

GENETIC VARIABILITY IN *Setaria italica*

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*Dedicated To
Love And Affection Of
My
Parents*

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C E R T I F I C A T E

I hereby certify that the thesis entitled "GENETIC VARIABILITY IN Setaria italica" submitted for the award of the degree of Doctor of Philosophy in Genetics and Plant Breeding, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, is a bonafide research work carried out by Sri Nihar Ranjan Biswas, M.Sc.(Ag.) (BAU) under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma. The help and sources of information, as have been availed during the course of this investigation, have been duly acknowledged.

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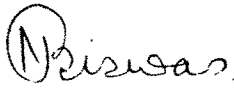
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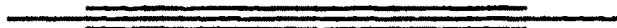
LIST OF ABBREVIATIONS USED

BARI	-	Bangladesh Agricultural Research Institute	Kg	-	Kilogram
bdth.	-	Breadth	KLN	-	Kalyani
B.Si.	-	Bangladesh <u>Setaria italica</u>	kR	-	Kilo Rontgen
Btn.	-	Between	Lati.	-	Latitude
C.D.	-	Critical difference	lgth.	-	Length
Cm	-	Centimetre	Loc.	-	Location
Cont.	-	Control	Longi.	-	Longitude
DAF	-	Days to flowering	Lst.	-	Lowest
DAM	-	Days to maturity	M ₁	-	Mutagen treated 1st generation
D.F	-	Degrees of freedom	M ₂	-	Mutagen treated 2nd generation
e.g.	-	Example	M ₃	-	Mutagen treated 3rd generation
EGG	-	Expected genetic gain	M ₄	-	Mutagen treated 4th generation
fam.	-	Family	g	-	Microgram
FL	-	Flag leaf	mg	-	Milligram
g	-	Gram	M.S.	-	Mean sum of square
GCV	-	Genotypic coefficient of variability	Pan.	-	Panicle
Genet.adv.	-	Genetic advance	PCV.	-	Phenotypic coefficient of variability
GV	-	Genotypic variance	pn.	-	Pollen
G ₁	-	Gamma irradiated 1st generation	Pop.	-	Population
G ₂	-	Gamma irradiated 2nd generation	pt.	-	Per plant
G ₃	-	Gamma irradiated 3rd generation	PV	-	Phenotypic variance
G ₄	-	Gamma irradiated 4th generation	q	-	Quintal
ha	-	Hectare	RBD	-	Randomized block design
Herit.	-	Heritability	Repli.	-	Replication
Hst.	-	Highest	Ster.	-	Sterile
ht.	-	Height	Var.	-	Variety
JGM	-	Jhargram			

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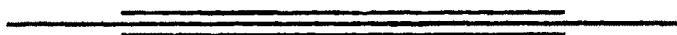
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CHAPTER—I

I N T R O D U C T I O N

INTRODUCTION

Milletts are warm weather cereals with small grains. They belong to the family Gramineae and include six genera, i.e. Panicum, Setaria, Echinochloa, Pennisetum, Paspalum and Eleusine. In Setaria there are about 60 annual or sometimes perennial species found in tropical countries and many of them are widespread as weeds. Setaria is considered to be mainly a genus of African origin. Panicum and Setaria are thought to have been brought to Italy by the ancient slaves across the Black Sea and the Mediterranean. Two cultivated species S. italica (L.) Beauv. and S. palmifolia (L.) Beauv. are widely distributed in Asia, South-eastern Europe and North Africa.

Foxtail millet, S. italica (L.) Beauv. is also known as Italian, German, Hungarian or Siberian millet. In India and Bangladesh it is named as Kakun and Kawn respectively. It is well known all over India and has vernacular names in different regional languages of India i.e. Kannada : Navane, Tamil : Tenai, Telugu : Korralu, Malayalam : Tena, Hindustani : Kangoone. This species is unknown in wild state, except as a weed escaped from cultivation. It is now generally considered to be domesticated first in eastern Asia, where it has been cultivated since ancient times. This millet is a very old crop. Seeds of this crops have been found in early remains such as those of the Swiss Lake-dwellers of the stone Age. Vavilov (1949) considered China or Central Asia as its place of origin. According to him, foxtail

millet has spread to India and other European countries from there. Hill (1952) states that it was one of the five sacred plants of China as early as 2700 BC. It was probably derived from Setaria viridis (L.), a common weed in the Old World. Because of its short duration it is a suitable crop for growing by nomads, and was probably brought to Europe in this way during the stone Age. Seeds abound in the Lake Dwellings in Europe, but it was also known in Syria and Greece. This crop is most likely mentioned as 'Kanguchina' in 'Charjyapoda', (14th Century AD) the oldest Bengali literature. It seems probable that S. italica (L.) Beauv. and Penicum miliaceum (L.) were among the first crops to be domesticated in Central or Eastern Asia. They were widely spread throughout Asia and Eastern Europe in prehistoric times.

In Asia, South-eastern Europe and North Africa, foxtail millet is used for human consumption. It is the most important millet in Japan and is also widely cultivated in India and Bangladesh. In Madras, Mysore and Bombay it is next in importance to Sorghum, Sorghum vulgare Pers. and finger millet, Eleusine coracana Gaertn. The major regions of its cultivation in India are Karnataka, Andhra Pradesh, Madhya Pradesh and Uttar Pradesh. This crop can be grown even at an altitude of 2000 m. Light soils including red loams, alluvials and even black cotton soils are all suitable for its cultivation. The crop is mostly grown under rainfed conditions and occasionally under irrigated conditions.

Foxtail millet grows well on marine sandy soil with the aid of local ground water irrigation and fertilizer (Phan, 1981). It can be grown throughout the year in Southern India. The rainfed crop is mostly sown in June-July and harvested in September, whereas, the irrigated crop is sown in February or March. It is essentially a dry land grain and is suited to conditions of low or moderate rainfall ranging from 50 cm to about 75 cm. It is generally sown mixed with other crops, but sometimes it is raised as a pure crop. The common crops with which it is mixed are cotton, finger millet and a number of pulses. The yield of the rainfed crop ranges from 500 to 1,000 kg/ha and that of straw from 1,000 to 2,000 kg/ha. The irrigated crop yield 1,000 to 1,600 kg/ha and fodder up to 40 q/ha. The grains show a great variability in colour, being smooth and shiny and coloured yellow, white, cream coloured, orange red, purple, black, greenish white, buff and so on. Varieties are given names which are generally descriptive of the colour of the grain and appearance of the panicle.

Foxtail millet is usually cooked and eaten like rice, either entire or broken. But it may also be ground and made into porridge, puddings and chapaties. In Russia, it is used for brewing beer. It is a well known birdseed in Britain and elsewhere for feeding to cagebirds. It is also an important fodder crop and is grown in the United States for hay and silage

(Purseglove, 1972). It has a high percentage of indigestible fibre because the seeds are enclosed in hulls which are not removed by ordinary processing methods. Foxtail millet is a good source of vitamins like, ascorbic acid, thiamine (B₁) and riboflavin (B₂) found in Georgain varieties (Wu, 1928; Anon, 1937; Maisaya and Tarasashvili, 1983). Considerable variation of oil content in the grain of Setaria was noted. Indian accessions from Andhra Pradesh had the highest oil content. In glutinous cultivar of this millet eight fatty acids were found of which linoleic acid formed 70% of the total, oleic and palmitic acids were also major components. The limiting amino acids are lysine followed by tryptophan, methionine and cysteine. The range for lipid, palmitic acid and stearic acid content overlapped between glutinous and nonglutinous cultivars in Setaria italica (L.) Beauv. (Takano et al., 1982; Seetharam et al., 1983; Taira, 1984). The composition of foxtail millet grain (per 100 gms. of edible portion) is as follows; edible portion 79%, moisture 11.2 g, protein 12.3 g, fat 4.3 g, minerals 3.3 g, fibre 8.0 g, carbohydrates 60.9 g, calcium 3.1 mg, phosphorus 290 mg, iron 12.9 mg, carotene 32 ug, thiamine 0.59 mg, riboflavin 0.11 mg and niacin 3.2 mg. In grains of this millet, iron, fat and thiamine content is comparatively higher than other major cereals and pulses. Protein and minerals contents are also higher than rice, wheat, maize, barley, oats and sorghum (Gopalan et al., 1985).

Natural variability in this crop is not very wide and it provides meagre scope for improvement. So variability has to be increased artificially for greater possibility of developing high yielding type with desirable features. (In the present investigation the gamma-rays have been used to widen the genetic variation in different characters relating to grain yield. of foxtail millet (*Setaria italica* L.)

CHAPTER—II

REVIEW OF LITERATURE

Species Relationship :

A numerical taxonomy study from fifteen collections of Setaria representing nine species in the subgenus Setaria and one species in the subgenus Ptychophyllum revealed that the genus Setaria is rather homogeneous and has relatively low intraspecific variability (Chikara and Gupta, 1980). Setaria italica was crossed with its subspecies maxima, wild species S. viridis and S. ketzchovelii. The cross compatibility data indicated that cultivated Georgian millet S. italica is closely related to both the wild Georgian millets S. ketzchovelii and S. viridis (Maisaya and Gordize, 1980). The interspecific triploid hybrid of S. verticillata X S. italica cross was sterile. Vegetative propagation and colchicine treatment of this hybrid produced offspring of varying chromosome number belonging to the modal classes $2n = 36$ or $2n = 54$ and one plant with a stable chromosome number of class $2n = 36$ was fertile and produced fertile S. verticillata type offspring. Offspring of $2n = 54$ hybrids were heterogeneous (Poirier-Hamon and Pernes, 1986). This indicates that S. verticillata is a probable allotetraploid species with some affinity to S. italica.

Karyotype :

Karyotype analysis in six different varieties of S. italica revealed the presence of one pair of satellited chromosomes in each. The karyotype difference between these varieties was not

wide through they differed in total chromatin length (Chikara and Gupta, 1979). Sun et al., (1983) studied the karyotype of S. italica, with giemsa C-banding technique. They found that the heterochromatic region in the chromosomes was mostly near the centromere and the width of the band zones varied between the pairs of chromosomes. Cytological studies on three species S. italica, S. mocharica and S. ketzchovelii revealed that all the species were diploid ($2n = 18$) with a fairly uniform symmetrical karyotype consisting of two pairs of long chromosomes with secondary constrictions and seven pairs of relatively small metacentric chromosomes (Kandelaki et al., 1983). These observations are at variance with those of Chikara and Gupta (1979) as they noted only one pair of chromosomes with satellite.

Male Sterility :

In S. italica, a male sterile line was found in 1978, in the hybrid progenies of a cross between Australian and Turfan types. Genetic analysis of seven generations, based on crosses with 400 varieties, revealed a segregation ratio of 3 sterile : 1 fertile. A restorer gene was also identified, which did not segregate for fertility through seven generations of selfing. The male sterile material produced some pollen and some selfed grains leading to the establishment of dominant pure or mixed male sterile lines (Cui et al., 1979; Hu, 1985).

Inheritance of Qualitative Characters :

Inheritance of qualitative characters in Setaria italica was studied and the following genes were identified : (1) yellow or white endosperm gene $\underline{Y}_1$ and $\underline{Y}_2$, (2) glutinous or non-glutinous endosperm gene $\underline{M}$, (3) ear colour, the three complementary genes $\underline{B}$, $\underline{I}$ and $\underline{K}$, (4) leaf sheath colour, the three complementary genes $\underline{C}$, $\underline{R}$ and $\underline{H}$, (5) spherical or ellipsoidal grain, the gene pair $\underline{Ee}$, (6) albino seedling, the three genes $\underline{A}_1$, $\underline{A}_2$ and $\underline{A}_3$ and (7) fertile or sterile ears, the gene pairs $\underline{Ss}$ (Takahashi, 1942). Linkage is reported between a gene for glume colour, probably the gene $\underline{P}$ for pigmentation of the whole plant proposed by Rangaswami, and a gene $\underline{Y}$ for endosperm character. The crossing-over value was 23.7 per cent. A gene for dry anther colour and the two above mentioned genes are independently inherited (Kihara, 1943). Four dwarf genotypes designated $\underline{D}_1$ to $\underline{D}_4$ were isolated from local lines and the segregating progeny of a natural hybrid of S. italica. Among these genotypes $\underline{D}_1$ is the highest yielder, $\underline{D}_3$ is characterized by a large leaf area and high number of effective tillers per plant and $\underline{D}_4$ has the shortest plant (26.97 ± 0.53 cm) and gives the lowest yield. It is suggested that the high grain yield of $\underline{D}_1$, leafiness and tillering characteristics of $\underline{D}_3$ and shortness of $\underline{D}_4$ could be combined to give a high yielding variety, responsive to fertilizer and resistant to lodging (Harinarayana et al., 1984). Inheritance of some marker genes of five S. italica hybrids, one

interspecific hybrid (S. viridis X S. italica) and their F₂ progenies were studied for seven isoenzymes. The following polymorphic loci were defined : Est 1, Est 2, Est 3, Adh 1, Got 1, Got 2, Acph 1, Mdh 1, Mdh 2, Pgd 1, Pgd 2 and Pox 1. Two other markers were also examined : waxy endosperm, controlled by one locus (Wx), and anthocyanin pigmentation of the collar, controlled by at least two loci. Studies on three F₂ progenies revealed two linkage groups : Mdh 1, Pox 1, Wx, Est 3 and a collar colour locus; and Est 2 and one or two other collar colour loci (Cherisey et al., 1985). The F₂ progenies of some crosses in S. italica showed marked variation in protein content (14 to 20%). Cream and golden yellow grain had higher protein content than red and light-red ones (Konstantinov, 1975; Varadinov and Tomilina, 1978; Liu, 1981).

Coefficient of Genetic Variation, Heritability and Genetic Advance :

From a study of 64 varieties of S. italica it was found that coefficient of genetic variability was high for grain yield and secondary tillers per plant, medium for primary tillers per plant, plant height, ear length and girth and low for days to flowering, days to maturity and 1000-grain weight (Sandhu et al., 1974). Similar high coefficient of genetic variation was recorded for grain yield per plant and low variation for days to heading and maturity, plant height, 1000-grain weight and tiller number per plant but the coefficient of genetic variation was high for

ear length and girth (Cill and Randhawa, 1975). From a study of 324 accessions from all over the world it was noted that the coefficient of genetic variation was low for earliness, tiller number per plant, panicle length and grain density per panicle whereas, it was high for grain and straw yield, awn length and five other traits (Vishwanatha, 1978; Vishwanatha et al., 1981). The pattern of variability was similar in parents, F_2 and F_3 generations in foxtail millet. Highest coefficient of genetic variation was noted for seed weight and lowest for plant height (Wang and Han, 1981). The coefficient of genetic variation was low for plant height, maturity date, maturity duration (heading to maturity) and number of nodes per plant as estimated from 74 varieties of this crop (Liu, 1984). The considerable genetic diversity noted in this mainly self-fertilizing crop is due to the possible slow release of hidden genetic variability through a low amount of natural outcrossing followed by segregation and recombination (Navale et al., 1984).

As a consequence to the studies mentioned above high heritability estimates and high genetic advance have been reported for grain yield per plant, days to flowering, days to maturity, 1000-grain weight (Sandhu et al., 1974), for days to heading and maturity, 1000-grain weight, plant height and tiller number per plant (Cill and Randhawa, 1975), for earliness, tillering, grain density per panicle and panicle length (Vishwanatha, 1978;

Vishwanatha et al., 1981), days to heading (Wang and Han, 1981); days to heading, total growth period, days to maturity, plant height, panicle length and 1000-grain weight (Xu and Zhang, 1981); plant height, panicle length, grain and straw yield (Rao et al., 1984); plant height, maturity date, maturity duration, number of nodes per plant (Liu, 1984). The genetic advance for grain protein content was poor as estimated from F_2 generation (Liu, 1981). However, the reliability of these high estimates of heritability has been questioned by Gian and Athwal (1966). These authors have noted highly significant genotype X environment interaction for various characters in foxtail millet. Consequently the estimates of heritability and genetic advance after eliminating environmental effects were always lower than the mean of individual estimates based on single tests. The sowing time and location of experiments were the two most important influencing factors of environment.

Regression :

Linear regression analysis between yield and yield component from 64 varieties of Setaria italica has revealed that primary tillers per plant and plant height influenced yield. Selection index based on these two characters would account for 19 per cent of variation for grain yield. Optimum height for selection was 132.7 cm (Sandhu et al., 1974). Phenotypic stability was studied in different varieties of foxtail millet grown under six different environments for five years. The linear regression between

varieties on environment in most of the cases was not significant, but some of the varieties indicated significant linear regression association between the said traits, of which only Co₃ and Ise 701 met all the requirements and represented as phenotypically stable varieties in all environments (Appadurai et al., 1978).

Correlation :

Interrelation between yield and yield component traits of 64 varieties of foxtail millet was studied and it was noted that yield per plant was significantly and positively correlated with ear length, plant height and primary tillers per plant (Sandhu et al., 1974). From a study of 48 varieties it was noted that grain yield was significantly and positively correlated with number of productive tillers and straw weight, but there was a significant negative correlation between grain yield and length of main panicle. However, grain yield was not correlated with plant height, days to panicle emergence and number of internodes. In this study twentyfive selection indices with a combination of two or more characters were constructed using the discriminant function technique and their efficiencies over straight selection for grain yield and alone were compared. It is concluded that number of productive tillers might serve as an index of selection for grain yield (Chinnaswamaiah, 1975). Correlation between yield and yield related characters of 18 diverse varieties of foxtail millet was estimated, which revealed that grain yield

and 1000-grain weight, grain weight of main ear and flag leaf area were positively correlated (Dhagat et al., 1977). From a study of nine varieties it was noted that grain yield per plant was significantly and positively correlated with number of ears per plant, ear length, 1000-grain weight and number of days to maturity. Path coefficient analysis has revealed that 1000-grain weight and number of ears per plant are the major yield contributing characters (Godawat, 1980). Association between yield and yield components was studied on F_2 , F_3 and parent generation. Yield per plant was significantly correlated with panicle length, panicle weight per plant and straw weight (Wang and Han, 1981). Another study involving spring sown 15 varieties of foxtail millet has indicated that spike weight per plant was positively correlated with days to maturity, growth period and straw weight. Highly significant negative association between straw weight and 1000-grain weight was recorded (Xu and Zhang, 1981). Inter-relationship and path coefficient analysis between the leafblades of leaf at different ranking position and ear character were studied, from which it was found that flag leaf area was positively correlated with ear weight and yield per plant. Path coefficient analysis has indicated that the effect of flag leaf area on grain weight was large. From this relation it was concluded that the top most four leaves with wider leafblade may contribute significantly to high yield per plant (Liu, 1982).

Radiation Breeding :

The first conclusive proof that ionizing radiation produces gene mutation was presented by Muller (1927) in Drosophila. Stadler (1928) produced mutations in barley and maize by irradiation with x-ray and gamma-rays. A new era of plant improvement through radiation breeding was thus initiated. Gaul (1961) has classified the vital mutations into macro-mutations and micro-mutations. Macro-mutations are large and can be recognised on a single plant basis. These are of two types : transspecific and intraspecific. Transspecific mutations occur very seldom. Mutations that are transspecific usually have greatly reduced vitality and/or fertility. They are not of immediate value for breeding. However, they could possibly be important as parents in crossing. There are good ground for supposing that it is possible to "disrupt" the character-complex of macro-mutation and to separate the desirable properties from the undesirable. The way to this is in crossing and thus depositing the macro-mutation in a completely new gene milieu. Intraspecific macro-mutations are also lethal or sublethal, monstrous, with reduced fertility or complete sterility. The large grain barley of a "gigas mutant", awnless barley and "semi-climbing" spring barley are the examples of intraspecific macro-mutations. Micro-mutations are mutations with small effects and can be recognised only when a group of mutant plants are compared with a normal one. Micro-mutations

differ from normals only quantitatively and mutations with larger or smaller grains or higher yield are the examples of micro-mutations.

The importance of micro-mutations ("Klein mutationen") in evolution was first recognized and stressed by Baur (1924). Since then the question of the role of macro and micro-mutations in evolution has been discussed repeatedly (Stubbe and Wettstein, 1941). Until recently, however, interest had been occupied almost exclusively in the macro-mutations particularly in plants. Although Stubbe (1934) studied some micro-mutations in Antirrhinum and later Gustafsson (1947) and Nybom (1954) in barley, little attention was paid to them in mutation experiments. Gaul (1964) accounted this surprising lapse for the fact that basic investigations on the traits of micro-mutations and the frequency of their occurrence required much more space, time, work and patience than selection of macro-mutations. Scossiroli (1965) stated that this delay was due to the difficulty in identifying at the phenotypic level and single events in the genotype. Gaul reported the usefulness of micro-mutations through series of papers (1958, 1964, 1965, 1969) for their frequency of occurrence and less reduced vitality in comparison to those of macro-mutations.

Deliberate selection of x-ray induced mutations in quantitatively inherited traits of plants was reported by Gregory through number of papers (1955, 1956, 1957). He showed that

yield test in subsequent generations after irradiation could conclusively prove that mutations affecting quantitative traits in crop plants could be induced and phenotypic selection could accumulate positive mutations to produce better strains. Later on (1968) he concluded that mutants with very small phenotypic effects will occur with high frequency and will have an equal probability of being positive or negative in their phenotypic effects. Substantial increase of genetic variance for days to heading, panicle length and plant height of rice through x-ray irradiation was reported by Kao et al., (1960). Gaul (1964, 1965, 1966) from his extensive work with x-irradiation in barley concluded that irradiation results in a decrease in the mean and an increase in variance. He also, isolated (1969) one micro-mutant from 1000-lines with an yield capacity 10 per cent higher than the mother cultivar.

High phenotypic variability for the characters of plant height and number of productive tillers per plant in wheat following x-irradiation was reported by Bhatia and Swaminathan (1963). Scossiroli in a series of papers (1965, 1966, 1968) reported the effects of irradiation on quantitative traits in different crop plants and emphasized the importance of large genetic variation as a source of better response to selection from the breeding point of view. Frey (1965) demonstrated the production of micro-mutations for seed weight in oats and their

values for altering the traits after irradiation. An increase or decrease of mean for grain weight, plant height and height of the ears in sorghum after x-irradiation were recorded by Sree Ramulu (1974).

In numerous experiments, mutants with changes in flowering or ripening time have been reported. Quantitative studies on variation of heading date on irradiated materials show that the induced variation in many instances were towards earliness and lateness in equal frequencies or in other cases more towards lateness (Abrams and Vilez-Fortuno, 1962; Abrams and Frey, 1964; Gonzalez and Frey, 1965). Several other characters were changed in early maturing mutants. Reduction of yielding capacity, panicle number, 1000-grain weight, number of internode and plant height were reported in many crops (Gustafsson et al., 1960; Gaul and Mittelstenscheid, 1960; Ehrenberg et al., 1956; von Wettstein, 1957; Scholz, 1957; Aastveit, 1965). However, early flowering mutants especially slightly early maturing ones, with yielding capacities equivalent to or higher than their original varieties had been induced in several crops (Gustafsson, 1947, 1963; Gustafsson et al., 1960; Froier, 1954; Zacharias, 1956, Gaul and Mittelstenscheid, 1960; Li et al., 1961; Aastveit, 1965). From this review it is evident that ionizing radiation can widen the genetic variability in any character and thereby can increase the scope of selecting improved types.

General Methodology of Radiation Breeding :

Radiation breeding usually starts with irradiation of seeds. There have been two different views on the effective dose of radiation to be applied on seeds of cereals. One view is that high dose of radiation (i.e. 30 kR or higher doses) should be used so that as large genetic variation as possible might be induced (Gaul, 1964). The second view propounds that low or medium doses (i.e. 10 to 20 kR) should be preferred since frequency of practically desirable mutants is not necessarily increased with high radiation doses (Yamagata and Syakudo, 1960; Hansel, 1967; Dumanovic et al., 1969). These two views are not yet resolved.

M₁ Generation :

It is suggested that measures may be taken to protect individual M₁ plants from foreign pollen contamination (Jana and Roy, 1973). Early emerging M₁ spikes should be used if loss of mutations due to diplontic selection is to be minimized (Gaul, 1961). M₁ spikes with high sterility should be avoided as they are likely to transmit a higher frequency of practically undesirable M₂ mutants than fertile M₁ spikes (Nishimura and Kurakami, 1952; Walther, 1971).

M₂ Generation :

Assuming that the rate of mutation is 10^{-4} or lower order in case of the optimum mutagen dose (Yonezawa and Yamagata, 1974),

it is estimated that 200,000 to 250,000 or more M_2 plants should be grown to recover desirable mutants in sufficient number (Samoto and Kanai, 1975). This figure is too high to be adopted in any breeding programme as space, personnels and cost become the limiting factors. The M_2 generation may consist of single rows, each from a single M_1 plant, and usually of 10 to 20 plants. On theoretical grounds (Yoshida, 1965) has found that nine plants from each M_1 head of cereal crops will be most efficient in the use of space and time. Selections may be made in M_2 generation with respect to the characters with relatively high heritabilities; only about five or lower per cent of the whole M_2 plants should be selected based on heading date and/or culm length (Futsuhara et al., 1967; Ree, 1970; Toda et al., 1972; Samoto and Kanai, 1975). On the other hand, Jana and Roy (1973) have suggested that for rice, the seeds of single M_1 plants be thoroughly mixed and a random sample of 100 seeds be grown to get a single M_2 line. For each treatment, 50 randomly chosen M_2 lines might be transplanted and equal numbers of control lines (untreated) might be grown alternately with these M_2 lines to form a plot of 300 m^2 with 10,000 plants. Fifty plants were to be selected at random from each M_2 line. These plants were to be harvested individually at maturity after taking necessary records.

M_3 Generation :

Mass selection should be initiated based on the characters such as heading date and culm length, where genotypic differences can be relatively easily distinguished with individual plants. It is proposed, however, that selection intensity should not be so high as in the conventional breeding programmes, rather, as loose selection as possible should be made; if circumstances permit, 20 to 30 per cent of the whole M_3 population should be taken up, rejecting those mutants as having remarkably altered phenotypes. (Futsuhara, 1963; Yonezawa, 1975). This can ensure against the accidental loss of desirable genotype.

M_4 and Later Generations :

Family selection can be effectively made in M_4 generation, considering all the characters composing the agronomic desirability of mutants. Breeding procedures in M_4 and succeeding generations could be made similarly as in the customary pedigree breeding method. Intensive selections should be avoided also with family selection when discrimination and evaluation of mutants have to be made based on some limited among all the relevant characters (Yonezawa, 1975).

Brim (1966) described a single seed descent (SSD) procedure and tested the advantages and disadvantages of the procedure compared to the pedigree breeding method. Knott and Kumar (1975) and Boerma and Cooper (1975) compared the effectiveness of various

selection schemes and their analyses have indicated some merit in single seed descent (SSD) procedure. Yoshida et al., (1969) calculated from their theoretical studies that X_4 or X_3 generation should be superior for the initial selection. Yonezawa et al., (1973) showed that delayed selection was much more efficient than the ordinary M_2 selection for obtaining mutants such as those occurring at multiple loci. Yonezawa and Yamagata (1975) further stressed that delayed selection in M_3 to M_5 generation had been of great practical merit when plants mutated at multiple loci were to be obtained. Several workers (Gaul, 1964; Kao et al., 1960; Matsuo et al., 1964; Oka et al., 1958; Yamagata and Syakudo, 1963) also opined in favour of delayed selection in M_3 or later generation following mutagenic treatment while describing their results in different crops.

Radiation Breeding in Foxtail Millet :

In Setaria italica, the frequency of induced mutation was found to vary between two varieties. Mutation frequency increased with the increase of dose or duration of mutagen treatment and were much higher in combined treatments (EMS and DES) of chemical and physical mutagen (gamma-ray) than the individual treatments. A synergistic effect was observed between the two groups of mutagens in culture MU-1. The mutation spectrum was also wider in culture MU-1 (Gupta and Yashvir, 1976). Seeds of K.221-1 (S. italica) were irradiated with gamma-ray with 20 kR, 30 kR

and 40 kR doses. M_2 progeny from each treatment was raised in a replicated design. The best 24 lines out of 500 plant progenies were selected on the basis of M_2 progeny row means. The range of genetic variability for plant height, tiller number, ear length and grain yield per plant increased due to gamma irradiation. The deviations in the means were highly significant for most of the progenies in all the three (M_2 , M_3 , M_4) generations. Several promising M_3 and M_4 lines with shorter plants and increased tiller number and grain yield per plant were selected (Madhava and Goud, 1973).

It is quite clear from the above review that there is very little information on the effect of gamma irradiation on the genetic variability in foxtail millet. So the present study was undertaken to find out the effect of different doses of gamma irradiation on the variability with regard^{to} various traits in this crop.

CHAPTER—III

MATERIALS AND METHODS

Materials :

Forty collections of Setaria italica from Bangladesh B.Si-1, 7, 123, 142, 150, 153, 161, 164, 166, 170, 191, 193, 287, 288, 331, 332, 335, 337, 344, 355, 357, 358, 362, 366, 373, 382, 384, 405, 410, 411, 427, 435, 439, 450, 452, 453, 479, 484, 488 and Shibnagar, were obtained from the cereal section of the Plant Breeding Division, Bangladesh Agricultural Research Institute, Joydebpur, Dhaka. An evaluation trial with these 40 collections was conducted at the two farms of Bidhan Chandra Krishi Viswavidyalaya, one located at Kalyani (District, Nadia) and the other at Jhargram (District, Midnapore). The physical features of the two locations are given in the Table 1.

Table 1. Physical features of the experimental farms.

Physical features	Location	
	Kalyani	Jhargram
Altitude	9.75 m	78 m
Lati./Longi.	23.5°N/89°E	22.5°N/87°E
Rainfall (annual)	150 cm	130.7 cm
Soil pH	6.7	5.5
Organic carbon (%)	0.74	0.58
Total N (%)	0.057	0.135
P ₂ O ₅	22.4 kg/ha	13 kg/ha
K ₂ O	225 kg/ha	100 kg/ha

Field Experiment :

At the time of final land preparation following doses of N:P:K were applied 30:40:30 kg/ha respectively. The sources of N,P and K were urea, single super phosphate and muriate of potash respectively. A top dressing of another 30 kg N/ha from urea was applied at boot stage of the crop. Block size was 8.4 x 2.8 m. Plot size was one meter long row. Each entry had a single row in a replication. Seeds were sown continuously by hand. Date of sowing at Kalyani and Jhargram were 9th and 24th May, 1984. The planting depth of seeds was about 2 cm. Adequate moisture was maintained for uniform germination of seeds. Three to four weeding and mulching were done. Thinning of plants was done at 15 days after sowing and a plant to plant distance of 8 cm was maintained. Row to row distance was 40 cm.

Height, length and breadth were measured in centimeter. Yield per plant was recorded in gram. Date of germination; days to flowering; plant height at maturity; number of leaves per plant at flowering; flag leaf length and breadth; pigmentation of auricle, awn and glume; panicle length; colour of grain; days to maturity and yield per plant were recorded.

Irradiation :

Fresh well dried 10 g seeds of collection B.Si.450 were exposed to each of four doses of gamma-ray irradiation i.e. 5 kR, 10 kR, 20 kR and 40 kR without interruption. The gamma irradiation

was done in a gamma cell having 1820 curies ^{60}Co cobalt source, located at the Jute Agricultural Research Institute, Barrackpore, 24-Parganas, West Bengal.

G_1 Generation :

In this generation land preparation, fertilizer doses and its application, methods of sowing seeds, intercultural operations etc. were same as in the initial evaluation trial. Seeds were sown on 7th November, 1984 at the research farm of Bidhan Chandra Krishi Viswavidyalaya at Kalyani. The experimental plot of this generation was two rows of 2 meter length for each treatment. Plant to plant distance was 8 cm and row to row distance was 40 cm. In this generation three irrigations were given i.e. first at mid vegetative growth stage, second at flowering stage and the third at mid grain filling stage. Random 20 plants from each treatment and in each replication were properly selfed by bagging the panicle. Pollen fertility was checked by aceto ^acermine method in freshly opened flowers in 10 randomly selected plants in each of the treatments and in each replication. Early flowered plants in each irradiated population were properly labeled and harvested separately for raising the G_2 generation. Date of germination; days to flowering; plant height at maturity; number of leaf per plant at flowering; flag leaf length and breadth; panicle length and breadth; days to maturity and yield per plant were recorded.

Seeds were threshed separately on single plant basis and stored properly in a desiccator for next generation. From recorded G_1 plants again six plants were randomly selected from each of the treatment for raising the G_2 generation.

G_2 Generation :

In this generation land preparation, fertilizer doses and time of application, method of sowing seeds, intercultural operations etc. were same as in the initial evaluation trial. The experiment was conducted at the research farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani. An experimental plot for each of the six families in each radiation dose consisted of two rows of 2 metres length. Date of sowing was 15th July, 1985.

Date of germination; days to flowering; plant height at maturity; number of leaves per plant at flowering; flag leaf length and breadth; panicle length and breadth; days to maturity and yield per plant. Seeds were threshed separately on single plant basis and stored properly in a desiccator for next generation.

G_3 Generation :

At the end of the G_2 generation yield per plant was critically analysed and 12 high to low yielding families were selected from each of the treatment to raise G_3 generation. Seeds from twelve selected families from G_2 generation and six

randomly selected families of G_1 generations from each of the treatment were laid out separately in randomised block design with three replications in two adjacent plots. Methods of land preparation, application of fertilizer, sowing of seeds, plant to plant and row to row distances and other interculture operations were similar to those in G_2 generation field experiment. Number of plants for each G_3 family in each treatment in each replication was 300 and that for each G_2 family for each treatment in each replication was 150.

Date of germination; days to flowering; plant height at maturity; number of leaves per plant at flowering; flag leaf length and breadth; panicle length and breadth; days to maturity and yield per plant were recorded.

Statistical Method :

The total variance in G_2 and G_3 generations, the estimates of genotypic variance, phenotypic variance, predicted heritability percentage were calculated following the methods of Comstock and Robinson (1952), Frey and Horner (1955), Johnson et al., (1955), Hanson et al., (1956) and Brock and Latter (1961). The expressions for the expected sum of squares and mean sum of squares for the analysis of variance are given in Table 2.

Table 2. Expected mean sum of squares for analysis of variance.

Source	D.F	S.S.	M.S.	F.
Total	$rl-1$	$\sum_{i=1}^r \sum_{j=1}^l y_{ij}^2 - C.T.$		
Line	$l-1$	$(1-r) \sum_{j=1}^l L_j^2 - C.T. = Vl$	$\frac{Vl}{l-1} = V_L$	$\frac{V_L}{V_E} = FL$
Repli.	$r-1$	$(1-l) \sum_{i=1}^r R_i^2 - C.T. = Vr$	$\frac{Vr}{r-1} = V_R$	
Error	$(l-1)(r-1)$	$SST-SSL-SSR = Ve$	$\frac{Ve}{(l-1)(r-1)} = V_E$	

where, V_L = treatment or line M.S.

V_E = error M.S.

r = number of replication.

Standard error of strain means = $\sqrt{\frac{EMS}{r}}$, where EMS = error mean square, r = no. of replication.

Table 3. Expected mean sum of squares for combined analysis of variance in two location trial.

Source	D.F	S.S.	M.S.	F.
Total	(rlv-1)	$\sum_{i=1}^r \sum_{j=1}^1 \sum_{k=1}^v Y_{ijk}^2 - C.T.$		
Var.	(v-1)	$(1-1) \sum_{k=1}^v V_i^2 - C.T = Vv$	$\frac{Vv}{1-1} = V_V$	$\frac{V_V}{VPE'} = FV$
Loc.	(1-1)	$(v-1) \sum_{j=1}^1 L_i^2 - C.T = V1$	$\frac{V1}{v-1} = V_L$	$\frac{V_V}{VE} = FV'$
Var. x Loc.	(v-1)(1-1)	$SST - SSV - SSL = V_e$	$\frac{V_e}{(v-1)(1-1)} = VE$	VPE'
Pooled Error	(rl-1)(v-1)	-	-	

Where, EMS of location.1 = A
 EMS of location.2 = B

$$\frac{A + B}{2} = VPE \text{ and}$$

$$\frac{VPE(E.DF \text{ of loc.1} + E.DF \text{ of loc.2}) + MS \text{ of loc. x Var.}}{DF \text{ of (Loc. x Var.)} + E.DF \text{ of Loc.1} + E.DF \text{ of Loc.2}} = VPE'$$

3. Test of homogeneity of experimental error and treatment comparisons.

$$\bar{S}^2 = \frac{1}{n} \sum_{i=1}^n S_r^2$$

$$X^2 = K(n \log \bar{S}^2 - \sum_{i=1}^n \log S_r^2)$$

$$C = 1 + \frac{n+1}{3nk}$$

where,

S_r^2 = error variance

n = no. of location

k = error degrees of freedom.

4. Critical Difference (C.D) was calculated from the standard error of difference multiplied by the value of 't' appropriate for the degrees of freedom for the experimental error in the analysis of variances :

$$\text{Standard error of difference (Sd)} = \sqrt{\frac{2 \times \text{Error Mean Square}}{\text{Number of replications}}}$$

$$\therefore \text{C.D} = \text{Sd} \times t_{.05} \text{ (at error degrees of freedom).}$$

5. Genetic variance :

$$V_G = \frac{V_L - V_E}{r}$$

where;

V_L = line or family M.S

V_E = error M.S.

V_G = genetic variance.

6. Phenotypic variance :

$$V_P = V_G + V_E$$

where;

V_P = phenotypic variance

7. Heritability :

$$H = \frac{\sigma_a^2}{\sigma_A^2} \times 100$$

where;

H = heritability in broad sense in percentage.

σ_a^2 = genetic variance.

σ_A^2 = phenotypic variance.

8. Genetic advance :

$$G_s = (K)(\sigma_A) \left[\frac{\sigma_a^2}{\sigma_A^2} \right]$$

where,

 G_s = genetic advance under selection; σ_A = phenotypic standard deviation; K = selection differential (expected value of $K = 2.07$) at 0.05% selection pressure in a large sample.

9. Genetic coefficient of variation %

$$GCV = \frac{\sqrt{\sigma_a^2}}{\bar{X}} \times 100$$

where,

 GCV = genetic coefficient of variation in percentage. $\sqrt{\sigma_a^2}$ = standard deviation of genetic variance. $\bar{X}$ = sample mean.

10. Phenotypic coefficient of variation :

$$PCV = \frac{\sqrt{\sigma_A^2}}{\bar{X}} \times 100$$

where,

 PCV = phenotypic coefficient of variation in percentage; $\bar{X}$ = sample mean. $\sqrt{\sigma_A^2}$ = standard deviation of phenotypic variance.

11. Expected genetic gain :

$$EGG = \frac{G_s}{\bar{X}} \times 100$$

where,

 EGG = expected genetic gain in percentage; G_s = genetic advance; $\bar{X}$ = sample mean.

12. To test whether the observed plant characters were in linear order, a linear regression was fitted by the least square method, and the formula for regression was as follows :

$$Y = a + bx$$

$$b = \frac{\text{Sum of product of } x.y}{\text{Sum of square of } x}$$

where,

b is regression coefficient and

x is independent variable.

13. Correlation :

Simple correlation coefficient among same characters of G_2 and G_3 families was calculated by the following method of Snedecor and Cochran (1967).

$$r = \frac{\sum xy - \frac{\sum x \sum y}{n}}{\sqrt{\sum x^2 - \frac{(\sum x)^2}{n} \sum y^2 - \frac{(\sum y)^2}{n}}}$$

where,

r = correlation coefficient, x and y are two variables and n = number of observations.

The significant calculated values of r should be further tested by "t" test at .01% and .05% level of significance :

$$t = \frac{r \sqrt{n-2}}{\sqrt{1-r^2}}$$

where,

n-2 is the degrees of freedom

n = number of observation.

CHAPTER—IV

RESULTS AND DISCUSSION

RESULTS

Initial Evaluation Trial

Forty varieties of foxtail millet from Bangladesh were laid out in field trial at Kalyani and at Jhargram in the kharif season in 1984. Analysis of variance was done for individual locations and from pooled data for eight characters : yield per plant, days to flowering, days to maturity, panicle length, plant height, number of leaves per plant and flag leaf length and breadth. It is noted from these analyses that the varieties differed significantly with regard to all the eight characters at both the locations as well as in pooled location. The location effects were also significant for all these characters. However, variety x location interaction was not significant for any one of the characters (Tables 4,5,6,7).

Yield per plant :

The average yield per plant at Kalyani varied from 2.08 to 4.89 g between these varieties. The average yield per plant at Jhargram varied from 1.97 to 4.16 g between these varieties. In pooled location the average yield per plant varied from 2.06 to 4.53 g between the varieties. In both the locations the top most yield was obtained in the variety B.Si.450 (vide Appendix Table I).

Days to flowering :

The average days to flowering in these varieties at Kalyani, Jhargram and pooled location varied from 46 to 58.66, 34 to 55.33 and 39.5 to 55.33 respectively. The variety B.Si. 450 was moderately early at both the locations. The variety B.Si.435 was noted as the most early flowering type in both the locations (vide Appendix Table II).

Days to maturity :

The average days to maturity between these varieties at Kalyani, Jhargram and pooled location varied from 73 to 85, 61.33 to 80.33 and 67.17 to 84.5 respectively. The variety B.Si.166 was recorded as the most early maturing type in both the locations, whereas B.Si.450 was also comparatively early maturing type at both locations (vide Appendix Table I).

Panicle length :

The mean panicle length between these varieties at Kalyani, Jhargram and Pooled location varied from 7.93 to 19.53 cm, 7.85 to 17.61 cm and 7.89 to 18.49 cm respectively (vide Appendix Table II).

Plant height :

The average plant height between these varieties at Kalyani, Jhargram and Pooled location varied from 74.33 to 133.66 cm, 66.33 to 121 cm and 70.33 to 130.67 cm respectively. The variety B.Si. 435 was noted to be the most dwarf type in both the locations and B.Si.450 was moderately dwarf type (vide Appendix Table III).

Number of leaves per plant :

The mean number of leaves per plant in these varieties at Kalyani, Jhargram and Pooled location varied from 10.07 to 13.47, 8.2 to 11.86 and 9.13 to 12.66 respectively. High number of leaves per plant in the variety B.Si.450 was noted in both the locations (vide Appendix Table III).

Flag leaf length :

The average flag leaf length of these varieties at Kalyani, Jhargram and Pooled location varied from 20.71 to 31.84, 18.04 to 29.2 cm and 19.37 to 30.52 cm respectively. B.Si.450 had large flag leaf at both locations. The largest flag leaf was noted in the variety. B.Si.439 at both the locations (vide Appendix Table IV).

Flag leaf breadth :

The average flag leaf breadth in these varieties at Kalyani, Jhargram and Pooled location varied from 1.42 to 2.68 cm, 1.11 to 2.47 cm and 1.27 to 2.54 cm respectively. The widest flag leaf

was found in the variety B.Si.373 at both the locations (vide Appendix Table IV).

Table 4. ANOVA of initial evaluation trial of 40 varieties (Reproductive characters).

Source	D.F.	Yield/plant M.S.			Days to flowering M.S.		
		KLN	JGM	Pool	KLN	JGM	Pool
Variety	39	1.54**	0.83**	1.16**	27.41**	60.45**	25.98**
Repli.	2	9.52	10.40	-	56.27	12.77	-
Error	78	0.23	0.09	-	4.38	2.26	-
Location	1	-	-	12.46**	-	-	1140.58**
Var.x Loc.	39	-	-	0.02	-	-	3.30
Error (Pooled)	195	-	-	0.13	-	-	3.32

** Significant at 1% level

Table 5. ANOVA of initial evaluation trial of 40 varieties (Reproductive characters).

Source	D.F.	Days to maturity M.S.			Panicle length M.S.		
		KLN	JGM	Pool	KLN	JGM	Pool
Variety	39	36.26**	65.35**	30.49**	24.60**	19.72**	14.69**
Repli.	2	26.17	13.36	-	19.30	27.73	-
Error	78	2.32	1.72	-	4.65	3.79	-
Location	1	-	-	1904.57**	-	-	23.09**
Var.x Loc.	39	-	-	3.38	-	-	0.10
Error (Pooled)	195	-	-	2.12	-	-	3.40

** Significant at 1% level

Table 6. ANOVA of initial evaluation trial of 40 varieties (Vegetative characters).

Source	D.F	Plant height			No. of leaves/plant		
		M.S.			M.S.		
		KLN	JGM	Pool	KLN	JGM	Pool
Variety	39	433.75**	414.77**	281.79**	1.56**	1.47**	1.00**
Repli.	2	763.05	1115.83	-	4.79	3.73	-
Error	78	186.49	131.44	-	0.21	0.26	-
Location	1	-	-	1910.91**	-	-	70.11**
Var.x Loc.	39	-	-	1.04	-	-	0.04
Error (Pooled)	195	-	-	127.37	-	-	0.19

** Significant at 1% level.

Table 7. ANOVA of initial evaluation trial of 40 varieties (Vegetative characters).

Source	D.F	Flag leaf length			Flag leaf breadth		
		M.S.			M.S.		
		KLN	JGM	Pool	KLN	JGM	Pool
Variety	39	21.83**	18.27**	12.89**	0.26**	0.29**	0.17**
Repli.	2	188.32	189.52	-	0.34	0.35	-
Error	78	16.54	15.34	-	0.06	0.06	-
Location	1	-	-	112.74**	-	-	1.36**
Var.x Loc.	39	-	-	0.47	-	-	0.004
Error (Pooled)	195	-	-	12.85	-	-	0.05

** Significant at 1% level.

G₁ Generation

The field trial for G₁ generation was laid out at Kalyani in Rabi season of 1984-'85. The following nine characters were studied.

Yield per plant :

In this generation significant difference in yield per plant was noted between the different doses of radiation (Table 8). Interplant variation in yield was significant in 10 kR and 20 kR doses only (Table 10).

Pollen sterility :

Variation in pollen sterility between the radiation doses was significant (Table 8). But interplant variation in pollen sterility was significant in none of the radiation doses (Table 11).

Days to maturity :

The difference between the various doses of radiation with regard to days to maturity was significant (Table 8). The maturity difference between plants was significant in only 20 kR dose (Table 12).

Panicle length :

The variation in panicle length between the radiation doses as well as that between plants within a radiation dose were not significant (Tables 8, 13).

Panicle breadth :

The panicle breadth did not differ significantly between the radiation doses (Table 8). Interplant variation in panicle breadth was significant in 20 kR dose only (Table 14).

Plant height :

The plant height did not differ significantly between the various radiation doses (Table 9) as well as between plants within any individual radiation dose (Table 15).

Number of leaves per plant :

The effect of radiation doses on the number of leaves per plant was not significantly different (Table 9). Similarly interplant variation in number of leaves was also not significant in any one of the radiation doses (Table 16).

Flag leaf length :

The variation in flag leaf length was not significant between the various radiation doses (Table 9). Interplant variation in flag leaf length was significant only in 20 kR dose (Table 17).

Flag leaf breadth :

Flag leaf breadth did not differ significantly between the radiation doses (Table 9). Significant variation in flag leaf breadth between the plants was noted only in 40 kR dose (Table 18).

Table 8. ANOVA of radiation dosage effect on reproductive characters in G_1 generation.

Source	D.F.	M.S.				
		Yield/ plant	Pollen sterility	Days to maturity	Panicle length	Panicle breadth
Dose	4	43.36**	1565.70**	31.70**	0.25	0.01
Repli.	3	6.02	30.79	1.33	4.72	0.17
Error	12	3.61	20.98	1.05	1.13	0.02

** Significant at 1% level.

Table 9. ANOVA of radiation dosage effect on vegetative characters in G_1 generation.

Source	D.F.	M.S.			
		Plant height	No. of leaves per plant	Flag leaf length	Flag leaf breadth
Dose	4	86.96	2.67	2.45	0.007
Repli.	3	420.86	1.40	28.00	0.03
Error	12	33.56	1.91	4.69	0.02

ANOVA Tables for between plant variation within radiation doses in G_1 generation.

Table 10. ANOVA for yield per plant.

Source	D.F.	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Plants	19	11.11	13.48	15.52*	22.36*	11.87
Repli.	3	238.30	42.72	64.00	10.66	25.94
Error	57	8.69	10.79	8.39	11.95	18.86

Table 11. ANOVA for pollen sterility per plant.

Source	D.F.	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Plants	19	44.26	110.79	371.71	286.85	689.39
Repli.	3	57.20	652.88	168.91	831.43	576.57
Error	57	77.71	79.59	263.45	390.84	551.81

Table 12. ANOVA for days to maturity.

Source	D.F.	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Plants	19	11.66	11.15	16.10	11.69*	3.22
Repli.	3	38.35	34.46	9.91	25.91	2.53
Error	57	7.91	12.48	15.50	6.69	2.84

* Significant at 5% level.

ANOVA Tables for between plant variation within radiation doses in G_1 generation.

Table 13. ANOVA for panicle length.

Source	D.F.	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Plants	19	3.39	3.60	6.44	4.42	8.79
Repli	3	80.10	10.25	38.38	28.80	28.12
Error	57	3.89	4.41	5.66	4.42	6.60

Table 14. ANOVA for panicle breadth.

Source	D.F.	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Plants	19	0.14	0.14	0.17	0.23**	0.17
Repli.	3	1.22	0.50	0.83	0.53	2.21
Error	57	0.13	0.10	0.14	0.07	0.17

Table 15. ANOVA for plant height.

Source	D.F.	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Plants	19	112.32	66.97	86.34	128.33	97.93
Repli.	3	3310.86	616.17	1610.13	3933.08	1500.18
Error	57	93.53	68.66	130.62	153.38	90.54

** Significant at 1% level.

ANOVA Table for between plant variation within radiation doses in G_1 generation.

Table 16. ANOVA for number of leaves per plant.

Source	D.F.	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Plants	19	0.87	1.46	0.84	1.84	0.69
Repli.	3	5.83	3.83	7.60	6.88	5.50
Error	57	1.10	1.25	0.98	1.36	1.39

Table 17. ANOVA for flag leaf length.

Source	D.F.	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Plants	19	22.63	35.75	41.75	48.28*	48.00
Repli.	3	365.21	104.28	54.50	239.19	233.82
Error	57	30.00	24.21	28.80	26.88	30.39

Table 18. ANOVA for flag leaf breadth.

Source	D.F.	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Plants	19	0.11	0.08	0.12	0.08	0.20*
Repli.	3	0.71	0.45	0.13	0.45	1.09
Error	57	0.16	0.14	0.13	0.10	0.10

* Significant at 5% level.

G₂ Generation (Kharif Trial)

One G₂ generation trial was laid out in Kalyani in Kharif season in 1985. The results of nine characters studied are presented below :

Yield per plant :

In G₂ generation, the yield per plant differed significantly between the radiation doses (Table 19). However, interfamilial variation in yield was not significant within any individual radiation dose (Table 21). From the mean values of this generation it is noted that only two families (No.3,4) in 5 kR had higher yield (more than the difference of C.D.), whereas three families in 10 kR (No.3,4,6) had lower yield as compared to the control (vide Appendix Table VI).

Days to flowering :

The effect of various radiation doses on this character in this generation was not significant (Table 19). Similarly the interfamilial variation in the onset of flowering was also not significantly different in any one of the radiation doses (Table 22).

Days to maturity :

Days to maturity did not show significant variation between the radiation doses as well as between families in any individual radiation dose (Tables 19,23).

Panicle length :

Panicle length differed significantly between the radiation doses (Table 19). However, between family variation in panicle length was significant in none of the radiation doses (Table 24). In this generation the mean values of panicle length was significantly higher from that of the control in three families (No.1,3,4) in 5 kR, one family (No.5) in 20 kR and four families (No.1,2,3,4) at 40 kR doses. The panicle length was decreased in four families (No.1,3,5,6) in 10 kR dose only (vide Appendix Table VI).

Panicle breadth :

Significant panicle breadth difference was noted between the radiation doses (Table 19). But interfamilial variation in panicle breadth was not significant in any of the radiation doses (Table 25). From the mean value for this trait it was noted that only one family each in 5 kR (No.1) and in 40 kR (No.2) had higher scores than that in the control. But there were four families in 10 kR (No.3,4,5,6) and one family in 20 kR (No.4) had thinner panicle than the control (vide Appendix Table VI).

Plant height :

Plant height variation between radiation doses was not significant (Table 20). But interfamilial variation was significant in 10 kR only (Table 21). The genotypic and phenotypic variances,

genotypic and phenotypic coefficient of variability, heritability estimate genetic advance and expected genetic gain had low values in 10 kR dose as compared to those in control (Table 30).

Number of leaves per plant :

Number of leaves per plant did not vary significantly between the radiation doses (Table 20). But between family variation in number of leaves per plant was significant only in 5 kR dose (Table 27). The ⁰genotypic and phenotypic variances, genotypic and phenotypic coefficients of variability genetic advance and expected genetic gain were low but the heritability estimate was of medium value in 5 kR population (Table 30).

Flag leaf length :

Significant difference was noted between the radiation doses with regard to flag leaf length (Table 20). Whereas interfamilial variation in this character was not significant in any one of the radiation doses (Table 28). Significantly higher mean value for flag leaf length was recorded in four families (No.1,2,3,4) in 5 kR; one family (No.2) in 20 kR and three families (No.1,4,5) in 40 kR doses as compared to that in control. But two families (No.4,6) in 10 kR had shorter flag leaf than the control (vide Appendix Table VI).

Flag leaf breadth :

Variation in flag leaf breadth was neither significant between the radiation doses nor between families in any individual radiation dose (Table 20,29).

Table 19. ANOVA for radiation dosage effect on reproductive characters in G_2 generation (Kharif Trial).

Source	D.F	M.S.				
		Yield/ plant	Days to flower	Days to maturity	Panicle length	Panicle breadth
Dose	4	2.90*	2.70	11.09	2.09*	0.04*
Repli.	2	5.18	10.02	8.86	0.14	0.02
Error	8	0.65	4.73	3.43	0.26	0.01

Table 20. ANOVA for radiation dosage effect on vegetative characters in G_2 generation (Kharif Trial).

Source	D.F	M.S.			
		Flag leaf length	Flag leaf breadth	Plant height	No.leaves/ plant
Dose	4	5.04*	0.02	25.72	0.31
Repli.	2	2.02	0.01	67.54	0.45
Error	8	0.91	0.02	88.42	0.28

* Significant at 5% level.

ANOVA Tables for interfamilial variation within radiation doses
in G_2 generation (Kharif Trial).

Table 21. ANOVA for yield per plant.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	5	0.46	1.52	0.81	1.15	1.06
Repli.	2	17.63	16.35	5.79	19.67	7.02
Error	10	2.37	1.44	0.97	1.12	1.15

Table 22. ANOVA for days to flowering.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	5	1.18	3.48	1.67	7.36	1.76
Repli.	2	3.78	39.27	19.74	91.09	10.52
Error	10	2.25	2.23	3.30	4.35	1.45

Table 23. ANOVA for days to maturity.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	5	0.84	3.86	2.28	4.03	4.68
Repli.	2	23.02	30.98	40.77	46.77	0.62
Error	10	2.55	3.07	3.96	3.58	3.37

ANOVA Tables for interfamily variation within radiation doses in G_2 generation (Kharif Trial).

Table 24. ANOVA for panicle length.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	5	0.45	2.12	0.43	0.92	1.11
Repli.	2	0.38	1.43	0.98	6.15	0.86
Error	10	0.72	0.81	1.19	1.55	1.27

Table 25. ANOVA for panicle breadth.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	5	0.03	0.02	0.05	0.03	0.03
Repli.	2	0.12	0.20	0.10	0.07	0.07
Error	10	0.05	0.03	0.03	0.03	0.02

Table 26. ANOVA for plant height.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	5	29.69	199.85	69.61*	25.61	49.11
Repli.	2	626.81	157.94	1636.84	76.59	100.67
Error	10	97.72	124.91	20.38	80.94	29.31

* Significant at 5% level.

ANOVA Tables for interfamilial variation within radiation doses in G_2 generation (Kharif Trial).

Table 27. ANOVA for number of leaves per plant.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	5	0.04	0.55*	0.49	0.13	0.17
Repli.	2	1.19	0.24	7.09	0.15	0.76
Error	10	0.24	0.13	0.17	0.26	0.16

Table 28. ANOVA for flag leaf length.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	5	1.93	6.97	1.26	1.95	1.87
Repli.	3	1.86	7.18	8.48	17.25	7.44
Error	10	3.05	2.23	2.46	0.89	4.40

Table 29. ANOVA for flag leaf breadth.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	5	0.004	0.01	0.006	0.11	0.01
Repli.	2	0.02	0.09	0.05	0.43	0.02
Error	10	0.01	0.01	0.006	0.09	0.009

* Significant at 5% level.

Table 30. Mean and variability estimates for plant height and number of leaves per plant in G₂ generation (Kharif Trial).

Doses	M e a n			GV	PV	GCV	PCV	Herit.	Genet. adv.	EGG
	Lst. fam.	Hst. fam.	Pop.							
<u>Plant height</u>										
Cont.	132.37	141.64	136.19	-	-	-	-	-	-	-
5 kR	127.39	147.36	136.25	-	-	-	-	-	-	-
10 "	128.90	142.23	136.82	16.41	36.79	2.96	4.43	44.60	5.60	4.09
20 "	101.60	134.74	132.26	-	-	-	-	-	-	-
40 *	128.16	139.58	133.17	-	-	-	-	-	-	-
<u>Number of leaves per plant</u>										
Cont.	12.64	12.98	12.77	-	-	-	-	-	-	-
5 kR	12.33	13.53	12.75	0.14	0.27	2.93	4.08	51.85	0.56	4.39
10 "	11.31	12.49	12.03	-	-	-	-	-	-	-
20 "	11.93	12.44	12.19	-	-	-	-	-	-	-
40 "	12.25	12.88	12.61	-	-	-	-	-	-	-

(-) not significant in 'F' test.

G₂ Generation (Rabi Trial)

This trial was laid out at Kalyani in Rabi season of 1985-'86. The characters studied were as follows :

Yield per plant :

In G₂ generation radiation doses differed significantly in their effect on yield per plant (Table 31). The ANOVA for families within radiation dosage effect also showed significant variation for this character in 5 kR dosage (Table 33). Only one family (No.2) in 5 kR had significantly higher yield, but lower yield was noted in two families (No.5,6) in 10 kR, three families each in 20 kR (No.1,5,6) and 40 kR (No.1,2,6). The highest family mean for yield per plant (17.61 g) was recorded at 5 kR dose (vide Appendix Table VII). The genotypic variance, phenotypic variance, genotypic and phenotypic coefficients of variability were higher at 5 kR in comparison to those of control. High heritability value (96.69%) was obtained in control, whereas lower heritability value was noted for 5 kR population. Genetic advance as well as expected genetic gain were both lower in 5 kR dose as compared to those in control (Table 42).

Days to flowering :

The variation for days to flowering between radiation doses was highly significant (Table 31). The induced variability of families within radiation doses were highly significant for all the four radiation doses (Table 34). Significant lateness as compared to the control was noted in three families (No.1,2,3) in 5 kR, two families (No.2,4) in 10 kR, three families (No.1,3,5) in 20 kR and two families (No.1,3) in 40 kR doses. But early flowering was observed in one family (No.5) in 5 kR, four families (No.1,3,5, 6) in 10 kR, two families (No.2,6) in 20 kR and two families (No.4, 6) in 40 kR doses (vide Appendix Table VII). Genotypic variance, phenotypic variance, genotypic and phenotypic coefficient of variability for different irradiated populations were high as compared to those in control. Heritability values were higher for control, 5 kR and 10 kR doses. Medium heritability values were noted for 20 kR and 40 kR doses. Genetic advance and expected genetic gain were higher in different radiation doses (except 40 kR) with regard to those in control (Table 42).

Days to maturity :

Highly significant variation for days to maturity was found between different radiation doses (Table 31). Between family variation was also significant for this character for all the four radiation doses (Table 35). Longer maturity duration was noted in

altogether three families - one (No.1) in 5 kR, one (No.2) in 10 kR and one (No.1) in 20 kR doses in comparison to the control population (vide Appendix Table VII). Genotypic variance, phenotypic variance, genotypic and phenotypic coefficients of variability were higher for all the radiation doses as compared to those in control. High heritability value (91.66%) was estimated for 10 kR radiation dose. High heritability values were also noted for control and 5 kR dose. Whereas medium heritability values were recorded for 20 kR and 40 kR doses. Except 40 kR, higher genetic advance as well as expected genetic gain were estimated for different radiation doses in comparison to those of control (Table 43).

Panicle length :

Highly significant variation in this character between radiation doses was recorded in this generation (Table 31). Between family variation was significant for this character in 20 kR dose only (Table 36). Higher mean value for panicle length was noted in three families (No.2,3,5) at 5 kR, two families (No.2,4) in 10 kR, three families (No.3,4,6) in 20 kR and in only one family (No.3) at 40 kR as compared to that in control. Whereas, only one family (No.2) in 40 kR had shorter panicle as compared to that in control (vide Appendix Table VII). Phenotypic variance and phenotypic coefficient of variability were higher whereas the estimated values for genotypic variance, genotypic coefficient of

variability, genetic advance and expected genetic gain were lower in 20 kR dose as compared to those in control. High heritability value (94.12%) was noted for control. Whereas, low heritability was estimated for this trait at 20 kR dose (Table 43).

Panicle breadth :

Panicle breadth differ significantly between radiation doses (Table 31). The between family variation was significant for all radiation doses except 40 kR (Table 37). Broader panicles were noted in four families (No.1,2,3,5) in 5 kR, one family (No.2) in 10 kR and one family (No.4) in 20 kR in comparison to that in control. Only one family (No.1) in 10 kR had thinner panicle than the control (vide Appendix Table VII). The highest family mean for panicle breadth (3.18 cm) was noted for 5 kR dose. Genotypic and phenotypic variances in most of the cases were higher for different doses in comparison to those in control. Genotypic coefficient of variability was higher only at 5 kR dose. Whereas, phenotypic coefficient of variability was higher for different radiation doses as compared to that in control. Very high heritability value (100%) was noted in control, whereas medium heritability values were estimated in irradiated populations. Genetic advance was noted to be higher at 5 kR dose with regard to control. But expected genetic gain did not increase at different radiation doses as compared to that in control (Table 44).

Flag leaf length :

The variation in flag leaf length between radiation doses was not significant (Table 32). Whereas between family variation was significant for this trait in 10 kR (Table 38). The maximum flag leaf length (34.62 cm) was noted at 20 kR dose (vide Appendix Table VII). Genotypic and phenotypic variances, genotypic and phenotypic coefficients of variability, genetic advance and expected genetic gain were higher at 10 kR dose with regard to those in control. High heritability value (90%) in control and medium heritability value (52.89%) at 10 kR dose were noted (Table 45).

Flag leaf breadth :

The variation in flag leaf breadth between radiation doses was significant (Table 32). The variation between families within radiation doses was significant for this character at 40 kR dosage (Table 39). Significant higher mean value for flag leaf breadth was recorded for all six families (No.1,2,3,4,5,6) in 40 kR dose only as compared to that in control. Whereas, the mean value for other families in other radiation doses for this trait was not significant (vide Appendix Table VII). Genotypic and phenotypic variances, genotypic and phenotypic coefficients of variability, genetic advance and expected genetic gain were higher for this trait at 40 kR dose in comparison to those in control. High

heritability value (90%) was estimated in control, whereas medium heritability value (50%) was noted at 40 kR dose (Table 45).

Plant height :

The variability of plant height between radiation doses was significant (Table 32). Families differed significantly in 20 kR, 40 kR and at control (Table 40). Significantly higher plant height as compared to the control was noted in two families (No.5,6) in 5 kR dose only. In none other families in other radiation doses plant height was significantly different from that of the control (vide Appendix Table VII). Genotypic variance was higher at 40 kR dose as compared to that in control. The phenotypic variances were higher in 20 kR and 40 kR doses with regard to control. Genotypic coefficient of variability was higher only at 40 kR dose in comparison to that in control. High phenotypic coefficient of variability was estimated for 20 kR and 40 kR doses. High heritability value (95.71%) was estimated in control, whereas low and high heritability values for this trait were noted for 20 kR and 40 kR doses respectively. Genetic advance and expected genetic gain were lower in 20 kR and 40 kR doses with regard to control (Table 44).

Number of leaves per plant :

The number of leaves per plant did not vary significantly between radiation doses (Table 32). The families showed significant difference in number of leaves per plant at 40 kR and at

control (Table 41). Genotypic and phenotypic variance, genotypic and phenotypic coefficients of variability, heritability, genetic advance and expected genetic gain were lower at 40 kR dose in comparison to those in control (Table 46).

Table 31. ANOVA for radiation dosage effect on reproductive characters in G_2 generation (Rabi Trial).

Source	D.F	M.S.				
		Yield/ plant	Days to flower	Days to maturity	Panicle length	Panicle breadth
Dose	4	4.03*	1.82**	6.20**	0.79**	0.04*
Repli.	2	0.53	0.03	0.59	1.94	0.004
Error	8	0.95	0.06	0.62	0.11	0.01

Table 32. ANOVA for radiation dosage effect on vegetative characters in G_2 generation (Rabi Trial).

Source	D.F	M.S.			
		Flag leaf length	Flag leaf breadth	Plant height	No. of leaves per plant
Dose	4	3.10	0.12*	272.50*	0.76
Repli.	2	1.17	0.06	53.32	0.08
Error	8	2.02	0.03	51.38	0.37

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

ANOVA Tables for interfamily variation within radiation doses in G_2 generation (Rabi Trial).

Table 33. ANOVA for yield per plant.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	5	6.24**	13.08*	2.76	1.56	1.25
Repli.	2	0.002	4.08	11.11	4.43	5.96
Error	10	0.07	3.50	1.81	1.52	2.43

Table 34. ANOVA for days to flowering.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	5	0.77**	4.61**	3.92**	4.53**	0.89*
Repli.	2	3.09	0.77	1.07	0.37	0.08
Error	10	0.04	0.27	0.11	0.79	0.17

Table 35. ANOVA for days to maturity.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	5	0.79**	4.72**	3.74**	3.20**	0.90*
Repli.	2	3.10	0.71	0.96	0.50	0.12
Error	10	0.04	0.27	0.11	0.36	0.20

* Significant at 5% level; ** Significant at 1% level.

ANOVA Tables for interfamilial variation within radiation doses
in G_2 generation (Rabi Trial).

Table 36. ANOVA for panicle length.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	5	2.45**	1.89	1.07	2.65*	1.29
Repli.	2	0.81	2.24	6.01	0.10	5.35
Error	10	0.05	0.80	0.69	0.74	0.90

Table 37. ANOVA for panicle breadth.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	5	0.07**	0.15*	0.07*	0.05*	0.01
Repli.	2	0.02	0.12	0.14	0.02	0.16
Error	10	0.002	0.03	0.02	0.01	0.008

Table 38. ANOVA for flag leaf length.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	5	3.89**	6.71	12.45*	7.31	5.97
Repli.	2	0.64	1.81	12.93	10.15	29.68
Error	10	0.13	5.16	2.85	2.63	2.60

* Significant at 5% level; ** Significant at 1% level.

ANOVA Tables for interfamily variation within radiation doses
in G_2 generation (Rabi Trial).

Table 39. ANOVA for flag leaf breadth.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	5	0.03**	0.03	0.001	0.02	0.05*
Repli.	2	0.03	0.009	0.03	0.02	0.14
Error	10	0.002	0.01	0.04	0.01	0.01

Table 40. ANOVA for plant height.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	5	76.02**	32.86	15.61	66.33*	85.89**
Repli.	2	0.32	45.18	781.88	194.68	77.28
Error	10	1.12	22.45	12.56	18.45	5.28

Table 41. ANOVA for number of leaves per plant.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	5	0.75**	0.11	0.21	0.10	0.17*
Repli.	2	2.37	0.61	3.78	2.47	0.17
Error	10	0.16	0.14	0.18	0.26	0.04

* Significant at 5% level; ** Significant at 1% level.

Table 42. Mean and variability estimates for yield and days to flowering in G₂ generation (Rabi Trial).

Doses	M e a n			GV	PV	GCV	PCV	Herit.	Genet. adv.	EGG
	Ist. fam.	Hst. fam.	Pop.							
<u>Yield per plant</u>										
Cont.	9.64	16.08	13.11	2.05	2.12	10.92	11.11	96.69	2.90	22.12
5 kR	11.95	17.61	13.64	3.19	6.69	13.09	18.96	47.68	2.54	18.62
10 kR	10.96	13.26	12.09	-	-	-	-	-	-	-
20 kR	10.32	12.02	11.18	-	-	-	-	-	-	-
40 kR	10.32	11.63	10.95	-	-	-	-	-	-	-
<u>Days to flowering</u>										
Cont.	92.61	94.47	93.65	0.24	0.28	0.52	0.56	85.71	0.92	0.98
5 kR	92.77	96.34	94.31	1.44	1.71	1.27	1.38	84.21	2.28	2.42
10 kR	92.21	95.34	93.38	1.27	1.38	1.21	1.26	92.03	2.23	2.39
20 kR	92.45	95.70	93.98	1.24	2.03	1.18	1.52	61.08	1.79	1.90
40 kR	93.10	94.24	93.73	0.24	0.41	0.52	0.68	58.54	0.78	0.83

(-) not significant in 'F' test.

Table 43. Mean and variability estimates for maturity and panicle length in G_2 generation (Rabi Trial).

Doses	M e a n			GV	PV	GCV	PCV	Herit.	Genet. adv.	EGG	
	Lst. fam.	Hst. fam.	Pop.								
<u>Days to maturity</u>											
Cont.	127.61	129.51	128.66	0.25	0.29	0.39	0.42	86.21	0.96	0.75	
5 kR	127.76	131.37	129.31	1.48	1.75	0.94	1.02	84.57	2.31	1.79	
10 kR	127.21	130.26	128.36	1.21	1.32	0.86	0.90	91.66	2.18	1.70	
20 kR	127.78	130.70	129.15	0.94	1.31	0.75	0.89	71.76	1.71	1.32	
40 kR	127.99	129.41	128.71	0.26	0.46	0.40	0.52	56.52	0.80	0.62	
<u>Panicle length</u>											
Cont.	18.80	21.96	20.75	0.80	0.85	4.31	4.44	94.12	1.79	8.63	
5 kR	20.98	22.79	21.97	-	-	-	-	-	-	-	
10 kR	20.19	22.24	21.16	-	-	-	-	-	-	-	
20 kR	20.39	22.88	21.18	0.64	1.37	3.78	5.53	46.72	1.13	5.34	
40 kR	19.94	21.81	20.70	-	-	-	-	-	-	-	

(-) not significant in 'F' test.

Table 44. Mean and variability estimates for panicle breadth and plant height in G₂ generation (Rabi Trial).

Doses	M e a n			GV	PV	GCV	PCV	Herit.	Genet. adv.	EGG
	Lst. fam.	Hst. fam.	Pop.							
<u>Panicle breadth</u>										
Cont.	2.58	3.21	2.93	0.02	0.02	4.83	4.83	100.00	0.29	9.90
5 kR	2.97	3.61	3.18	0.04	0.07	6.30	8.32	57.14	0.31	9.75
10 kR	2.90	3.32	3.08	0.02	0.04	4.59	6.49	50.00	0.21	6.82
20 kR	2.75	3.14	2.91	0.01	0.02	3.44	4.86	50.00	0.15	5.15
40 kR	2.82	2.95	2.89	-	-	-	-	-	-	-
<u>Plant height</u>										
Cont.	123.59	145.77	134.18	24.97	26.09	3.72	3.81	95.71	10.12	7.54
5 kR	137.29	146.54	143.21	-	-	-	-	-	-	-
10 kR	134.96	141.14	137.66	-	-	-	-	-	-	-
20 kR	124.40	138.73	131.04	15.96	34.41	3.05	4.48	46.38	5.63	4.29
40 kR	123.38	139.43	131.55	26.87	32.15	3.94	4.31	83.57	9.81	7.45

(-) not significant in 'F' test.

Table 45. Mean and variability estimates for flag leaf length and breadth in G₂ generation (Rabi Trial).

Doses	Mean			GV	PV	GCV	PCV	Herit.	Genet. adv.	EGG
	lst. fam.	Hst. fam.	Pop.							
<u>Flag leaf length</u>										
Cont.	29.27	34.11	32.16	1.25	1.38	3.48	3.65	90.58	2.19	6.81
5 kR.	32.28	35.78	34.46	-	-	-	-	-	-	-
10 kR	30.71	36.85	33.97	3.20	6.05	5.26	7.24	52.89	2.69	7.92
20 kR	32.97	37.37	34.62	-	-	-	-	-	-	-
40 kR	32.23	36.37	34.43	-	-	-	-	-	-	-
<u>Flag leaf breadth</u>										
Cont.	2.15	2.54	2.40	0.009	0.01	3.95	4.17	90.00	0.19	7.92
5 kR	2.31	2.59	2.41	-	-	-	-	-	-	-
10 kR	2.29	2.49	2.37	-	-	-	-	-	-	-
20 kR	2.29	2.55	2.38	-	-	-	-	-	-	-
40 kR	2.08	2.47	2.89	0.01	0.02	3.46	4.89	50.00	0.14	4.84

(-) not significant in 'F' test.

Table 46. Mean and variability estimates for number of leaves per plant in G₂ generation (Rabi Trial).

Doses	M e a n			GV	PV	GCV	PCV	Herit.	Genet. adv.	EGG
	Lst. fam.	Hst. fam.	Pop.							
<u>Number of leaves per plant</u>										
Cont.	12.22	14.23	12.82	0.20	0.36	3.49	4.68	55.56	0.69	5.38
5 kR	12.94	13.43	13.16	-	-	-	-	-	-	-
10 kR	12.04	12.73	12.47	-	-	-	-	-	-	-
20 kR	11.95	12.36	12.13	-	-	-	-	-	-	-
40 kR	11.68	12.25	11.91	0.04	0.08	1.68	2.37	50.00	0.29	2.43

(-) not significant in 'F' test.

G₃ Generation

This trial was laid out at Kalyani in Rabi season of 1985-'86. The results of the characters studied are presented below :

Yield per plant :

In this generation significant difference in yield per plant was noted between the different doses of radiation (Table 47). Interfamily variation in yield was significant in 10 kR, 20 kR and 40 kR radiation doses (Table 49).

Days to flowering :

The effect of different radiation doses on this character was significant (Table 47). Similarly the interfamily variation in onset of flowering was also significantly different in 5 kR, 20 kR and 40 kR radiation doses (Table 50).

Days to maturity :

The difference between the various doses of radiation with regard to days to maturity was significant (Table 47). The maturity difference between families was significant in 5 kR, 20 kR and 40 kR radiation doses (Table 51).

Panicle length :

Panicle length differed significantly between the radiation doses (Table 47). The variation in panicle length between families

within radiation dose was significant in 5 kR, 10 kR and 20 kR doses (Table 52).

Panicle breadth :

Significant difference in panicle breadth was noted between the radiation doses (Table 47). Interfamily variation in panicle breadth was significant in 10 kR and 20 kR doses (Table 53).

Plant height :

The plant height differ significantly between the various radiation doses (Table 48). Significant interfamily variation in plant height was recorded in radiation doses of 5 kR, 10 kR and 20 kR (Table 54).

Number of leaves per plant :

The effect of radiation doses on the number of leaves per plant was not significantly different between the radiation doses (Table 48). Interfamily variation in number of leaves was also not significant in any one of the radiation doses (Table 55).

Flag leaf length :

Significant difference was noted between the radiation doses with regard to flag leaf length (Table 48). Similar significant variation in flag leaf length between the families was noted in 5 kR, 10 kR and 20 kR radiation doses (Table 56).

Flag leaf breadth :

The effect of various radiation doses on this character in this generation was significant (Table 48). Interfamily variation was significant in 10 kR and 20 kR radiation doses (Table 57).

Table 47. ANOVA for radiation dosage effect on reproductive characters in G_3 generation.

Source	D.F	M.S.				
		Yield/ plant	Days to flowering	Days to maturity	Panicle length	Panicle breadth
Doses	4	8.98**	0.80*	0.83*	14.15**	0.102**
Repli.	2	0.65	3.65	3.74	0.01	0.001
Error	8	0.86	0.20	0.19	0.66	0.009

Table 48. ANOVA for radiation dosage effect on vegetative characters in G_3 generation.

Source	D.F	M.S.			
		Plant height	No. of leaves per plant	Flag leaf length	Flag leaf breadth
Doses	4	113.15**	0.11	62.61**	0.08**
Repli.	2	91.42	0.07	7.88	0.01
Error	8	29.38	0.21	2.61	0.01

* Significant at 5% level; ** Significant at 1% level.

ANOVA Tables for interfamilial variation within radiation doses in G_3 generation.

Table 49. ANOVA for yield per plant.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	11	3.45**	1.53	15.51**	7.63*	6.29**
Repli.	2	1.93	5.37	10.33	19.28	12.30
Error	22	0.38	2.04	2.45	2.56	1.48

Table 50. ANOVA for days to flowering.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	11	0.98**	3.23**	0.93	2.27**	2.22**
Repli.	2	4.15	18.78	5.93	10.60	14.79
Error	22	0.02	0.43	0.49	0.59	0.38

Table 51. ANOVA for days to maturity.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	11	1.02**	2.39**	1.09	2.28**	2.23**
Repli.	2	3.84	14.31	6.22	10.39	15.00
Error	22	0.04	0.69	0.50	0.59	0.37

* Significant at 5% level; ** Significant at 1% level.

ANOVA Tables for interfamilial variation within radiation doses in G_3 generation.

Table 52. ANOVA for panicle length.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	11	2.89**	2.88**	6.82**	4.80**	5.35
Repli.	2	5.82	1.72	7.94	11.17	12.02
Error	22	0.04	0.86	0.65	0.79	3.78

Table 53. ANOVA for panicle breadth.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	11	0.08**	0.02	0.14**	0.05*	0.03
Repli.	2	0.16	0.03	0.01	0.16	0.06
Error	22	0.0009	0.02	0.02	0.02	0.03

Table 54. ANOVA for plant height.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	11	133.75**	69.04**	109.28**	89.48**	28.06
Repli.	2	19.94	1495.96	493.47	167.91	325.50
Error	22	1.57	10.12	14.08	11.46	16.91

*Significant at 5% level; ** Significant at 1% level.

ANOVA Tables for interfamily variation with radiation doses
in G_3 generation.

Table 55. ANOVA for number of leaves per plant.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	11	0.92**	0.22	0.28	0.24	0.10
Repli.	2	1.14	2.18	7.51	0.19	0.17
Error	22	0.02	0.16	0.18	0.18	0.09

Table 56. ANOVA for flag leaf length.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	11	6.46**	12.49**	23.36**	17.20**	7.25
Repli.	2	8.41	14.39	130.66	17.88	49.19
Error	22	0.13	3.39	3.07	5.01	4.82

Table 57. ANOVA for flag leaf breadth.

Source	D.F	M.S.				
		Control	5 kR	10 kR	20 kR	40 kR
Family	11	0.09**	0.04	0.12**	0.10**	0.06
Repli.	2	0.16	0.26	0.06	0.06	0.25
Error	22	0.003	0.04	0.02	0.02	0.03

** Significant at 1% level.

Variability in G_3 generation

The mean and different parameters of variability estimated for various characters in G_3 generation are presented below :

Yield per plant :

The average yield per plant was higher at different radiation doses as compared to that in control. The highest family mean for yield per plant (16.69 g) was recorded at 10 kR dose. Genotypic and phenotypic variances for 10 kR population were higher than those in other populations. Genetic advance as well as expected genetic gain were both very high in 10 kR dose as compared to control and other doses of radiation. Genotypic and phenotypic coefficients of variability for yield per plant at 10 kR dose were also high. Medium heritability value (72.85%) was estimated in control. Medium heritability value was also arrived at for 10 kR and 40 kR populations but this value was in low range for 20 kR population (Table 58).

Days to flowering :

The average days to flower in different radiation doses as compared to that in control did not differ very much. Genotypic and phenotypic variances for 5 kR with regard to those in control and other radiation doses were higher. Genetic advance and expected genetic gain were also higher in 5 kR and 40 kR doses as compared to those in control. Genotypic and phenotypic

coefficients of variability for this character at different radiation doses were also higher with regard to those in control. High heritability value (94.12%) was obtained in control, whereas medium heritability values were estimated in 5 kR, 10 kR and 40 kR dose populations (Table 58).

Days to maturity :

The mean days to maturity did not differ very much at different radiation doses with regard to that in control. Genotypic and phenotypic variances for 5 kR, 20 kR and 40 kR doses were higher as compared to those in control. Genetic advance and expected genetic gain were higher only at 40 kR dose as compared to those control. Genotypic as well as phenotypic coefficients of variability were higher for 5 kR, 20 kR and 40 kR doses with regard to those in control. High heritability value (89.19%) was estimated in control, whereas medium heritability values were recorded at 5 kR, 20 kR and 40 kR doses (Table 59).

Panicle length :

The mean of panicle length for families was higher at different radiation doses as compared to that in control. The highest family mean for this character was noted at 40 kR dose. Genetic variance for this character was higher at 10 kR and 20 kR doses. The phenotypic variance was higher in 5 kR, 10 kR and 20 kR doses as compared to that in control. Genetic advance as well as

expected genetic gain were higher only at 10 kR dose in comparison to the control. Genotypic coefficient of variability for panicle length was higher only at 10 kR dose whereas the phenotypic coefficient of variability for 5 kR, 10 kR and 20 kR doses was high as compared to that in control. High heritability value (95.96%) was noted in control and medium heritability values were estimated for 10 kR and 20 kR populations but this value was in low range for 5 kR population (Table 59).

Panicle breadth :

The mean panicle breadth was higher at different radiation doses as compared to that in control. The highest family mean for panicle breadth (3.33 cm) was noted in 10 kR dose. Genotypic and phenotypic variances, genetic advance, expected genetic gain, genotypic and phenotypic coefficients of variability were lower at 10 kR dose as compared to those in control. High heritability value was noted in control, whereas medium heritability value was noted for this character at 10 kR dose (Table 60).

Plant height :

The average plant height increased at different radiation doses as compared to that in control. The tallest plant (148.03 cm) was noted at 5 kR dose. Genotypic and phenotypic variance, genetic advance, expected genetic gain, genotypic and phenotypic coefficients of variability were lower in all radiation

doses in comparison^{to} those in control. High heritability value (97.78%) was estimated in control whereas, medium heritability values were noted for 5 kR, 10 kR and 20 kR populations (Table 60).

Flag leaf length :

The mean flag leaf length was higher at different radiation doses as compared to that in control. Maximum flag leaf length (38.38 cm) was noted at 20 kR dose. Genotypic and phenotypic variances for 10 kR were highest amongst the control and other radiation doses. Genetic advance and expected genetic gain were higher in 10 kR dose as compared to those in control. Genotypic coefficient of variability for this character was higher only at 10 kR dose as compared to control whereas, phenotypic coefficient of variability was higher in all the radiation doses in comparison to that in control. High heritability value (94.19%) for control, medium (68.77%) for 10 kR dose and low range (44.76 to 47.2%) for 5 and 20 kR doses were noted (Table 61).

Flag leaf breadth :

The average flag leaf breadth was higher at different radiation doses as compared to that in control. Genotypic and phenotypic variance, genetic advance, expected genetic gain and genotypic coefficient of variability for this character were

lower whereas, phenotypic coefficient of variability was higher in 10 kR and 20 kR doses than those in control. High heritability value (90.91%) was estimated in control, whereas medium heritability values were arrived at for 10 kR and 20 kR dose populations (Table 61).

Table 58. Mean and variability estimates for yield and days to flowering in G₃ generation.

Doses	Mean			GV	PV	GCV	PCV	Herit.	Genet. adv.	EGG
	Lst. fam.	Hst. fam.	Pop.							
<u>Yield per plant</u>										
Cont.	7.03	11.01	8.96	1.02	1.40	11.27	13.21	72.85	1.78	19.87
5 kR	10.56	12.83	11.65	-	-	-	-	-	-	-
10 kR	10.03	16.69	12.07	4.35	6.80	17.28	21.60	63.97	3.46	28.67
20 kR	11.00	16.56	13.52	1.69	4.25	9.62	15.25	39.95	1.89	12.86
40 kR	11.05	15.54	12.72	1.60	3.08	9.94	13.80	51.95	1.89	14.86
<u>Days to flowering</u>										
Cont.	92.83	94.54	93.69	0.32	0.34	0.60	0.62	94.12	1.13	1.21
5 kR	91.48	94.85	92.95	0.93	1.36	1.04	1.25	68.38	1.66	1.79
10 kR	92.03	93.69	92.93	-	-	-	-	-	-	-
20 kR	92.78	95.53	94.04	0.56	1.15	0.80	1.14	48.69	1.08	1.15
40 kR	92.66	95.51	93.84	0.61	0.99	0.83	1.06	61.62	1.27	1.35

(-) Not significant in 'F' test.

Table 59. Mean and variability estimates for days to maturity and panicle length in G₃ generation.

Doses	M e a n			GV	PV	GCV	PCV	Herit.	Genet. adv.	EGG
	Ist. fam.	Hst. fam.	Pop.							
<u>Days to maturity</u>										
Cont.	127.92	129.52	128.66	0.33	0.37	0.45	0.47	89.19	1.12	0.87
5 kR	126.47	129.12	127.86	0.57	1.26	0.59	0.88	45.24	1.05	0.82
10 kR	126.85	128.68	127.89	-	-	-	-	-	-	-
20 kR	127.78	130.53	129.04	0.56	1.15	0.58	0.83	48.70	1.08	0.84
40 kR	127.66	130.51	128.83	0.62	0.99	0.61	0.77	62.63	1.29	1.00
<u>Panicle length</u>										
Cont.	14.33	17.50	16.06	0.95	0.99	6.07	6.19	95.96	1.98	12.33
5 kR	17.68	20.56	19.06	0.67	1.53	4.29	6.49	43.79	1.12	5.88
10 kR	17.57	21.98	19.45	2.06	2.71	7.38	8.46	76.10	2.59	13.32
20 kR	19.90	23.62	21.56	1.34	2.13	5.37	6.77	62.91	1.90	8.81
40 kR	18.97	23.68	20.82	-	-	-	-	-	-	-

(-) not significant in 'F' test.

Table 60. Mean and variability estimates for panicle breadth and plant height in G₃ generation.

Doses	M e a n			GV	PV	GCV	PCV	Herit	Genet. adv.	EGG
	Lst. fam.	Hst. fam.	Pop.							

(-) not significant in 'F' test.

Table 61. Mean and variability estimates for flag leaf length and breadth in G₃ generation.

Doses	M e a n					GV	PV	GCV	PCV	Herit.	Genet. adv.	EGG
	Lst. fam.	Hst. fam.	Pop.									
				<u>Flag leaf length</u>								
Cont.	20.52	25.16	23.19	2.11	2.24	6.26	6.45	94.19	2.91	12.55		
5 kR	26.24	32.98	29.43	3.03	6.42	5.91	8.61	47.20	2.47	8.39		
10 kR	24.44	34.19	30.46	6.76	9.83	8.54	10.29	68.77	4.47	14.67		
20 kR	31.12	38.38	34.92	4.06	9.07	5.77	7.99	44.76	2.79	7.99		
40 kR	31.67	35.94	38.58	-	-	-	-	-	-	-		
				<u>Flag leaf breadth</u>								
Cont.	1.88	2.42	2.16	0.03	0.03	8.02	8.41	90.91	0.34	15.74		
5 kR	2.25	2.61	2.41	-	-	-	-	-	-	-		
10 kR	2.20	2.81	2.44	0.03	0.05	7.10	9.16	60.00	0.28	11.48		
20 kR	2.32	2.90	2.59	0.03	0.06	6.69	9.46	50.00	0.25	9.65		
40 kR	2.32	2.79	2.54	-	-	-	-	-	-	-		

(-) not significant in 'F' test.

Correlation Between G_2 and G_3 Families
and Regression of G_3 on G_2 Families.

Correlation between G_2 and G_3 families from the same Rabi season trial was estimated for different characters. Regression of G_3 on G_2 families was estimated wherever correlation was significant. These results are presented below :

Yield per plant :

Significant negative correlation for this character was noted for family 8 at 20 kR radiation dose, whereas positive or negative correlations for all other cases were not significant (Table 62). The regression value of this family for yield per plant is presented in Table 65.

Days to flowering :

Positive and significant correlation for this character was noted in family 3 at 20 kR radiation dose only (Table 62) and its regression value is also shown in Table 65. Correlation values for this character in other families at various radiation doses were not significant.

Days to maturity :

Significant positive correlation was noted for this character for family 3 at 20 kR radiation dose only. Positive and negative correlation values for other families for various radiation doses

were not significant (Table 62). Regression value of this family is shown in Table 65.

Panicle length :

Significant positive correlation for family 9 at 20 kR radiation dose was noted (Table 63), the regression value for this family is presented in Table 65. The correlation values for other families for various radiation doses were also analysed but none of them were significant.

Panicle breadth :

The correlation value for this character for family 1 at 10 kR radiation dose was significant and positive whereas the family 8 at the radiation doses of 10 kR and 20 kR the correlation values were negative and significant (Table 63). The regression values for these four families are given in Table 65.

Plant height :

Significant positive correlation values for this character were noted for families 3 and 7 at 5 kR radiation dose; for families 6,7,10 and 12 at 10 kR radiation dose; whereas significant, negative correlation values for this character were found for families 5 and 8 at the radiation doses of 5 kR and 20 kR (Table 63). The regression values for these families are presented in Table 65.

Flag leaf length :

Correlation value for family 9 at 40 kR radiation dose was positive and significant for flag leaf breadth. Significant, negative correlation values for this character were noted for family 7 at 20 kR radiation dose; for family 10 at the radiation dose of 10 kR and 40 kR (Table 64). The regression values for these families are given in Table 65.

Flag leaf breadth :

Significant, positive correlation for flag leaf breadth was noted for families 7 and 12 at the radiation dose of 5 kR and 20 kR respectively. Significant, negative correlation for this character was estimated for family 6 at 5 kR radiation dose (Table 64). The regression values of these families are presented in Table 65.

Number of leaves per plant :

Significant positive correlations for number of leaves per plant were found for family 3 at 5 kR radiation dose; for families 2,4,5,6 and 10 at 10 kR radiation dose. Significant negative correlation for this character was noted for families 5 and 11 at 5 kR radiation dose (Table 64). The regression values for all these families are given in Table 65.

Table 62. Intergeneration correlation between G₂ and G₃ families (Rabi trial 1985-'86)
for yield per plant, days to flowering and maturity.

Families	Yield per plant				Days to flowering				Days to maturity			
	5 kR	10 kR	20 kR	40 kR	5 kR	10 kR	20 kR	40 kR	5 kR	10 kR	20 kR	40 kR
1	-0.07	0.07	-0.08	-0.23	0.02	0.01	0.15	-0.15	0.02	0.02	0.15	0.10
2	0.14	-0.02	0.07	0.01	-0.01	-0.01	0.19	0.09	-0.01	-0.01	0.19	0.14
3	0.05	-0.03	-0.17	-0.02	0.05	-0.14	0.28*	-0.12	0.05	-0.04	0.29*	-0.12
4	-0.15	0.12	-0.17	-0.01	0.01	0.08	0.14	-0.21	-0.01	0.08	0.14	-0.21
5	-0.03	0.16	0.02	-0.12	0.07	0.03	0.23	0.02	0.07	0.04	0.23	0.02
6	-0.01	-0.01	0.13	0.23	0.02	-0.08	0.05	-0.08	-0.02	-0.08	0.07	-0.06
7	0.19	0.23	0.06	0.01	-0.03	-0.09	0.08	0.06	-0.02	0.01	0.08	0.05
8	-0.11	-0.23	-0.35**	0.03	0.15	-0.19	0.04	0.08	-0.15	-0.15	0.06	0.07
9	-0.02	0.04	-0.06	-0.04	0.15	-0.17	0.06	0.13	0.22	-0.21	0.06	0.12
10	-0.02	-0.04	0.08	-0.16	0.12	0.01	-0.22	-0.15	0.06	-0.03	-0.23	-0.15
11	0.09	-0.14	0.03	-0.02	0.18	-0.13	0.05	-0.02	0.19	-0.11	0.01	-0.09
12	0.12	0.12	0.22	-0.01	0.09	0.09	-0.19	-0.08	0.04	-0.02	-0.19	-0.08

* Significant at 5% level, ** Significant at 1% level.

Table 63. Intergeneration correlation between G_2 and G_3 families (Rabi trial 1985-'86) for panicle length, breadth and plant height.

Families	Panicle length				Panicle breadth				Plant height			
	5 kR	10 kR	20 kR	40 kR	5 kR	10 kR	20 kR	40 kR	5 kR	10 kR	20 kR	40 kR
1	0.01	0.21	-0.16	-0.16	-0.11	0.26*	-0.04	-0.05	-0.08	-0.06	-0.05	-0.06
2	0.20	-0.06	0.05	-0.02	0.16	0.08	-0.24	0.20	-0.08	0.09	-0.16	-0.13
3	-0.03	0.19	0.15	-0.20	-0.07	0.14	0.07	-0.04	0.28*	0.13	-0.03	-0.24
4	-0.17	0.21	-0.13	-0.05	-0.08	0.10	-0.09	0.03	-0.20	0.23	-0.10	-0.19
5	0.10	0.14	0.06	-0.05	-0.08	0.05	0.08	-0.12	-0.29*	-0.01	-0.15	-0.07
6	0.07	0.12	-0.09	0.08	0.17	0.01	0.21	0.02	-0.07	0.49**	0.16	0.05
7	0.14	0.10	-0.16	-0.15	0.31	0.19	0.07	0.21	0.28*	0.26*	0.10	0.03
8	0.13	0.13	0.09	0.06	-0.20	-0.34**	-0.33**	-0.01	-0.05	0.05	-0.32*	0.09
9	-0.15	0.01	0.28*	0.03	0.01	0.04	-0.05	0.15	0.01	0.19	-0.08	-0.21
10	-0.20	-0.08	0.10	0.08	0.07	-0.08	-0.16	0.10	-0.04	0.44**	0.03	0.17
11	0.09	0.11	0.17	0.08	0.12	-0.22	-0.12	0.02	0.16	-0.15	0.02	-0.04
12	0.07	0.01	0.05	0.15	-0.07	-0.02	0.10	-0.03	0.09	0.32*	-0.07	0.02

* Significant at 5% level, ** Significant at 1% level.

Table 64. Intergeneration correlation between G_2 and G_3 families (Rabi trial 1985-'86) for flag leaf length, breadth and number of leaves per plant.

Families	Flag leaf length				Flag leaf breadth				Number of leaves per plant			
	5 kR	10 kR	20 kR	40 kR	5 kR	10 kR	20 kR	40 kR	5 kR	10 kR	20 kR	40 kR
1	0.05	-0.20	0.12	0.17	-0.02	-0.01	0.06	0.11	0.02	0.14	0.30*	-0.01
2	0.05	0.12	0.13	0.12	0.02	0.10	0.06	-0.03	0.06	0.45**	0.09	0.15
3	-0.01	-0.03	0.15	-0.22	-0.16	0.10	0.17	0.17	0.27*	0.13	-0.10	-0.18
4	-0.14	-0.02	0.11	0.09	0.07	-0.06	0.05	-0.04	-0.08	0.36**	0.06	-0.07
5	-0.14	-0.05	0.18	0.16	-0.10	-0.03	0.10	-0.15	-0.33**	0.28*	0.17	-0.17
6	-0.14	0.21	-0.21	-0.07	-0.27*	-0.15	-0.05	0.14	0.09	0.43**	0.12	0.09
7	0.12	0.04	-0.25*	0.05	0.28*	0.16	-0.02	0.15	0.12	0.14*	0.08	0.24
8	0.02	-0.01	-0.03	-0.02	-0.06	-0.16	-0.16	0.09	0.07	0.25	-0.23	0.13
9	-0.06	-0.18	-0.17	0.25*	0.06	0.10	-0.09	-0.10	-0.22	0.16	0.09	-0.07
10	-0.10	-0.30*	-0.02	-0.27*	-0.01	-0.16	0.15	-0.03	0.02	0.33**	0.14	0.19
11	0.22	-0.02	-0.10	0.04	-0.05	0.23	0.09	0.16	-0.31*	0.01	0.06	-0.03
12	-0.12	-0.13	-0.05	0.18	-0.22	-0.15	0.34**	0.11	-0.15	0.27*	0.12	-0.16

* Significant at 5% level, ** Significant at 1% level.

Table 65. Intergeneration linear regression of G_3 on G_2 families (Rabi trial 1985-'86) for different characters.

Family	Doses	Regression equation.	Family	Doses	Regression equation
Yield per plant			Number of leaves/plant		
8	20 kR	$Y = 15.62 - 0.33x$	3	5 kR	$Y = 10.77 + 0.12x$
	Days to flowering		5	5 kR	$Y = 15.67 - 0.22x$
3	20 kR	$Y = 67.34 + 0.28x$	11	5 kR	$Y = 18.29 - 0.4x$
	Days to maturity		2	10 kR	$Y = 7.41 + 0.42x$
3	20 kR	$Y = 88.22 + 0.31x$	4	10 kR	$Y = 9.61 + 0.36x$
	Panicle length		5	10 kR	$Y = 9.13 + 0.24x$
9	20 kR	$Y = 25.26 - 0.22x$	6	10 kR	$Y = 4.62 + 0.67x$
	Panicle breadth		8	10 kR	$Y = 8.97 + 0.28x$
7	5 kR	$Y = 2.49 + 0.14x$	10	10 kR	$Y = 9.04 + 0.28x$
1	10 kR	$Y = 2.95 + 0.26x$	12	10 kR	$Y = 11.18 + 0.16x$
8	10 kR	$Y = 4.18 - 0.4x$	1	20 kR	$Y = 8.33 + 0.31x$
8	20 kR	$Y = 3.61 - 0.26x$		Flag leaf length	
	Plant height		10	10 kR	$Y = 41.9 - 0.25x$
3	5 kR	$Y = 91.9 + 0.27x$	7	20 kR	$Y = 45.74 - 0.26x$
5	5 kR	$Y = 169.53 - 0.21x$	9	40 kR	$Y = 29.41 + 0.18x$
7	5 kR	$Y = 121.69 + 0.16x$	10	40 kR	$Y = 43.57 - 0.21x$
6	10 kR	$Y = 63.64 + 0.51x$		Flag leaf breadth	
7	10 kR	$Y = 113.33 + 0.15x$	6	5 kR	$Y = 2.8 - 0.2x$
10	10 kR	$Y = 111.79 + 0.22x$	7	5 kR	$Y = 2.09 + 0.19x$
12	10 kR	$Y = 127.65 + 0.13x$	12	20 kR	$Y = 1.8 + 0.42x$
8	20 kR	$Y = 155.69 - 0.18x$	-	-	-

DISCUSSION

Natural variability in a crop plant is the source material for starting a breeding programme. This variability can be increased through hybridization followed by segregation and recombination of the constituent genes. Utilization of this conventional method in crop depends upon the easiness of producing hybrid. In foxtail millet Setaria italica the individual flowers (spikelets) are extremely small and hence difficult to manipulate for crossing. Moreover, here a single pollination results in a single seed only. That is why in this crop another standard method of widening the genetic variability through induction of micromutants has been attempted in the present study.

In order to start the process of induction of micromutant and thereby widening the existing ~~of~~ genetic variation, a suitable variety with high yield and stability over locations was chosen through initial evaluation trial of 40 varieties of foxtail millet in two widely different agroclimatic locations. This trial has revealed that the varieties differed significantly (in both the locations and in pooled analysis) with regard to all the eight reproductive as well as vegetative characters. That the chosen locations were agroclimatically different was established by the significant location effect in the initial evaluation trial. The interesting feature was that the varieties in general behaved in similar fashion in the two locations as indicated in the non-significant variety x location interaction. It was noted that

in Jhargram location the flowering and maturity of the varieties were earlier by 4 to 12 days as compared to these characters at Kalyani location. The difference is conspicuous particularly with regard to the early maturity type. However, the yield per plant in Jhargram was not significantly different from that in Kalyani. On the basis of the initial evaluation trial at two locations the variety B.Si.450 was selected for further work. This variety was characterised by highest yield at both locations, medium flowering time but early grain maturity, large panicle length, larger flag leaf size, medium plant height but more number of leaves.

Widening of genetical variability through the induction of micromutation has become a standard method now a days. In foxtail millet seeds were irradiated with gamma-rays of 5 kR, 10 kR, 20 kR and 40 kR doses and G_1 generation was raised from them. It has been noted that all the four radiation doses have significantly lower the yield per plant. This was evidently due to the increase in the pollen sterility observed in the plants of G_1 generation under different radiation doses. It was also observed that the effect of a particular dose of radiation in causing sterility in plants did not vary from individual to individual. However, interplant variation in yield was significant in 10 kR and 20 kR doses. This effect of radiation on pollen fertility and subsequent yield of the affected plants is universal wherever the dose has been adequate. In G_1 generation the difference in days to

maturity between the control population and the irradiated population varied from 1.43 to 7.08 days (vide Appendix Table V) but even this small amount of difference in maturity date has been found to be significant. The radiation doses did not have immediate significant effect on the dimension of the panicle in G_1 generation. The different radiation doses **did** not have significantly different effect on plant height, the dimension of flag leaf in this generation. In general, it has been noted that the different doses of radiation seemed to have more significant effect on the reproductive features of **foxtail** millet rather than the vegetative characters.

In G_2 generation the yield per plant between the different doses of radiation varied significantly in Kharif and Rabi seasons. But the **interfamily** variation within radiation doses was significant only for 5 kR at Rabi season. In general, other families under the various radiation doses performed in a similar manner in both the seasons. In G_2 generation (sum of Kharif and Rabi) it is noted that only four families had higher yield but total of eleven families had lower yield than the control.

In foxtail millet, Madhava Rao and Goud (1973) noted in M_2 generation that the mean value of yield per plant in the 40 kR dose only was significantly different than that in the control. The mean value of yield per plant in 20 kR and 40 kR populations

were not different from the control but five families in 20 kR and only one family in 30 kR had significantly higher yield.

The radiation doses had significantly different effect in both the seasons for length and breadth of panicle, but the interfamilial variation within radiation doses was not significant in Kharif though significant variation was noted in some radiation doses in Rabi season. From the mean values of different families in G_2 it was noted that total of nineteen families had significantly longer panicle and ten families had shorter panicle than the control. With regard to panicle breadth, seven families had higher scores whereas six families had lower scores than the control (vide Appendix Table VI, VII).

Madhava Rao and Goud (1973) have reported in foxtail millet that the panicle length in M_2 generation of 20 kR, 30 kR and 40 kR doses of gamma radiation had decreased significantly in all the families.

In Kharif season, the effect of radiation doses varied significantly only in case of flag leaf length but for other characters e.g. days to flowering, days to maturity plant height, flag leaf breadth and number of leaves per plant the variation was not significant. Conspicuous seasonal difference on the variance of different characters in G_2 generation was noted. In Rabi season the variation between the radiation doses was found to be significant for days to flowering and maturity, plant height

and flag leaf breadth. These observations indicate that the trial for assessment of the effect of radiation doses on quantitative characters should preferably be done in multiple environments.

It was inferred from the mean values of flag leaf length in G_2 generation (Kharif Trial) that eight families had higher values but two families had lower values as compared to the control. In G_2 generation (Tabi Trial) it was noted that the mean values of ten families were higher but nine families had lower maturity but none of the families were significantly earlier in maturity as compared to control. In the same trial, six families had higher flag leaf breadth and two families had higher plant height as compared to the control (vide Appendix Tables VI,VII).

In M_2 generation of foxtail millet irradiated with 20 kR, 30 kR and 40 kR doses, all the families had shorter plant height in comparison to the control (Madhava Rao and Goud, 1973).

In G_2 generation wherever the different components of variability have been estimated it was noted that the variability in the irradiated populations have been widened in most of the cases as compared to that in control population. As a result of this widening of genetic variability the heritability, genetic advance and expected genetic gain in irradiated populations have been decreased in those cases (vide Tables 42 to 46).

In M_2 generation of other crops widening of genetic variability, shift of the mean towards positive and negative direction, lowering of heritability and consequent decrease in genetic advance and expected genetic gain have been reported by various workers e.g. Jalil and Yamajuchi (1965), Matsuo and Quozaawa (1961), Oka et al., (1958), Sakai and Suzuki (1964), Jana and Roy (1973), Yamagata (1964) in rice, Ghosh and Sen (1974) in Jute and Gaul (1964) in barley.

In G_3 generation, the effect of different doses of radiation varied significantly with regard to grain yield per plant, days to flowering and maturity, panicle length and breadth, flag leaf length and breadth and plant height. In all these characters within family variation was also significant in two to three radiation doses.

In G_3 generation the mean yield per plant in the different irradiated populations increased considerably over that of the control. The variability in yield per plant in the irradiated populations was also increased as evidenced by the larger standard error of the irradiated populations as well as larger estimates of genotypic and phenotypic variances as compared to the respective estimates in the control population. The range of means of the highest and lowest scoring family for different radiation doses was also on the upper side as compared to that of the control population. The genotypic and phenotypic

coefficients of variability for yield per plant have increased considerably in 10 kR population over those in control population.

Madhava Rao and Goud (1973) have noted in M_3 generation of foxtail millet that for yield per plant the mean performance of ten families (out of twenty four) was superior to that of the control. They have reported a decrease in genotypic variance and heritability for yield per plant in M_3 generation as compared to those in M_2 generation.

An increase in mean of the irradiated populations as compared to the control was noted in G_3 generation for panicle length and breadth, flag leaf length and breadth and plant height. For panicle length the decrease in standard error was noted in all the irradiated populations except that of 40 kR. In general, the genotypic and phenotypic variances for panicle length in the irradiated populations was increased as compared to that in control. However, for panicle breadth and plant height the standard errors of the irradiated populations and the also genotypic and phenotypic variances were lower as compared to those in control. For flag leaf length and breadth the standard errors of the irradiated populations were lower whereas, the genotypic and phenotypic variances were usually higher than the respective estimates of the control population. For days to flowering the maturity the mean of the irradiated populations have shifted towards negative as well as positive directions as compared to

the control population. The standard errors of the irradiated populations were decreased in days to flowering. Whereas, for days to maturity the standard errors of the irradiated populations were increased. The genotypic and phenotypic variances of the irradiated populations for days to flowering and maturity had higher scores as compared to the control populations (Tables 58, 59, 60, 61, Appendix Table VIII).

In general, increase of the mean values of the irradiated populations in G_3 generation might have been due to the use of comparatively lower doses of radiation in the present study. Borojevic (1969) suggested that mean values in M_3 generation might increase specially when low doses of irradiation were used and also when the characters were free from pleiotropic gene effects. But in the present case it is difficult to comment on the presence of the pleiotropic gene effects in the characters studied.

It is quite well known that irradiation can increase the variability of a plant population. The genotypic and phenotypic variances which are measures of variation without any reference to the mean have indicated that the variability in the irradiated populations has increased considerably in the comparison to the control population with regard to yield per plant, days to flowering and maturity, panicle length and flag leaf dimension. The genotypic and phenotypic coefficients of variability are the measures of variability in comparison to the mean. According to

this criterion also it can be seen that in general, different doses of radiation have increased the variability in the irradiated populations for yield per plant, days to flowering and maturity and panicle length. However, radiation has failed to increase variability with regard to plant height and panicle breadth.

In foxtail millet the M_3 populations had significantly lower panicle length and plant height in comparison to those in control (Madhava Rao and Goud, 1973).

Oka et al., (1958), Kao et al., (1960), Mutsuo and Onezawa (1961) in rice; Rawlings et al., (1958) and Williams and Hannway (1961) in Soybean; Scossiroli (1966), Swaminathan (1963) and Borojevic (1969) in Wheat; Gaul et al., (1969) in barley; Brock (1965) in Arabidopsis; Krull and Frey (1961) in Oats; Ghosh and Sen (1974) and Sinhamahapatra (1980) in jute have reported substantial increase in genetic variability in different quantitative traits in M_2 and subsequent generations.

Another indirect evidence of increase in genetic variability induced by the gamma irradiation in the G_3 generation of the present study comes from the lower heritability estimates in all the irradiated populations as compared to the control for all the characters. Heritability in the control population has varied between 72.85 to 98.87 per cent for various characters, whereas it ranged between 39.95 to 76.10 per cent in the irradiated

populations (Tables 58, 59, 60, 61; Appendix Table VIII).

The genetic advance at five per cent selection intensity was higher for the irradiated populations as compared to that in control for yield per plant at 10 kR, for days to flowering at 5 kR and 40 kR, for days to maturity in 40 kR, for panicle length in 10 kR and for flag leaf length at 10 kR. The expected genetic gain was higher in the irradiated populations in comparison to that in control for yield per plant at 10 kR, for days to flowering at 5 kR and 40 kR, for days to maturity at 40 kR, for panicle length at 10 kR and for flag leaf length at 10 kR. From the above two estimates it can be inferred that in G_3 generation the 10 kR population indicated the possibility of improvement over the control through selection for higher grain yield per plant, longer panicle and longer flag leaf (Tables 58, 59, 60, 61; Appendix Table VIII).

From the estimates of correlation values between G_2 and G_3 generations with regard to different characters it can be seen that the intergeneration correlation was not significant except in a few cases only. It is quite clear that it will not be possible to predict the performance of G_3 generation from that of the G_2 generation for any character. This may be due to the possible unstable situation of the polygenic variation induced by irradiation.

CHAPTER—V

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

(Forty different varieties of foxtail millet, Setaria italica (L.) Beauv. from Bangladesh were grown at Kalyani (gangetic alluvium) and Jhargram (lateritic tract) in RBD with 3 replications in Kharif season of 1984. Nine characters studied were : yield per plant, panicle length and breadth, days to maturity and flowering, flag leaf length and breadth, number of leaves per plant and plant height. These varieties differed significantly for all these characters at both the locations as well as in pooled analysis.) Variety x location interaction was not significant. (The performance of the variety B.Si.450 was best in both the locations.) It had highest yield, medium days to flowering, early maturity, large panicle length, medium plant height and more number of leaves per plant. (This variety was selected for gamma irradiation to widen its genetic variability.)

G₁ generation :

(Fresh well dried seeds of the variety B.Si.450 were exposed to 5 kR, 10 kR, 20 kR and 40 kR doses of gamma-rays. The treated seeds of all these irradiation doses along with control were sown in RBD with four replications at Kalyani at Rabi season of 1984-'85.) (Nine characters were studied in G₁ generation.) Significant lower yield per plant was noted at all the four radiation doses. This was evidently due to the increase in the pollen sterility observed

in plants of G_1 generation under different radiation doses. It was also observed that the effect of a particular dose of radiation in causing sterility in plants did not vary from individual to individual. The yield per plant was significantly different between the individuals in 10 kR and 20 kR doses. Significant variation for days to maturity was recorded in between radiation doses. The different radiation doses did not have significantly different effect on panicle length and breadth, flag leaf dimensions and plant height in this generation. (In general, different radiation doses had more significant effect on reproductive features of this millet than on the vegetative characters. in G_1 generation)

G_2 generation :

(The G_2 generation trial was conducted in RBD with three replications for each radiation dose and control at Kalyani in Kharif season of 1985 and Rabi season of 1985-'86.)

In Kharif trial between radiation dosage effect was significant for yield per plant, panicle length and breadth and flag leaf length.

In Rabi trial between radiation dosage effect varied significantly for yield per plant, days to flowering, days to maturity, panicle length and breadth, flag leaf breadth and plant height.

In Kharif trial, the mean yield per plant was higher only in two families in 5 kR dose, whereas three families in 10 kR had lower yield as compared to the control. For panicle length the mean values were significantly higher from that of control in three families in 5 kR, one family in 20 kR and four families at 40 kR doses. But four families in 10 kR dose had shorter panicle than the control. The mean panicle breadth was higher in one family each in 5 kR and in 40 kR doses but it was lower in four families in 10 kR and one family in 20 kR populations. Significantly higher mean value for flag leaf length was recorded in four families in 5 kR, one family in 20 kR and three families in 40 kR doses as compared to that in control. But two families in 10 kR had shorter flag leaf than the control.

In Rabi trial, only one family at 5 kR had significantly higher yield, but lower yield was noted in two families in 10 kR and three families each in 20 kR and in 40 kR as compared to the control. Lateness was noted in three families in 5 kR, two families in 10 kR, three families in 20 kR and two families in 40 kR doses. But early flowering was observed in one family in 5 kR, four families in 10 kR, two families in 20 kR and two families in 40 kR doses. Longer maturity duration was noted in altogether three families, one each in 5 kR, 10 kR and 20 kR doses. Longer panicle was noted in three families at 5 kR, two families in 10 kR, three families in 20 kR and in one family in

40 kR dose. Whereas, only one family in 40 kR had shorter panicle as compared to that in control. Panicle breadth was higher in four families in 5 kR, one family in 10 kR and in one family in 20 kR population in comparison to that in control. Only one family in 10 kR had thinner panicle than the control. Flag leaf breadth was higher for all the six families in 40 kR dose. Plant height was increased in two families in 5 kR dose only.

(It ~~was~~ also noted from other estimates of variability e.g. genotypic and phenotypic variances, genotypic and phenotypic coefficients of variability that in general, various radiation doses increased the variability in different characters in G_2 generation.)

G_3 generation :

(In ^{G_3} ~~this~~ generation the effect of different doses of radiation varied significantly in grain yield per plant, days to flowering and maturity, panicle length and breadth, flag leaf length and breadth and plant height. In all these characters interfamily variation was also significant in two to three radiation doses in each case.)

For yield per plant the population means of the different radiation doses increased considerably over the mean of the control population. Increase in mean of the irradiated populations as compared to the control was also noted for panicle

length and breadth, flag leaf length and breadth and plant height. For days to flowering and maturity the mean of the irradiated populations have shifted towards negative as well as positive directions as compared to the control populations.

The genotypic and phenotypic variances which are estimates of variation without any reference to the mean have indicated that the variability in the irradiated populations has increased considerably in comparison to the control population with regard to yield per plant, days to flowering and maturity, panicle length and flag leaf dimension. Another indirect evidence of increase in genetic variability induced by the gamma irradiation in the G_3 generation of the present study comes from the lower heritability estimates in all the irradiated populations as compared to the control for all characters.

The genetic advance at five per cent selection intensity and expected genetic gain were higher for the irradiated populations as compared to that in control for yield per plant at 10 kR, for days to flowering at 5 kR and 40 kR, for flag leaf length at 10 kR and for panicle length at 10 kR. From ~~the~~ all these estimates it can be inferred that in G_3 generation the 10 kR population indicated the possibility of improvement over the control through selection for higher grain yield per plant, longer panicle and for longer flag leaf.

Conclusion :

(From the present investigation the following conclusions can be made about the radiation breeding procedures in foxtail millet. Dry seeds may be irradiated with comparatively low dose (10 kR) of gamma irradiation in order to widen the variability. The G_2 generation can be raised from random samples of bulked seeds of G_1 plants. In G_3 generation it was noted that even the performance of some of the progenies of extremely low yielding G_2 families was not much different from that of the progenies raised from very high yielding families. So the G_3 generation can be raised also from bulked seeds of G_2 families without appreciable chance of losing valuable segregants. The selection may be started at G_3 generation, that too in comparatively low intensity. Trials should preferably be conducted in multiple environments wherever the quantity of seed permits, as this will give better estimates of the variability components.)

CHAPTER—VI

FUTURE SCOPE OF RESEARCH

FUTURE SCOPE OF WORK

In foxtail millet G_4 generation may be raised from the elite lines of G_3 generation in ear to row progeny method. Low intensity of selection for high grain yield, early maturity, larger panicle and flag leaf, larger number of leaves per plant and shorter plant height may be initiated at G_3 generation and the performance of the selected lines may be assessed in G_4 generation. Plants with erect leaves and flag leaves must be searched for in the population. Advanced generation trials should be conducted in multiple environments.

CHAPTER—VII

B I B L I O G R A P H Y

B I B L I O G R A P H Y

- * Aastveit, K. (1965) Induced mutations in barley. Meld.Norg. Land br Hoisk. 44 : 1-31.
- * Abrams, R., Velez-Fortuno, J. (1962) Radiation research with pigeon peas, Cajanus cajan Mill sp., results on X_3 and X_4 generation. J. Agric. Univ. Puerto Rice. 64 : 34-42.
- Abrams, R., Frey, K.J. (1964) Variation in quantitative characters of oats, Avena sativa (L.), after various mutagen treatments. Agron. J. 4 : 163-167.
- * Annon (1937) The food and nutrition of African natives. International Institute of Africa Languages and Cultures. Memo. 13.
- Appadurai, R., Natarajan, U.S. and Raveendran, T.S. (1978) Phenotypic stability in certain varieties of foxtail millet, Setaria italica (L.) Beauv. Madras agric. J. 65(10) : 631-635.
- * Baur, E. (1924) Untersuchungen uber das Wesen, die Entstehung and die verevbung von Rassenunterschieden bei Antirrhinum majus (L.) Bibliotheca Genet. 4 : 1-170.
- Bhatia, C. and Swaminathan, M.S. (1963) Frequency and spectrum of mutations induced by radiations in some varieties of bread wheat. Euphytica 12 : 97-112.

- Boerma, H.R. and Cooper, R.C. (1975a) Comparison of three selection procedures for yield in soybean. Crop Sci. 15 : 225-229.
- Borojevic, K. (1969) Genetic changes in quantitative characters of irradiated population. Suppl. Japan J. Genet. 44 : 404-416.
- Brim, C.A. (1966) A modified pedigree method of selection in soybeans. Crop Sci. 6 : 220.
- * Brock, R.D. and Latter, B.D.H. (1961) Radiation induced quantitative variation in subterranean clover. Third August Conf. Radiobiology, Sydney. pp.205-215.
- Brock, R.D. (1965) Induced mutations affecting quantitative characters. On : "The Use of induced mutations in Plant Breeding". Suppl. Radiation Bot. 5 : 451-464.
- Cherisey, H.DE., Barreneche, M.T., Jusuf, M., Ouin, C. and Pernes, J. (1985) Inheritance of some marker genes in Setaria italica (L.) Beauv. Theor. Appl. Genet., 71(1) : 57-60.
- Chikara, J. and Gupta, P.K. (1979) Karyological studies in the genus Setaria. I. Variability within Setaria italica (L.) Beauv. J. Cytol. Genet., 14 : 75-79.

Chikara, J. and Gupta, P.K. (1980) Numerical taxonomy in the genus Setaria. Proc. Indian Acad. Sci. B. 14 : 75-79.

Chinnaswamaiah, B. (1975) Formulation of selection indices through discriminant function technique for yield in Setaria italica (L.) Beauv. Mysore J. agric. Sci., 9(2) : 357-358.

Cill, A.S. and Randhawa, A.S. (1975) Heritable variation and interrelationship in foxtail millet, Setaria italica (L.) Beauv. Madras agric. J., 62(5) : 253-258.

* Comstock, R.E. and Robinson, H.F (1952) Genetic parameters, their estimation and significance. Proc. Sixth Internal. Grasslands Congr., pp. 284-291.

* Cui, W.S., Ma, H.X. and Zhang, D.Y. (1979) Breeding and utilization of the male-sterile millet variety Suanxi 28. Scientia agric. Sinica, China. 1 : 43-46.

Dhagat, N.K., Goswame, U. and Narsinghani, V.C. (1977) Character correlations and selection indices in Italian millet. Indian agric. Sci. 47 : 599-603.

Dumanovic, J., Denic, M., Ehrenberg, L. and Bergstrand, K.G. (1969) Radiation induced heritable variation of quantitative characters in wheat. Hereditas 62 : 221-238.

- * Ehrenberg, L., Gustafsson, A., Wettstein, D von. (1956)
Studies on the mutation process in plants,
regularities and intentional control. Proc. Conf.
Chromosome, Wageningen 16-17 April 1956 pp.1-29.
- Frey, K.J. and Horner, T. (1955) Comparison of actual and
predicated gains in barley selection experiments.
Agron. J. 47 : 186-188.
- Frey, K.J. (1965) Mutation breeding for quantitative attributes.
In : "Use of induced mutations in plant breeding".
Suppl. Radiation Bot. 5 : 465-475.
- * Froier, K. (1954) Aspects of the agricultural value of certain
barley X-ray mutations produced and tested at the
Sweedish Seed Association, Svolof and its branch
stations. Acta Agric.Scand. 4 : 115-143.
- * Futsuhara, Y. (1963) Selection of mutants. In : Recent Advance
in Breeding Science. 4 : 88-95.
- Futsuhara, Y., Toriyama, K. and Tsunoda, K. (1967) Breeding of
a new rice variety "Reimei" gamma-ray irradiation.
Japan. J. Breed. 17 : 85-90.
- Gaul, H. (1958) Present aspects of induced mutations in plant
breeding. Euphytica. 7 : 275-289.

- Gaul, H. (1961) Studies on diplontic selection after X-radiation of barley seeds. In : "Effects of Ionizing Radiations on Seeds". Proc. Symp. Karlsruhe. IAEA and FAO, Vienna. pp. 117-138.
- Gaul, H. (1964) Mutations in plant breeding. Radiation Bot. 4 : 155-232.
- Gaul, H. (1965) The concept of macro- and micro-mutations and results on induced micro-mutations in barley. Radiation Bot. 5 (Suppl.) : 407-248.
- *Gaul, H. (1966) Zuchtersche Bedeutung von Kleinmutationen. I. Durch Rontgenstrahlen induzierte variabilität von Kerner trat Korngross and vegetations lange beider Gorste Haisa II. Z. Pflanzenzuchtg. 5 : 1-20.
- * Gaul, H. and Mittelstenscheid, L. (1960) Hinweise Zur Herstellung von Mutationen durch ionisierende Strahlen in der Pflanzenzuchtung Z. Pflanzenzuchtg. 43 : 404-422.
- Gaul, H., Ulonska, E., Winkel, C. Zum and Braker, G. (1969) Micro-mutations influencing yield in barley. Studies over nine generations. Proc. Symp. on induced mutations in plants, IAEA, Vienna. pp. 375-398.
- Ghosh, N. and Sen, S. (1973) An induced non-flowering mutation in jute. Proc. Symp. SABRAO, New Delhi (Abst) : 204.

- Ghosh, N, and Sen, S. (1974) Effect of radiation in jute. Indian J. Genet. 34 A : 931-936.
- Gian, S. and Athwal, D.S. (1966) Variability in Kangni-2, Genotype X environment interaction, heritability and genetic advance. Indian J. Genet. 26 : 158-161.
- Godawat, S.L. (1980) A note on the path coefficient analysis in foxtail millet, Setaria italica (L.) Beauv. Madras agric. J., 67 : 690-692.
- Gonzalez, C., Frey, K.J. (1965) Genetic variability in quantitative characters induced by thermal neutron treatment of diploid, tetraploid and hexaploid oats seeds. Radiation Bot. 5 : 321-335.
- Gopalan, C., Rama Sastri, B.V. and Balasubramanian, S.C. (1985) Nutritive Value of Indian Foods. National Inst. of Nutrition, Hyderabad. pp. 60-63.
- Gregory, W.C. (1955) X-ray Breeding of peanuts Arachis hypogaea L. Agron. J. 47 : 396-399.
- Gregory, W.C. (1956) Induction of useful mutations in the peanut. Brookhaven Symp. Biol. 9 : 177-190.
- Gregory, W.C. (1957) Progress in establishing the effectiveness of radiation in breeding peanuts. Proc. 9th Oak Ridge Reg. Symp. "Radiation in Plant Breeding". pp. 36-48.

- Gregory, W.C. (1968) A radiation breeding experiment with peanuts. *Radiation Bot.* 8 : 84-147.
- Gupta, P.K. and Yashvir (1976) Induced mutations in foxtail millet, *Setaria italica* (L.) Beauv. II. Variable mutations in ear characters induced by gamma-rays, EMS and dES. *Theor. Appl. Genet.* 48 : 131-136.
- Gustafsson, A. (1947) Mutations in Agricultural plants. *Hereditas* 33 : 1-100.
- Gustafsson, A. (1963) Productive mutations induced in barley by ionizing radiations and chemical mutagens. *Hereditas.* 50 : 211-263.
- Gustaffson, A., Hagberg, A. and Lundquist, U. (1960) The induction of early mutants in Bonus barley. *Hereditas* 46 : 675-699.
- * Hansel, H. (1967) Model for a theoretical estimate of optimal mutation rates per M_1 - nucleus with a view to selecting beneficial mutations in different M-generation. In : *Induced Mutations and Their Utilization.* Akademik-Verlag, Berlin. pp.79-87.
- Hanson, C.H., Robinson, H.F. and Comstock, R.E. (1956) Biometrical studies of yield in segregating populations of Korean Lespedeza. *Agron. J.* 48 : 268-272.

- Harinarayana, G., Navale, P.A. and Mungse, H.B. (1984) Dwarf genotypes of foxtail millet, Setaria italica (L.) Beauv. J. Maharashtra agric. Univ. 9 : 343-344.
- Hill, A.E. (1952) Economic Botany. 2nd edn. New York, McGraw-Hill. pp. 273.
- * Hu, H.K. (1985) Discovery and utilization of a dominant gene for male sterility in Setaria italica (L.) Beauv. Hereditas, (China) 7 : 4.
- Jalil, M.A. and Yamaguchi, H. (1965) The variation of quantitative characters in the irradiated progenies of two rice varieties and their hybrids. Radiation Bot. 5 : 187-196.
- Jana, M.K. and Roy, K. (1973) Induced quantitative mutation in rice. Radiation Bot. 13 : 245-257.
- Johnson, H.W., Robinson, H.F. and Comstock, R.E. (1955) Estimates of genetic and environmental variability in soybeans. Agron. J. 47 : 314-318.
- * Kandelaki, G.V., Gorgidze, A.D. and Maisaya, I.I. (1983) Cytological study of some representatives of Setaria P.B. from the flora of the Georgian SSR. 111(1) : 113-116.

- *Kao, K.N., Hu, C.H., Chang, W.T. and Oka, H.I. (1960) A biometrical genetic study of irradiated populations in rice; genetic variances due to different doses of x-rays. Bot. Bull. Acad. Sinica 1 : 101-108.
- * Kihara, H. (1943) Genetic studies in millet. I. Sciken Ziho. 2 : 1-3.
- Knott, D.R. and Kumar, J. (1975) Comparison of early generation yield testing and a single seed descent procedure in wheat breeding. Crop Sci. 15 : 295-299.
- *Konstantinov, S.I. (1975) Use of Setaria millet in breeding for high protein content. Selektsiya i Semenovodstvo. Resp. meahved. temat. mauch Sb., 29 : 29-35.
- Krull, C.F. and Frey, K.J. (1961) Genetic variability in oats following hybridization and irradiation. Crop Sci. 1 : 141-146.
- *Liu, W.H. (1981) Studies on protein content of F_2 millet grain. Shanxi Ag. Sci., China, 11 : 17-18.
- *Liu, W.H. (1982) Preliminary studies on relationship between the leaf blades of leaves at different ranking positions and ear characters. J. Shanxi agric. Univ., China. 2(2) : 14-18.

(x)

- *Liu, W.H. (1982) Preliminary studies on millet flag leaf characters. J. Shanxi agric. Univ. China. 8 : 11-12.
- *Liu, W.H. (1984) Estimation of the genetic parameters for the main characters of millet and their application in breeding. J. Shanxi agric. Univ. China. 4 : 173-181.
- Madhava Rao, T. and Goud, J.V. (1973) Induced polygenic variation in Setaria. Madras agric. J. 60 : 236-241.
- *Maisaya, I.I. and Gorgidze, A.D. (1980) Establishing the genome composition of Georgian Setaria millet. Bull. Acad. Sci. Georgian, SSR. 99 : 169-172.
- *Maisaya, I.I. and Tarasashvili, K.M. (1983) Content of some vitamins in Setaria millet. Bull. Acad. of Sci. Georgian, SSR. 111 : 361-364.
- *Matsuo, T. and Onozawa, H. (1961) Mutations induced by ionizing radiations and chemicals in rice. Effects of Ionizing Radiations on Seeds, Proc. Symp. Karlsruhe (IAEA and FAO, Vienna). pp. 495-501.
- Matsuo, T., Onozawa, Y. and Shiomi, M. (1964) Studies on mutation induced by radiations and chemicals III. Variations of quantitative characteristics in M₆ generation. Japan J. Breed. 14 : 173-176.

- Muller, H.J. (1927) Artificial transmutation of gene. Science.
66 : 84-87.
- Navale, P.A., Harinarayana, G. and Mungse, H.B. (1984) Intra-
population variability in a variety of foxtail
millet. J. Maharashtra agric. Univ. 9 : 354-356.
- Nishimura, Y. and Kurakami, H. (1952) Mutations in rice induced
by X-rays. Japan J. Breed. 2 : 65-71.
- *Nybom, N. (1954) Mutations types in barley. Acta Agr. Scand.
4 : 430-456.
- Oka, H.I., Hayashi, J. and Shiojiri, I. (1958) Induced mutation
of polygenes for quantitative characters in rice.
J. Hered. 49 : 11-14.
- *Phan, L. (1981) Results of studying ways of increasing the
productivity of Italian millet on marinesandy soil.
Khoa Hoc Va Ky Thuat Nongnghiep, Vietnamese.
10(11) : 627-632.
- *Poiriet-Hamon, S. and Pernes, J. (1986) Chromosomal instability
in the somatic tissues of descendant of an inter-
specific hybrid of Setaria verticillata (L.) X
Setaria italica (L.) Beauv. Sci. de la vie, France.
302 : 313-324.

- Purseglove, J.W. (1972) Tropical Crops, Monocotyledons. 2nd Impre. Longman, Group Ltd. London. pp. 428.
- Rao, Y.G., Anjanappa, M. and Rao, P.A. (1984) Genetic variability in yield and certain yield components of Italian millet, Setaria italica (L.) Beauv. Madras agric. J. 71 : 332-333.
- Rawlings, J.O., Hanway, D.G. and Gardner, C.O. (1958) Variation in quantitative characters of soybean after seed irradiation. Agron. J. 50 : 524-528.
- Ree, J.H. (1970) Induced mutations of rice for short-culm selections in M₂ generation. In : Rice Breeding with Induced Mutations II. IAEA, Vienna. pp. 57-67.
- Sakai, K. and Suzuki, A. (1964) Induced mutation and pleiotropy of genes responsible for quantitative characters in rice. Radiation Bot. 4 : 141-151.
- Samoto, S. and Kanai, D. (1975) Studies on the mutation breeding in rice. I. Short stiff mutations induced by gamma-ray irradiation to the rice variety Koshihikari. Japan J. Breed. 25 : 1-17.
- Sandhu, T.S., Arora, B.S. and Singh, Y. (1974) Interrelationships between yield and yield components in foxtail millet. Indian J. agric. Sci. 44 : 563-566.

*Scholz, F. (1957) Mutations vasuche and Kultur pflanzen VII.

Unlersuchungen uber den zuchterischen wert rontgenin
duzierfer Mutanten verschiedener Merkmalsgruppen bei
Sommer-und Wintergerste, Z. Pflanzenzuchtg. 38 :
181-220.

Scossiroli, R.E. (1965) Value of induced mutations for quantative
characters in plant breeding. In : "The use of
induced mutations in plant breeding". Suppl.
Radiation Bot. 5 : 443-450.

Scossiroli, R.E. (1966) What mutagenesis in quantitative traits.
Hereditas Suppl. 2 : 86-101.

Scossiroli, R.E. (1968) Selection experiments in a population of
Triticum durum (Desf.) irradiated with x-rays.
In : "Mutations in Plant Breeding". IAEA, Vienna.
11 : 205-217.

Seetharam, A., Mallikarjunaradhya, K. and Laxminarayana, M.R.(1983)
Variation for oil content in a world collection of
foxtail millet, Setaria italica (L.) Beauv.
SABRAO J. 15(2) : 99-102.

Sinhamahapatra, S.P. (1980) Studies on x-ray induced Quantitative
variations in jute, Corchorus capsularis (L.).
Unpublished Ph.D. Thesis, submitted to the Bidhan
Chandra Krishi Viswavidyalaya, Kalyani pp. 135.

Snedecor, G.W. and Cochran, W.G. (1967) Statistical Methods.

Iowa State Univ. Press, Iowa USA. pp. 386.

Sree Ramulu, K. (1974) Radiation and chemical induced quantitative variation in sorghum. Z. Pflanzenzuchtg. 72 : 260-265.

Stadler, L.J. (1928) Genetic effects of x-ray in maize. Proc. Nat. Acad. Sci. US. 14 : 69-75.

*Stubbe, H. (1934) Einige Kleimutationen von Antirrhinum majus L. Zuchter. 6 : 299-303.

*Stubbe, H. and Von Wettstein F. (1941) Über die Bedeutung von Klein- und Grossmutationen in der Evolution. Biol. Zbl. 61 : 265-297.

*Sun, P.Y., Chou, Y.L., Guo, X.C., Xu, J.Q. and Hou, B.Y. (1983) A cytogenetical study of Setaria italica (L.) Beauv. I. Constitution of somatic cells and Giemsa C-band analysis. Shanxi Ag. Sci., China. 6 : 13-15.

Swaminathan, M.S. (1963) Evaluation of the use of induced micro and macro-mutations in the breeding of polyploids crop plants. In : L' Energia Nuchari in Agricoltura, pp. 243-277.

- Taira, H. (1984) Lipid content and fatty acid composition of non-glutinous and glutinous varieties of foxtail millet. J. agric. Food Chem. 32 : 369-371.
- Takahashi, N. (1942) Genetical studies with Setaria italica (L.) Beauv. Japan J. Genet. 18 : 150-151.
- Takano, K., Matsumoto, S. and Kamoi, I. (1982) Studies on lipids of glutinous Italian millet, Setaria italica (L.) Beauv. J. agric. Sci. Japan. 27 : 141-144.
- Toda, M., Nakada, T., Miki, S. and Tsukada, T. (1972) Studies on mutation breeding in barley and wheat plants. II. Breeding of a new variety and desirable shortculm strains in wheat by gamma-ray irradiation. Japan. J. Breed. 22 : 239-245.
- *Varadinov, S.G. and Tomilina, T.B. (1978) Study of the world collection of millet crops. Trudy Po Prikladnoi Botanike, Genetikei Seleksii, USSR. 63(1) : 67-73.
- Vavilov, N.I. (1949) The origin, variation, immunity and breeding of cultivated plants. Chronica Bot. 13 : 1-364.
- Vishwnatha, J.K. (1978) Studies on the genetic variability in the world germplasm collection of foxtail millet, Setaria italica (L.) Beauv., Mysore J. agric. Sci. 12 : 519-520.

- Vishwanatha, J.K., Mallanna, K.N., Aradhya, K.M. and Gowda, M.V.C. (1981) Genetic variability in world collection of germplasm of foxtail millet, Setaria italica (L.) Beauv., Mysore J. agric. Sci., 15 : 234-238.
- *Walther, F. (1971) Interaction between radiation induced sterility and mutability. In : Barley Genetics II. Washington University Press, Washington.
- *Wang, Z.C. and Han, M.S. (1981) Studies on the heritabilities and Correlations of major characters of Setaria italica (L.) Beauv. Shanxi Nongye Kexue, Wuzhai Ag. Expt. Sta., Shanxi Acad. Ag. Sci., China. 10 : 9-11.
- Wettstein, D von (1957) Mutations and the intentional reconstruction of crop plants. Hereditas. 43 : 298-302.
- Williams, J.H. and Hanway, D.G. (1961) Genetic variation in oil and protein content of soybeans induced by seed irradiation. Crop Sci. 1 : 34-36.
- *Wu, H. (1928) Nutritive value of chinese foods. Chinese J. Phys., Rept. Series. Vol. I.
- * Xu, Z.S. and Zhang, Z.M. (1981) A preliminary study on the heritability and genetic correlations of the main characters in spring sown millet. Shanxi agric. Sci., China. 12 : 8-11.

- Yamagata, H. and Syakudo, K. (1960) Studies on the utility of artificial mutations in plant breeding. I. gamma-ray sensitivity of rice and induced aberrant plants in the X_2 generation. Japan J. Breed. 10 : 153-162.
- Yamagata, H. and Syakudo, K. (1963) Studies on the utilization of artificial mutations in plant breeding II. On the appearance of mutations in the X_3 generation following gamma-ray irradiation of rice seeds. Japan. J. Breed. 13 : 14-20.
- Yamagata, H. (1964) Mutations induced with radiations in the heading date of rice. Gamma Field Symp. 3 : 31-47.
- Yonezawa, K., Yamagata, H. and Tanisaka, T. (1973) Practical merit of delayed selection after single and recurrent mutagenic treatments. I. General considerations based on changes in mutant frequency and heritability. Radiation Bot. 13 : 1-12.
- Yonezawa, K. and Yamagata, H. (1974) Studies on the artificial mutations in relation to plant breeding. XXXV. On the optimum mutation rate and mutagenic dose for mutation breeding. Japan. J. Breed. 24 Suppl. 2 : 42-43.

Yonezawa, K. (1975) Method and efficiency of mutation breeding for quantitative characters Gamma Field Symp. 14 : 39-58.

Yonezawa, K. and Yamagata, H. (1975) Practical merit of delayed selection after single and recurrent mutagenic treatments II. Optimum generation for selection. Radiation Bot. 15 : 169-184.

Roshida, Y. (1965) Theoretical studies on the methodological procedures of radiation breeding in cereal crops. Heredity, 20 : 37.

Yoshida, Y., Tsuku, M. and Kitahara, S. (1969) Theoretical studies on the methodological procedures of radiation breeding. III. Adequate generation and method for selection in autogamous plant following seed irradiation. Radiation Bot. 9 : 15-20.

*Zacharias, M. (1956) Mutations vasuche an Kulturpflanzen VI. Rontgen bestrahlung der Sojabohre. Zuchter 26 : 321-328.

* Original not seen

APPENDIX

A P P E N D I X

Table I. Mean of different characters of initial evaluation trial at two locations.

Varieties (B.Si.NO.)	Yield per plant(g)			Days to maturity		
	KLN	JGM	Pool	KLN	JGM	Pool
1	2	3	4	5	6	7
1	3.47 ±1.30	3.18 ±1.73	3.32 ±0.21	75.33 ±2.94	66.00 ±1.73	70.66 ±6.59
7	4.18 ±1.87	2.73 ±0.12	3.46 ±1.02	76.33 ±0.87	67.33 ±1.52	71.83 ±6.36
123	3.67 ±1.46	3.37 ±0.28	3.52 ±0.21	75.00 ±1.73	65.66 ±0.57	70.33 ±9.43
142	3.64 ±1.49	2.59 ±0.50	3.12 ±0.74	77.00 ±3.61	62.66 ±2.08	69.83 ±8.01
150	2.88 ±0.53	2.45 ±1.83	2.67 ±0.31	74.00 ±1.73	62.33 ±0.57	68.16 ±8.01
153	3.71 ±0.60	2.28 ±0.33	3.00 ±1.01	73.20 ±0.00	61.66 ±1.15	67.43 ±7.54
161	3.60 ±0.91	3.13 ±0.64	3.37 ±0.34	74.00 ±1.73	61.66 ±1.15	67.83 ±8.72
164	3.73 ±0.23	3.31 ±0.20	3.52 ±0.29	74.00 ±1.73	63.33 ±2.51	68.66 ±8.72
166	3.82 ±0.45	1.94 ±1.14	2.88 ±1.33	73.00 ±0.00	61.33 ±0.57	67.16 ±6.86
170	2.78 ±0.68	2.95 ±0.44	2.87 ±0.14	73.08 ±0.00	80.33 ±1.52	76.70 ±8.25
191	4.43 ±0.31	3.29 ±0.73	3.86 ±0.81	88.66 ±2.52	79.66 ±0.57	84.16 ±5.89
193	4.43 ±1.09	3.28 ±0.08	3.86 ±0.81	88.33 ±3.05	65.66 ±1.15	76.99 ±6.13

Contd..... Table I.

1	2	3	4	5	6	7
287	3.85 ± 0.51	3.40 ± 1.18	3.63 ± 0.32	76.33 ± 0.57	67.00 ± 2.00	71.66 ± 7.54
288	3.49 ± 0.82	2.74 ± 0.07	3.12 ± 0.53	76.33 ± 0.57	64.66 ± 0.57	70.49 ± 6.59
331	4.11 ± 0.22	2.47 ± 0.17	3.29 ± 1.16	76.33 ± 0.57	66.00 ± 1.73	71.16 ± 8.25
332	3.78 ± 0.08	3.22 ± 1.14	3.50 ± 0.39	76.66 ± 1.63	69.66 ± 0.57	73.16 ± 7.53
335	4.54 ± 1.51	3.99 ± 2.29	4.27 ± 0.38	76.66 ± 1.63	66.00 ± 0.00	71.33 ± 4.94
337	3.79 ± 1.26	1.97 ± 1.32	2.88 ± 1.29	76.66 ± 1.63	61.66 ± 1.15	69.16 ± 7.53
344	4.32 ± 0.22	2.23 ± 0.13	3.27 ± 1.41	75.33 ± 2.08	67.00 ± 2.00	71.16 ± 5.89
355	3.33 ± 1.50	2.56 ± 1.40	2.95 ± 0.55	76.33 ± 0.57	70.33 ± 0.57	73.33 ± 4.24
357	2.48 ± 1.11	2.60 ± 2.05	2.54 ± 0.10	76.66 ± 3.51	72.66 ± 0.57	74.66 ± 2.82
358	4.80 ± 0.00	2.72 ± 0.45	3.76 ± 1.54	74.00 ± 1.73	61.33 ± 0.57	67.67 ± 8.95
362	4.42 ± 2.33	2.72 ± 1.36	3.57 ± 1.20	85.00 ± 0.00	77.33 ± 1.52	81.17 ± 5.42
366	4.46 ± 0.33	2.12 ± 0.64	3.29 ± 1.65	76.66 ± 1.15	72.00 ± 1.73	74.33 ± 3.29
373	4.04 ± 0.75	4.10 ± 2.43	4.15 ± 0.72	76.66 ± 1.15	67.00 ± 1.73	71.83 ± 6.83
382	3.05 ± 1.98	2.60 ± 1.90	2.83 ± 0.32	74.00 ± 1.73	61.33 ± 0.57	67.67 ± 8.95
384	3.06 ± 0.54	3.02 ± 1.81	3.04 ± 0.06	76.66 ± 1.63	63.66 ± 1.15	70.16 ± 9.19

Contd..... Table I.

1	2	3	4	5	6	7
405	3.63 ± 1.06	2.88 ± 1.01	3.26 ± 0.53	76.66 ± 1.63	72.00 ± 1.73	74.33 ± 3.29
410	4.80 ± 0.35	3.90 ± 0.39	4.35 ± 0.64	76.66 ± 1.63	71.33 ± 1.52	74.00 ± 3.76
411	3.72 ± 1.18	3.37 ± 2.27	3.55 ± 0.25	76.66 ± 1.63	65.66 ± 0.57	71.16 ± 7.77
427	4.75 ± 1.04	3.40 ± 0.09	4.08 ± 0.95	76.66 ± 1.63	71.66 ± 1.15	74.16 ± 3.53
435	2.64 ± 0.22	2.90 ± 0.07	2.77 ± 0.19	76.66 ± 1.63	66.00 ± 1.00	71.33 ± 7.53
439	3.37 ± 1.45	2.97 ± 0.51	3.17 ± 0.29	77.00 ± 3.61	66.33 ± 0.57	71.67 ± 7.54
450	4.89 ± 0.42	4.16 ± 0.33	4.53 ± 0.51	76.66 ± 1.63	66.66 ± 1.15	71.66 ± 7.07
452	3.13 ± 0.71	2.70 ± 1.28	2.92 ± 0.31	76.66 ± 1.63	66.00 ± 1.00	71.33 ± 7.53
453	3.61 ± 0.81	3.00 ± 1.27	3.31 ± 0.43	76.66 ± 1.63	66.66 ± 1.15	71.66 ± 7.07
479	3.52 ± 0.87	2.97 ± 0.60	3.25 ± 0.38	81.33 ± 2.31	67.66 ± 0.57	74.50 ± 9.66
484	2.08 ± 0.16	2.04 ± 1.17	2.06 ± 0.08	81.00 ± 1.73	67.66 ± 0.57	74.33 ± 9.66
488	3.03 ± 0.22	3.10 ± 1.33	3.07 ± 0.10	75.66 ± 2.51	67.33 ± 1.52	71.50 ± 5.89
Shib- nagar	4.05 ± 1.76	2.20 ± 0.11	3.13 ± 1.30	76.66 ± 1.55	66.33 ± 0.57	71.50 ± 7.30
Pop. mean	3.73 ± 0.34	2.94 ± 0.22	3.33 ± 0.25	76.92 ± 0.88	67.16 ± 0.65	72.04 ± 1.02
C.D.	0.81	0.51	0.71	2.44	1.17	2.85

Table II. Mean of different characters of initial evaluation trial at two locations.

Varieties (B.Si.No.)	Days to flowering			Panicle length (cm)		
	KLN	JGM	Pool	KLN	JGM	Pool
1	2	3	4	5	6	7
1	49.33 ± 1.52	42.66 ± 2.08	45.99 ± 4.71	14.60 ± 1.83	13.57 ± 1.75	14.09 ± 0.73
7	48.00 ± 1.00	42.33 ± 1.53	45.17 ± 4.00	13.72 ± 1.21	12.33 ± 1.34	13.03 ± 0.98
123	49.00 ± 1.73	39.33 ± 1.55	44.17 ± 6.83	14.71 ± 2.81	13.66 ± 2.29	14.19 ± 0.74
142	52.00 ± 3.61	42.33 ± 1.52	47.17 ± 6.83	14.90 ± 3.49	13.97 ± 3.19	14.44 ± 0.66
150	52.00 ± 1.00	42.66 ± 1.52	47.33 ± 6.60	10.32 ± 1.77	9.49 ± 1.19	9.91 ± 0.59
153	46.00 ± 2.00	35.33 ± 1.53	40.66 ± 7.54	15.78 ± 1.13	14.59 ± 1.00	15.19 ± 0.84
161	47.00 ± 3.00	36.33 ± 1.52	41.67 ± 7.55	14.72 ± 2.38	13.51 ± 1.89	14.12 ± 0.85
164	49.00 ± 1.73	38.66 ± 1.15	43.83 ± 7.31	14.60 ± 1.76	13.77 ± 2.54	14.19 ± 0.59
166	47.33 ± 2.51	39.33 ± 1.15	43.33 ± 5.65	16.28 ± 1.16	14.67 ± 1.67	15.48 ± 1.13
170	47.33 ± 1.53	38.66 ± 0.57	43.00 ± 6.13	15.01 ± 1.14	13.60 ± 1.36	14.31 ± 0.81
191	58.66 ± 1.53	51.66 ± 1.53	55.16 ± 4.94	19.53 ± 0.96	17.45 ± 1.05	18.49 ± 1.47
193	58.33 ± 2.08	52.33 ± 1.15	55.33 ± 4.24	18.93 ± 1.62	17.61 ± 1.72	18.27 ± 0.93
287	51.33 ± 0.57	40.66 ± 0.57	46.00 ± 7.54	14.32 ± 1.87	12.75 ± 1.75	13.54 ± 1.11

Contd..... Table II.

1	2	3	4	5	6	7
288	51.00 ± 2.00	43.33 ± 1.53	47.17 ± 5.42	15.08 ± 1.76	13.04 ± 2.54	14.06 ± 1.44
331	49.66 ± 1.52	42.33 ± 1.52	46.00 ± 5.18	9.74 ± 0.24	8.84 ± 0.34	9.29 ± 0.63
332	48.66 ± 1.52	40.33 ± 1.53	44.50 ± 5.89	7.93 ± 0.74	7.85 ± 0.97	7.89 ± 0.08
335	52.33 ± 2.31	47.66 ± 0.58	50.00 ± 3.30	9.11 ± 1.66	8.84 ± 1.16	8.98 ± 0.19
337	51.00 ± 1.00	43.33 ± 2.31	47.17 ± 5.42	9.88 ± 0.66	9.11 ± 0.31	9.50 ± 0.54
344	48.66 ± 2.08	42.00 ± 1.73	45.33 ± 4.71	16.74 ± 2.55	14.85 ± 2.43	15.80 ± 1.33
355	51.33 ± 3.51	48.66 ± 1.15	50.00 ± 1.88	11.47 ± 3.03	10.73 ± 2.48	11.10 ± 0.52
357	53.33 ± 3.78	47.66 ± 0.58	50.50 ± 4.01	12.10 ± 3.44	11.33 ± 2.78	11.72 ± 0.54
358	48.00 ± 2.64	43.00 ± 1.73	45.50 ± 3.53	17.06 ± 3.20	15.67 ± 2.88	16.37 ± 0.98
362	54.00 ± 3.46	48.66 ± 0.58	51.33 ± 3.77	15.53 ± 4.92	14.40 ± 4.61	14.97 ± 0.80
366	52.33 ± 2.31	49.33 ± 1.53	50.83 ± 4.51	9.82 ± 1.35	9.28 ± 1.17	9.55 ± 0.37
373	51.66 ± 1.15	42.66 ± 0.57	47.16 ± 6.36	10.28 ± 0.91	9.52 ± 0.97	9.90 ± 0.53
382	49.33 ± 2.88	42.66 ± 2.88	46.00 ± 4.71	14.21 ± 2.49	13.31 ± 1.67	13.76 ± 0.64
384	46.00 ± 2.64	35.33 ± 0.58	40.67 ± 7.55	13.74 ± 1.54	12.73 ± 2.01	13.24 ± 0.71
405	54.33 ± 2.08	49.00 ± 1.73	51.67 ± 3.76	14.20 ± 0.98	12.94 ± 0.92	13.57 ± 0.89
410	53.00 ± 2.00	48.66 ± 2.08	50.83 ± 3.07	18.55 ± 1.40	17.13 ± 1.13	17.84 ± 1.00

Contd..... Table II.

1	2	3	4	5	6	7
411	49.00 ± 2.00	42.66 ± 2.04	45.83 ± 4.48	13.39 ± 2.81	12.40 ± 2.44	12.90 ± 0.70
427	49.00 ± 5.29	48.66 ± 2.06	48.83 ± 0.25	14.89 ± 3.95	14.00 ± 4.36	14.45 ± 0.63
435	45.00 ± 2.00	34.00 ± 1.74	39.50 ± 7.77	14.81 ± 0.42	13.89 ± 1.06	14.35 ± 0.65
439	50.00 ± 2.64	42.66 ± 2.05	46.33 ± 5.19	16.62 ± 2.58	15.09 ± 1.96	15.86 ± 1.08
450	52.33 ± 1.15	41.33 ± 0.57	46.83 ± 7.77	15.71 ± 4.22	15.53 ± 2.74	15.62 ± 0.16
452	52.66 ± 3.05	43.00 ± 1.73	47.83 ± 6.83	8.82 ± 1.16	8.21 ± 0.98	8.52 ± 0.43
453	47.33 ± 2.51	37.66 ± 2.05	42.50 ± 6.84	14.63 ± 0.61	13.83 ± 1.04	14.23 ± 0.57
479	50.66 ± 1.52	42.00 ± 1.72	46.33 ± 6.12	15.65 ± 0.45	14.22 ± 0.86	14.94 ± 1.01
484	53.33 ± 1.53	43.33 ± 1.52	48.33 ± 7.07	13.65 ± 3.15	12.09 ± 1.86	12.87 ± 1.10
488	50.00 ± 3.61	44.66 ± 1.50	47.33 ± 3.77	9.45 ± 1.11	8.85 ± 0.92	9.15 ± 0.43
Shib- nagar	51.66 ± 1.52	42.00 ± 0.00	46.83 ± 6.83	14.11 ± 2.61	12.96 ± 2.77	13.54 ± 0.81
Pop. Mean	50.50 ± 1.21	42.95 ± 0.86	46.72 ± 1.28	13.86 ± 1.24	12.79 ± 1.12	13.32 ± 1.30
C.D.	3.35	2.41	3.58	3.45	3.12	3.61

Table III. Mean of different characters of initial evaluation trial at two locations.

Varieties (B.Si.No.)	Plant height (cm)			No. leaves per plant		
	KLN	JGM	Pool	KLN	JGM	Pool
1	2	3	4	5	6	7
1	108.33 ± 5.51	99.00 ±2.54	130.67 ± 6.59	12.54 ±0.43	11.13 ±0.94	11.83 ±0.99
7	103.66 ±15.01	95.33 ±17.61	99.50 ±5.89	11.82 ±0.81	10.00 ±0.52	10.91 ±1.28
123	99.66 ±21.00	91.33 ±22.18	95.50 ±5.84	12.03 ±1.06	10.83 ±0.83	11.18 ±1.20
142	99.66 ±22.47	88.33 ±22.12	94.00 ±8.01	11.87 ±0.62	10.33 ±0.64	11.10 ±1.08
150	102.66 ±15.94	92.66 ±17.61	97.66 ±7.07	12.24 ±0.70	10.20 ±0.52	11.23 ±1.46
153	98.00 ±8.00	88.66 ±10.01	93.33 ±6.60	12.04 ±0.66	9.93 ±0.50	10.98 ±1.49
161	96.33 ±11.14	88.33 ±15.63	92.33 ±5.65	11.83 ±0.52	10.00 ±0.52	10.91 ±1.29
164	101.66 ±10.69	88.66 ±6.65	95.16 ±9.19	12.58 ±0.58	10.80 ±0.72	11.69 ±1.25
166	103.00 ± 2.91	89.33 ±2.51	96.17 ±9.66	11.83 ±0.22	9.86 ±0.31	10.84 ±1.39
170	92.33 ± 3.78	84.00 ±7.00	88.17 ±5.89	11.36 ±0.62	9.33 ±0.64	10.34 ±1.43
191	133.66 ± 4.93	121.00 ± 3.46	127.33 ± 8.95	12.24 ±0.57	10.33 ±0.23	11.28 ±1.35
193	124.00 ±14.79	115.00 ±17.32	119.5 ± 6.36	12.16 ±0.35	10.26 ±0.57	11.21 ±1.34
287	99.33 ± 5.50	90.33 ±6.65	94.83 ±6.36	12.45 ±0.64	10.40 ±0.60	11.42 ±1.45

Contd..... Table III.

1	2	3	4	5	6	7
288	104.33 ± 11.93	94.33 ± 11.15	99.33 ± 7.07	12.76 ± 0.53	11.00 ± 0.72	11.88 ± 1.24
331	96.33 ± 1.15	87.33 ± 2.08	91.83 ± 6.36	12.40 ± 0.81	10.60 ± 0.34	11.50 ± 1.27
332	79.66 ± 4.16	71.33 ± 2.88	75.50 ± 5.89	12.16 ± 1.13	10.00 ± 0.72	11.08 ± 1.52
335	100.33 ± 4.04	90.33 ± 3.21	95.33 ± 7.07	13.30 ± 0.51	11.40 ± 0.40	12.35 ± 1.31
337	93.66 ± 8.32	85.33 ± 6.18	89.50 ± 5.89	11.95 ± 0.76	10.26 ± 0.76	11.10 ± 0.41
344	96.66 ± 7.02	86.66 ± 7.02	91.66 ± 7.07	11.78 ± 0.56	9.86 ± 0.98	10.82 ± 1.35
355	76.00 ± 19.67	67.33 ± 21.12	71.67 ± 6.13	11.54 ± 0.41	10.06 ± 0.61	10.80 ± 1.04
357	85.33 ± 16.50	75.66 ± 15.63	80.50 ± 6.83	12.23 ± 0.72	10.33 ± 0.61	11.28 ± 1.81
358	96.66 ± 9.29	86.33 ± 9.07	91.50 ± 7.30	11.75 ± 0.34	9.13 ± 0.98	10.44 ± 1.85
362	87.33 ± 7.76	75.33 ± 4.04	81.33 ± 8.48	12.15 ± 0.33	10.33 ± 0.31	11.24 ± 1.28
366	90.00 ± 10.58	80.33 ± 11.59	85.17 ± 6.83	11.87 ± 0.25	10.20 ± 0.40	11.03 ± 1.18
373	94.33 ± 10.26	83.66 ± 7.50	89.00 ± 7.54	12.33 ± 0.26	10.60 ± 0.47	11.46 ± 1.22
382	90.33 ± 15.79	80.66 ± 19.62	85.50 ± 6.83	11.92 ± 0.41	10.13 ± 0.50	11.02 ± 1.26
384	84.33 ± 8.96	75.33 ± 8.32	79.83 ± 6.22	10.30 ± 0.56	8.93 ± 0.94	9.61 ± 0.97
405	98.33 ± 4.93	89.00 ± 5.56	93.67 ± 6.59	13.10 ± 0.31	11.73 ± 0.52	12.41 ± 0.97

Contd..... Table - III.

1	2	3	4	5	6	7
410	108.66 ± 4.72	98.66 ± 4.72	103.66 ± 7.07	12.20 ± 0.19	10.26 ± 0.41	11.23 ± 1.37
411	84.33 ± 4.93	75.00 ± 2.64	79.67 ± 6.59	10.81 ± 0.56	9.06 ± 0.70	9.93 ± 1.23
427	86.00 ± 9.00	75.33 ± 10.11	80.67 ± 7.54	11.22 ± 0.18	9.33 ± 0.70	10.27 ± 1.33
435	74.33 ± 10.01	66.33 ± 10.26	70.33 ± 5.65	10.07 ± 0.31	8.20 ± 0.34	9.13 ± 1.32
439	95.00 ± 14.73	85.66 ± 15.33	90.33 ± 6.59	11.93 ± 0.38	10.00 ± 0.00	10.96 ± 1.36
450	106.33 ± 21.93	98.33 ± 19.73	102.33 ± 5.65	13.47 ± 0.50	11.86 ± 0.61	12.66 ± 1.28
452	99.00 ± 11.13	91.33 ± 8.51	95.17 ± 5.42	12.87 ± 0.34	10.50 ± 0.34	11.68 ± 1.67
453	92.33 ± 5.51	82.00 ± 5.29	87.17 ± 7.30	11.06 ± 0.59	9.13 ± 0.41	10.09 ± 1.36
479	121.00 ± 3.61	110.66 ± 5.03	115.83 ± 7.31	12.59 ± 0.34	10.53 ± 0.31	11.56 ± 1.45
484	114.33 ± 17.38	105.00 ± 17.77	109.67 ± 6.59	13.40 ± 0.87	10.86 ± 0.46	12.13 ± 1.79
488	90.66 ± 16.16	78.00 ± 22.53	84.33 ± 8.95	11.87 ± 0.55	10.33 ± 0.64	11.10 ± 1.08
Shib nagar	98.33 ± 16.01	80.00 ± 15.71	89.17 ± 7.30	12.09 ± 0.31	9.93 ± 0.57	11.01 ± 1.52
Pop. mean	97.66 ± 7.88	87.88 ± 6.61	92.77 ± 7.98	12.05 ± 0.26	10.17 ± 0.29	11.11 ± 0.31
C.D.	21.85	18.35	22.23	0.73	0.81	0.85

Table IV. Mean of different characters of initial evaluation trial at two locations.

Varieties (B.Si.No.)	Flag leaf length (cm)			Flag leaf breadth (cm)		
	KLN	JGM	Pool	KLN	JGM	Pool
1	2	3	4	5	6	7
1	26.85 ± 2.84	25.13 ± 2.76	25.99 ± 1.21	1.84 ± 0.12	1.59 ± 0.15	1.72 ± 0.18
7	26.73 ± 5.41	24.30 ± 5.81	25.51 ± 1.71	2.00 ± 0.20	1.75 ± 0.24	1.88 ± 0.18
123	28.26 ± 2.72	25.56 ± 3.17	26.91 ± 1.91	2.13 ± 0.31	1.75 ± 0.24	1.94 ± 0.28
142	31.16 ± 7.62	28.66 ± 7.64	29.91 ± 1.76	2.40 ± 0.55	1.99 ± 0.39	2.20 ± 0.30
150	27.45 ± 4.15	25.98 ± 3.51	26.71 ± 1.04	2.32 ± 0.43	2.03 ± 0.29	2.18 ± 0.21
153	29.76 ± 2.28	26.84 ± 2.91	28.30 ± 2.06	2.21 ± 0.14	1.92 ± 0.12	2.07 ± 0.22
161	28.57 ± 3.77	25.89 ± 2.71	27.23 ± 1.89	2.18 ± 0.39	1.89 ± 0.29	2.04 ± 0.21
164	28.40 ± 2.44	24.86 ± 1.93	26.63 ± 2.50	2.20 ± 0.21	1.95 ± 0.24	2.08 ± 0.18
166	31.24 ± 2.01	28.80 ± 1.58	30.02 ± 1.72	2.28 ± 0.09	1.97 ± 0.06	2.13 ± 0.22
170	25.64 ± 5.84	26.40 ± 2.86	26.02 ± 0.53	2.13 ± 0.13	1.88 ± 0.14	2.01 ± 0.17
191	30.93 ± 3.61	28.20 ± 2.63	29.56 ± 3.24	1.71 ± 0.21	1.34 ± 0.09	1.53 ± 0.19
193	27.10 ± 1.45	24.42 ± 1.31	25.76 ± 1.89	1.56 ± 0.15	1.23 ± 0.15	1.40 ± 0.23
287	23.52 ± 2.57	21.24 ± 1.62	22.38 ± 1.61	1.80 ± 0.08	1.51 ± 0.07	1.67 ± 0.22

Contd..... Table IV.

1	2	3	4	5	6	7
288	24.63 ± 3.26	22.39 ± 2.01	23.51 ± 1.58	1.86 ± 0.23	1.55 ± 0.18	1.71 ± 0.23
331	30.36 ± 2.03	25.78 ± 3.36	23.51 ± 1.58	2.63 ± 0.08	2.44 ± 0.14	2.54 ± 0.53
332	24.51 ± 2.53	22.22 ± 2.76	28.07 ± 3.21	2.11 ± 0.07	1.81 ± 0.15	1.96 ± 0.22
335	26.19 ± 5.82	23.99 ± 4.71	23.36 ± 1.62	2.26 ± 0.34	1.97 ± 0.32	2.12 ± 0.22
337	28.60 ± 3.53	25.49 ± 2.31	25.09 ± 1.55	2.22 ± 0.18	2.31 ± 0.11	2.27 ± 0.07
344	31.32 ± 6.04	27.93 ± 5.36	27.04 ± 2.20	2.35 ± 0.28	2.12 ± 0.21	2.24 ± 0.16
355	21.66 ± 6.33	19.21 ± 5.92	29.62 ± 2.39	1.63 ± 0.38	1.63 ± 0.11	1.63 ± 0.06
357	26.55 ± 6.32	23.77 ± 5.27	25.16 ± 1.96	1.94 ± 2.37	1.61 ± 0.32	1.78 ± 0.23
358	31.05 ± 6.70	28.12 ± 7.11	29.58 ± 2.07	1.93 ± 0.17	1.63 ± 0.24	1.78 ± 0.22
362	31.52 ± 6.99	27.08 ± 7.61	29.30 ± 3.19	2.60 ± 0.45	2.33 ± 0.52	2.47 ± 0.19
366	26.98 ± 4.19	24.39 ± 3.00	25.68 ± 1.83	2.33 ± 0.20	2.13 ± 0.21	2.23 ± 0.16
373	31.59 ± 4.19	27.89 ± 4.83	29.74 ± 2.61	2.68 ± 0.23	2.47 ± 0.35	2.53 ± 0.22
382	27.72 ± 2.25	25.19 ± 6.37	26.45 ± 1.79	1.99 ± 0.38	1.76 ± 0.42	1.88 ± 0.16
384	28.47 ± 2.32	25.72 ± 3.17	27.09 ± 1.94	2.43 ± 0.21	2.12 ± 0.28	2.26 ± 0.22
405	26.83 ± 3.27	24.29 ± 4.57	25.56 ± 1.79	2.00 ± 0.17	1.70 ± 0.26	1.85 ± 0.22
410	29.84 ± 3.96	27.86 ± 3.10	28.58 ± 1.96	2.15 ± 0.06	2.07 ± 0.39	2.11 ± 0.08

Contd..... Table IV.

1	2	3	4	5	6	7
411	26.43 ± 5.46	26.46 ± 2.21	26.44 ± 0.08	2.42 ± 0.09	2.13 ± 0.11	2.28 ± 0.20
427	28.26 ± 7.68	26.61 ± 8.61	27.43 ± 1.17	2.12 ± 0.29	1.88 ± 0.35	2.00 ± 0.16
435	27.00 ± 2.06	24.92 ± 5.46	25.96 ± 1.47	2.22 ± 0.21	1.98 ± 0.27	2.10 ± 0.16
439	31.48 ± 5.58	29.20 ± 6.61	30.52 ± 1.86	2.25 ± 0.36	1.93 ± 0.41	2.09 ± 0.23
450	28.13 ± 4.55	26.66 ± 3.71	27.39 ± 1.04	2.15 ± 0.34	1.92 ± 0.26	2.04 ± 0.17
452	25.06 ± 3.10	23.40 ± 2.49	24.23 ± 1.17	2.20 ± 0.19	1.94 ± 0.15	2.07 ± 0.21
453	30.36 ± 1.82	28.24 ± 1.78	29.30 ± 1.51	2.41 ± 0.17	2.21 ± 0.14	2.31 ± 0.14
479	27.38 ± 3.25	25.69 ± 3.45	26.53 ± 1.19	1.82 ± 0.33	1.44 ± 0.15	1.63 ± 0.03
484	20.71 ± 4.05	18.04 ± 4.06	19.37 ± 1.88	1.42 ± 0.22	1.11 ± 0.25	1.27 ± 0.22
488	29.81 ± 3.59	27.58 ± 3.65	28.69 ± 1.57	2.57 ± 0.25	2.33 ± 0.31	2.45 ± 0.18
Shib nagar	25.48 ± 5.64	24.52 ± 6.47	25.00 ± 0.67	1.90 ± 0.15	1.67 ± 0.35	1.79 ± 0.17
Pop. Mean	27.85 ± 2.34	25.47 ± 2.26	26.66 ± 2.53	2.14 ± 0.15	1.87 ± 0.14	2.00 ± 0.16
C.D.	-	-	-	0.40	0.39	0.44

(-) not significant in 'F' test.

Table V. Mean of different characters in G_1 generation.

Charac- ters.	Doses					C.D. Btn. doses
	Cont.	5 kR	10 kR	20 kR	40 kR	
Yield	12.81 ± 1.47	12.65 ± 1.64	12.34 ± 1.44	9.22 ± 1.72	5.66 ± 2.17	2.74
Ster. Pn.	85.11 ± 4.41	39.23 ± 4.46	47.15 ± 8.11	55.29 ± 9.88	67.58 ± 11.74	6.61
DAM	132.82 ± 1.14	134.25 ± 1.76	133.82 ± 1.96	136.41 ± 1.29	139.90 ± 0.84	1.47
Pan. lgth.	18.69 ± 0.98	18.32 ± 1.05	18.21 ± 1.18	18.08 ± 1.05	18.99 ± 1.28	-
Pan. bth.	2.76 ± 0.18	2.85 ± 0.15	2.81 ± 0.18	2.71 ± 0.13	2.79 ± 0.21	-
Plant ht.	135.45 ± 4.83	133.63 ± 4.14	132.50 ± 5.71	127.44 ± 6.19	124.04 ± 4.75	-
FL gth.	31.68 ± 2.73	32.07 ± 2.46	33.23 ± 2.68	33.31 ± 2.59	33.68 ± 2.75	-
FL bdth.	2.85 ± 0.20	2.90 ± 0.19	2.94 ± 0.14	2.91 ± 0.15	2.85 ± 0.15	-

(-) not significant in 'F' test.

Table VI. Mean of different characters in G₂ families (Kharif Trial).

Charac- ters.	Cont.	5 kR Families						Pool fam.	C.
		1	2	3	4	5	6		
Yield	8.46 ±2.97	9.57 ±1.68	9.38 ±2.22	10.17 ±3.47	10.24 ±1.50	8.45 ±1.03	8.83 ±0.66	9.44 ±0.69	-
DAF	45.24 ±2.14	48.98 ±1.55	46.11 ±4.39	46.61 ±3.21	46.20 ±3.66	47.17 ±2.01	46.43 ±0.98	46.92 ±0.86	-
DAM	75.58 ±2.64	78.72 ±2.41	77.75 ±3.70	79.61 ±1.60	78.60 ±4.24	78.81 ±2.36	77.80 ±0.81	78.88 ±1.01	-
Pan. lgth.	17.81 ±1.16	19.81 ±0.55	17.85 ±1.28	18.87 ±1.55	18.94 ±0.54	17.74 ±0.56	17.79 ±0.71	18.50 ±0.51	-
Pan. bdth	2.48 ±0.28	2.65 ±0.16	2.55 ±0.31	2.56 ±0.43	2.62 ±0.09	2.52 ±0.27	2.42 ±0.07	2.55 ±0.10	-
Plant ht.	136.19 ± 6.79	143.13 ± 2.51	147.36 ±14.21	134.14 ±13.40	137.90 ±11.00	127.39 ±15.81	127.59 ± 4.83	136.25 ± 6.45	-
FL lgth.	29.83 ±2.92	33.52 ±0.16	31.84 ±2.81	32.39 ±2.50	33.12 ±0.51	29.49 ±1.96	30.68 ±0.21	31.84 ±0.86	-
FL bdth.	1.81 ±0.16	1.87 ±0.17	1.87 ±0.07	1.80 ±0.14	1.80 ±0.13	1.67 ±0.25	1.74 ±0.12	1.79 ±0.05	-
Leaf pt.	12.77 ±1.17	13.53 ±0.16	12.71 ±0.52	12.66 ±0.64	12.88 ±0.16	12.41 ±0.36	12.33 ±0.21	12.75 ±0.21	0.1

(-) not significant in 'F' test.

Contd.... Table VI.

Charac- ters.	10 kR Families						Pool fam.	C.D
	1	2	3	4	5	6		
Yield	7.43 ± 0.31	7.80 ± 2.07	6.82 ± 1.62	6.52 ± 0.97	6.98 ± 0.87	6.48 ± 1.43	7.01 ± 0.56	-
DAF	45.02 ± 1.33	44.55 ± 3.13	46.43 ± 1.35	45.65 ± 3.04	44.74 ± 3.18	46.02 ± 1.83	45.41 ± 1.04	-
DAM	77.58 ± 1.50	76.22 ± 4.21	78.76 ± 2.16	76.94 ± 4.20	77.88 ± 3.32	77.88 ± 1.61	77.54 ± 1.14	-
Pan. lgth.	16.39 ± 0.81	17.06 ± 1.00	16.63 ± 1.26	17.05 ± 0.53	16.33 ± 0.85	16.17 ± 1.55	16.61 ± 0.62	-
Pan. bdth.	2.39 ± 0.24	2.44 ± 0.28	2.19 ± 0.21	2.08 ± 0.15	2.29 ± 0.15	2.20 ± 0.24	2.26 ± 0.11	-
Plant ht.	140.85 ± 13.65	142.32 ± 14.34	137.04 ± 13.39	137.70 ± 17.46	134.19 ± 15.86	128.90 ± 15.39	136.82 ± 2.61	8.21
FL lgth.	28.63 ± 0.28	29.40 ± 2.05	29.34 ± 2.99	27.88 ± 1.38	28.55 ± 2.11	27.96 ± 1.05	28.63 ± 0.91	-
FL bdth.	1.66 ± 0.09	1.65 ± 0.11	1.60 ± 0.12	1.62 ± 0.06	1.62 ± 0.19	1.55 ± 0.11	1.61 ± 0.04	-
Leaf pt.	12.49 ± 1.46	12.26 ± 1.04	12.19 ± 1.55	11.31 ± 0.87	12.01 ± 1.05	11.94 ± 1.23	12.03 ± 0.23	-

(-) not significant in 'F' test.

Contd..... Table VI

Charac- ter.	20 kR						Pool fam.	C.D.
	1	2	3	4	5	6		
Yield	9.29 ± 2.46	8.12 ± 2.14	7.83 ± 1.75	8.15 ± 2.75	7.65 ± 1.90	7.61 ± 0.57	8.11 ± 0.61	-
DAF	46.23 ± 3.86	49.57 ± 3.29	49.12 ± 3.04	47.22 ± 4.13	47.43 ± 4.50	45.58 ± 6.36	47.52 ± 1.20	-
DAM	78.56 ± 3.51	81.89 ± 0.93	81.13 ± 3.94	80.57 ± 3.63	80.35 ± 2.83	79.64 ± 3.83	80.35 ± 1.09	-
Pan. lgth.	18.10 ± 0.76	18.32 ± 0.82	17.81 ± 1.17	17.97 ± 1.28	18.93 ± 3.07	17.26 ± 0.41	18.06 ± 0.71	-
Pan. bdth.	2.59 ± 0.19	2.35 ± 0.14	2.34 ± 0.19	2.28 ± 0.33	2.31 ± 0.08	2.41 ± 0.19	2.38 ± 0.10	-
Plant ht.	134.74 ± 3.96	134.01 ± 3.34	126.93 ± 2.16	131.15 ± 11.32	101.60 ± 5.86	134.21 ± 16.94	132.26 ± 5.16	-
FL lgth.	30.83 ± 0.97	31.94 ± 1.24	31.17 ± 2.11	30.08 ± 3.19	30.19 ± 1.71	29.77 ± 1.28	30.66 ± 0.54	-
FL bdth.	2.10 ± 0.64	1.52 ± 0.61	1.75 ± 0.19	1.91 ± 0.23	1.81 ± 0.14	1.75 ± 0.15	1.81 ± 0.17	-
Leaf pt.	12.44 ± 0.35	12.21 ± 0.36	11.93 ± 0.11	11.94 ± 0.60	12.34 ± 0.21	12.30 ± 0.88	12.19 ± 1.73	-

(-) not significant in 'F' test.

Contd... Table VI

Charac- ters.	40 kR Families						Pool fam.	C.D.	C.D. btn. doses
	1	2	3	4	5	6			
Yield	8.78 ± 0.71	9.66 ± 0.47	9.30 ± 2.30	8.12 ± 2.46	8.78 ± 0.60	8.23 ± 0.54	8.81 ± 0.61	-	1.52
DAF	45.75 ± 1.01	45.49 ± 1.38	47.52 ± 2.01	46.35 ± 1.55	45.94 ± 2.27	45.53 ± 1.80	46.10 ± 0.69	-	-
DAM	78.85 ± 0.44	80.15 ± 1.61	81.52 ± 1.17	80.00 ± 2.65	79.95 ± 1.71	77.85 ± 1.83	79.72 ± 1.05	-	-
Pan. lgth.	18.75 ± 0.41	19.36 ± 2.03	18.65 ± 1.03	18.81 ± 1.21	17.71 ± 0.30	17.92 ± 0.55	18.54 ± 0.65	-	0.76
Pan. bdth.	2.64 ± 0.12	2.69 ± 0.16	2.44 ± 0.26	2.65 ± 0.26	2.53 ± 0.71	2.46 ± 0.08	2.57 ± 0.08	-	0.18
Plant ht.	135.96 ± 6.93	139.58 ± 2.23	128.16 ± 8.96	132.90 ± 7.94	131.39 ± 5.82	131.01 ± 4.07	133.17 ± 3.12	-	-
FL lgth.	32.35 ± 1.40	30.89 ± 0.82	31.27 ± 2.19	32.83 ± 2.81	32.10 ± 3.72	31.04 ± 0.36	31.75 ± 1.21	-	1.77
FL bdth.	1.78 ± 0.10	1.81 ± 0.04	1.75 ± 0.12	1.88 ± 0.21	1.67 ± 0.11	1.75 ± 0.09	1.78 ± 0.05	-	-
Leaf pt.	12.62 ± 0.41	12.88 ± 0.35	12.47 ± 0.53	12.25 ± 0.81	12.84 ± 0.44	12.55 ± 0.39	12.61 ± 0.23	-	-

(-) not significant in 'F' test.

Table VII. Mean of different characters in G_2 families (Rabi Trial).

Charac- ters.	Cont.	5 kR Families						Pool fam.	C.D.
		1	2	3	4	5	6		
Yield	13.11 ± 0.65	12.21 ± 2.46	17.61 ± 1.11	13.78 ± 1.58	13.72 ± 1.81	12.57 ± 2.17	11.95 ± 2.09	13.64 ± 1.08	3.40
DAF	93.65 ± 0.67	96.34 ± 1.03	94.46 ± 0.27	94.92 ± 0.99	93.63 ± 0.11	92.77 ± 0.15	93.74 ± 0.07	94.31 ± 0.30	0.96
DAM	128.66 ± 0.67	131.37 ± 0.98	129.64 ± 0.27	129.92 ± 0.99	128.63 ± 0.11	127.76 ± 0.15	128.72 ± 0.11	129.31 ± 0.30	0.94
Pan. lgth.	20.75 ± 0.97	21.08 ± 1.35	22.69 ± 0.19	22.79 ± 0.45	22.40 ± 0.49	21.91 ± 1.50	20.98 ± 1.31	21.97 ± 0.51	-
Pan. bdth.	2.93 ± 0.11	3.16 ± 0.27	3.61 ± 0.11	3.04 ± 0.17	3.17 ± 0.26	3.13 ± 0.21	2.97 ± 0.24	3.18 ± 0.10	0.31
Plant ht.	134.18 ± 0.84	137.29 ± 9.44	144.23 ± 1.57	142.21 ± 3.52	142.92 ± 3.84	146.54 ± 2.08	145.84 ± 5.84	143.21 ± 2.73	-
FL lgth.	32.16 ± 1.02	35.06 ± 2.09	35.67 ± 1.10	35.68 ± 3.32	35.08 ± 0.38	32.88 ± 2.23	32.28 ± 2.41	34.46 ± 1.31	-
FL bdth.	2.40 ± 0.16	2.36 ± 0.21	2.59 ± 0.11	2.40 ± 0.11	2.44 ± 0.14	2.31 ± 0.08	2.31 ± 0.11	2.41 ± 0.07	-
Leaf pt.	12.82 ± 1.56	13.08 ± 0.63	13.26 ± 0.29	13.00 ± 0.47	12.94 ± 0.46	13.26 ± 0.35	13.43 ± 0.53	13.16 ± 0.21	-

(-) not significant in 'F' test.

Contd.... Table VII.

Charac- ters.	10 kR Families						Pool fam.	C.D.
	1	2	3	4	5	6		
Yield	11.86 ± 1.68	12.97 ± 2.78	12.43 ± 1.74	13.26 ± 2.19	11.09 ± 0.81	10.96 ± 1.06	12.09 ± 0.77	-
DAF	92.63 ± 0.68	95.34 ± 0.49	92.21 ± 0.48	94.08 ± 0.56	93.00 ± 0.33	93.02 ± 0.48	93.38 ± 0.18	0.59
DAM	127.63 ± 0.68	130.26 ± 0.41	127.21 ± 0.48	129.08 ± 0.56	128.00 ± 0.33	128.03 ± 0.48	128.36 ± 0.19	0.60
Pan. lgth.	21.25 ± 1.37	22.24 ± 1.40	20.92 ± 0.44	21.75 ± 1.57	20.60 ± 1.34	20.19 ± 1.09	21.16 ± 0.47	-
Pan. bdth.	2.22 ± 0.20	3.32 ± 0.31	2.98 ± 0.03	3.08 ± 0.26	2.99 ± 0.11	2.90 ± 0.21	3.08 ± 0.08	0.26
Plant ht.	137.16 ± 12.04	136.45 ± 10.40	136.64 ± 8.21	141.14 ± 11.03	134.96 ± 15.13	139.63 ± 13.17	137.66 ± 2.04	-
FL lgth.	34.41 ± 1.61	36.85 ± 1.61	33.99 ± 1.65	34.84 ± 3.19	33.01 ± 1.94	33.71 ± 2.30	33.97 ± 0.97	3.07
FL bdth.	2.49 ± 0.15	2.29 ± 0.38	2.36 ± 0.14	2.37 ± 0.20	2.33 ± 0.11	2.36 ± 0.15	2.37 ± 0.12	-
Leaf pt.	12.73 ± 0.99	12.40 ± 0.47	12.33 ± 0.74	12.66 ± 0.66	12.04 ± 1.27	12.68 ± 0.94	12.47 ± 0.24	-

(-) not significant in 'F' test.

Contd..... Table VII.

Charac- ters.	20 kR Families						Pool fam.	C.D.
	1	2	3	4	5	6		
Yield	10.32 ± 1.17	11.76 ± 1.28	11.69 ± 1.28	12.02 ± 1.72	10.65 ± 0.13	10.65 ± 2.28	11.18 ± 0.71	-
DAF	95.70 ± 0.84	92.45 ± 1.46	94.77 ± 0.59	93.81 ± 0.35	94.38 ± 0.26	92.78 ± 9.96	93.98 ± 0.51	1.61
DAM	130.70 ± 0.84	128.44 ± 0.32	129.77 ± 0.59	128.81 ± 0.35	129.38 ± 0.26	127.78 ± 0.96	129.15 ± 0.34	1.09
Pan. lgth.	21.09 ± 1.11	20.67 ± 0.48	21.55 ± 1.19	22.88 ± 0.12	20.39 ± 0.44	20.48 ± 0.85	21.18 ± 0.49	1.56
Pan. bdth.	2.93 ± 0.15	2.92 ± 0.19	2.80 ± 0.14	3.14 ± 0.08	2.75 ± 0.11	2.94 ± 0.14	2.91 ± 0.07	0.18
Plant ht.	124.40 ± 3.41	129.26 ± 5.69	132.92 ± 7.96	138.73 ± 3.91	130.70 ± 9.93	130.27 ± 8.09	131.04 ± 2.47	7.81.
FL lgth.	34.32 ± 2.32	33.39 ± 1.31	35.17 ± 1.22	37.37 ± 2.29	34.48 ± 1.84	32.97 ± 2.46	34.62 ± 0.93	-
FL bdth.	2.43 ± 0.24	2.39 ± 0.06	2.29 ± 0.06	2.55 ± 0.12	2.31 ± 0.04	2.32 ± 0.05	2.38 ± 0.05	-
Leaf pt.	12.36 ± 0.43	12.02 ± 0.38	12.37 ± 0.68	11.95 ± 0.39	12.00 ± 1.33	12.12 ± 1.03	12.13 ± 0.29	-

(-) not significant in 'F' test.

Contd.... Table VII.

Charac- ters.	40 kR Families						Pool fam.	C.D.	C.D. Btn. Dose
	1	2	3	4	5	6			
Yield	10.29 ± 1.12	10.34 ± 1.04	11.37 ± 1.05	11.59 ± 2.22	11.63 ± 2.14	10.47 ± 2.41	10.95 ± 0.90	-	1.77
DAF	94.41 ± 0.69	93.77 ± 0.44	94.24 ± 0.11	93.12 ± 0.21	93.72 ± 0.13	93.10 ± 0.48	93.73 ± 0.23	0.75	0.46
DAM	129.41 ± 0.69	128.77 ± 0.44	129.24 ± 0.11	128.12 ± 0.21	128.72 ± 0.13	127.99 ± 0.61	128.71 ± 0.25	0.81	1.48
Pan. lgth.	20.62 ± 0.41	19.94 ± 1.37	21.81 ± 1.03	20.37 ± 1.31	21.06 ± 1.21	20.39 ± 1.20	20.70 ± 0.54	-	0.65
Pan. bdth.	2.94 ± 0.12	2.82 ± 0.17	2.87 ± 0.14	2.82 ± 0.26	2.95 ± 0.20	2.95 ± 0.18	2.89 ± 0.05	-	0.18
Plant ht.	123.38 ± 3.51	130.52 ± 5.85	130.75 ± 4.25	130.35 ± 2.44	139.43 ± 3.02	134.88 ± 4.88	131.55 ± 1.32	4.18	10.82
FL lgth.	35.18 ± 1.02	32.23 ± 3.16	36.37 ± 1.49	34.38 ± 1.94	34.78 ± 2.69	33.62 ± 4.28	34.43 ± 0.93	-	-
FL bdth.	2.94 ± 0.12	2.82 ± 0.17	2.87 ± 0.14	2.82 ± 0.26	2.95 ± 0.20	2.95 ± 0.18	2.89 ± 0.05	0.18	0.32
Leaf pt.	11.82 ± 0.19	11.89 ± 0.15	11.68 ± 0.19	11.69 ± 0.39	12.17 ± 0.15	12.25 ± 0.36	11.91 ± 0.11	0.36	-

(-) not significant in 'F' test.

Table VIII. Mean of different characters in G₃ families.

Charac- ters.	Cont.	5 KR Families												Pool fam.	C.D.
		1	2	3	4	5	6	7	8	9	10	11	12		
Yield	8.96 +0.56	12.00 +1.94	11.89 +2.21	10.56 +1.22	10.66 +1.30	11.28 +1.18	11.12 +1.32	12.83 +1.88	12.46 +1.11	11.98 +0.41	11.89 +1.36	12.10 +1.87	11.00 +1.57	11.65 +0.82	-
DAF	93.69 +0.52	93.86 +1.23	94.12 +1.42	91.86 +2.31	92.07 +1.46	93.60 +1.18	93.21 +1.41	93.26 +1.12	92.78 +1.00	94.85 +1.37	91.48 +1.21	92.36 +1.48	91.97 +1.15	92.95 +0.37	1.11
DAM	128.66 +0.12	128.87 +1.23	129.12 +1.42	126.86 +2.31	127.07 +1.46	128.58 +1.21	128.21 +1.41	128.26 +1.12	127.77 +0.97	128.74 +0.57	126.47 +1.21	127.36 +1.48	126.97 +1.15	127.86 +0.47	1.40
Pan. lgth.	16.06 +0.71	19.62 +0.81	20.21 +1.07	17.68 +0.02	17.83 +1.04	19.36 +0.83	18.04 +1.05	19.95 +1.61	19.63 +1.02	20.56 +0.97	18.60 +0.89	19.04 +0.80	18.16 +0.73	19.06 +0.53	1.56
Pan. bdth.	2.56 +0.14	2.80 +0.13	2.81 +0.17	2.90 +0.11	2.83 +0.06	2.80 +0.15	2.79 +0.10	2.98 +0.15	2.83 +0.15	3.10 +0.11	2.89 +0.16	2.95 +0.21	2.85 +0.14	2.88 +0.08	-
Plant ht.	123.23 +3.15	132.57 +8.52	135.87 +10.68	131.20 +7.85	135.10 +12.09	138.93 +10.89	137.40 +11.71	144.28 +9.77	140.66 +13.25	148.03 +9.58	136.71 +16.41	142.02 +12.52	137.74 +12.93	138.37 +1.83	5.38
FL lgth.	23.19 +1.31	30.08 +0.58	29.84 +1.11	27.02 +0.58	26.24 +2.11	29.34 +3.15	29.35 +3.33	31.87 +2.56	31.58 +2.50	32.98 +1.92	28.40 +1.98	29.77 +1.43	28.67 +1.12	29.43 +1.06	3.11
FL bdth.	2.16 +0.14	2.57 +0.56	2.32 +0.17	2.33 +0.09	2.25 +0.07	2.41 +0.20	2.26 +0.43	2.51 +0.19	2.61 +0.41	2.45 +0.23	2.39 +0.28	2.44 +0.13	2.31 +0.08	2.41 +0.12	-
Leaf pt.	12.43 +1.55	12.32 +0.05	12.57 +0.46	12.56 +0.22	12.93 +0.25	12.76 +0.21	12.70 +0.42	13.24 +0.45	12.40 +0.75	13.14 +0.32	12.88 +1.02	12.78 +0.97	12.62 +0.73	12.74 +0.23	-

(-) not significant in 'F' test.

Contd..... Table VIII

Charac- ters.	10 KR Families												Pool fam.	C.D. Bt. Dose
	1	2	3	4	5	6	7	8	9	10	11	12		
Yield	10.48 +1.13	10.03 +1.09	10.38 +1.34	11.20 +1.51	15.96 +1.29	10.72 +0.41	10.17 +0.91	10.61 +1.10	13.03 +2.89	14.48 +1.23	15.36 +1.88	16.69 +3.66	12.07 +0.90	2.65
DAF	93.42 +0.54	93.69 +1.21	93.17 +0.80	92.89 +1.12	92.52 +1.50	92.03 +0.99	92.52 +0.61	92.84 +0.51	93.52 +0.99	92.12 +0.88	93.53 +0.16	92.98 +1.07	92.93 +0.40	-
DAM	128.42 +0.54	128.59 +1.36	128.03 +0.99	127.89 +1.12	127.41 +1.68	127.03 +0.99	127.52 +0.61	127.81 +0.71	128.68 +0.73	126.85 +0.99	128.51 +0.19	127.98 +1.07	127.89 +0.41	-
Pan. lgth.	17.87 +1.23	18.36 +0.25	18.81 +0.76	19.00 +0.79	18.35 +0.96	17.57 +1.00	18.91 +1.32	19.07 +0.97	21.49 +0.92	20.82 +0.57	21.21 +1.70	21.98 +1.90	19.45 +0.46	19.36
Pan. bdth.	2.67 +0.18	2.81 +0.16	2.77 +0.11	2.88 +0.15	2.68 +0.07	2.74 +0.07	2.75 +0.11	2.94 +0.15	3.14 +0.24	3.12 +0.18	3.18 +0.03	3.33 +0.31	2.92 +0.09	0.28
Plant ht.	127.12 +7.33	128.31 +9.01	129.34 +9.02	136.12 +4.68	133.98 +7.38	133.87 +7.90	135.08 +6.59	139.69 +6.15	143.58 +5.95	142.13 +11.30	135.60 +3.45	146.04 +6.03	135.90 +2.16	6.35
FL lgth.	25.67 +2.34	27.16 +2.78	32.63 +3.94	29.55 +3.94	29.69 +3.89	24.44 +4.60	30.18 +5.97	30.09 +3.94	33.98 +3.07	33.44 +2.01	31.54 +2.33	34.19 +3.67	30.46 +1.01	2.90
FL bdth.	2.29 +0.07	2.30 +0.13	2.36 +0.16	2.35 +0.15	2.20 +0.16	2.23 +0.12	2.40 +0.13	2.44 +0.08	2.58 +0.13	2.60 +0.17	2.76 +0.24	2.81 +0.30	2.44 +0.08	0.23
Leaf pt.	12.51 +0.42	12.52 +0.82	12.32 +1.00	12.53 +0.89	12.38 +0.75	12.86 +1.08	12.50 +0.97	12.42 +0.86	12.13 +0.85	12.53 +1.35	13.11 +0.04	13.14 +0.52	12.58 +0.24	-

(-) not significant in 'F' test.

Contd..... Table VIII

Charac- ters.	20 KR Families												Pool fam.	C.D.
	1	2	3	4	5	6	7	8	9	10	11	12		
Yield	11.85 +1.11	13.05 +0.88	11.00 +1.64	12.63 +1.68	14.63 +3.83	13.97 +1.29	13.23 +1.39	12.13 +0.93	13.31 +1.21	15.67 +1.08	16.56 +3.51	14.19 +2.59	13.52 +0.92	2.70
DAF	94.03 +0.95	93.76 +1.34	93.78 +1.27	93.13 +1.78	95.53 +2.04	94.23 +1.31	93.72 +1.43	92.78 +0.81	92.94 +0.75	94.93 +0.07	94.73 +0.54	95.00 +0.30	94.04 +0.44	1.30
DAM	129.03 +0.95	128.76 +1.35	128.78 +1.27	128.11 +1.77	130.53 +2.04	129.23 +1.31	128.72 +1.43	127.78 +0.81	127.91 +0.71	129.93 +0.07	129.70 +0.48	130.00 +0.30	129.04 +0.44	1.30
Pan. lgth.	20.43 +0.46	21.61 +0.56	19.90 +1.54	20.30 +1.18	22.70 +2.71	22.41 +0.72	21.50 +1.47	20.21 +1.17	20.59 +0.88	23.04 +0.52	22.43 +1.61	23.62 +0.64	21.56 +0.51	1.50
Pan. bdth.	2.87 +0.20	3.08 +0.13	3.03 +0.28	3.92 +0.21	3.17 +0.22	3.14 +0.13	2.88 +0.08	2.87 +0.12	2.84 +0.11	3.08 +0.12	3.14 +0.36	3.21 +0.27	3.02 +0.09	0.23
Plant ht.	129.16 +10.01	137.33 +7.01	129.79 +0.27	136.33 +4.44	140.91 +2.60	142.29 +7.38	142.10 +5.50	132.02 +3.68	130.18 +2.00	140.26 +1.62	137.49 +1.24	144.92 +3.54	136.90 +1.95	5.73
FL lgth.	33.06 +3.85	32.75 +1.48	32.08 +2.01	31.12 +1.81	36.06 +1.77	35.99 +1.40	39.79 +2.68	34.18 +3.64	34.87 +3.64	38.88 +0.53	37.86 +1.72	37.38 +2.61	34.92 +1.29	3.97
FL bdth.	2.32 +0.16	2.49 +0.12	2.40 +0.16	2.38 +0.04	2.60 +0.29	2.68 +0.12	2.69 +0.24	2.49 +0.08	2.52 +0.13	2.90 +0.06	2.78 +0.32	2.83 +0.18	2.59 +0.09	0.27
Leaf pt.	12.13 +1.02	12.23 +0.72	12.10 +0.22	12.13 +0.32	13.80 +0.08	12.10 +0.09	12.88 +0.08	12.87 +0.12	12.84 +0.11	13.08 +0.12	13.14 +0.36	13.21 +0.27	13.02 +0.09	-

(-) not significant in 'F' test.

Contd..... Table VIII

Charac- ters.	40 kR Families												Pool fam.	C.D.	C.D. Stn. Doses.
	1	2	3	4	5	6	7	8	9	10	11	12			
Yield	11.76 ±1.42	11.24 ±1.55	12.47 ±1.82	12.20 ±2.53	13.78 ±1.29	11.99 ±1.23	13.30 ±1.30	12.11 ±1.68	15.19 ±1.56	15.54 ±1.01	12.07 ±2.14	11.05 ±0.44	12.72 ±0.70	2.06	1.74
DAF	92.86 ±1.81	93.44 ±1.39	94.15 ±1.22	94.16 ±1.28	95.51 ±1.14	93.75 ±1.67	93.45 ±1.48	92.66 ±1.19	93.25 ±0.28	93.25 ±1.28	94.90 ±0.72	94.65 ±0.70	93.84 ±0.35	1.04	0.84
DAM	127.82 ±1.79	128.44 ±1.39	129.11 ±1.28	129.19 ±1.28	130.51 ±1.14	128.75 ±1.67	128.45 ±1.48	127.66 ±1.19	128.23 ±0.27	128.29 ±0.33	129.90 ±0.72	129.65 ±0.70	128.83 ±0.35	1.03	0.82
Pan. lgth.	20.83 ±0.68	20.04 ±0.91	20.18 ±1.29	21.30 ±2.41	18.97 ±6.08	20.45 ±1.07	20.07 ±0.88	19.32 ±1.39	23.68 ±1.46	22.64 ±1.22	21.60 ±0.08	20.82 ±0.13	20.82 ±1.12	-	1.52
Pan. bdth.	3.03 ±0.13	2.76 ±0.09	2.99 ±0.12	3.14 ±0.26	3.03 ±0.25	2.90 ±0.06	2.95 ±0.11	3.03 ±0.25	3.10 ±0.17	3.12 ±0.26	3.12 ±0.21	3.13 ±0.04	3.02 ±0.10	-	0.18
Plant ht.	133.87 ±8.64	135.10 ±7.53	135.32 ±7.38	134.25 ±8.01	136.71 ±8.40	134.42 ±5.48	138.48 ±7.53	133.59 ±7.52	141.82 ±1.99	140.58 ±3.69	132.94 ±3.78	132.06 ±4.28	135.76 ±2.37	-	10.20
FL lgth.	33.63 ±1.66	32.39 ±2.83	31.69 ±3.31	33.46 ±6.03	35.47 ±4.40	31.67 ±1.56	32.62 ±1.51	32.82 ±2.56	35.94 ±0.65	35.77 ±1.54	34.96 ±3.12	32.34 ±1.66	33.35 ±1.26	-	1.52
FL bdth.	2.79 ±0.39	2.36 ±0.22	2.53 ±0.13	2.42 ±0.27	2.57 ±0.22	2.32 ±0.32	2.58 ±0.12	2.47 ±0.29	2.68 ±0.08	2.72 ±0.18	2.50 ±0.21	2.50 ±0.19	2.54 ±0.11	-	0.18
Leaf pt.	12.33 ±0.38	12.25 ±0.12	12.44 ±0.43	12.37 ±0.55	12.71 ±0.24	12.12 ±0.17	12.58 ±0.29	12.13 ±0.58	12.55 ±0.07	12.48 ±0.13	12.42 ±0.19	12.63 ±0.19	12.41 ±0.17	-	-

(-) not significant in 'F' test.