	Sequential	All Sequential	--	--	206	--	--
	PGN1 X TAP5	Sequential	All Sequential	--	--	307	--	--
	TMV2 X TAP5	Sequential	All Sequential	--	--	215	--	--
	JL24 X TAP5	Sequential	All Sequential	--	--	178	--	--
	J11 X TAP5	Sequential	All Sequential	--	--	174	--	--
	PI350680 X TAP5	Sequential	All Sequential	--	--	168	--	--
	JL24 X MH2BC28	Sequential	All Sequential	--	--	203	--	--
	MH2BC28 X TMV2NLM	Sequential	All Sequential	--	--	201	--	--
Alternate x Alaternate	M13 X TMV2NLM	Alternate	All Alternate	--	--	230	--	--
	MK374 X TMV2NLM	Alternate	All Alternate	--	--	193	--	--
	KADIRI-3 X TMV2NLM	Alternate	All Alternate	--	--	294	--	--
	G201 X TMV2NLM	Alternate	All Alternate	--	--	188	--	--
	TMV2NLM X 32-2-5	Alternate	All Alternate	--	--	217	--	--
	GNLM X 32-2-5	Alternate	All Alternate	--	--	245	--	--
	KADIRI-3 X 32-2-5	Alternate	All Alternate	--	--	274	--	--
	TMV2NLM X GNLM	Alternate	Alternate	63	312	316	0.7647	0.50
			Sequential	1	3			

a segregation ratio of 3 alternate : 1 sequential indicating the monogenic control of branching pattern. While the segregation ratios of F_2 population of nine crosses viz., MK374 x MH2, Kadiri-3 x MH2, M13 x TAP5, MK374 x TAP5, G201 x TAP5, ICG2271 x TAP5, G201 x MH2BC28, TMV2NLM x MH2BC28 and PGN1 x TMV2NLM gave a good fit for the ratio of 15 alternate : 1 sequential suggesting the digenic control of branching pattern. Only one cross Kadiri-3 x JL24 recorded a segregation ratio of 9 alternate : 7 sequential in F_2 generation indicating that presence of two dominant genes is required for alternate branching pattern (Table 28).

4.9.1.2 Sequential x Sequential

All the crosses involving both the parents with sequential branching pattern showed no segregation for branching in F_2 population viz., TMV2 x MH2, PGN1 x MH2, JL24 x MH2, PGN1 x TAP5, TMV2 x TAP5, JL24 x TAP5, J11 x TAP5, PI350680 x TAP5, JL24 x MH2BC28 and MH2BC28 x TMV2.

4.9.1.3 Alternate x Alternate

The F_2 population of the crosses viz., M13 x TMV2NLM, MK374 x TMV2NLM, Kadiri-3 x TMV2NLM, G201 x TMV2NLM, TMV2NLM x 32-2-5, GNLM x 32-2-5 and Kadiri-3 x 32-2-5 involving both the parents with alternate branching pattern showed no segregation for branching, except one cross TMV2NLM x GNLM which exhibited a segregation ratio of 63 alternate : 1 sequential indicating the trigenic control of branching pattern (Table 28).

4.9.2 Inheritance of Narrow Leaf Character

The crosses viz., M13 x TMV2NLM, MK374 x TMV2NLM, Kadiri-3 x TMV2NLM, G201 x TMV2NLM, TMV2 x TMV2NLM, PGN1 x TMV2NLM, JL24 x TMV2NLM, J11 x TMV2NLM, TMV2NLM x MH2, TMV2NLM x 32-2-5, TMV2NLM x TAP5 involving TMV2 narrow leaf mutant as one of their parents showed a segregation ratio of 1 narrow : 2 intermediate : 1 normal in F_2 generation. The F_2 population of the crosses involving Gujarat narrow leaf mutant as one of their parents exhibited a segregation ratio of 3 narrow : 1 normal indicating that the narrow leaf character was governed by a single dominant gene. Whereas the F_2 generation of the cross involving both the narrow leaf mutants TMV2NLM x GNLM showed a ratio of 1 needle shape leaf : 60 narrow : 3 normal. This indicates that the genes controlling the narrow leaf character in both the mutants are non-allelic (Table 29).

4.9.3 Inheritance of Aerial Podding

The aerial podding mutant 'TAP5' was crossed with alternate as well as sequential branching genotypes. All the crosses involving the alternate genotype x TAP5 viz., M13 x TAP5, ICG2271 x TAP5, MK374 x TAP5, GNLM x TAP5, TMV2NLM x TAP5, G201 x TAP5 and Kadiri-3 x TAP5 showed a segregation ratio of 1 aerial podding : 3 normal in F_2 generation. The F_2 population of the crosses involving sequential genotype x aerial podding genotype exhibited a segregation ratio of 3 aerial podding : 1 normal indicating the monogenic inheritance of aerial podding character (Table 30).

Table 29 : Inheritance of narrow leaf shape.

Crosses	Phenotype of F_1	Phenotypic classes in F_2	Ratio	Observed frequency F_2	Total population in F_2	Chi-square value	'P' value
M13 X TMV2NLM	Narrow	Narrow	1	56	230	0.7043	0.50
(Normal x Narrow)		Intermediate	2	121			
		Normal	1	53			
MK374 X TMV2NLM	Narrow	Narrow	1	41	193	1.4664	0.25
(Normal x Narrow)		Intermediate	2	102			
		Normal	1	50			
Kadiri-3 X TMV2NLM	Narrow	Narrow	1	68	294	1.1293	0.50
(Normal x Narrow)		Intermediate	2	156			
		Normal	1	70			
G201 X TMV2NLM	Narrow	Narrow	1	41	188	1.3086	0.50
(Normal x Narrow)		Intermediate	2	101			
		Normal	1	46			
TMV2 X TMV2NLM	Narrow	Narrow	1	81	315	0.7715	0.50
(Normal x Narrow)		Intermediate	2	162			
		Normal	1	72			
PGN1 X TMV2NLM	Narrow	Narrow	1	60	230	0.9826	0.50
(Normal x Narrow)		Intermediate	2	119			
		Normal	1	51			
JL24 X TMV2NLM	Narrow	Narrow	1	58	222	1.7387	0.25
(Normal x Narrow)		Intermediate	2	117			
		Normal	1	47			
J11 X TMV2NLM	Narrow	Narrow	1	60	212	1.3113	0.50
(Normal x Narrow)		Intermediate	2	103			
		Normal	1	49			
TMV2NLM X MH2	Narrow	Narrow	1	60	254	1.2047	0.50
(Narrow x Normal)		Intermediate	2	123			
		Normal	1	71			
TMV2NLM X 32-2-5	Narrow	Narrow	1	56	217	0.2719	0.75
(Narrow x Normal)		Intermediate	2	110			
		Normal	1	51			
TMV2NLM X TAP5	Narrow	Narrow	1	61	227	0.6123	0.50
(Narrow x Normal)		Intermediate	2	108			
		Normal	1	58			
GNLM X MH2	Narrow	Narrow	3	135	174	0.6207	0.25
(Narrow x Normal)		Normal	1	39			
GNLM X 32-2-5	Narrow	Narrow	3	187	245	0.2299	0.50
(Narrow x Normal)		Normal	1	58			
GNLM X TAP5	Narrow	Narrow	3	150	194	0.5567	0.25
(Narrow x Normal)		Normal	1	44			
TMV2NLM X GNLM	Narrow	Needle shape	1	4	316	7.4792	0.01
(Narrow x Narrow)		Narrow	60	287			
		Normal	3	25			

Table 30 : Inheritance of aerial podding.

Crosses	Phenotype of F_1	Phenotypic classes in F_2	Ratio	Observed frequency in F_2	Total population in F_2	Chi-square value	'P' Value
M13 X TAP5	Normal	Aerial podding	1	49	223	1.0897	0.25
(Alternate x aerial podding)		Normal	3	174			
ICG2271 X TAP5	Normal	Aerial podding	1	30	143	1.2331	0.25
(Alternate x aerial podding)		Normal	3	113			
MK374 X TAP5	Normal	Aerial podding	1	40	179	0.6723	0.25
(Alternate x aerial podding)		Normal	3	139			
GNLM X TAP5	Normal	Aerial podding	1	42	194	1.1615	0.25
(Alternate x aerial podding)		Normal	3	152			
TMV2NLM X TAP5	Normal	Aerial podding	1	50	227	1.0705	0.25
(Alternate x aerial podding)		Normal	3	177			
G201 X TAP5	Normal	Aerial podding	1	38	167	0.4491	0.25
(Alternate x aerial podding)		Normal	3	129			
Kadiri-3 X TAP5	Aerial podding	Aerial podding	1	64	231	0.9012	0.25
(Alternate x aerial podding)		Normal	3	167			
PGN1 X TAP5	Aerial podding	Aerial podding	3	233	307	0.1313	0.50
(Sequential x aerial podding)		Normal	1	74			
TMV2 X TAP5	Aerial podding	Aerial podding	3	157	215	0.4480	0.25
(Sequential x aerial podding)		Normal	1	58			
JL24 X TAP5	Aerial podding	Aerial podding	3	139	178	0.9064	0.25
(Sequential x aerial podding)		Normal	1	39			
J11 X TAP5	Aerial podding	Aerial podding	3	127	174	0.3755	0.50
(Sequential x aerial podding)		Normal	1	47			
PI350680 X TAP5	Aerial podding	Aerial podding	3	117	162	0.6667	0.25
(Sequential x aerial podding)		Normal	1	45			

4.9.4 Inheritance of Canopy Compaction

4.9.4.1 Medium Compact x Compact (2 x 1)

The segregation ratio of F_2 population of three crosses viz., TMV2 x MH2, PGN1 x MH2 and JL24 x MH2 gave a good fit for the ratio of 1 compact : 15 medium compact indicating the digenic control of this character. Whereas the F_2 population of the cross G201 x MH2 segregated into 1 compact : 35 medium comapct : 24 medium spreading : 4 spreading indicating the trigenic control of this character (Table 31).

4.9.4.2 Medium Spreading x Compact (3 x 1)

The crosses involving medium spreading x compact parents showed the trigenic inheritance of this trait. The F_2 population of the cross MK374 x MH2 gave a good fit for the ratio of 1 compact : 4 medium compact : 48 medium spreading : 11 spreading. The cross Kadiri-3 x MH2 showed a F_2 segregation of 1 compact : 12 medium compact : 47 medium spreading : 4 spreading. A segregation ratio of 1 compact : 14 medium compact : 35 medium spreading : 14 spreading was observed in the cross GNLM x MH2. The F_2 population of the cross TMV2NLM x MH2 segregated into 1 compact : 23 medium compact : 36 medium spreading : 4 spreading.

4.9.4.3 Spreading x Compact (4 x 1)

The F_2 population of the cross involving spreading x compact parents viz., M13 x MH2 showed a segregation ratio of 1 compact : 12 medium compact : 15 medium spreading : 36 spreading for canopy compaction.

Table 31 : Inheritance of canopy compaction.

Canopy cross combination	Crosses	Phenotype of F_1	Phenotypic classes in F_2	Ratio	Observed frequency in F_2	Total population in F_2	Chi-square value	'P' Value
Medium Compact X Compact (2 X 1)	G201 X MH2	Medium Compact(2)	Compact (1)	1	3	167	0.3530	0.900
			Medium Compact(2)	35	89			
			Medium spreading (3)	24	63			
			Spreading (4)	4	12			
Medium Compact X Compact (2 X 1)	TMV2 X MH2	Medium Compact(2)	Compact (1)	1	14	190	0.4038	0.500
			Medium Compact(2)	15	176			
Medium Compact X Compact (2 X 1)	PGN1 X MH2	Medium Compact(2)	Compact (1)	1	28	395	0.4733	0.250
			Medium Compact(2)	15	367			
Medium Compact X Compact (2 X 1)	JL24 X MH2	Medium Compact(2)	Compact (1)	1	17	206	1.4062	0.100
			Medium Compact(2)	15	189			
Medium Spreading X Compact (3 X 1)	MK374 X MH2	Medium spreading(3)	Compact (1)	1	4	336	0.3463	0.950
			Medium Compact(2)	4	22			
			Medium spreading (3)	48	252			
			Spreading (4)	11	58			
Medium Spreading X Compact (3 X 1)	Kadiri-3 X MH2	Medium spreading(3)	Compact (1)	1	5	368	0.3688	0.900
			Medium Compact(2)	12	71			
			Medium spreading (3)	47	267			
			Spreading (4)	4	25			
Medium Spreading X Compact (3 X 1)	GNLM X MH2	Medium spreading(3)	Compact (1)	1	4	174	0.8269	0.750
			Medium Compact(2)	14	36			
			Medium spreading (3)	35	94			
			Spreading (4)	14	40			
Medium Spreading X Compact (3 X 1)	TMV2NLM X MH2	Medium spreading(3)	Compact (1)	1	3	254	0.3745	0.900
			Medium Compact(2)	23	93			
			Medium spreading (3)	36	141			
			Spreading (4)	4	17			
Spreading X Compact (4 X 1)	M13 X MH2	Spreading(4)	Compact (1)	1	6	333	0.1682	0.975
			Medium Compact(2)	12	63			
			Medium spreading (3)	15	79			
			Spreading (4)	36	185			
Medium Compact X M.Compact (2 X 2)	G201 X JL24	Medium spreading (3)	Medium Compact(2)	6	67	186	0.9787	0.500
			Medium spreading (3)	9	110			
			Spreading (4)	1	9			

Table 31 : Continued...

Canopy cross combination	Crosses	Phenotype of F_1	Phenotypic classes in F_2	Ratio	Observed frequency in F_2	Total population in F_2	Chi-square value	'P' Value
Medium Compact X M.Compact (2 X 2)	G201 X MH2BC28	Medium Compact (2)	Compact (1)	1	4	153	1.2483	0.500
			Medium Compact(2)	35	81			
			Medium spreading (3)	24	59			
			Spreading (4)	4	9			
Medium Compact X M.Compact (2 X 2)	JL24 X MH2BC28	Medium compact (2)	Compact (1)	1	14	203	0.1442	0.500
			Medium Compact(2)	15	189			
Medium Compact X M.Compact (2 X 2)	MH2BC28 X TMV2	Medium compact (2)	Compact (1)	1	11	201	0.2067	0.500
			Medium Compact(2)	15	190			
Medium Compact X M.spreading (2 X 3)	G201 X TMV2NLM	Medium spreading (3)	Medium Compact(2)	6	73	188	0.3547	0.750
			Medium spreading (3)	9	102			
			Spreading (4)	1	13			
Medium Compact X M.spreading (2 X 3)	TMV2 X TMV2NLM	Medium spreading (3)	Medium Compact(2)	4	81	315	0.5424	0.750
			Medium spreading (3)	9	180			
			Spreading (4)	3	54			
Medium Compact X M.spreading (2 X 3)	PGN1 X TMV2NLM	Medium spreading (3)	Medium Compact(2)	6	87	230	0.8541	0.500
			Medium spreading (3)	9	132			
			Spreading (4)	1	11			
Medium Compact X M.spreading (2 X 3)	JL24 X TMV2NLM	Medium spreading (3)	Medium Compact(2)	1	56	222	0.0060	0.900
			Medium spreading (3)	3	166			
Medium Compact X M.spreading (2 X 3)	J11 X TMV2NLM	Medium spreading (3)	Medium Compact(2)	1	59	212	0.9056	0.250
			Medium spreading (3)	3	153			
Medium Compact X M.spreading (2 X 3)	PI259747 X 32-2-5	Medium spreading (3)	Medium Compact(2)	1	40	143	0.6736	0.250
			Medium spreading (3)	3	103			
Medium Compact X M.spreading (2 X 3)	JL24 X 32-2-5	Medium spreading (3)	Medium Compact(2)	1	60	211	1.3285	0.100
			Medium spreading (3)	3	151			
Medium Compact X M.spreading (2 X 3)	TMV2 X 32-2-5	Medium spreading (3)	Medium Compact(2)	1	49	177	0.6799	0.250
			Medium spreading (3)	3	128			
Medium Compact X M.spreading (2 X 3)	G201 X TAP5	Medium spreading (3)	Medium Compact(2)	1	45	167	0.3373	0.500
			Medium spreading (3)	3	122			
Medium Compact X M.spreading (2 X 3)	PGN1 X TAP5	Medium Compact (2)	Medium Compact(2)	15	284	307	0.8068	0.250
			Medium spreading (3)	1	23			

Table 31 : Continued...

Canopy cross combination	Crosses	Phenotype of F_1	Phenotypic classes in F_2	Ratio	Observed frequency in F_2	Total population in F_2	Chi-square value	'P' Value
Medium Compact X M.spreading (2 X 3)	TMV2 X TAP5	Medium Compact (2)	Medium Compact(2)	3	168	215	1.1303	0.250
			Medium spreading (3)	1	47			
Medium Compact X M.spreading (2 X 3)	JL24 X TAP5	Medium Compact (2)	Medium Compact(2)	15	164	178	0.7898	0.250
			Medium spreading (3)	1	14			
Medium Compact X M.spreading (2 X 3)	J11 X TAP5	Medium Compact (2)	Medium Compact(2)	15	159	174	1.6723	0.100
			Medium spreading (3)	1	15			
Medium Compact X M.spreading (2 X 3)	PI350680 X TAP5	Medium Compact (2)	Medium Compact(2)	3	122	168	0.5080	0.250
			Medium spreading (3)	1	46			
Medium Spreading X M.Compact (3 X 2)	Kadiri-3 X JL24	Medium spreading (3)	Medium Compact(2)	6	84	231	0.6891	0.500
			Medium spreading (3)	9	135			
			Spreading (4)	1	12			
Medium Spreading X M.Compact (3 X 2)	Kadiri-3 X MH2BC28	Medium spreading (3)	Medium Compact(2)	3	22	133	0.4641	0.750
			Medium spreading (3)	12	103			
			Spreading (4)	1	8			
Medium Spreading X M.Compact (3 X 2)	TMV2NLM X MH2BC28	Medium spreading (3)	Compact (1)	1	5	228	0.6930	0.750
			Medium Compact(2)	11	39			
			Medium spreading (3)	48	171			
			Spreading (4)	4	13			
Medium Compact X Spreading (2 X 4)	MH2BC28 X M13	Medium spreading (3)	Compact (1)	1	4	159	1.0935	0.750
			Medium Compact(2)	12	28			
			Medium spreading (3)	37	91			
			Spreading (4)	14	36			
Spreading X M. Compact (4 X 2)	M13 X JL24	Spreading (4)	Medium Compact(2)	4	63	238	0.6956	0.500
			Medium spreading (3)	3	40			
			Spreading (4)	9	135			
M. Spreading X M. Spreading (3 X 3)	MK374 X TMV2NLM	Medium spreading (3)	Medium spreading (3)	3	147	193	0.1399	0.500
			Spreading (4)	1	46			
M. Spreading X M. Spreading (3 X 3)	Kadiri-3 X TMV2NLM	Medium spreading (3)	Medium spreading (3)	15	276	294	0.0084	0.900
			Spreading (4)	1	18			
M. Spreading X M. Spreading (3 X 3)	TMV2NLM X 32-2-5	Medium spreading (3)	Medium spreading (3)	15	201	217	0.4684	0.250
			Spreading (4)	1	16			

Table 31 : Continued...

Canopy cross combination	Crosses	Phenotype of F_1	Phenotypic classes in F_2	Ratio	Observed frequency in F_2	Total population in F_2	Chi-square value	'P' Value
M. Spreading X M. Spreading (3 X 3)	GNLM X 32-2-5	Medium spreading (3)	Medium spreading (3)	15	233	245	0.7633	0.250
			Spreading (4)	1	12			
M. Spreading X M. Spreading (3 X 3)	Kadiri-3 X 32-2-5	Medium spreading (3)	Medium spreading (3)	15	254	274	0.5165	0.250
			Spreading (4)	1	20			
M. Spreading X M. Spreading (3 X 3)	MK374 X TAP5	Medium spreading (3)	Medium Compact (2)	1	13	179	0.3123	0.500
			Medium spreading (3)	15	166			
M. Spreading X M. Spreading (3 X 3)	Kadiri-3 X TAP5	Medium spreading (3)	Medium Compact (2)	1	61	231	0.2439	0.500
			Medium spreading (3)	3	170			
M. Spreading X M. Spreading (3 X 3)	GNLM X TAP5	Medium spreading (3)	Medium spreading (3)	3	153	194	1.5464	0.100
			Spreading (4)	1	41			
M. Spreading X M. Spreading (3 X 3)	TMV2NLM X TAP5	Medium spreading (3)	Medium spreading (3)	3	177	227	1.0705	0.250
			Spreading (4)	1	50			
M. Spreading X M. Spreading (3 X 3)	TMV2NLM X GNLM	Medium spreading (3)	Compact (1)	1	4	316	0.3978	0.900
			Medium Compact(2)	3	16			
			Medium spreading (3)	55	273			
			Spreading (4)	5	23			
Spreading X M. Spreading (4 X 3)	M13 X TMV2NLM	Spreading (4)	Medium spreading (3)	7	100	230	0.0070	0.900
			Spreading (4)	9	130			
Spreading X M. Spreading (4 X 3)	M13 X TAP5	Spreading (4)	Medium Compact(2)	1	14	223	0.5810	0.500
			Medium spreading (3)	6	89			
			Spreading (4)	9	120			
Spreading X M. Spreading (4 X 3)	ICG2271 X TAP5	Spreading (4)	Medium Compact(2)	1	7	143	0.6281	0.500
			Medium spreading (3)	6	52			
			Spreading (4)	9	84			

M. Compact = Medium Compact

M. Spreading = Medium Spreading

4.9.4.4 Medium Compact x Medium Compact (2 x 2)

Out of four crosses involving medium compact x medium compact parents, two crosses viz., JL24 x MH2BC28 and MH2BC28 x TMV2 exhibited a segregation ratio of 1 compact : 15 medium compact in F_2 generation. The F_2 segregation of the cross G201 x JL24 gave a good fit for 6 medium compact : 9 medium spreading : 1 spreading. While the cross G201 x MH2BC28 showed a segregation ratio of 1 compact : 35 medium compact : 24 medium spreading : 4 spreading (Table 31).

4.9.4.5 Medium Compact x Medium Spreading (2 x 3) (or) Medium Spreading x Medium Compact (3 x 2)

The F_2 population of the crosses viz., JL24 x TMV2NLM, J11 x TMV2NLM, PI259747 x 32-2-5, JL24 x 32-2-5, TMV2 x 32-2-5 and G201 x TAP5 exhibited the segregation ratio of 1 medium compact : 3 medium spreading. The crosses viz., TMV2 x TAP5 and PI350680 x TAP5 showed a segregation ratio of 3 medium compact : 1 medium spreading. A F_2 segregation ratio of 15 medium compact : 1 medium spreading was observed in PGN1 x TAP5, JL24 x TAP5 and J11 x TAP5. The F_2 segregation of the crosses viz., G201 x TMV2NLM, PGN1 x TMV2NLM and Kadiri-3 x JL24 gave a good fit for 6 medium compact : 9 medium spreading : 1 spreading. The F_2 population of the crosses viz., TMV2 x TMV2NLM and Kadiri-3 x MH2BC28 recorded the segregation ratio of 4 medium compact : 9 medium spreading : 3 spreading and 3 medium compact : 12 medium spreading : 1 spreading respectively. The cross TMV2NLM x MH2BC28 exhibited a F_2 segregation ratio of 1 compact : 11 medium compact : 48 medium spreading : 4 spreading.

4.9.4.6 Medium Compact x Spreading (2 x 4) (or) Spreading x Medium Compact (4 x 2)

The segregation ratio of F_2 population of the cross MH2BC28 x M13 gave a good fit for the ratio of 1 compact : 12 medium compact : 37 medium spreading : 14 spreading suggesting trigenic inheritance of canopy compaction. Whereas the M13 x *JL24 segregated into 4 medium compact : 3 medium spreading* : 9 spreading.

4.9.4.7 Medium Spreading x Medium Spreading (3 x 3)

Among the ten crosses belonging to this canopy cross combination, three crosses viz., MK374 x TMV2NLM, GNLM x TAP5 and TMV2NLM x TAP5 showed a segregation ratio of 3 medium spreading : 1 spreading in F_2 generation. The F_2 population of four crosses viz., Kadiri-3 x TMV2NLM, TMV2NLM x 32-2-5, GNLM x 32-2-5 and Kadiri-3 x 32-2-5 exhibited a segregation ratio of 15 medium spreading : 1 spreading. The F_2 population of MK374 x TAP5 and Kadiri-3 x TAP5 segregated into 1 medium compact : 15 medium spreading and 1 medium compact : 3 medium spreading respectively. The F_2 segregation pattern of the cross TMV2NLM x GNLM gave a good fit for 1 compact : 3 medium compact : 55 medium spreading : 5 spreading (Table 31).

4.9.4.8 Spreading x Medium Spreading (4 x 3)

The crosses M13 x TAP5 and ICG2271 x TAP5 belonging to this canopy cross combination showed a segregation pattern of 1 medium compact : 6 medium spreading : 9 spreading in F_2 generation. While, the F_2 population of the cross M13 x TMV2NLM exhibited a segregation ratio of 7 medium spreading : 9 spreading.

4.10 MEANS AND VARIANCES FOR CANOPY AND REPRODUCTIVE ATTRIBUTES IN M_1, M_2 AND M_3 GENERATIONS

The means and variances of various canopy and reproductive characters in M_1, M_2 and M_3 generations following mutagenic treatments of Sodium azide 3 mM and EMS 0.3 per cent on groundnut variety TAP5 are presented in Tables 32, 33 and 34 respectively. The precentage increase in variance over the respective controls was given in Table 35 for M_1, M_2 and M_3 generations.

4.10.1 M_1 Generation

4.10.1.1 Canopy Circumference

Sodium azide treatment (209.04 cm) showed enhanced mean canopy circumference as compared to control (197.22 cm). Whereas, EMS treatment recorded decreased mean value (186.86 cm). Both the treatments induced enhanced variance for canopy circumference over the control. The highest variance was observed in EMS treatment. Increase in variance over the control was 60.92 per cent in EMS and 47.39 per cent in NaN_3 treatments.

4.10.1.2 Canopy Diameter

Increased mean canopy diameter was recorded in Sodium azide treatment (93.02 cm) as compared to control (91.72 cm). Reduced mean value was observed in EMS treatment (89.57 cm).

Table 32 : Effect of Sodiumazide (3mM) and EMS (0.3%) on means and variances of canopy and reproductive attributes in the M_1 generation of TAP5.

	Canopy circumference (cm)	Canopy diameter (cm)	Plant height (cm)	Number of primaries	Number of secondaries	Number of aerial pegs	Number of mature pods	Mature pod weight (g)	Number of mature kernels	Mature kernel weight (g)	Total dry matter at harvest (g)
Control											
Mean	197.22	91.72	47.41	4.44	0.518	13.30	15.84	13.15	26.35	7.29	25.52
Variance	21.42	10.54	10.77	0.85	0.849	9.92	6.32	7.28	10.46	4.70	7.96
NaN_3											
Mean	209.04	93.02	42.17	4.87	1.800	27.72	17.69	14.08	28.86	7.69	39.07
Variance	31.57	25.35	12.65	1.25	1.080	18.79	10.90	10.51	16.82	6.68	17.35
	(47.39%)	(140.51%)	(17.46%)	(47.06%)	(27.21%)	(89.42%)	(72.47%)	(44.37%)	(60.80%)	(42.13%)	(117.96%)
EMS											
Mean	186.86	89.57	48.43	4.58	2.170	20.60	19.51	15.73	34.16	9.64	37.79
Variance	34.37	31.06	13.36	1.27	1.470	19.77	11.23	11.32	17.35	7.42	16.90
	(60.92%)	(194.69%)	(24.05%)	(49.41%)	(73.14%)	(99.29%)	(77.69%)	(55.49%)	(65.87%)	(57.87%)	(112.31%)

Note : The values in parenthesis indicate the percentage increase in variance over the control.

Enhanced variance for canopy diameter was obtained in both the treatments over the control. The enhancement of variance was higher in EMS treatment than in NaN_3 treatment. In terms of percentage increase in variance was 194.69 per cent and 140.51 per cent in EMS and NaN_3 treatments respectively.

4.10.1.3 Plant Height

The highest mean plant height was recorded by EMS treatment (48.23 cm) over the control (47.41 cm). While, the NaN_3 treatment showed reduced mean plant height (42.17 cm). EMS treatment recorded the highest variance for plant height. NaN_3 also showed higher variance than the control. The enhancement of variance over the control was 24.05 per cent in EMS and 17.46 per cent in NaN_3 treatments.

4.10.1.4 Number of Primaries

Both the treatments NaN_3 (4.87) and EMS (4.58) recorded increased mean number of primaries over the control (4.44). The variance for number of primaries was enhanced in both the treatments. The enhancement was more in EMS treatment. The percentage increase in variance was 49.41 per cent in EMS treatment and 47.06 per cent in NaN_3 treatment over the control.

4.10.1.5 Number of Secondaries

The mean number of secondaries was high in EMS treatment (2.17) followed by NaN_3 treatment (1.80) as compared to control (0.52). Enhanced variance over the control was recorded in both the treatments. The highest variance was observed in EMS treatment. Increase in variance was 73.14 per cent in EMS treatment, while NaN_3 treatment recorded 27.21 per cent increase over the control.

4.10.1.6 Number of Aerial Pegs

The highest mean number of aerial pegs was obtained in NaN_3 treatment (27.72) followed by EMS treatment (20.60) as compared to control (13.30). The treatment EMS recorded the highest variance followed by NaN_3 treatment over the control. As compared to control, EMS and NaN_3 treatments recorded 99.29 per cent and 89.42 per cent increase in variance respectively.

4.10.1.7 Number of Mature Pods

Increased mean number of mature pods was obtained in both the treatments. EMS (19.51) and NaN_3 (17.69) as compared to control (15.84). Enhanced variance was observed for number of mature pods in both the treatments over the control. EMS treatment induced the highest variance. The percentage increase in variance was 77.69 per cent in EMS and 72.47 per cent in NaN_3 over the control.

4.10.1.8 Mature Pod Weight

The EMS treatment recorded the highest mature pod weight (15.73 g) followed by NaN_3 treatment (14.08 g) as compared to their control (13.15 g). Both the treatments resulted in enhanced variance over the control. The highest variance was obtained in EMS treatment. The enhancement of variance was 55.49 per cent in EMS and 44.37 per cent in NaN_3 treatments as compared to control.

4.10.1.9 Number of Mature Kernels

The mean number of mature kernels was high in EMS treatment (34.16) followed by NaN_3 treatment (28.86) as compared to control (26.35). The highest variance for this trait was found in EMS treatment followed by NaN_3 treatment as compared to control. There was 65.89 per cent and 60.80 per cent increase in variance in the EMS and NaN_3 treatments respectively over the control.

4.10.1.10 Mature Kernel Weight

The EMS treatment showed highest mean mature kernel weight (9.64 g). Whereas, NaN_3 treatment recorded slightly increased mean value (7.69 g) as compared to control (7.29 g). The EMS and NaN_3 treatments enhanced the variance for this trait over the control. The highest variance was found in EMS treatment. The increase in variance was 57.87 per cent in EMS and 42.13 per cent in NaN_3 treatments as compared to control.

4.10.1.11 Total Dry Matter at Harvest

The highest dry matter production at harvest was obtained in NaN_3 treatment (39.07 g) followed by EMS treatment (37.79 g) as compared to control (25.52g). Enhanced variance for this trait was obtained in both the treatments. The NaN_3 treatment recorded the highest variance. The increase in variance over the control was 117.96 per cent in case of NaN_3 treatment and 112.31 per cent in EMS treatment.

4.10.2 M_2 Generation

4.10.2.1 Canopy Circumference

The data presented in table 33 indicated that in the M_2 generation, the Sodium azide treatment (208.16 cm) recorded the highest mean canopy circumference followed by EMS treatment (146.14 cm) as compared to the control (142.29 cm). It was observed that the EMS treatment induced the highest variance for canopy circumference followed by NaN_3 treatment. Increase in variance over the control was 405.85 per cent in EMS and 125.93 per cent in NaN_3 treatments.

4.10.2.2 Canopy Diameter

The highest mean canopy diameter was observed in NaN_3 treatment (77.66 cm) followed by EMS treatment (65.30 cm) as compared to control value (48.39 cm). The variance induced for this trait was high in both the treatments over the control. The highest variance was observed in EMS treatment. The treatments EMS and NaN_3 showed 292.54 per cent and 257.46 per cent increase in variance over the control respectively.

4.10.2.3 Leaf Area at 60 Days

The EMS treatment resulted in highest mean leaf area (1939.65 cm^2) followed by NaN_3 treatment (1898.59 cm^2) as compared to control(1639.16 cm^2). Both the treatments recorded enhanced variance for this trait. The enhancement was high in EMS treatment. In terms of percentage the increase in variance was 115.43 per cent in EMS and 84.33 per cent in NaN_3.

Table 33 : Effect of Sodiumazide (3mM) and EMS (0.3%) on means and variances of canopy and reproductive attributes in the M_2 generation of TAP5.

	Canopy circum-ference (cm)	Canopy diameter (cm)	Leaf area at 70 days (sq. cm)	Chloro-phyll content (mg/g)	Plant height (cm)	Number of primar-ies	Number of secon-daries	Number of aerial pegs	Number of mature pods	Mature pod weight (g)	Number of mature kernels	Mature kernel weight (g)	Total dry matter at harvest (g)
Control													
Mean	142.29	48.39	1639.16	0.68	42.83	4.43	1.86	27.39	17.87	15.08	23.67	7.18	39.68
Variance	14.54	5.36	273.35	0.13	9.93	0.53	1.34	10.26	3.52	3.89	9.02	2.01	10.51
NaN_3													
Mean	208.16	77.66	1898.59	1.04	55.00	8.59	7.30	27.94	18.82	16.83	24.52	8.10	48.69
Variance	32.85	19.16	503.87	0.23	16.76	2.29	4.56	20.41	7.07	7.27	15.33	4.43	24.78
	(125.93%)	(257.46%)	(84.33%)	(76.92%)	(68.78%)	(332.08%)	(240.30%)	(98.93%)	(100.85%)	(86.89%)	(69.95%)	(120.40%)	(135.78%)
EMS													
Mean	146.14	65.30	1939.65	1.01	52.49	8.03	7.67	34.23	22.09	19.26	41.04	15.42	57.20
Variance	73.55	21.04	588.89	0.26	16.44	2.55	4.71	25.16	7.36	8.25	17.90	6.67	27.16
	(405.85%)	(292.54%)	(115.43%)	(100.00%)	(65.56%)	(381.13%)	(251.49%)	(145.22%)	(109.09%)	(112.08%)	(98.45%)	(231.84%)	(158.42%)

Note : The values in parenthesis indicate the percentage increase in variance over the control.

4.10.2.4 Chlorophyll Content

High chlorophyll content was observed in both the treatments as compared to control (0.68 mg). The highest was recorded in NaN_3 treatment (1.04 mg) followed by EMS treatment (1.01 mg). Enhanced variance was observed in both the treatments for this trait. However, the variance induced by EMS treatment was found to be the highest. Hundred per cent increase in variance was found in EMS treatment and 76.92 per cent increase in NaN_3 treatment.

4.10.2.5 Plant Height

Increased plant height was recorded in NaN_3 (55.00 cm) and EMS (52.49 cm) treatments as compared to control (42.83 cm). Both the treatments recorded almost equal variances which were more than that observed in control. The increase over the control was 68.78 per cent in NaN_3 treatment and 65.56 per cent in EMS treatment.

4.10.2.6 Number of Primaries

The mean number of primaries was increased in both the treatments NaN_3 (8.59) and EMS (8.03) as compared to control (4.43). The variance induced was high in both the treatments over the control. EMS treatment recorded 381.13 per cent increase in variance over the control. Whereas, NaN_3 treatment showed 332.08 per cent increase.

4.10.2.7 Number of Secondaries

The EMS and NaN_3 treatments resulted in increased mean number of secondaries (7.67 and 7.30) respectively as compared to control (1.86). Enhanced variance was observed in both the treatments for this character. EMS treatment induced the highest variance. As compared to control the increase in variance was 251.49 per cent in EMS treatment and 240.30 per cent in NaN_3 treatment.

4.10.2.8 Number of Aerial Pegs

The EMS treatment (34.23) recorded the highest mean number of aerial pegs. Whereas, NaN_3 treatment (27.94) recorded almost equal number of aerial pegs observed in control (27.39). As compared to the control, the variance was enhanced in both the treatments. The enhancement was more in EMS treatment as comapred to NaN_3 treatment. The increase in variance was 145.22 per cent in case of EMS treatment and 98.83 per cent in NaN_3 treatment.

4.10.2.9 Number of Mature Pods

The highest mean number of mature pods was observed in EMS treatment (22.09) followed by NaN_3 treatment (18.82) as compared to control (17.87). The variance was increased in both the treatments as compared to control. The highest variance was obtained in EMS treatment. Over the control, the increase in variance was 109.09 per cent in EMS treatment and 100.85 per cent in NaN_3 treatment.

4.10.2.10 Mature Pod Weight

Both the treatments EMS (19.26 g) and NaN_3 (16.83 g) recorded increased mean pod weight as compared to control (15.08 g). For this character, enhanced variance was observed in both the treatments. EMS treatment induced the highest variance. The enhancement in variance was 112.08 per cent in EMS treatment and 86.89 per cent in NaN_3 treatment over the control.

4.10.2.11 Number of Mature Kernels

Mean number of mature kernels was increased in both the treatments as compared to control (23.67). The highest mean value was found in EMS treatment (41.04). Whereas, NaN_3 treatment (24.52) showed slight increase in mean over the control. The variance induced for this trait was highest in EMS treatment followed by NaN_3 treatment over the control. In the treatments EMS and NaN_3, the increase in variance was 98.45 per cent and 69.95 per cent respectively as compared to control.

4.10.2.12 Mature Kernel Weight

Increased mature kernel weight was obtained in both the treatments EMS (15.42 g) and NaN_3 (8.10 g) as compared to control (7.18 g). The EMS and NaN_3 treatments induced enhanced variances for the mature kernel weight over the control. The percentage increase in variance was 231.84 per cent and 120.40 per cent in EMS and NaN_3 treatments respectively.

4.10.2.13 Total Dry Matter at Harvest

Total dry matter production at harvest high in the treatments EMS (57.20 g) and NaN_3 (48.69 g) as compared to control(39.68g). Enhanced variance was obtained in both the treatments over the control. The EMS treatment showed maximum enhancement of variance followed by NaN_3 treatment. In terms of percentage the increase in variance was 158.42 per cent in EMS treatment and 135.78 per cent in NaN_3 treatment.

4.10.3 M3 Generation

4.10.3.1 Canopy Circumference

The mean canopy circumference was increased in both the treatments NaN_3 (180.07 cm) and EMS (177.83 cm) as compared to control (166.25 cm). Both the treatments resulted in enhanced variance for this trait over the control. The highest variance was recorded in EMS treatment. The enhancement in variance was 70.83 per cent in EMS and 37.46 per cent in NaN_3 treatments.

4.10.3.2 Canopy Diameter

The highest mean canopy diameter was obtained in EMS treatment (68.99 cm) followed by NaN_3 treatment (66.10 cm) as compared to the control (62.58 cm). As a result of EMS and NaN_3 treatments, the variance for this trait was increased over the control. The increase in variance was 161.71 per cent and 130.94 per cent in EMS and NaN_3 treatments respectively.

4.10.3.3 Leaf Area at 60 Days

Increased mean leaf area was observed in the treatments EMS (1569.54 cm^2) and NaN_3 (1566.24 cm^2) as compared to control (1477.85 cm^2). The variance for this character was enhanced due to EMS and NaN_3 treatments over the control. The EMS treatment induced the highest variance. The percentage increase in

Table 34 : Effect of Sodiumazide (3mM) and EMS (0.3%) on means and variances of canopy and reproductive attributes in the M_3 generation of TAP5.

	Canopy circum-ference (cm)	Canopy diameter (cm)	Leaf area at 70 days (sq. cm)	Plant height (cm)	Number of primar-ies	Number of secon-daries	Number of aerial pegs	Number of mature pods	Mature pod weight (g)	Total dry matter at harvest (g)
Control										
Mean	166.25	62.58	1477.85	49.31	4.06	0.00	20.17	12.72	9.00	19.00
Variance	10.25	2.78	345.41	7.15	0.56	0.00	11.73	2.94	3.77	3.69
NaN_3										
Mean	180.07	66.10	1566.24	50.40	4.49	0.35	22.89	17.39	13.95	26.32
Variance	14.09	6.42	556.29	12.09	1.24	0.98	18.88	5.80	6.74	8.57
	(37.46%)	(130.94%)	(61.05%)	(69.09%)	(121.43%)	(98.00%)	(60.95%)	(97.28%)	(78.78%)	(132.25%)
EMS										
Mean	177.83	68.99	1569.54	52.58	5.85	0.56	41.43	17.12	12.98	27.12
Variance	17.51	7.28	568.49	11.54	1.46	1.08	26.93	5.98	7.81	9.41
	(70.83%)	(161.87%)	(64.58%)	(61.40%)	(160.71%)	(108.00%)	(129.58%)	(103.4%)	(107.16%)	(155.01%)

Note : The values in parenthesis indicate the percentage increase in variance over the control.

Table 35 : The percentage increase in variance over the control in M_1, M_2 and M_3 generations.

Characters	M_1		M_2		M_3	
	NaN_3 (3mM)	EMS(0.3%)	NaN_3 (3mM)	EMS(0.3%)	NaN_3 (3mM)	EMS(0.3%)
Canopy circumference	47.39%	60.92%	125.93%	405.85%	37.46%	70.83%
Canopy diameter	140.51%	194.69%	257.46%	292.54%	130.94%	161.87%
Plant height	17.46%	24.05%	68.78%	65.56%	69.09%	61.40%
Number of primaries	47.06%	49.41%	332.08%	381.13%	121.43%	160.71%
Number of secondaries	27.06%	72.94%	240.30%	251.49%	98.00%	108.00%
Number of aerial pegs	89.42%	99.29%	98.93%	145.22%	60.95%	129.58%
Number of mature pods	72.47%	77.69%	100.85%	109.09%	97.28%	103.40%
Mature pod weight	44.37%	55.49%	86.89%	112.08%	78.78%	107.16%
Number of mature kernels	60.80%	65.87%	69.95%	98.45%	--	--
Mature kernel weight	42.13%	57.87%	120.40%	231.84%	--	--
Total dry matter at harvest	117.96%	112.31%	135.78%	158.42%	132.25%	155.01%
Leaf area at 70 days	--	--	84.33%	115.43%	61.05%	64.58%
Chlorophyll content at 70 days	--	--	76.92%	100.00%	--	--

variance was 64.58 per cent in EMS treatment and 61.05 per cent in NaN_3 treatment.

4.10.3.4 Plant Height

The data on plant height indicates that the EMS treatment recorded the highest mean plant height (52.58 cm) followed by NaN_3 treatment (50.40 cm) as compared to control (49.31 cm). Induced variance for this character was high in NaN_3 treatment followed by EMS treatment. The NaN_3 and EMS treatments resulted in 69.09 per cent and 61.40 per cent increase in variance respectively over the control.

4.10.3.5 Number of Primaries

The EMS treatment recorded the highest mean number of primaries (5.85). Whereas, Sodium azide treatment (4.49) recorded slightly increased mean value as compared to control (4.06). The variance induced by EMS and NaN_3 treatments was high as compared to control. The EMS treatment resulted in higher variance than the NaN_3 treatment. As compared to control, the increase in variance was 160.71 per cent in EMS and 121.43 per cent in NaN_3 treatments.

4.10.3.6 Number of Secondaries

The mean number of secondaries in EMS and NaN_3 treatments was 0.56 and 0.35 respectively. Secondary branches were not observed in control. For this trait, the highest variance was found in EMS treatment followed by NaN_3 treatment. The enhancement in variance was 108.00 per cent in EMS and 98.00 per cent in NaN_3 treatments.

4.10.3.7 Number of Aerial Pegs

Both the treatments EMS (41.73) and NaN_3 (22.89) recorded more number of aerial pegs as compared to control (20.17). The enhancement in variance was high in EMS treatment followed by NaN_3 treatment over the control. The EMS treatment showed 129.58 per cent increase, while NaN_3 treatment recorded 60.95 per cent increase in variance over the control.

4.10.3.8 Number of Mature Pods

Increased number of mature pods was obtained in both the treatments NaN_3 (17.39) EMS (17.12) as compared to control (12.72). As compared to control, the variance for this character was high in EMS treatment followed by NaN_3 treatment. The percentage increase in variance was 103.40 per cent in EMS and 97.28 per cent in NaN_3 treatments.

4.10.3.9 Mature Pod Weight

The Sodium azide treatment (13.95 g) resulted in the highest mean mature pod weight followed by EMS treatment (12.98 g) as compared to control (9.00 g). Enhanced variance for mature pod weight was observed as a result of EMS and NaN_3 treatments. Maximum increase in variance was observed in EMS treatment. Enhanced variance in terms of percentage was 107.16 per cent in EMS and 78.78 per cent in NaN_3 treatments.

4.10.3.10 Total Dry Matter at Harvest

The data on dry matter production revealed that the EMS (27.12 g) and NaN_3 (26.32 g) treatments recorded increased mean values as compared to control (19.00 g). Increased variance was obtained for this trait as a result of EMS and NaN_3 treatments over the control. The EMS treatment induced the highest variance. Over the control, the increase in variance was 155.01 per cent and 132.25 per cent in EMS and NaN_3 treatments respectively.

4.11 VIABLE MUTATION FREQUENCY IN M_2 GENERATION

The mutations which affect the morphology of different parts of the plant like plant height, plant habit, internodal length, inflorescence, pegs, canopy etc are known as viable mutations.

Viable mutation frequencies were estimated on both M_2 family basis and M_2 plant basis (Table 36). It was observed that the EMS treatment at 0.3 per cent concentration resulted in the highest frequency of viable mutations both on M_2 family basis (31.43%) and on M_2 plant basis (3.95%). The viable mutation frequencies recorded in NaN_3 3mM were 27.03 per cent on M_2 family basis and 2.43 per cent on M_2 plant basis.

4.12 MUTAGENIC EFFECTIVENESS AND EFFICIENCY

Mutagenic effectiveness is the ratio between the percentage of M_2 families segregating for mutations and the product of time of mutagenic treatment and concentration of the mutagen. It measures the frequency of mutations induced by a unit dose of mutagen.

Mutagenic efficiency is the proportion of M_2 families segregating in relation to the percentage of sterility induced by

Table 36 : Frequency of viable mutations recovered in the M_2 generation of TAP5.

	Viable mutation frequency	
	Based on families	Based on plants
Control	0	0
NaN_3 (3mM)	27.03	2.43
EMS (0.3%)	31.43	3.95

Table 37 : Mutagenic effectiveness and efficiency of NaN_3 and EMS.

	% M_2 families segregating for mutants	Seed Sterility	Mutagenic effectiveness (Me/t.c.)	Mutagenic efficiency (Me/s)
Control	0	0	0	0
NaN_3(3mM)	27.03	20.50	462.05	1.31
EMS (0.3%)	31.43	10.60	34.92	2.97

the mutagen. It gives an idea of the proportion of mutations in relation to undesirable changes like lethality and sterility. It was estimated based on the percentage seed sterility.

It can be observed from the data presented in Table 37 that the treatment of Sodium azide at the concentration of 3 mM (462.05) was more effective than EMS 0.3 per cent (34.92). The mutagenic treatment EMS at 0.3 per cent concentration (2.97) resulted in higher mutagenic efficiency as compared to NaN_3 3 mM (1.31).

4.13 MUTANTS ISOLATED IN M_2 GENERATION

The following mutants were identified in the M_2 generation of TAP5 subjected to the mutagenic treatment of NaN_3 (3mM) and EMS (0.3%). The characteristic features of these mutants in M_2 generation and their M_3 progeny means are given in Table 38.

4.13.1 Alternate Branching Mutants

These mutants were characterised by the absence of flowering on the main axis and had profuse branching with erect nature. A total of five alternate branching mutants were isolated in both the treatments. These mutants exhibited increased canopy circumference, canopy diameter, leaf area, number of primaries and secondaries, number of mature pods and mature kernels, mature pod weight and kernel weight and also total dry matter at harvest as compared to control values.

Out of five alternate branching mutants, three were identified in EMS treatment and two in Sodium azide treatment.

Table 38 : Mutants isolated in M_2 generation of TAPS along with their M_3 progeny means.

Mutants	Mutagen	Canopy circumference (cm) M_2	Canopy circumference (cm) M_3	Canopy diameter (cm) M_2	Canopy diameter (cm) M_3	Leaf area at [illegible]0 days (sq. cm.) M_2	Leaf area at [illegible]0 days (sq. cm.) M_3	Plant Height (cm) M_2	Plant Height (cm) M_3	Number of primaries M_2	Number of primaries M_3	Number of secondaries M_2	Number of secondaries M_3
Control		142.29	166.25	48.39	62.58	1639.16	1477.85	42.83	49.31	4.43	4.06	1.86	0.00
Alternate branching mutants	(1) EMS(0.3%)	180	170.85	70.00	66.48	2713.77	2588.60	32	30.25	9	5.95	8	6.50
	(2) EMS(0.3%)	170	175.50	64.00	67.25	2488.29	2016.14	34	34.45	10	6.80	9	5.30
	(3) EMS(0.3%)	185	180.35	72.00	69.32	2814.45	2294.08	37	45.32	11	10.00	9	7.40
	(4) NaN3(3mM)	207	195.62	85.00	73.35	1715.27	1819.49	36	38.25	6	7.20	5	4.20
	(5) NaN3(3mM)	200	183.75	79.00	70.02	1881.63	1629.51	37	40.15	5	5.10	7	5.50
Mutants with reduced branch number	(1) EMS(0.3%)	142	160.40	39.00	50.65	871.85	1094.72	62	54.34	3	4.10	0	0
	(2) EMS(0.3%)	140	159.50	40.00	46.05	1030.12	1128.16	61	62.26	3	4.00	0	0
	(3) EMS(0.3%)	150	161.50	43.00	49.15	925.45	864.58	65	55.77	3	3.30	0	0
	(4) EMS(0.3%)	144	158.35	42.00	50.25	899.34	982.13	57	60.10	3	3.00	0	0
	(5) NaN3(3mM)	145	163.25	43.00	54.05	853.91	1123.47	47	50.15	2	2.00	0	0
	(6) NaN3(3mM)	138	157.32	41.00	52.15	901.25	1010.73	55	49.36	2	4.00	0	0
	(7) NaN3(3mM)	140	161.15	47.00	60.59	1000.19	1221.18	46	50.45	2	3.00	0	0
Compact canopy Mutants	(1) EMS(0.3%)	132	148.15	31.00	41.11	1325.45	1099.86	36	40.15	6	4.10	3	2.50
	(2) EMS(0.3%)	130	142.18	33.00	40.24	1651.53	2022.42	40	38.95	5	5.20	4	4.10
	(3) EMS(0.3%)	133	145.35	30.00	35.49	1543.29	1393.21	42	41.28	5	4.80	2	3.20
	(4) EMS(0.3%)	135	150.34	34.00	42.26	1723.14	1671.86	34	43.18	8	7.30	7	5.80
	(5) NaN3(3mM)	120	136.15	31.00	43.13	1337.63	1632.15	50	50.00	4	4.00	3	2.50
	(6) NaN3(3mM)	122	130.20	27.00	38.00	1025.45	944.92	45	49.00	4	4.60	4	3.50
	(7) NaN3(3mM)	125	141.35	32.00	42.15	929.56	1058.32	48	46.00	4	5.00	2	0.00
Slow senescing large leaf mutants	(1) EMS(0.3%)	170	175.50	69.00	66.75	3123.78	2818.63	40	50.12	8	6.10	3	2.50
	(2) EMS(0.3%)	190	180.94	74.00	68.82	3019.18	2911.21	46	48.98	8	5.30	4	3.10
	(3) EMS(0.3%)	180	190.39	72.00	71.00	2952.67	2619.62	40	51.50	6	6.40	2	4.20
	(4) NaN3(3mM)	178	165.50	69.00	64.25	2896.91	2613.14	46	40.55	9	6.50	5	2.50
	(5) NaN3(3mM)	190	201.55	75.00	81.35	2419.93	2521.35	45	50.05	6	5.50	0	3.00
	(6) NaN3(3mM)	170	171.95	67.00	66.18	2684.17	2418.22	40	55.56	7	8.60	1	3.50
	(7) NaN3(3mM)	160	172.46	60.00	70.24	3046.34	2596.47	42	52.54	10	5.50	4	4.20
Profusely branched mutants	(1) EMS(0.3%)	170	169.14	66.00	62.00	2742.87	2189.99	45	42.54	10	8.20	16	9.90
	(2) EMS(0.3%)	175	170.11	65.00	60.00	2421.06	2441.36	46	52.35	9	7.50	18	10.30
	(3) EMS(0.3%)	185	178.45	70.00	68.22	2654.64	2344.18	51	56.24	8	6.90	17	8.40
Profusely branched mutants with shorter internodes	(1) NaN3(3mM)	180	185.50	76.00	70.95	2647.52	2415.64	27	32.04	12	9.50	10	8.50
	(2) NaN3(3dM)	229	195.44	83.00	72.55	2279.71	2056.39	25	30.55	10	6.40	9	6.50

Table 38 : Continued...

Mutants	Mutagen	Number of Mature pods M_2	Number of Mature pods M_3	Number of Aerial pods M_2	Number of Aerial pods M_3	Mature pod weight (g) M_2	Mature pod weight (g) M_3	Number of mature kernels M_2	Number of mature kernels M_3	Mature kernel weight (g) M_2	Mature kernel weight (g) M_3	Total dry matter at harvest (g) M_2	Total dry matter at harvest (g) M_3
Control		17.87	12.72	5.25	4.50	15.08	9.00	23.67	18.30	7.18	6.20	39.68	19.00
Alternate branching mutants	(1) EMS(0.3%)	43	25.25	--	--	40.18	24.30	68.00	44.60	24.45	13.25	59.75	42.40
	(2) EMS(0.3%)	38	22.40	--	--	34.67	20.50	41.00	38.07	18.34	12.50	62.33	38.10
	(3) EMS(0.3%)	40	30.00	--	--	38.94	26.95	66.00	53.96	23.37	17.50	83.95	49.10
	(4) NaN3(3mM)	18	25.05	--	--	17.90	23.80	24.00	40.05	9.53	12.23	50.00	40.55
	(5) NaN3(3mM)	20	23.45	--	--	21.80	20.80	30.00	39.00	11.10	10.89	61.00	39.10
Mutants with reduced branch number	(1) EMS(0.3%)	10	14.62	--	--	9.25	12.30	16.00	24.50	4.11	8.13	24.20	19.20
	(2) EMS(0.3%)	11	13.34	--	--	10.99	12.60	20.00	25.41	7.53	7.18	26.50	20.60
	(3) EMS(0.3%)	9	11.55	--	--	9.10	10.80	14.00	21.28	4.95	7.01	23.60	18.30
	(4) EMS(0.3%)	13	12.61	--	--	12.94	11.60	22.00	20.80	6.32	6.32	24.35	21.00
	(5) NaN3(3mM)	7	11.50	--	--	9.10	10.70	15.00	19.60	5.12	6.38	22.50	20.56
	(6) NaN3(3mM)	11	10.02	--	--	10.91	11.10	16.00	18.86	6.19	6.91	17.80	14.80
	(7) NaN3(3mM)	9	12.21	--	--	11.35	9.98	12.00	21.08	7.09	7.09	18.30	16.78
Compact canopy Mutants	(1) EMS(0.3%)	31	27.18	--	--	29.08	23.10	43.00	36.34	17.08	11.98	41.82	36.10
	(2) EMS(0.3%)	27	21.38	--	--	25.56	19.30	45.00	39.08	18.15	10.25	40.13	39.20
	(3) EMS(0.3%)	28	22.52	--	--	29.59	20.40	58.00	42.59	20.68	12.13	38.99	36.23
	(4) EMS(0.3%)	30	25.76	--	--	28.78	22.20	68.00	40.67	21.02	11.18	39.65	30.50
	(5) NaN3(3mM)	27	23.36	--	--	27.40	20.40	37.00	35.23	13.32	10.18	30.90	29.40
	(6) NaN3(3mM)	26	21.54	--	--	24.10	23.20	35.00	25.15	12.61	9.56	31.50	32.30
	(7) NaN3(3mM)	22	15.49	--	--	20.00	15.40	29.00	38.21	11.60	11.27	30.95	30.00
Slow senescing large leaf mutants	(1) EMS(0.3%)	53	42.11	12.00	9.30	59.83	38.45	104.00	81.22	46.89	27.87	96.79	62.42
	(2) EMS(0.3%)	43	44.78	11.00	10.20	41.55	37.12	70.00	74.14	30.07	22.95	75.71	49.56
	(3) EMS(0.3%)	46	40.47	9.00	9.25	43.76	32.46	74.00	68.40	31.47	20.08	68.24	55.99
	(4) NaN3(3mM)	34	29.05	10.00	9.50	32.27	24.21	48.00	46.24	19.17	13.16	78.68	52.40
	(5) NaN3(3mM)	32	28.40	8.00	8.30	31.62	26.40	50.00	39.35	20.42	14.01	65.51	54.00
	(6) NaN3(3mM)	30	30.30	9.00	7.50	30.76	25.30	56.00	40.42	21.60	13.17	66.63	40.26
	(7) NaN3(3mM)	39	36.25	10.00	8.75	40.86	30.30	65.00	53.10	22.67	20.15	72.53	45.23
Profusely branched mutants	(1) EMS(0.3%)	49	32.05	9.00	8.20	44.09	27.45	71.00	49.66	29.80	18.92	115.68	50.76
	(2) EMS(0.3%)	33	30.93	7.00	6.50	35.55	26.33	55.00	46.12	20.50	14.15	76.66	49.25
	(3) EMS(0.3%)	36	29.50	8.00	7.65	32.67	24.20	48.00	38.71	21.01	12.94	73.25	41.25
Profusely branched mutants with shorter internodes	(1) NaN3(3mM)	30	20.23	10.00	9.00	30.14	20.20	41.00	30.22	16.62	9.32	99.40	50.23
	(2) NaN3(3mM)	28	19.18	8.00	8.25	28.40	18.50	38.00	35.52	12.02	11.55	61.40	38.11

These mutants bred true in M_3 generation in respect of alternate branching character and showed higher yield than the parent (Table 38).

4.13.2 Mutants with Reduced Branch Number

In these mutants, it was observed that the number of primaries and secondaries were reduced as compared to the parent. About seven mutants of this type were identified in both the treatments. All the mutants exhibited reduced number of branches, leaf area at 60 days and also pod and kernel yields when compared to the parent (Table 38). In M_3 generation there was slight increase in mean number of primaries as compared to that in M_2 generation but almost equal to the control value.

4.13.3 Compact Canopy Mutants

These mutants were characterised by compact plant stature giving a bushy appearance to the plant. Seven compact canopy mutants were isolated, of which four were selected in EMS treatment and three in Sodium azide treatment. All these mutants showed reduced canopy diameter when compared to its parent. The number of branches was increased in these mutants as compared to parent. The data on yield and other characters are given in Table 38. They bred true for compact canopy in M_3 generation.

4.13.4 Slow Senescing Large Leaf Mutants

The characteristic features of these mutants were, high leaf area at 60 days and increased size of the leaves. They exhibited increased number of branches and total dry matter production at harvest. It was observed that, these mutants recorded high yields as compared to control and also other mutants. Out of the total seven mutants, 4 in NaN_3 treatment and 3 in EMS treatment were identified in M_2 generation. These were found to bred true for the above characters in M_3 generation and also exhibited enhanced yield as compared to control (Table 38).

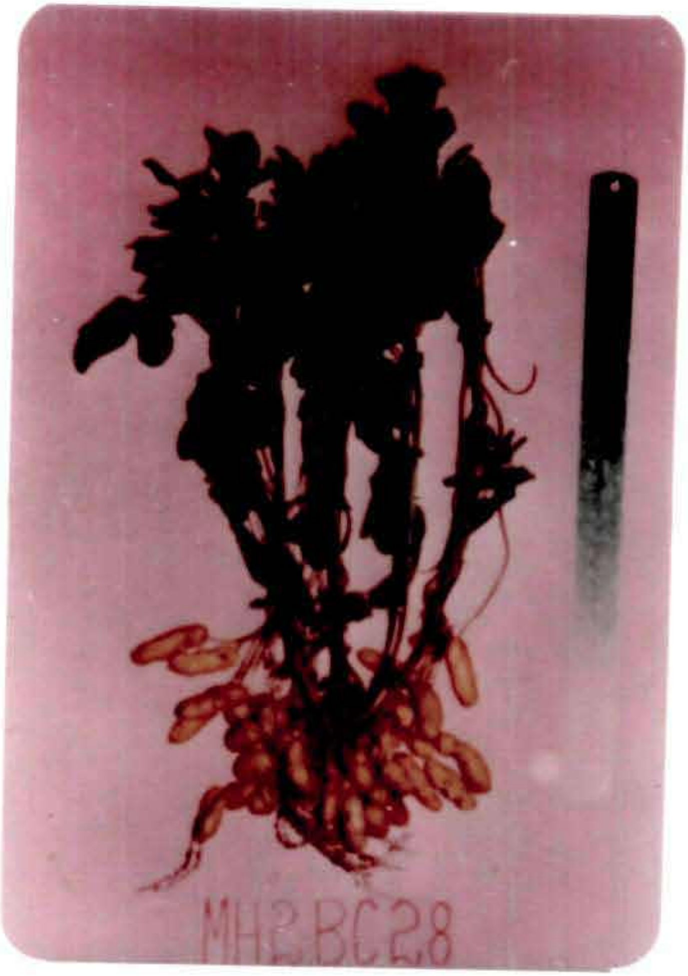
4.13.5 Profusely Branched Mutants

These mutants were characterised by increased number of secondary and primary branches. They also recorded enhanced canopy diameter, leaf area at 60 days and yield. They were observed only in EMS treatment. These mutants bred true for number of secondaries in M_3 generation as compared to control (Table 38).

4.13.6 Profusely Branched Mutants with Shorter Internodes

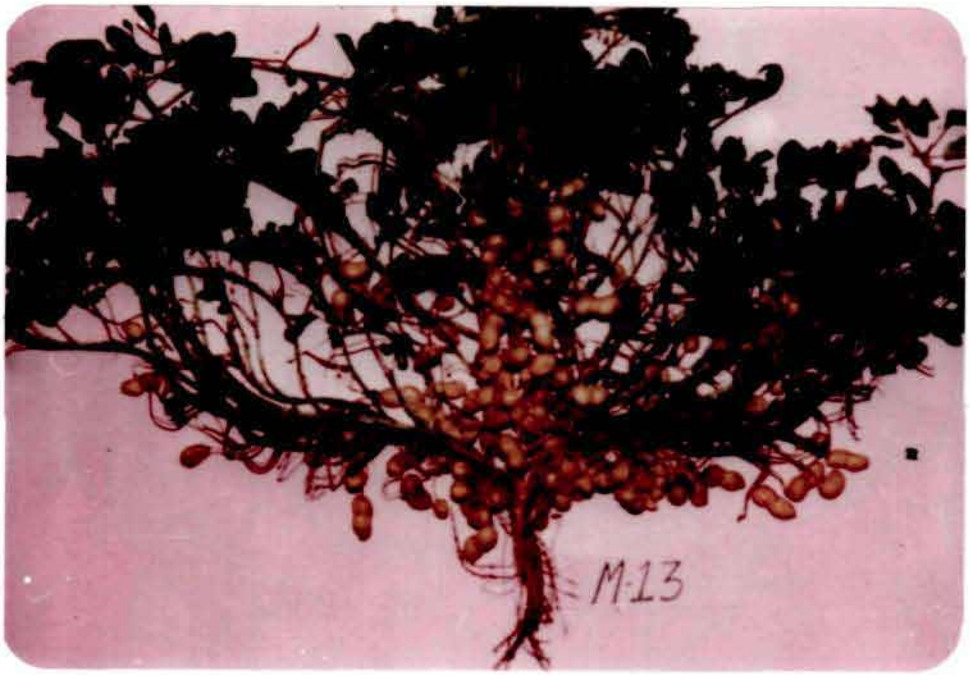
These mutants were identified only in Sodium azide treatment. The two mutants, identified in this treatment were characterised by reduced plant height and increased number of branches as compared to the parent. They yielded more than the control. In M_3 generation, these mutants bred true for reduced internodal length and also recorded increased kernel yield than the control.


MH2


MH2BC28


TMV2


TMV2NLM


M-13


COM MUT M-13

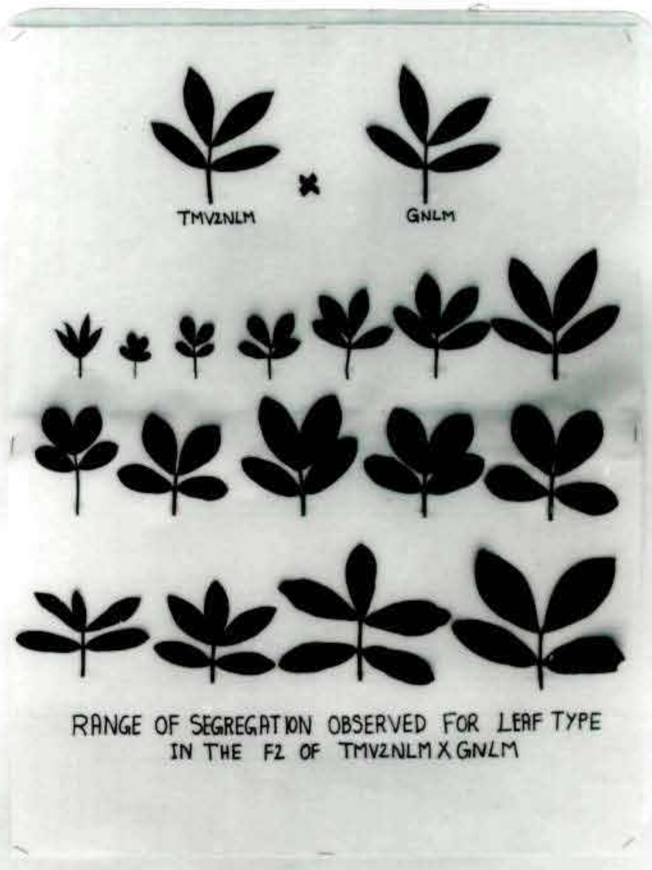

F PGN-1 x TAP-5


F2(TMV2 X 32-2-5)


F2(TMV2NLM X 32-2-5)


F2 TMV 2 NLM × TAP 5

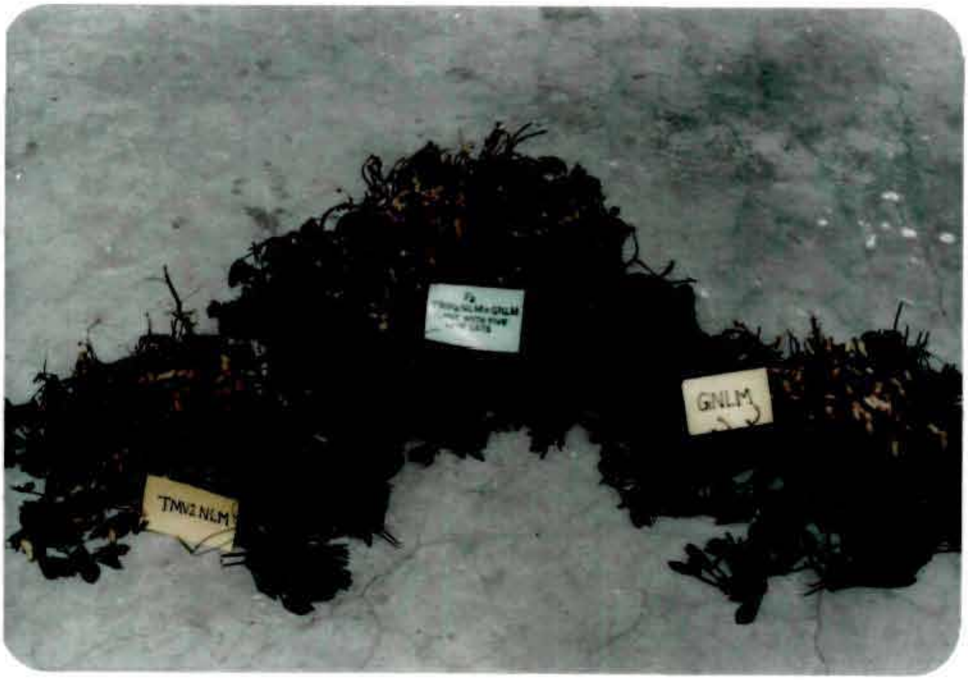

TMV2 NLM

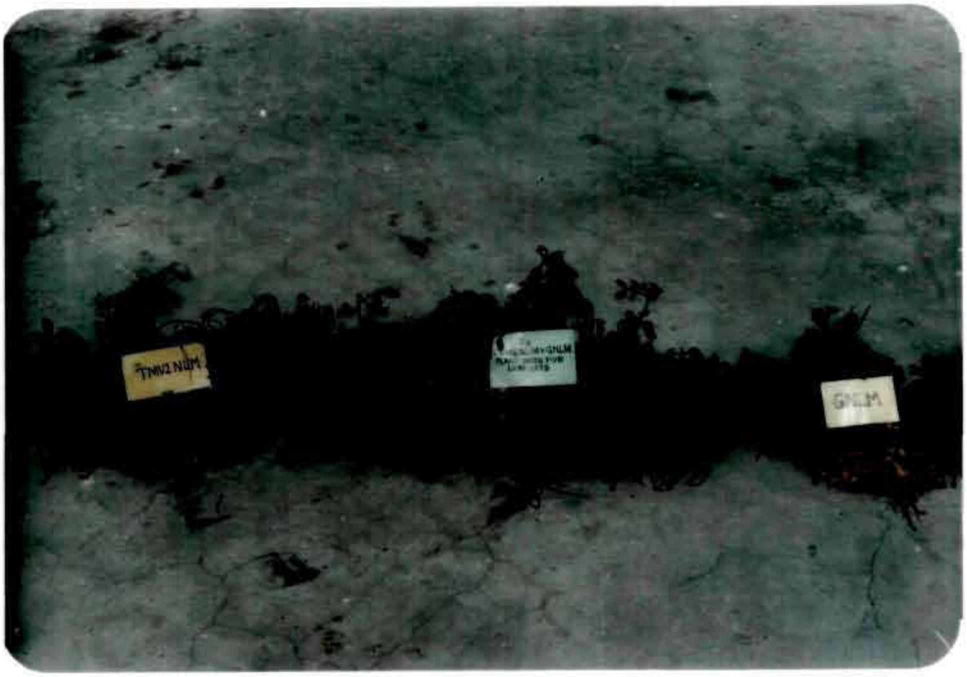

TMV2NLM
GNLM
RANGE OF SEGREGATION OBSERVED FOR LEAF TYPE
IN THE F2 OF TMV2NLM X GNLM

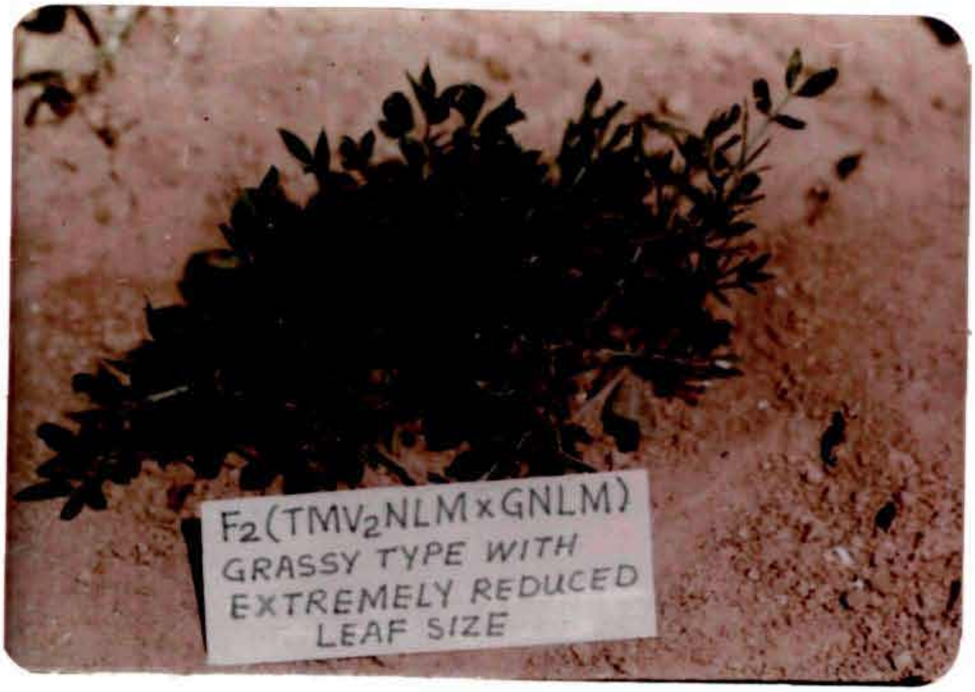

F2 (TMV2 NLM x GNLM)

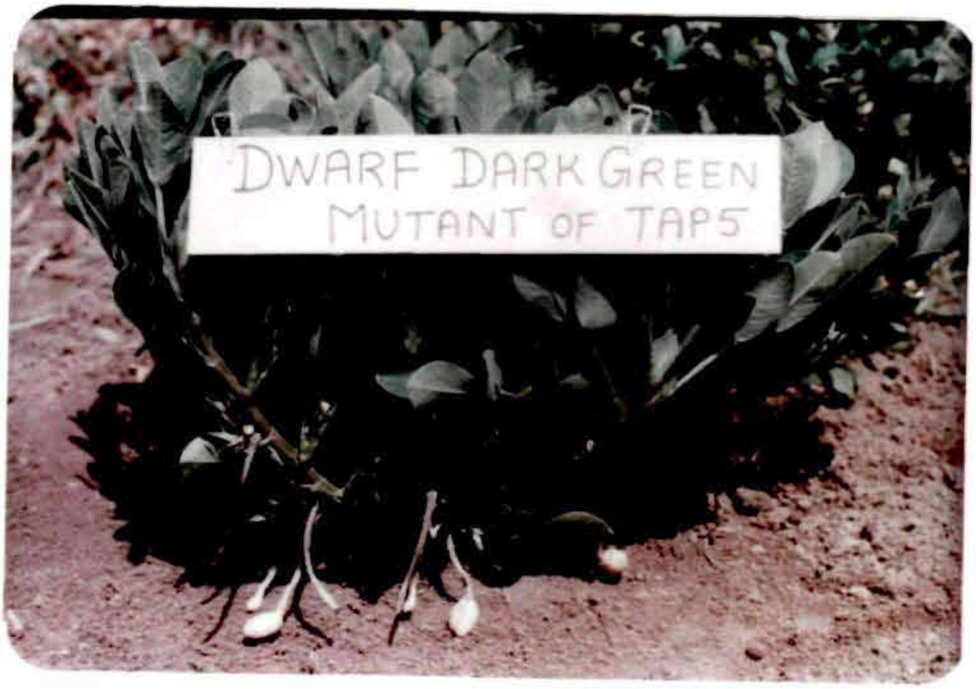

F2 (TMV2 NLM x GNLM)


F2(TMV2NLM x GNLM)


TMV2 NLM
GNLM


TMV2 NLM


F2(TMV2NLM x GNLM)
GRASSY TYPE WITH
EXTREMELY REDUCED
LEAF SIZE


DWARF DARK GREEN
MUTANT OF TAP5

DISCUSSION

CHAPTER V

DISCUSSION

5.1 CATEGORISATION OF GROUNDNUT GENOTYPES FOR CANOPY DEVELOPMENT

A perusal of history of groundnut breeding indicates that genotypes have been characterised and indentified based on branching pattern and erect or spreading habit (Gregory et al., 1951; Bunting, 1955, 1958; Krapovickas and Rigoni, 1960 and Gibbons et al., 1972). A similar sort of characterisation was the basis for selection of the parents for hybridization programme. The above method of characterisation although based on botanical classification involving two subspecies, has been useful as a taxonomic tool. Recognizing the importance of the physiological attributes, such as canopy development as a stable selection criteria (Madhavi, 1988 and Nagabhushanam 1989), it would be more relevant to use the same for the characterisation of the parental material as well as the other breeding material.

The first such effort was made by Nagabhushanam (1989) by developing the score as 1, 2, 3 and 4 representing the most compact, medium compact, medium spreading and spreading categories based on canopy diameter, canopy circumference and shoot dry weight. Such categorisation has been useful in not only identifying the stable canopy types possessing stability for kernel yield as well as appropriate parental combinations with intermediate levels of genetic divergence conducive for heterosis in the F_1 and recovery of wider degrees of variance for agronomic attributes down the generations.

While, Nagabhushanam (1989) employed a simple scoring technique for categorisation, in the present study Duncan's Multiple Range test was employed to categorise for allocation and classification of scores for eighteen genotypes in respect of canopy diameter, canopy circumference and leaf area at 60 days. Interestingly this classification based on DMRT also very much agreed with the categorisation arrived at by Nagabhushanam (1989). In otherwords based on the classification, MH2 characterised by the most compact canopy fell in the category of score 1 while the genotypes such as G201, PI259747, PI350680, TMV2, MH2BC28, PGN1, J11 and JL24 fell in the category 2, while Compact Mutant of M13, Gujarat narrow leaf mutant, 32-2-5, Kadiri-3, TMV2NLM, TAP5 and MK374 come under the category 3, lastly the most spreading genotypes ICG2271 and M13 fell in the category 4. It may be noted that while the most of the compact category pertained to sequential branching genotypes, the most of the spreading category was of the alternate branching Virginia runner type. In the intermediate categories 2 and 3 both the sequential as well as alternate branching types occurred thereby suggesting, that the canopy compaction formed an important factor of genetic differentiation at the sub-specific level in groundnut. While the canopy enhancement proceeded from sequential to alternate branching types, the intermediate levels of canopy development embrace both the systems of branching. According to the investigations of Nagabhushanam (1989), these intermediate levels possessing both sequential and alternate branching types were characterised by higher levels of stability for kernel yield unlike the extreme types such as score 1 and 4.

The results of the present investigation revealed that while the parent viz., MH2 pertained to canopy category 1 and its mutant MH2BC28 fell in the category 2. Similarly while M13 fell in the canopy category 4, its mutant Compact Mutant of M13 was of canopy category 3, characterised by higher levels of stability (Nagabhushanam, 1989). Therefore, it is also evident that it is possible to launch a canopy conversion programme from 1 to 2 and from 4 to 3 in order to bring about not only higher levels of stability for kernel yield but also to develop usable parental material in hybridization programmes for the recovery of higher levels of variances down the generations according to Nagabhushanam (1989). The literature for canopy categorisation as is very scarce in groundnut breeding, the results of these investigations have to be reviewed in appropriate perspective. Further investigations in this direction will be of immense use in groundnut breeding.

5.2 APPROPRIATE MICRO-ENVIRONMENTAL CONDITIONS FOR PROPER EXPRESSION OF THE GENOTYPIC POTENTIAL

The traditional groundnut breeding work in India was being carried out under conditions of inadequate nutrient supply particularly with reference to nitrogen as well as limited inter-row spacing of 30 cm and intrarow spacing of 10 cm . This could be one of the reasons for inadequate expression of the potential of the genetic material under evaluation (Rao, 1976). In the present study when wide range of contrasting genotypes were evaluated under six micro-environmental situations, it was observed that the present level of nutrient supply (20 kg N) as well as spacing adopted (40 cm) were infact inadequate to bring about the proper expression of wide range of characters which are crucial for selection by the breeder. The study also indicated the necessity of enhancing the nitrogen dose to 40 kg ha^{-1} supplied by 20 kg as basal and 20 kg as top dressing in order to get proper expression of the characters. It may be observed that almost all the characters such as canopy diameter, number of primaries, mature pod weight, number of mature kernels, mature kernel weight, shelling per cent, harvest index and total dry matter at harvest exhibited better expression at higher dose of nitrogen i.e., 40 kg. It may also be observed that the treatment which resulted in consistently superior expression was N2 (20 kg basal + 20 kg top dressing) - 60 cm (spacing between the rows). Although the treatment of N2 (20 kg basal + 20 kg top dressing) - 90 cm (inter-row spacing) has also shown higher mature pod weight, number of mature pods, harvest index etc, the differences between these two were not significant. The results obtained in the study clearly warrant adoption of appropriate micro-environment particularly higher dose of nitrogen (40 kg) and secondly more inter-row spacing (60 cm) for groundnut breeding work. Of all the characters studied, canopy diameter exhibited consistently stable expression while other characters such as number of primaries, number of secondaries, pod and kernel attributes showed a better expression under 40 kg nitrogen and 60 cm spacing (N2-60). The oil content was found to be stable in all genotypes, the expression of which was better under N2-60 cm. In other words at higher nutrient level and adequate spacing the pod and kernel development would attain a satisfactory level leading to better oil accumulation in the kernel.

In groundnut, this is the first attempt of suggesting a change in the nutrition regime as well as the crop geometry in order to bring about better and purposeful selection facilitating more efficient groundnut breeding. Similar results were also obtained in respect of dry land wheat (Singh *et al.*, 1975 and Gardner and Jackson, 1976) and upland rice (Patrick *et al.*, 1974, Gomez and DeDutta, 1975 and Allen and Terman, 1978) which facilitate the identification of promising genotypes. In view of the urgent necessity of restructuring the groundnut breeding work there is every need to adopt suggested nutrient regime and spacing, so as to allow the better expression of characters.

With regard to genotypes, MH2 characterised by most compact canopy exhibited no significant differences for kernel and pod yield in both *kharif* and *rabi* seasons. The strain also has not shown much difference in oil content in both the seasons. All the genotypes irrespective of branching pattern except MH2 responded well to higher dose of nitrogen and wider spacing of 60 cm, thereby showing the necessity of adopting the above spacing and nutrient management.

In the case of aerial podding genotype TAP5, this treatment brought about enhancement of kernel and pod yield as well as higher number of aerial pods per plant. With regard to oil content, the *Virginia* genotypes in general and specifically Kadiri-3 have shown a slight increase in oil per cent in *rabi* season which may not be significant. However, the increase in oil content was more perceptible in respect of TMV2NLM, Compact Mutant of M13 and M13.

The above investigation also brings to fore the differential response of genotypes such as better expression of aerial pods in aerial podding TAP5 on one hand and lack of any change in the performance under wide range of nutrient management conditions on the other in respect of MH2.

5.3 STABILITY OF THE GENOTYPES

Stability of yield performance is an important criterion for selecting any genotype for productivity (Hammons, 1976; Norden *et al*., 1986, Yadava and Kumar 1978 a&b). It has been generally reported that the yield stability in groundnut varieties is always at the lower ebb in comparison with other grain legumes. The low yield stability of groundnut is one of the reasons for the fluctuations in yield of the most of the recommended varieties. In this context, an evaluation of seven genotypes consisting of three induced mutants together with other four varieties recommended for cultivation has revealed that the Compact canopy Mutant of M13 (canopy category 3) showed the highest stability not only for yield but also for a wide range of other characters such as canopy diameter, number of mature pods, mature pod weight, mature kernel weight, 100 kernel weight and oil per cent, while the standard variety M13 (canopy category 4) which is also the parent of the above induced mutant was found to be unstable for yield as well as days to initial flowering, days to 50 per cent flowering, days to 100 per cent flowering, days to peg initiation, canopy circumference, plant height, number of primaries, number of secondaries, number of mature pods, mature pod weight, number of mature kernels, mature kernel weight and harvest index. Similarly the other varieties viz., JL24 (canopy category 2) and MH2 (canopy category 1) were highly unstable not only for yield but also for other characters such as days to initial flowering, days to 50 per cent flowering, days to 100 per cent flowering, days to peg initiation, canopy circumfernce, plant height, number of primaries, number of secondaries, number of mature pods, mature pod weight, number of mature kernels, mature kernel weight and harvest index, while the two mutants viz., TAP5 (canopy category 3) and TMV2NLM (canopy category 3) showed stability for canopy diameter, number of primaries, number of aerial pegs, 100 kernel weight and shelling per cent and days to 50 per cent flowering, days to 100 per cent flowering, days to peg initiation, canopy diameter and 100 kernel weight respectively. The investigations carried out by Nagabhushanam and Prasad (1992) have also shown that the induced mutant TMV2NLM (a mutant for enhanced canopy of TMV2) was the most stable than its parental variety TMV2.

The results of present investigation as supported by the observations made by Nagabhushanam (1989) clearly brings out that

1. The intermediate canopy types offer higher levels of yield stability than extreme canopy types such as MH2 (most compact 1) and M13 (most spreading 4).

2. Induced mutant representing the intermediate levels of canopy development like compact mutant of M13 (canopy category 3) isolated from the most spreading canopy type M13 (canopy category 4) offers higher levels of yield stability than the parent. Another instance of induced mutant with intermediate canopy development showing higher stability than its parent was that of MH2BC28 (canopy category 2) giving a stable kernel yield than its parent with the most compact canopy type MH2 (canopy category 1) (Nagabhushanam, 1989).

3. The investigation also brings to the fore that induced mutants for canopy attributes play a valuable role in groundnut breeding for stability of yield performance.

5.4 HETEROSIS

Heterosis in the F_1 generation is of considerable significance in genetic improvement of crops not only in terms of developing hybrids in allogamous systems but also in identifying appropriate parental combinations resulting in desirable segregants down the generations (Arunachalam et al., 1984). However, lack of perceptible levels of heterosis is a very characteristic feature of genetic system of groundnut (Raju, 1982 and Arunachalam et al., 1982). This finding is of greater relevance in groundnut breeding. According to the available evidence heterosis in groundnut as in the case of other crop species such as wheat (Fonesca and Patterson, 1968; Sun et al., 1972; Widner and Lebsock, 1973), alfalfa (Sriwatanapongise and Wilsie, 1968), Cotton (Marani, 1963, 1968), Corn (Moll et al., 1962) and Tobacco (Matzinger and Wernsman, 1968) is related to genetic diversity. Despite the reports of non occurrence of higher levels of heterosis, Wynne and Gregory (1981) observed heterosis in peanuts most often occurred in crosses such as Virginia x Spanish and Virginia x Valencia. However, Arunachalam et al. (1984) and Madhavi(1988) reported on the other hand occurrence of heterosis in the hybrids involving Spanish x Valencia combinations. Most of such investigations did not yield consistently any tangible results as there was no systematic attempt to study F_1 heterosis based on parental material characterised for certain stable character combinations viz., Canopy development for example (Nagabhushanam, 1989). The earlier investigations of Reddy et al. (1984), Ashley (1984) and Duncan et al. (1978) as well as the more recent studies conducted by Nagabhushanam and Prasad (1992) clearly bring out not only the decisive influence of canopy development on yield but also its stability over different environmental conditions.

The studies carried out by Nagabhushanam (1989) based on different parental combinations characterised for canopy development indicated that majority of the crosses belonging to medium compact x medium spreading and medium spreading x medium compact combinations showed significant positive heterosis for kernel yield. It was suggested the optimum levels of parental genetic divergence conducive for higher levels of heterosis was provided by the genotypes of intermediate canopy categories, while the other parental combinations involving extreme degrees of divergence did not result in positive heterosis.

In the present investigation the parental material involving selected induced mutants for canopy development and the traditional varieties characterised for canopy development were hybridized to study the heterotic pattern in F_1. It could be observed (Table 39) that only the crosses involving the medium compact x medium spreading canopy types as well as medium spreading x medium spreading canopy types exhibited significant levels of positive heterosis for a wide range of characters such as days to initial flowering, days to 50 per cent flowering, days to 100 per cent flowering, canopy diameter, canopy circumference and leaf area at 60 days, plant height, number of primaries, number of secondaries, number of mature pods, mature pod weight, number of mature kernels, mature kernel weight, total dry matter at harvest, shelling per cent and harvest index.

In view of the consistent evidence (Wynne and Gregory, 1981) that heterosis in groundnut was related to genetic divergence, the initial choice of the parental combinations should be such that resulting in significant levels of heterosis for important agronomic characters including kernel yield so as to obtain desirable segregants in subsequent generations. As observed by

Table 39. The crosses exhibiting significant heterosis under different canopy combinations

Canopy category combination	Days to initial flowering	Days to 50% flowering	Days to 100% flowering	Canopy diameter	Canopy Circum-ference	Leaf area at 60 days	Number of mature pods	Mature pod weight	Mature kernel weight	Harvest index
2 x 1	-	-	-	3	2	3	1	2	1	-
2x3 (or) 3x2	7	6	3	8	7	10	1	6	4	1
3 x 1	-	-	-	1	1	2	-	-	-	-
3 x 3	3	1	-	8	5	7	2	3	3	1
4 x 1	-	-	-	-	-	-	-	-	-	-
4 x 3	2	2	1	1	1	-	-	-	-	-

1 = compact :: 2 = medium compact :: 3 = medium spreading :: 4 = spreading

Nagabhushanam (1989), extreme levels of divergence reflected in the mating involving canopy type combinations such as 1x4 or 1x3 do not seem to be conducive for recovery of higher levels of heterosis. The optimum level of genetic divergence appeared to have been observed in categories 2 and 3, combinations of which resulted higher levels of heterosis. The present investigation is also in agreement with such results. A sporadic occurrence of heterosis, such as TMV2 x MH2 might be due to either high sca or heterosis for one character only, for which the magnitude of heterosis could be substantial due to contrasting attributes like high vs low gca status or adaptation to divergent environments (Arunachalam et al., 1984).

The results of the investigation draw strong support from conclusions drawn by Nagabhushanam (1989) thus indicating the usefulness of selecting parental combinations for intermediate levels of canopy development probably involving intermediate levels of genetic divergence conducive for higher levels of positive heterosis. Even the heterotic crosses based on botanical classification reported by earlier workers, must have been necessarily of combinations involving intermediate canopy types. Analysis of the heterotic pattern arrived at by the substitution of the corresponding induced mutant for canopy development in the place of original parent reveals an interesting trend. Whenever, the canopy category of the parental types in question was changed due to the involvement of an induced mutant for canopy development such as in respect of JL24 x MH2BC28 (intermediate canopy type replacing the original parent

Table 40 : Comparison of heterosis in crosses involving parents and their respective mutants for canopy development.

Crosses	Canopy categorization	Mature kernel weight
* JL24 x MH2	2 x 1	-32.90
* JL24 x MH2BC28	2 x 2	111.04**
* Kadiri-3 x MH2	3 x 1	-51.70**
* Kadiri-3 x MH2BC28	3 x 2	18.45
MK374 x TMV2NLM	3 x 3	-31.17**
TMV2NLM x 32-2-5	3 x 3	49.64**
TMV2 x 32-2-5	2 x 3	78.11**
TMV2NLM x 32-2-5	3 x 3	49.64**
TMV2 x TAP5	2 x 3	-3.980
TMV2NLM x TAP5	3 x 3	14.563

* Source : Madhavi (1988)

MH2 belonging to extreme canopy category) there was a perceptible jump in heterosis for kernel yield (Table 40). A similar consistent trend revealed in all the combinations studied there by indicating the genetic manipulation of canopy by the way of induced mutants for canopy development is the certain way of ensuring the higher levels of heterosis, due to involving appropriate and optimum degrees of parental genetic divergence which could result in a wider variances down the generations reflecting in a better array of desirable agronomic segregants.

5.5 MEANS AND VARIANCES IN F_2 GENERATION OF CROSSES INVOLVING INDUCED MUTANTS CATEGORISED FOR CANOPY DEVELOPMENT

The major problem in groundnut breeding so far has been lack of perceptible levels of variances in segregating generations of the crosses effected, there by restricting the probability of occurrence of segregants in desirable character combinations, unlike in other crops like wheat, sorghum and rice (Dutta et al., 1986). Not withstanding the occurrence of wide range of variability in germplasm for canopy characters influencing wide range of other attributes (Prasad, 1988 and Madhavi, 1988), very little effort has gone into the studies regarding pattern of segregation and variances for important agronomic characters in mating system involving different canopy types. Parker et al. (1970) and Wynne et al. (1970), however studied the crosses involving different botanical types for F_1 heterosis without adding any information in respect of variances in segregating generations. The studies carried out by Nagabhushanam and Prasad (1992) revealed that the groundnut breeder can depend upon canopy development at 60 days as selection criteria in view of its stability of expression and strong positive correlation with kernel yield. A comprehensive investigation was also carried out (Nagabhushanam, 1989) to study the means and variances for important agronomic attributes including kernel yield in F_2 generations of crosses involving parents with different and similar canopy types as per the characterisation and categorisation arrived by him. His investigation has shown that the variances and means for the canopy and kernel yield were the least in F_2's of the crosses involving 1x4, 1x3, 2x4 and 2x1. While, a major proportion of the crosses involving 2x3 and 3x3 combinations exhibited a high variance with high mean, high variance with medium mean, high variance with low mean and medium variance with high mean for the above characters there by indicating such parental cross combinations should be prefered in groundnut breeding.

In the present investigation however, a similar trend was observed both in kharif as well as rabi seasons. Low variances with medium and low means were observed for canopy development and kernel yield in the crosses involving 2x1, 4x1, 3x1 and 4x3 canopy combinations (Table 41). However, it could be further observed that the picture was totally transformed towards high and medium levels of variances together with high and medium means for these characters in the majority of the crosses by substituting the respective induced mutations of the above leading to parental combinations for intermediate canopy development such as 3x2, 2x3 and 3x3.

Table 41: The crosses exhibiting low variance with low mean and medium mean in F_2 generations (*Kharif* and *Rabi*)

Mean and variance	*Kharif* F_2		*Rabi* F_2	
	Canopy diameter	Mature kernel yield	Canopy diameter	Mature kernel yield
Low variance low mean	M13 x MH2 (4x1)	Kadiri-3 x MH2(3x1)	MK374 x MH2 (3x1)	GNLM x MH2 (3x1)
	JL24 x MH2 (2x1)			M13 x TAP5 (4x3)
	G201 x MH2 (2x1)			
Low variance medium mean	TMV2NLM x MH2 (3x1)	M13 x MH2 (4x1)	M13 x MH2 (4x1)	TMV2 x MH2 (2x1)
	Kadiri-3 x MH2 (3x1)	JL24 x MH2 (2x1)	Kadiri-3 x MH2 (3x1)	PGN1 x MH2 (2x1)
		G201 x JL24 (2x2)	M13 x TMV2NLM (4x3)	M13 x MH2 (4x1) MK374 x MH2 (3x1)
				Kadiri-3 x MH2 (3x1)
				M13 x TMV2NLM (4x3)

A perusal of the data with regard to means and variances, in the F_2s of crosses involving MH2 (compact canopy category 1) and MH2BC28, an induced mutant of MH2 (representing canopy category 2) on one hand and wide range of other genotypes such as G201 (canopy category 2), JL24 (canopy category 2), Kadiri-3 (canopy category 3), TMV2NLM (canopy category 3) and M13 (canopy category 4) clearly brought out that the means as well as variances in F_2 generation were much higher when the induced mutant viz., MH2BC28 was involved as a male parent with the above mentioned varieties than those obtained in the F_2 of the crosses involving MH_2 with the above varieties. Similarly examining the F_2's of the crosses of MH2BC28 x TMV2 and TMV2NLM x MH2BC28 indicates a conspicuous enhancement of variances for wide range of attributes in the latter. Similarly the F_2's of the crosses involving TMV2xMH2 and TMV2NLM x MH2 indicated perceptible enhancement of variances for all the agronomic characters studied (days to initial, 50% and 100% flowering, canopy diameter, canopy circumference, leaf area at 60 days, plant height, number of primaries, secondaries and aerial pegs, number of mature pods and kernels, mature pod weight and kernel weight, total dry matter at harvest, shelling per cent and harvest index) and means of the majority of the characters studied. A similar trend of incidence of enhanced means and variances could be observed in the F_2's of crosses involving induced mutants when the crosses TMV2 x TAP5, TMV2NLM x TAP5, TMV2 x 32-2-5 and TMV2NLM x 32-2-5 were examined.

The clustering carried out based on combinations of different levels of means and variances for wide range of characters in respect of the crosses involving aerial podding genotype on one hand and wide range of varieties representing different levels of canopy development on the other hand also clearly brings out the combination of high mean and high variance, and high mean and medium variance for kernel and pod yield rested with the crosses such as Kadiri-3 x TAF (3x3 canopy combination), PGN1 x TAP5 and J11 x TAP5 both representing canopy combination 2x3. The crosses, M13 x TAP5 and ICG2271 x TAP5 both representing 4x3 canopy combination on other hand resulted in low mean and low variance. This once again proves the conclusion arrived at that higher levels of variances for important agronomic attributes such as yield components could be observed only in the F_2 generations of the cross combinations representing intermediate canopy development.

This observation is of immense importance in groundnut breeding suggesting an appropriate conversion programme of the parental types towards intermediate levels of canopy development might pay rich dividends interms of wider variances in F_2 generation. It could also be observed that such a conversion programme would be facilitated by the induced mutants for canopy attributes as in the case of MH2BC28 of MH2, TMV2NLM of TMV2 and 32-2-5 of MK374 (Prasad, 1988). It could also be observed that by and large these induced mutants for canopy attributes have resulted in wider variances in large array of cross combinations involving themselves as compared to crosses involving their parents. The observations of Arunachalam _et al_. (1984) emphasizing the importance of intermediate parental genetic divergence resulting in higher levels of heterosis subsequently leading to wider variances in the segregating generations support the above results obtained in the investigation. Further, the study also amply indicates for the first time that induced mutants for intermediate levels of canopy development could be an effective genetic tool for achieving such intermediate genetic divergence of the parents involved. In other words genetic conversion of canopy category 4 to canopy category 3 as well as canopy category 1 to canopy category 2 through induced mutations could be a step towards developing such parental combinations with required levels of genetic divergence. The occurrence of high degree of variances in such combinations could be due to the fact that these parental types exhibited different patterns of general combining ability as reported by Nagabhushanam et al. (1992).

Investigations of this nature bringing out the importance of parental canopy development as a tool for the selection of appropriate parental combinations are very rare except for those of Prasad and Nagabhushanam (1991). The present investigation is a further step in this direction suggesting genetic conversion of the canopy of the otherwise inappropriate parental canopy characters as an effective procedure for the development of right parental combinations conducive for higher levels of variances in the segregating generations thereby facilitating a wider choice of selection which hither to was missing in the groundnut breeding work.

5.6 AGRONOMICALLY SUPERIOR RECOMBINANTS

Out of the hybridization programme undertaken, apart from collecting the basic data, the results of which have been presented and discussed, a number of F_2 segregants for agronomic attributes such as canopy diameter, canopy circumference, leaf area at 60 days, number of primaries, number of secondaries, number of mature kernels and pods, mature pod weight and kernel weight, total dry matter at harvest, shelling per cent and harvest index have been isolated and their breeding behaviour studied in the F_3 generation. While the selections viz., ASR-7, ASR-8, ASR-9, ASR-10, ASR-11, ASR-12, ASR-13 and ASR-14 did not show any segregation and bred true for the characters selected for, the rest exhibited segregation in F_3 generation. From the data, it could be observed that these materials offer prospects of selecting superior genotypes for yield and canopy attributes. It could be observed that most of the selected types occurred in the F_2 generations of the crosses involving intermediate canopy types, thereby conforming the utility of restricting the hybridization programme largely to intermediate canopy combinations as suggested by Nagabhushanam (1989) and confirmed the present study. Further studies on the agronomic evaluation of the true breeding selections and further selection for the agronomically superior plant types in the segregating F_3 material could be rewarding.

5.7 INHERITANCE OF BRANCHING PATTERN

Branching pattern has been one of the key characters which played a decisive role in the genetic differentiation and evaluation of *Arachis hypogaea* L. A number of investigations were carried out with regard to the inheritance pattern of branching attribute by several workers, by and large the conclusions in this regard were that the alternate branching pattern associated with the *Virginia* type was dominant to sequential branching pattern of *Spanish* and *Valencia* types (Dalal, 1962; Jadhav and Shinde, 1979 and Balaiah *et al*., 1977). The F_2 data reported by several workers indicated a monogenic inheritance with 3:1 (3 alternate : 1 sequential) segregation pattern. There were however, certain exceptions (Coffelt, 1974; Varan *et al*., 1986; Desale, 1987 and Essomba *et al*., 1988) indicating a deviation from monogenic inheritance.

An analysis of 45 crosses representing alternate x sequential (27), alternate x alternate (8) and sequential x sequential (10) brought out that in F_1 the alternate branching was dominant whenever a parent with alternate branching was involved in the crosses. In F_2 generation, however presented a varied picture. The F_2 generation of all the sequential x sequential combinations showed all sequential types in F_2. The behaviour of alternate x sequential crosses was variable, the majority of the above (17) of which TMV2 x TMV2NLM was also studied showed a simple monogenic inheritance pattern with 3:1 ratio (3 alternate : 1 sequential), there by indicating involvement of a pair of contrasting alleles. One cross viz., Kadiri-3 x JL24 revealed F_2 segregation pattern of 9:7 ratio (9 alternate : 7 sequential). While, 9 such crosses gave 15 alternate : 1 sequential segregation ratio, there by indicating the involvement of either more than a pair of alleles or the effect of modifier complex on the pair of alleles for branching. It may also be seen that the parents which resulted monogenic segregation in certain combinations, themselves gave a deviant segregation pattern in certain other combinations there by emphasizing that the decisive role of modifier gene complex or genetic background in the phenotypic expression of the branching pattern. These conclusions draw support from the investigations of Dalal (1962) and Varan et al., (1986).

While, 7 out of eight crosses involving the parents with alternate branching resulted in no segregation for sequential branching and alone combination of TMV2NLM x GNLM segregated in the F_2 generation in a proportion of 63 alternate to 1 sequential. This observation is of immense importance in the sense that both the parental types although represent alternate branching pattern are genetically dissimilar and as such divergent. Interestingly TMV2NLM is alternate branching mutant of a sequential branching variety TMV2 (Prasad et al., 1984) while GNLM is a mutant of alternate branching variety Punjab-1 (Gopani and Vaishnani, 1970). In other words the parental types represent two genetically divergent mutational events which could be employed for widening the genetic variability for attaining higher degrees of variances in groundnut breeding. This observation draws support from Coffelt, (1974).

5.8 INHERITANCE OF NARROW LEAF SHAPE

Leaf shape and leaf orientation are considered to be important attributes of canopy development which has bearing on the photosynthesis as well as transpiration rate of groundnut plant (McCloud et al., 1980 and Mahapatra, 1966). The narrow leaf character in groundnut is supposed to be associated with low levels of transpiration and as such is considered important for developing genotypes with tolerance to moisture stress (Nageshwara Rao, 1992). Gopani and Vaishnani (1970) reported a Virginia type Gujarat Narrow Leaf Mutant (GNLM) which has been reported to be one of the genotypes tolerant to drought. Prasad et al., (1984) also recovered a narrow leaf Virginia mutant from EMS treated TMV2 Spanish bunch variety which was found to be genetically different from GNLM. The earlier investigations carried out by Matlock et al.(1970) indicated a partial dominance of narrow leaf mutant with monogenic inheritance. Balaiah et al. (1977) conducted the studies on the inheritance of narrow leaf character using GNLM and reported dominant nature of narrow leaf with monogenic inheritance pattern. Results of this investigation also confirmed the earlier observations of the dominant nature of the narrow leaf character. The F_2 data also indicates a typical monogenic inheritance based on two alleles as reported by earlier workers. However, the segregation pattern with regard to crosses involving TMV2NLM (induced narrow leaf mutant) on one hand and the normal leaved parents on the other, indicated a segregation pattern of 1 narrow : 2 intermediate : 1 normal. The crosses involving GNLM on the other hand exhibited a segregation pattern of 3 narrow : 1 normal, thereby indicating that the TMV2NLM and GNLM could be genetically different as reported by Prasad et al. (1984).

The cross involving TMV2NLM and GNLM both narrow leaf types on the other hand showed a very interesting trend. While F_1 of this cross showed absolutely narrow leaf type, the F_2 segregated for 1 needle shaped narrow leaves with sterility : 60 narrow leaf types : 3 normal leaf types suggesting a trigenic model involving recessive sterile due to complementary gene action. Such type of results were also obtained for chlorophyll attributes by Coffelt and Hammons (1971) and Tai et al. (1977). These results amply bring out that the TMV2NLM (TMV2 narrow leaf mutant) reported by Prasad et al. (1984) is genetically different from GNLM (Gujarat narrow leaf mutant) of Gopani and Vaishnani (1970). It could also be observed that in the case of TMV2NLM the narrowness of leaflet starts manifesting after a first 4 to 5 normal leaves while in the case of GNLM the narrow leaflet starts from 3rd leaf onwards (Prasad et al., 1984). Such genetically different genotypes for the same phenotypic attribute could be of immense use in overcoming the genetic vulnerability (Hammons, 1976).

5.9 INHERITANCE OF AERIAL PODDING

The aerial podding of groundnut was first reported by Prasad (1985). The aerial podding genotypes TAP1 to TAP5 occurred as spontaneous mutations in a population of Brazilian groundnut variety 'Tatu' exhibiting a large proportion of well developed aerial pods. The aerial pegs which otherwise go waste without developing into pods in traditional varieties, develop into pods with good seed filling in the reported material, perhaps due to a different mechanism of 'Ca' translocation (Prasad and Muralidharudu, 1991) which is absent in the traditional groundnut varieties. Wynne and Gregory (1981) suggested structural alterations of groundnut plant involving the enhancement of fruiting sites would be one of the possible ways of breeding groundnut genotypes possessing perceptibly higher levels of productivity. The aerial podding genotype of groundnut fulfils the above requirements and as such offer tremendous potentiality to enhance productivity of the groundnut plant. An aerial podding segregant was also reported by Nagabhushanam et al. (1990) in a progeny of MH2BC28 x ICG(C)8. In view of the tremendous potentiality of the aerial podding genotype the information on the inheritance of this attribute is of great interest in groundnut breeding.

Data reported in the present study in this regard is first of its kind. The investigations have indicated that the pattern of inheritance varies with the female parent employed in the cross, the male parent being TAP5 (an aerial podding genotype). The crosses involving all the sequential parents on one hand and the aerial podding on another as well as an alternate branching variety Kadiri-3 x TAP5 an aerial podding genotype have resulted the F_1 with aerial podding attribute thereby indicating the dominant nature of this attribute. In F_2 generation of these crosses excepting Kadiri-3 x TAP5 exhibited a monogenic Mendelian inheritance pattern of 3 aerial podding: 1 non aerial podding. In the case of involvement of the other alternate branching Virginia types as female parent, the F_1 did not show any aerial podding while the F_2 of these crosses segregated in a proportion of 1 aerial podding : 3 non aerial podding (normal). The same was true in respect of the F_2 of Kadiri-3 x TAP5. These results showed that in the F_2's of the crosses of aerial podding involving Virginia parents, the heterozygote did not show any aerial podding and got similar phenotypic appearance as the non aerial podding which probably of recessive homozygote constitution.

The fact that the aerial podding attribute is dominant or partially dominant could be observed from the phenotypic expression for aerial podding nature in respect of the F_1s of all the aerial podding crosses involving non aerial podding and sequential branching traditional genotypes as well as Kadiri-3 a Virginia genotype. In the case of the F_2's of crosses involving sequential branching parents, the heterozygote had similar phenotypic expression as that of dominant homozygote with aerial podding, hence the observed proportion of segregation 3 aerial podding : 1 non aerial podding (normal). From the foregoing it is amply clear that the expression of the aerial podding attribute is very much conditioned by the genetic background. While the genetic background of sequential branching type is conducive for better expression of this trait, the genetic background of alternate branching character tends to modify the expression of aerial podding attribute. This investigation could be considered a comprehensive one on this subject, in addtion to a preliminary report in this regard by Prasad (1988). Considering the suggestion that the aerial podding attribute could be the result of a different mechanism of 'Ca' translocation to developing gynophore (Prasad and Muralidharudu, 1991), it would be worthwhile to investigate the inheritance pattern of aerial podding attribute with detailed studies on the 'Ca' translocation pattern in all the segregants.

5.10 INHERITANCE OF CANOPY COMPACTION

The cultivated groundnut offers clearcut and perceptible levels of variability for canopy development including branching and leaf type. In view of this seemingly discontinuous variation available, there have been a number of investigations to work out and understand the mode of inheritance of various components of canopy development (Hammons, 1973b and Wynne and Coffelt, 1982). By and large with some exceptions a monogenic type of inheritance has been attributed to branching pattern (Hassan and Srivastava, 1966; Shchori and Ashri, 1970, Balaiah _et al_., 1977 and 1984 and Jadhav and Shinde, 1979) and leaf type (Hammons, 1964; Bhide and Desale, 1970; Balaiah _et al_., 1977; Branch, 1987 and Desale, 1987). However a mode of inheritance of different canopy categories as classified by Nagabhushanam (1989) has not been carried out.

In the present investigation the genotypes categorised for canopy development as 1, 2, 3 and 4 (Nagabhushanam 1989) have been used for studying the inheritance of canopy compaction which is a non-traditional approach. The results obtained indicate the universal dominance of canopy category 4 over the rest. In respect of combinations not involving canopy category 4, the F_1 exhibited a canopy category 3 indicating its dominance over 1 and 2, barring a few exceptions of occurrence of F_1 with canopy category 2 in the case of certain 2 x 3 canopy combinations (PGN1xTAP5, TMV2xTAP5, JL24xTAP5, J11xTAP5 and PI350680xTAP5). Segregation pattern in respect of the crosses studied was not uniform. Combinations involving MH2, MH2BC28, TMV2NLM, GNLM and M13 segregated in F_2 generation trigenically. The other crosses involving all the above and TAP5 and 32-2-5 as one of the parents predominantly exhibited a digenic segregation involving duplicate and complementary factors (Table 42). It is interesting to note that the crosses which segregated monogenically for canopy development in F_2 consisted of largely 32-2-5, TAP5, TMV2NLM and GNLM as one of the parents.

The trigenic inheritance was observed in respect of 10 crosses out of which seven involved combinations of extreme canopy types such as 1x4, 1x3, 1x2 and 2x4 and there were also combinations involving intermediate canopy types such as 2x2, 3x2 and 3x3. In otherswords a large proportions of these crosses involved an extreme category for canopy development as one of the parents and only one third of the crosses involved both parents with intermediate canopy development.

Examining the cross combinations resulting in digenic segregation pattern one could observe that 16 (around 70%) out of 23 such crosses formed combinations involving both parents of intermediate canopy types such as 2 and 3. In other words only 30 per cent of the above crosses consisted of extreme canopy category types such as 1 and 4 as one of the parents. Conside-ring the crosses segregating monogenically in F_2, it could be

Table 42: The crosses exhibiting monogenic, digenic and trigenic inheritance of canopy compaction

Monogenic		Digenic		Trigenic	
JL24 x TMV2NLM	(2x3)	TMV2 x MH2	(2x1)	G201 x MH2	(2x1)
J11 x TMV2NLM	(2x3)	PGN1 x MH2	(2x1)	MK374 x MH2	(3x1)
PI259747 x 32-2-5	(2x3)	JL24 x MH2	(2x1)	Kadiri-3 x MH2	(3x1)
JL24 x 32-2-5	(2x3)	G201 x JL24	(2x2)	GNLM x MH2	(3x1)
TMV2 x 32-2-5	(2x3)	JL24 x MH2BC28	(2x2)	TMV2NLM x MH2	(3x1)
G201 x TAP5	(2x3)	MH2BC28 x TMV2	(2x2)	M13 x MH2	(4x1)
TMV2 x TAP5	(2x3)	G201 x TMV2NLM	(2x3)	G201 x MH2BC28	(2x2)
PI350680 x TAP5	(2x3)	TMV2 x TMV2NLM	(2x3)	TMV2NLM x MH2BC28	(3x2)
MK374 x TMV2NLM	(3x3)	PGN1 x TMV2NLM	(2x3)	MH2BC28 x M13	(2x4)
Kadiri-3 x TAP5	(3x3)	PGN1 x TAP5	(2x3)	TMV2NLM x GNLM	(3x3)
GNLM x TAP5	(3x3)	JL24 x TAP5	(2x3)		
TMV2NLM x TAP5	(3x3)	J11 x TAP5	(2x3)		
		Kadiri-3 x JL24	(3x2)		
		Kadiri-3 x MH2BC28	(3x2)		
		M13 x JL24	(4x2)		
		Kadiri-3 x TMV2NLM	(3x3)		
		TMV2NLM x 32-2-5	(3x3)		
		GNLM x 32-2-5	(3x3)		
		Kadiri-3 x 32-2-5	(3x3)		
		MK374 x TAP5	(3x3)		
		M13 x TMV2NLM	(4x3)		
		M13 x TAP5	(4x3)		
		ICG2271 x TAP5	(4x3)		
Percentage of intermediate canopy combinations in each model:					
100%		70%		30%	

observed that all the cross combinations involved both the parents with only intermediate canopy development and practically without even a single parent of extreme canopy types.

It is very interesting to note that while the trigenic inheritance was characterised by 70 per cent of parental combinations involving extreme types and 30 per cent with intermediate parental combinations, in the digenic segregation pattern the reverse was true with enhancement of the proportion of intermediate canopy type parental combinations to 70 per cent and the reduction of parental combinations involving extreme types to 30 per cent. As is evident from the Table 42, the monogenic segregation pattern was totally characterised by intermediate canopy type parental combinations. Therefore it appears from the foregoing that the intermediate levels of canopy development justifiably represent genetically intermediate levels of divergence as suggested by Nagabhushanam (1989). Therefore, it is also probable to guess the involvement of parents characterised by extreme levels of canopy development such as MH2(1), M13(4) and ICG2271(4) brings about the probable involvement of genetic modifiers including zygotic and developmental lethals for canopy development as suggested by Coffelt and Hammons (1971).

5.11 MUTATIONAL IMPROVEMENT OF AERIAL PODDING GENOTYPE TAP5

The aerial podding attribute in groundnut has been first reported by Prasad (1985) in the mutants of Brazilian groundnut variety 'Tatu'. The mutants bred true for the aerial podding character, which offers immense potential for improving the productivity of groundnut plant due to enhancement of the number of fruiting sites as suggested by Wynne and Gregory (1981). Madhavi (1988) conducted genetic and physiological analysis of the one of the aerial podding genotypes TAP5 reported by Prasad (1985). The observations of Madhavi (1988) regarding the dominant nature of the aerial podding attribute was confirmed in the present combinations particularly when hybridized with Spanish and Valencia parents. It was also observed that the tremendous yield potential of the genotype TAP5 is limited severely by its early leaf senescence. Therefore a programme of induced mutations to rectify this defect by developing slow senescent mutants was initiated.

5.11.1 Means and Variances for Wide Range of Characters in M_1, M_2 and M_3 Generations

The results of the investigation amply bring out the general enhancement of the variances for characters such as canopy diameter, canopy circumference, plant height, number of primaries, secondaries and aerial pegs, mature pod weight and kernel weight and total dry matter at harvest in M_1, M_2 and M_3 generations as compared to control parental populations, thereby clearly bringing about the usefulness of the chemical mutagens employed for widening the variances. The M_2 variances in general were much higher than the M_1 and M_3 variances in respect of both the mutagens. Between the two mutagens EMS was found to be more effective in broadening the variances for the above characters. These observations are in agreement with the earlier reports of

Prasad *et al.*, (1985), Nagabhushanam and Prasad (1992) and Anuradha (1987) and particularly with Anuradha (1987), which confirms the incidence of wider degrees of variances in the progenies of EMS treated groundnut populations than in that of NaN_3.

It could also be observed that despite the enhancement of variances for the above characters in M_3 generation as compared to control population, the M_3 variances were lower than those of M_2 generation. Groundnut being a segmental polyploid with polysomic inheritance in many characters, it is expected that the M_3 generation should result in wider degrees of variances than that of M_2 generation. A similar trend was reported by Nagabhushanam and Prasad (1992) in sequentially branching genotypes of groundnut due to the probable higher degree of genetic diploidization of groups of sub species of *Arachis*. The material employed in the present investigation also being a sequentially branching *Valencia* type, it is expected that the above trend was perhaps due to its genetic diploidization for several characters.

5.11.2 Mutagenic Effectiveness and Efficiency

A higher incidence of viable mutations in EMS treated M_2 populations of TAP5 as compared to that of NaN_3 could be due to wider variances probably as a result of the antimorphic effect brought about resulting in functional alterations of genes in mutations (Prasad 1972 and Prasad *et al.*, 1984).

An analysis of mutagenic effectiveness and efficiency has revealed that while NaN_3 was more effective than EMS, the EMS was more efficient than NaN_3. The lower level of efficiency in the case of NaN_3 could be attributed to the high sterility induced by mutagen. Similar results have been reported by Anuradha (1987) and Shylaja (1987).

5.11.3 Mutants of Agronomic Value

A wide range of mutants with altered morphological attributes have been identified. The objective of the study was totally achieved in the isolation of 7 mutants which bred true for retention of green leaf mass even at pod maturity thereby signifying their slow senescent nature. The mutants were also characterised by higher biomass, higher branch number and canopy diameter. These mutants are several times superior in pod and kernel yield as compared to the parent, which could be due to physiologically active canopy as compared to the original parent. Although investigations of these types are not many, some researches have led to the development of mutants for physiological attributes such as slowsenescence (Ashley 1984) in groundnut and other crops Barley (Gustafsson et al., 1971 and Nilan, 1972), wheat (Khvostova et al. 1965 and Kumar,1977) and Rice (Swaminathan et al., 1970 and Reddy et al., 1975). These mutants are expected to be of immense use in groundnut breeding.

The alternate branching mutants reported in the present study are of systemic nature involving a change at the subspecific level. The frequency of these mutants being of a fairly higher order, it appears that the sequentially branching forms perhaps constituted the earlier step in the evolutionary order from which the alternate branching forms have evolved. Similar reports of the isolation of alternate branching mutants from sequentially branching forms have come from the investigations of Prasad et al. (1984). The TMV2NLM reported by them and used in the present study is one such an example. Nagabhushanam et al. (1992) have also reported the occurrence of alternate branching mutants in the sequentially branching parents.

The above mutants as well as the other agronomically desirable mutants such as compact canopy mutants, profusely branched mutants and profusely branched mutants with shorter internodes have not only represent new gene mutations for the respective attributes they were selected for, but also have resulted in positive yield transformation. Therefore, all the above mutants could be of profound value in groundnut breeding programmes which have to be strengthened with new genetic variability such as the ones reported as suggested by Gregory et al. (1973) and Prasad (1988).

The study amply brings about that the new and novel mutants for canopy and pod development would certainly enrich the genetic diversity in groundnut breeding thereby contributing to minimizing not only the genetic vulnerability of the cultivated groundnut but also being of direct value in the recombination breeding for enhancing the productivity level of groundnut.

SUMMARY

CHAPTER VI

SUMMARY

The categorization of wide range of 18 groundnut genotypes differing in canopy development based on DMRT has enabled precise characterization of these genotypes in respect of canopy diameter, canopy circumference and leaf area at 60 days. This classification indicated that MH2 the most compact canopy type fell in category 1, while the genotypes G201, P1259747, P1350680, J11, JL24, TMV2, MH2BC28 and PGN1 fell in category 2, while Compact Mutant of M13, TMV2NLM, GNLM, 32-2-5, Kadiri-3, TAP5 and MK374 came under category 3 and the most spreading genotypes ICG2271 and M13 fell in category 4. While canopy category 1 pertain to sequential branching and most spreading pertain to alternate branching types, intermediate types pertain to both sequential and alternate branching types, thereby suggesting that canopy compaction formed an important factor for genetic differentiation at sub-specific level in groundnut.

It was observed that the genetic potential of groundnut genotypes in general could be better expressed with higher dose of nitrogen at the rate of 40 kg/ha supplied as 20 kg as basal and 20 kg as top dressing and 60 cm spacing between the rows. Therefore, it is suggested that higher nutrient level and adequate spacing of 60 cm could be adopted not only for selecting the genotypes for kernel and pod development but also for a wide range of agronomic attributes.

Among the genotypes studied MH2 the most compact canopy type did not show much difference for kernel and pod yield and oil per cent in both kharif and rabi seasons. The aerial podding genotype had shown considerable enhancement of kernel and pod yield as well as the number of aerial pods at higher dose of nitrogen and wider spacing of 60 cm. The Virginia genotypes in general and more specifically Kadiri-3 had shown slight increase in oil content in rabi season.

It was found that the intermediate canopy types pertaining to category 2 and 3 offered higher levels of yield stability than the extreme canopy types such as MH2 (canopy category 1) and M13 (canopy category 4). It was also found that the induced mutants representing the intermediate levels of canopy development such as Compact Mutant of M13 (canopy category 3) developed from the most spreading type M13 (canopy category 4) offered higher levels of yield stability than the parental type. Therefore, it was suggested that induced mutants for intermediate canopy types isolated from parents of extreme canopy types could be valuable tools for breeding for stability of yield performance.

With regard to heterosis for agronomic attributes in F_1 generation, it was found that the crosses involving the medium compact canopy types (category 2) and medium spreading canopy types (category 3) as well as the medium spreading (canopy category 3) x medium spreading (canopy category 3) exhibited significant levels of positive heterosis for a wide range of characters, thereby indicating that the intermediate levels of genetic divergence were more conducive for recovery of higher levels of heterosis in groundnut.

Analysis of heterotic pattern arrived at by the substitution of a parent by corresponding induced mutant for canopy development revealed that replacing the original parent of extreme canopy category by the induced mutant of intermediate canopy category resulted in the perceptible jump in heterosis for kernel yield, thereby suggesting that the genetic manipulation by the way of induced mutants for intermediate canopy development was the certain way of ensuring higher levels of heterosis.

With regard to the means and variances in the crosses involving induced mutants for canopy development revealed that low variances with medium and low means for a wide range of agronomic characters was associated with the crosses involving 2x1, 4x1, 3x1 and 4x3 canopy combinations. It was also found that high and medium levels of variances together with high and medium means for these characters were observed in the F_2's of the crosses in which the induced mutants for intermediate canopy development were substituted leading to canopy combinations of 3x2, 2x3 and 3x3. A similar trend was observed in the crosses involving the aerial podding genotype TAP5 (canopy category 3) on one hand and rest of the genotypes on the other. This observation suggested that an appropriate conversion programme of parental types through induced mutations towards intermediate levels of canopy development might pay rich dividends in terms of wider degrees of variances in the F_2 generation. Several agronomically superior segregants were isolated mostly from the F_2 generations of the crosses involving intermediate canopy types for further use in groundnut breeding. The present investigation could be considered as a step towards a genetic conversion of canopy of otherwise inappropriate canopy of the parental material.

The studies on inheritance of branching pattern indicated that alternate branching was dominant over sequential branching and segregated in monogenic fashion in F_2. In certain specific combinations, however, such as Kadiri-3 x JL24, the involvement of more than one pair of alleles or the effect of modifier complex was observed.

A cross involving TMV2NLM (alternate narrow leaved) x GNLM (alternate narrow leaved) indicated a segregation ratio of 63 alternate : 1 sequential, thereby indicating that despite the morphological similarity the two mutants were genetically dissimilar. Similarly the inheritance of narrow leaf character in the above cross showed F_2 segregation of 1 needle shaped sterile type : 60 narrow leaf types : 3 normal leaf types, suggesting a trigenic model involving a recessive sterile due to complementary gene action.

The aerial podding although monogenically inherited, the segregation pattern varied with the branching pattern of the other parent involved. While the crosses involving alternate and aerial podding segregated in a proportion of 1 aerial podding : 3 non-aerial podding, the crosses involving sequential branching types and the aerial podding resulted in segregation pattern of 3 aerial poding : 1 non-aerial podding. The expression of aerial podding in the F_1 generation was also conditioned by the branching pattern of the other parent involved.

With regard to inheritance of canopy compaction, the trigenic inheritance was observed in respect of ten crosses, out of which seven involved combinations of extreme canopy types such as 1x4, 1x3, 1x2 and 2x4. The digenic segregation pattern for canopy compaction was observed in 23 crosses in which 16 were characterised with parental combinations of 2x3 and the rest in which extreme canopy category types such as 1 and 4 were involved as one of the parents. The monogenic segregation pattern for canopy compaction was observed in the F_2's of crosses involving both the parents of intermediate canopy development only and practically without a single parent of extreme canopy type, thereby indicating that intermediate levels of canopy development represented intermediate levels of divergence.

The mutational rectification of specific defects in the aerial podding genotype TAP5 resulted in identification of slow senescent and high yielding mutants of TAP5. The alternate branching mutants were also identified with higher frequency suggesting that the sequential branching forms perhaps constituted the earliest in the evolutionary order from which the alternate branching forms were evolved.

It was also observed that the variances in the M_2 generation were much higher in both the mutagens as compared to M_1

and M_3 variances suggesting that TAP5 Valencia type characterised by sequential branching pattern had probably attained genetic diploidization with disomic genetic behaviour. It was also observed that the NaN_3 was more effective than EMS, while EMS was more efficient than NaN_3. The lower degree of efficiency in the case of NaN_3 could be attributed to higher sterility.

APPENDICES

Appendix 1: Chi-square test for inheritance of branching pattern

Crosses	Phenotypic classes	Ratio	Observed frequency (O)	Expected frequency (E)	O-E	$\frac{(O-E)^2}{E}$	χ^2 value	P value
M13 x MH2	Alternate	3	246	249.75	-3.75	0.0563	0.2252	0.50
	Sequential	1	87	83.25	3.75	0.1689		
MK374 x MH2	Alternate	15	311	315.00	-4.00	0.0508	0.8127	0.25
	Sequential	1	25	21.00	4.00	0.7619		
Kadiri-3 x MH2	Alternate	15	340	345.00	-5.00	0.0725	1.1595	0.25
	Sequential	1	28	23.00	5.00	1.0870		
G201 x MH2	Alternate	3	129	125.25	3.75	0.1123	0.4491	0.25
	Sequential	1	38	41.75	-3.75	0.3368		
GNLM x MH2	Alternate	3	133	130.5	2.5	0.0479	0.1916	0.50
	Sequential	1	41	43.5	-2.5	0.1437		
TMV2NLM x MH2	Alternate	3	193	190.50	2.50	0.0328	0.1312	0.50
	Sequential	1	61	63.50	-2.50	0.0984		
M13 x TAP5	Alternate	15	212	209.06	2.94	0.0413	0.6614	0.25
	Sequential	1	11	13.94	-2.94	0.6201		
MK374 x TAP5	Alternate	15	166	167.81	-1.81	0.0195	0.3123	0.50
	Sequential	1	13	11.19	1.81	0.2928		
Kadiri -3 x TAP5	Alternate	3	177	173.25	3.75	0.0812	0.3247	0.50
	Sequential	1	54	57.75	-3.75	0.2435		
G201 x TAP5	Alternate	15	154	156.56	-2.56	0.0419	0.6696	0.25
	Sequential	1	13	10.44	2.56	0.6277		
ICG2271 x TAP5	Alternate	15	136	134.06	1.94	0.0281	0.4491	0.25
	Sequential	1	7	8.94	-1.94	0.4210		
GNLM x TAP5	Alternate	3	148	145.50	2.50	0.0430	0.1719	0.50
	Sequential	1	46	48.50	-2.50	0.1289		
TMV2NLM x TAP5	Alternate	3	172	170.25	1.75	0.0180	0.0720	0.75
	Sequential	1	55	56.75	-1.75	0.0540		
M13 x JL24	Alternate	3	175	178.50	-3.50	0.0686	0.2745	0.50
	Sequential	1	63	59.50	3.50	0.2059		
Kadiri-3 x JL24	Alternate	9	127	129.94	-2.94	0.0665	0.1520	0.50
	Sequential	7	104	101.06	2.94	0.0855		

Appendix 1 contd..

Crosses	Phenotypic classes	Ratio	Observed frequency (O)	Expected frequency (E)	O-E	$\frac{(O-E)^2}{E}$	χ^2 value	P value
G201 x JL24	Alternate	3	141	139.50	1.50	0.0161	0.0645	0.75
	Sequential	1	45	46.50	-1.50	0.0484		
G201 x MH2BC28	Alternate	15	142	143.44	-1.44	0.0145	0.2314	0.50
	Sequential	1	11	9.56	1.44	0.2169		
Kadiri-3 x MH2BC28	Alternate	3	102	99.75	2.25	0.0508	0.2032	0.50
	Sequential	1	31	33.25	-2.25	0.1524		
TMV2NLM x MH2BC28	Alternate	15	218	213.75	4.25	0.0845	1.3520	0.10
	Sequential	1	10	14.25	-4.25	1.2675		
TMV2 x TMV2NLM	Alternate	3	239	236.25	2.75	0.0320	0.1280	0.50
	Sequential	1	76	78.75	-2.75	0.0960		
PGN1 x TMV2NLM	Alternate	15	213	215.63	-2.63	0.0321	0.5095	0.25
	Sequential	1	17	14.38	2.62	0.4774		
JL24 x TMV2NLM	Alternate	3	174	166.50	7.5	1.014	1.3520	0.10
	Sequential	1	48	55.50	-7.5	0.338		
J11 x TMV2NLM	Alternate	3	153	159.00	-6.00	0.2264	0.9056	0.25
	Sequential	1	59	53.00	6.00	0.6792		
PI259747 x 32-2-5	Alternate	3	112	107.25	4.75	0.2104	0.8415	0.25
	Sequential	1	31	35.75	-4.75	0.6311		
JL24 x 32-2-5	Alternate	3	155	158.25	-3.25	0.0667	0.2669	0.50
	Sequential	1	56	52.75	3.25	0.2002		
TMV2 x 32-2-5	Alternate	3	135	132.75	2.25	0.0381	0.1525	0.50
	Sequential	1	42	44.25	-2.25	0.1144		
MH2BC28 x M13	Alternate	3	121	119.25	1.75	0.0257	0.1027	0.50
	Sequential	1	38	39.75	-1.75	0.0770		
TMV2NLM x GNLM	Alternate	63	312	311.06	0.94	0.0028	0.7647	0.50
	Sequential	1	3	4.94	-0.94	0.7619		

Appendix 2: Chi-square test for inheritance of narrow leaf shape

Crosses	Phenotypic classes	Ratio	Observed frequency (O)	Expected frequency (E)	O-E	$\frac{(O-E)^2}{E}$	χ^2 value	P value
M13 x TMV2NLM	Narrow	1	56	57.50	-1.50	0.0391	0.7043	0.50
	Intermediate	2	121	115.00	6.00	0.3130		
	Normal	1	53	57.50	-4.50	0.3522		
MK374 x TMV2NLM	Narrow	1	41	48.25	-7.25	1.0894	1.4664	0.25
	Intermediate	2	102	96.20	5.50	0.3135		
	Normal	1	50	48.25	1.75	0.0635		
Kadiri-3 x TMV2NLM	Narrow	1	68	73.50	-5.50	0.4116	1.1293	0.50
	Intermediate	2	156	147.00	9.00	0.5510		
	Normal	1	70	73.50	-3.50	0.1667		
G201 x TMV2NLM	Narrow	1	41	47.00	-6.00	0.7660	1.3086	0.50
	Intermediate	2	101	94.00	7.00	0.5213		
	Normal	1	46	47.00	-1.00	0.0213		
TMV2 x TMV2NLM	Narrow	1	81	78.75	2.25	0.0643	0.7715	0.50
	Intermediate	2	162	157.50	4.50	0.1286		
	Normal	1	72	78.75	-6.75	0.5786		
PGN1 x TMV2NLM	Narrow	1	60	57.50	2.50	0.1087	0.9826	0.50
	Intermediate	2	119	115.00	4.00	0.1391		
	Normal	1	51	57.50	-6.50	0.7348		
JL24 x TMV2NLM	Narrow	1	58	55.50	2.50	0.1126	1.7387	0.25
	Intermediate	2	117	111.00	6.00	0.3243		
	Normal	1	47	55.50	-8.50	1.3018		
J11 x TMV2NLM	Narrow	1	60	53.00	7.00	0.9245	1.3113	0.50
	Intermediate	2	103	106.00	-3.00	0.0849		
	Normal	1	49	53.00	-4.00	0.3019		
TMV2NLM x MH2	Narrow	1	60	63.50	-3.50	0.1929	1.2047	0.50
	Intermediate	2	123	127.00	-4.00	0.1260		
	Normal	1	71	63.50	7.50	0.8858		
TMV2NLM x 32-2-5	Narrow	1	56	54.25	1.75	0.0565	0.2719	0.75
	Intermediate	2	110	108.50	1.50	0.0207		
	Normal	1	51	54.25	-3.25	0.1947		
TMV2NLM x TAP5	Narrow	1	61	56.75	4.25	0.3183	0.6123	0.50
	Intermediate	2	108	113.50	-5.50	0.2665		
	Normal	1	58	56.75	1.25	0.0275		

contd...

Appendix 2 contd...

Crosses	Phenotypic classes	Ratio	Observed frequency (O)	Expected frequency (E)	O-E	$\frac{(O-E)^2}{E}$	χ^2 value	P value
GNLM x MH2	Narrow	3	135	130.50	4.50	0.1552	0.6207	0.25
	Normal	1	39	43.50	-4.50	0.4655		
GNLM x 32-2-5	Narrow	3	187	183.75	3.25	0.0575	0.2299	0.50
	Normal	1	58	61.25	-3.25	0.1724		
GNLM x TAP5	Narrow	3	150	145.50	4.50	0.1392	0.5567	0.25
	Normal	1	44	48.50	-4.50	0.4175		
TMV2NLM x GNLM	Needleshape	1	4	4.94	-0.94	0.1789	7.4792	0.01
	Narrow	60	287	296.25	-9.25	0.2888		
	Normal	3	25	14.81	10.19	7.0115		

Appendix 3 : Chi-square test for inheritance of aerial podding

Crosses	Phenotypic classes	Ratio	Observed frequency (O)	Expected frequency (E)	O-E	$\frac{(O-E)^2}{E}$	χ^2 value	P value
M13 x TAP5	Aerial podding	1	49	55.75	-6.75	0.8173	1.0897	0.25
	Normal	3	174	167.25	6.75	0.2724		
ICG2271 x TAP5	Aerial podding	1	30	35.75	-5.75	0.9248	1.2331	0.25
	Normal	3	113	107.25	5.75	0.3083		
MK374 x TAP5	Aerial podding	1	40	44.75	-4.75	0.5042	0.6723	0.25
	Normal	3	139	134.25	4.75	0.1681		
GNLM x TAP5	Aerial podding	1	42	48.50	-6.50	0.8711	1.1615	0.25
	Normal	3	152	145.50	6.50	0.2904		
TMV2NLM x TAP5	Aerial podding	1	50	56.75	-6.75	0.8029	1.0705	0.25
	Normal	3	177	170.25	6.75	0.2676		
G201 x TAP5	Aerial podding	1	38	41.75	-3.75	0.3368	0.4491	0.25
	Normal	3	129	125.25	3.75	0.1123		
Kadiri-3 x TAP5	Aerial podding	1	64	57.75	6.25	0.6764	0.9012	0.25
	Normal	3	167	173.75	-6.25	0.2248		
PGN1 x TAP5	Aerial podding	3	233	230.25	2.75	0.0328	0.1313	0.50
	Normal	1	74	76.75	-2.75	0.0985		
TMV2 x TAP5	Aerial podding	3	157	161.25	-4.25	0.1120	0.4480	0.25
	Normal	1	58	53.75	4.25	0.3360		
JL24 x TAP5	Aerial podding	3	139	133.50	5.50	0.2266	0.9064	0.25
	Normal	1	39	44.50	-5.50	0.6798		
J11 x TAP5	Aerial podding	3	127	130.50	-3.50	0.0939	0.3755	0.50
	Normal	1	47	43.50	3.50	0.2816		
PI350680 x TAP5	Aerial podding	3	117	121.50	-4.50	0.1667	0.6667	0.25
	Normal	1	45	40.50	4.50	0.5000		

Appendix 4 : Chi-square test for inheritance of canopy compaction

Crosses	Phenotypic classes	Ratio	Observed frequency (O)	Expected frequency (E)	O-E	$\frac{(O-E)^2}{E}$	χ^2 value	P value
G201 x MH2	Compact(1)	1	3	2.61	0.39	0.0583	0.3530	0.90
	Medium compact(2)	35	89	91.33	-2.33	0.0594		
	Medium spreading(3)	24	63	62.63	0.37	0.0022		
	Spreading(4)	4	12	10.44	1.56	0.2331		
TMV2 x MH2	Compact(1)	1	14	11.88	2.12	0.3783	0.4038	0.50
	Medium compact(2)	15	176	178.13	-2.12	0.0255		
PGN1 x MH2	Compact(1)	1	28	24.69	3.31	0.4437	0.4733	0.25
	Medium compact(2)	15	367	370.31	-3.31	0.0296		
JL24 x MH2	Compact(1)	1	17	12.88	4.12	1.3179	1.4062	0.10
	Medium compact(2)	15	189	193.13	-4.13	0.0883		
MK374 x MH2	Compact(1)	1	4	5.25	-1.25	0.2976	0.3463	0.95
	Medium compact(2)	4	22	21.00	1.00	0.0476		
	Medium spreading(3)	48	252	252.00	0.00	0.0000		
	Spreading(4)	11	58	57.75	0.25	0.0011		
Kadiri-3 x MH2	Compact(1)	1	5	5.75	-0.75	0.0978	0.3688	0.90
	Medium compact(2)	12	71	69.00	2.00	0.0580		
	Medium spreading(3)	47	267	270.25	-3.25	0.0391		
	Spreading(4)	4	25	23.00	2.00	0.1739		
GNLM x MH2	Compact(1)	1	4	2.72	1.28	0.6024	0.8269	0.75
	Medium compact(2)	14	36	38.06	-2.06	0.1115		
	Medium spreading(3)	35	94	95.16	-1.16	0.0141		
	Spreading(4)	14	40	38.06	1.94	0.0989		
TMV2NLM x MH2	Compact(1)	1	3	3.97	-0.97	0.2370	0.3745	0.90
	Medium compact(2)	23	93	91.28	1.72	0.0324		
	Medium spreading(3)	36	141	142.88	-1.88	0.0247		
	Spreading(4)	4	17	15.88	1.13	0.0804		
M13 x MH2	Compact(1)	1	6	5.20	0.80	0.1231	0.1682	0.975
	Medium compact(2)	12	63	62.44	0.56	0.0050		
	Medium spreading(3)	15	79	78.05	0.95	0.0116		
	Spreading(4)	36	185	187.31	-2.31	0.0285		
G201 x JL24	Medium compact(2)	6	67	69.75	-2.75	0.1084	0.9787	0.50
	Medium spreading(3)	9	110	104.63	5.37	0.2756		
	Spreading(4)	1	9	11.63	-2.63	0.5947		

Appendix 4 contd..

Crosses	Phenotypic classes	Ratio	Observed frequency (O)	Expected frequency (E)	O-E	$\frac{(O-E)^2}{E}$	χ^2 value	P value
G201 x MH2BC28	Compact(1)	1	4	2.39	1.61	1.0846	1.2483	0.50
	Medium compact(2)	35	81	83.67	-2.67	0.0852		
	Medium spreading(3)	24	59	57.38	1.62	0.0457		
	Spreading(4)	4	9	9.56	-0.56	0.0328		
JL24 x MH2BC28	Compact(1)	1	14	12.69	1.31	0.1352	0.1442	0.50
	Medium compact(2)	15	189	190.31	-1.31	0.0090		
MH2BC28 x TMV2	Compact(1)	1	11	12.56	-1.56	0.1938	0.2067	0.50
	Medium compact(2)	15	190	188.44	1.56	0.0129		
G201 x TMV2NLM	Medium compact(2)	6	73	70.50	2.50	0.0887	0.3547	0.75
	Medium spreading(3)	9	102	105.75	-3.75	0.1330		
	Spreading(4)	1	13	11.75	1.25	0.1330		
TMV2xTMV2NLM	Medium compact(2)	4	81	78.75	2.25	0.0643	0.5424	0.75
	Medium spreading(3)	9	180	177.19	2.81	0.0446		
	Spreading(4)	3	54	59.06	-5.06	0.4335		
PGN1xTMV2NLM	Medium compact(2)	6	87	86.25	0.75	0.0065	0.8541	0.50
	Medium spreading(3)	9	132	129.38	2.62	0.0531		
	Spreading(4)	1	11	14.38	-3.38	0.7945		
JL24 x TMV2NLM	Medium compact(2)	1	56	55.50	0.50	0.0045	0.0060	0.90
	Medium spreading(3)	3	166	166.50	-0.50	0.0015		
J11 x TMV2NLM	Medium compact(2)	1	59	53.00	6.00	0.6792	0.9056	0.25
	Medium spreading(3)	3	153	159.00	-6.00	0.2264		
PI259747x32-2-5	Medium compact(2)	1	40	35.75	4.25	0.5052	0.6736	0.25
	Medium spreading(3)	3	103	107.25	-4.25	0.1684		
JL24 x 32-2-5	Medium compact(2)	1	60	52.75	7.25	0.9964	1.3285	0.10
	Medium spreading(3)	3	151	158.25	-7.25	0.3321		
TMV2 x 32-2-5	Medium compact(2)	1	49	44.25	4.75	0.5099	0.6799	0.25
	Medium spreading(3)	3	128	132.75	-4.75	0.1700		
G201 x TAP5	Medium compact(2)	1	45	41.75	3.25	0.2530	0.3373	0.50
	Medium spreading(3)	3	122	125.25	-3.25	0.0843		
PGN1 x TAP5	Medium compact(2)	15	284	287.81	-3.81	0.0504	0.8068	0.25
	Medium spreading(3)	1	23	19.19	3.81	0.7564		

Appendix 4 contd..

Crosses	Phenotypic classes	Ratio	Observed frequency (O)	Expected frequency (E)	O-E	$\frac{(O-E)^2}{E}$	χ^2 value	P value
TMV2 x TAP5	Medium compact(2)	3	168	161.25	6.75	0.2826	1.1303	0.25
	Medium spreading(3)	1	47	53.75	-6.75	0.8477		
JL24 x TAP5	Medium compact(2)	15	164	166.88	-2.88	0.0497	0.7898	0.25
	Medium spreading(3)	1	14	11.13	2.87	0.7401		
J11 x TAP5	Medium compact(2)	15	159	163.13	-4.13	0.1046	1.6723	0.10
	Medium spreading(3)	1	15	10.88	4.13	1.5677		
PI350680xTAP5	Medium compact(2)	3	122	126.00	-4.00	0.1270	0.5080	0.25
	Medium spreading(3)	1	46	42.00	4.00	0.3810		
Kadiri-3xJL24	Medium compact(2)	6	84	86.63	-2.63	0.0798	0.6891	0.50
	Medium spreading(3)	9	135	129.94	5.06	0.1970		
	Spreading(4)	1	12	14.44	-2.44	0.4123		
Kadiri-3xMH2BC28	Medium compact(2)	3	22	24.94	2.94	0.3466	0.4641	0.75
	Medium spreading(3)	12	103	99.75	3.25	0.1059		
	Spreading(4)	1	8	8.31	0.31	0.0116		
TMV2NLMxMH2BC28	Compact(1)	1	5	3.56	1.44	0.5825	0.6930	0.75
	Medium compact(2)	11	39	39.19	-0.19	0.0009		
	Medium spreading(3)	48	171	171.00	0.00	0.0000		
	Spreading(4)	4	13	14.25	-1.25	0.1096		
MH2BC28 x M13	Compact(1)	1	4	2.48	1.52	0.9316	1.0935	0.75
	Medium compact(2)	12	28	29.81	-1.81	0.1099		
	Medium spreading(3)	37	91	91.92	-0.92	0.0092		
	Spreading(4)	14	36	34.78	1.22	0.0428		
M13 x JL24	Medium compact(2)	4	63	59.50	3.50	0.2059	0.6956	0.50
	Medium spreading(3)	3	40	44.63	-4.63	0.4803		
	Spreading(4)	9	135	133.88	1.12	0.0094		
MK374 x TMV2NLM	Medium spreading(3)	3	147	144.75	2.25	0.0350	0.1399	0.50
	Spreading(4)	1	46	48.25	-2.25	0.1049		
Kadiri-3xTMV2NLM	Medium spreading(3)	15	276	275.63	0.37	0.0005	0.0084	0.90
	Spreading(4)	1	18	18.38	-0.38	0.0079		
TMV2NLMx32-2-5	Medium spreading(3)	15	201	203.44	-2.44	0.0293	0.4684	0.25
	Spreading(4)	1	16	13.56	2.44	0.4391		

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Appendix 4 contd..

Crosses	Phenotypic classes	Ratio	Observed frequency (0)	Expected frequency (E)	0-E	$\frac{(0-E)^2}{E}$	χ^2 value	P value
GNLM x 32-2-5	Medium spreading(3)	15	233	229.69	3.31	0.0477	0.7633	0.25
	Spreading(4)	1	12	15.31	-3.31	0.7156		
Kadiri-3x32-2-5	Medium spreading(3)	15	254	256.88	-2.88	0.0323	0.5165	0.25
	Spreading(3)	1	20	17.13	2.88	0.4842		
MK374 x TAP5	Medium compact(2)	1	13	11.19	1.81	0.2928	0.3123	0.50
	Medium.spreading(3)	15	166	167.81	-1.81	0.0195		
Kadiri-3xTAP5	Medium compact(2)	1	61	57.75	3.25	0.1829	0.2439	0.50
	Medium spreading(3)	3	170	173.25	-3.25	0.0610		
GNLM x TAP5	Medium spreading(3)	3	153	145.50	7.50	0.3866	1.5464	0.10
	Spreading(4)	1	41	48.50	-7.50	1.1598		
TMV2NLMxTAP5	Medium spreading(3)	3	177	170.25	6.75	0.2676	1.0705	0.25
	Spreading(4)	1	50	56.75	-6.75	0.8029		
TMV2NLM x GNLM	Compact(1)	1	4	4.94	-0.94	0.1789	0.3978	0.90
	Medium compact(2)	3	16	14.81	1.19	0.0956		
	Medium spreading(3)	55	273	271.56	1.44	0.0076		
	Spreading(4)	5	23	24.69	-1.69	0.1157		
M13 x TMV2NLM	Medium spreading(3)	7	100	100.63	-0.63	0.0039	0.0070	0.90
	Spreading(4)	9	130	129.38	0.63	0.0031		
M13 x TAP5	Medium compact(2)	1	14	13.94	0.06	0.0003	0.5810	0.50
	Medium spreading(3)	6	89	83.63	5.37	0.3448		
	Spreading(4)	9	120	125.44	-5.44	0.2359		
ICG2271 x TAP5	Medium compact(2)	1	7	8.94	-1.94	0.4210	0.6281	0.50
	Medium spreading(3)	6	52	53.63	-1.63	0.0495		
	Spreading(4)	9	84	80.44	3.56	0.1576		