

**EFFECT OF PROVENANCE, METHOD OF
PROPAGATION AND TECHNIQUE OF SEED
PRODUCTION ON SEED YIELD AND QUALITY OF
HYBRID RICE (*Oryza sativa* L.)**

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**DEPARTMENT OF SEED TECHNOLOGY
UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE**

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PRODUCTION ON SEED YIELD AND QUALITY OF
HYBRID RICE (*Oryza sativa* L.)**

VIVEKANAND. K. DESHPANDE

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DEDICATED TO MY BELOVED

FATHER : KRISHNARAO

MOTHER : PUSHPAVATI

SISTER : NAGARATNA

BROTHER : DATTATRAYA

AND

GUIDE : Dr.M.MAHADEVAPPA

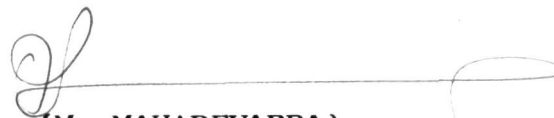
DEPARTMENT OF SEED TECHNOLOGY
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BANGALORE

CERTIFICATE

This is to certify that the thesis entitled "EFFECT OF PROVENANCE, METHOD OF PROPAGATION AND TECHNIQUE OF SEED PRODUCTION ON SEED YIELD AND QUALITY OF HYBRID RICE (Oryza sativa L.)" submitted by Mr. VIVEKANAND. K. DESHPANDE in partial fulfilment of the requirement for the degree of DOCTOR OF PHILOSOPHY (AGRICULTURE) in SEED TECHNOLOGY to the University of Agricultural Sciences, Bangalore is a record of bonafide research work carried out by him under my guidance and supervision and that no part of the thesis has been submitted for the award of any other degree, diploma, associateship, fellowship or other similar titles.

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Bangalore
September , 1993


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INTRODUCTION

I. INTRODUCTION

Rice (Oryza sativa L.) is the most important cereal staple food crop being the major source of calories for about 40 per cent of the world's population, particularly for the people of Asian continent. Globally, rice stands second only to wheat in terms of area and production occupying an area of 145.8 m. ha with an annual production of 518.8 m tonnes (IRRI, 1990). About 90 per cent of rice grown in the world is produced and consumed in the Asian region. Among the rice growing countries, India has the largest area under rice followed by China and Bangladesh. In India, rice is the leading cereal both in area (41.8 m.ha) and production (109.5 m. tonnes). In Karnataka, rice is cultivated in an area of 11.84 lakh hectares with an annual production of 23.00 lakh tonnes (KSDA, 1991).

Self sufficiency and reasonable level of stability attained in food production since early eighties has been possible due to development and wide spread adoption of plant type based high yield technology in rice and wheat. To sustain this state of self sufficiency in food, we have to add nearly 80 million tonnes to the present level of 175 m. tonnes in the next 10 years. For achieving the targetted requirement, a major share of about 30 m.tonnes has to come from rice alone. The task of raising the estimated quantum of rice in such a short period is quite a serious challenge considering practically no scope for area expansion under rice.

Another matter of great concern to all is that the yield level of high yielding dwarf varieties of rice is plateaued in area of assured irrigation, which accounts for over 75 per cent of rice production. This situation warrants search for and adoption of innovative breeding approaches to further rise the ceiling to genetic yield. After the Peoples Republic of China announced the successful development and use of F₁ rice hybrids in the late 1970's, hybrid rice technology attracted the attention of researchers around the world. The yield advantage of hybrid rice, as currently understood is about 20 per cent higher than that of the top yielding semidwarf commercial varieties, and this would help to nearly meet future rice demands of the growing world population.

China's initial success led IRRI to intensify research on hybrid rice, particularly on the potentials and problems of developing the technology for the tropics. Subsequent progress in China and at IRRI encouraged several other countries to take critical look at the prospects for hybrid rice. Now, in India also, hybrid rice breeding research and seed technology research are receiving attention in some of Agricultural Universities and Rice Research Stations. In Karnataka, the work on hybrid rice was initiated as early as 1970 and a male sterile line was obtained in the cross involving IR 8 and Jeerigessanna (Mahadevappa, 1973).

Chinese and IRRI scientists have observed up to 45 per cent natural outcrossing on male sterile line of rice (Virmani et al., 1981) which is sufficient to produce bulk quantities of hybrid seed at economically feasible level. It is the extent of seed set on outcrossing that determines the success and feasibility of hybrid rice programme. To achieve higher seed set in hybrid seed production, the percentage outcrossing is the main factor and this depends on floral structures, flowering behaviour, synchronization of parents by staggered planting, optimum ratio of parents (male to female) and use of growth regulators and other cheaper chemicals and supplementary pollination, which have been successfully adopted in China (Xu Shijue and LiBihu, 1988).

Rice, being a strictly self pollinated crop, seed set due to outcrossing even on male sterile plant is very low. This is the major constraint in commercialising rice hybrids. Despite several studies on adopting supplementary pollination techniques, the extent of seed set due to outcrossing on male sterile line has not crossed 25 per cent in many trials resulting in very low yields of hybrid seed. Considering the existence of exploitable level of heterosis in rice and the inherent problem associated with seed production, research is initiated in the University of Agricultural Sciences, Bangalore, India to study the feasibility of vegetative propagation to aid economic seed

production in order to exploit the heterosis. In the course of study, it is revealed that besides cost factor and saving on fresh seed requirement, the other advantages of vegetative propagation are i) reduction in total duration and ii) minimization of cost of production. Further, by effective roguing in main crop season, the problem of rogues and pollen shedders in hybrid seed production and sterile plants in commercial hybrid field, if any, can be avoided in ratoon and stubble or slip planted crops. Ratooning, tiller separation and stubble planting are different vegetative propagation methods that have been tried so far.

Ratooning is already in practice in some places with conventional high yielding varieties where with only 30 per cent of the cost and 60 to 70 per cent of main crop duration, more than 60 per cent of the yield is realised (Mahadevappa et al., 1988). The success of experiments of ratooning is attributed to the development of varieties incorporating genes for good ratoonability and virus resistance, and identification of suitable growing conditions where such cropping system can be remunerative and sustainable. The advantage of ratoon cropping is even greater with hybrids where the seed cost is much higher than the conventional varieties. Several hybrids evaluated at the University of Agricultural Sciences for their ratoonability have revealed good potential having genes for ratooning ability and

resistance to viruses that are required for raising a successful ratoon crop.

Profused tillering during the early phase of vegetative growth in hybrid rice offers a great scope for tiller separation and planting them to establish individual plants and exploit the hybrid vigour. The recovery of total number of tillers and their further performance depends on their tillering ability, growth duration (early or late maturing) and stage of tiller separation. Richharia (1960) and Richharia et al. (1964) have indicated the scope of extending this technique to normal cultural and environmental conditions. They have suggested that vegetative propagation would probably act as a trigger mechanism in increasing the scope of vegetative multiplication through individual tillers.

The stubbles of the previous main crop form potential planting material for the next season crop of rice if the varieties or hybrids have the genetic potential to respond to this practice. For each unit of the main crop of hybrid rice, one can get stubbles sufficient for planting about 10 such units. Stubble planting appears to be relatively more promising because yields recorded by stubble planted crops are close to the main crop, being mostly higher than the ratoon crop yields. The only disadvantage with stubble

planting compared to ratooning is that land preparation for transplanting has to be done in the traditional way for planting the stubbles as done for the previous crop. At present the question before researchers is to test the feasibility of vegetative propagation in parental seed multiplication (A/B) and hybrid seed production (A/R).

The ultimate aim of successful seed programme is to produce the maximum quantity of best quality. Seed quality parameters such as viability, vigour and storability ultimately depend on the production location, source of seed (main/ ratoon) and existence of seed on particular tiller etc. Hence, keeping in mind the above aspects of seed production, seed quality and storability, the present investigation entitled "Effect of Provenance, method of Propagation and Technique of Seed Production on Seed Yield and Quality of Hybrid Rice (Oryza sativa L.) was initiated with the following objectives:

- i) to study the influence of provenance and seasons on seed quality attributes of some rice genotypes,
- ii) to study the storability of rice genotypes as influenced by provenance and seed treatment under ambient conditions,
- iii) to study the production of hybrid seed through ratooning of parents (A/R) and to compare the seed yield and seed quality attributes of ratoon crop with main crop,

- iv) to study the vegetative propagation with special reference to tiller separation and stubble planting of parents, hybrids and varieties in rice and
- v) to study the influence of planting ratio, synchronization of flowering and foliar chemical spray on outcrossing, seed yield and quality in seed multiplication (A/B) and hybrid seed production.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

Literature available on aspects pertaining to (i) seed quality, storability and presence of seed borne pathogens as influenced by production location and seasons, (ii) seed longevity - possible causes of loss of viability and consequences of deterioration, (iii) various aspects of vegetative propagation and seed quality (iv) agromorphological and floral traits that influencing seed setting, (v) seed set and seed yield as influenced by planting ratios, synchronization of flowering in parents and (vi) foliar chemical spray on seed quality are reviewed in this chapter. Since literature on these aspects especially on rice is limited, review on other related crops are included.

2.1 Effect of Provenance and Season on Seed Quality

The advantages of producing seed in areas especially adopted to seed production are increased seed yield and quality. Yet not all kinds of seed can be produced in areas with highly favourable environments. Indeed, most of the seed used in crop production in India are produced in the same areas where the commercial crop is grown. Agroclimatic components are probably the most important determinants in the location of seed production. Thus the place of production is one of the most important factors that

influence the seed quality. The weather conditions such as temperature, relative humidity, photoperiod, wind velocity, soil type, nutrition and soil chemical reactions vary from location to location and season to season resulting in differential seed quality. Therefore, the selection of the best provenance of seed production for better seed becomes an integral part of a seed production programmes.

2.1.1 Production location and seed quality

Funk et al. (1962) showed that maize seed lots of the same hybrids differed among locations greatly in field performance and quality. Burris (1977) reported that maize seeds produced from three locations differed significantly in germination, shoot and root growth.

Seed materials of seven early maturing pigeonpea cultivars planted over seven locations were tested for seed quality by Tripathi and Laxman Singh (1979). The variation for seed index and protein was significant for cultivars and locations. Mean 100-seed weight (seed index) for varieties ranged from 8.3 to 9.7 (TT-6) whereas location mean ranged from 7.1 (Dantiwada) to 11.2 (Nowgong). Nowgong location had more pronounced effect on seed size than genotypic differences.

In wheat, Mathenge and Grabe (1977), Berezkin and Guida (1980) and Kristan and Skala (1980) reported that location of

seed production has the greatest effect on seed quality and yielding ability. They opined that good climatic condition, soil, etc. were essential for production of good quality seed.

Banumurthy and Gupta (1981), while studying the effect of four locations and five soybean cultivars on seed germination and vigour, reported that crops grown under the humid conditions (Kalyani, West Bengal) produced seeds of poor quality which deteriorated at a faster rate than that of the seeds produced in other locations.

In sorghum, seed samples of four varieties produced in three locations differed in germination and seedling vigour (Maeda and Sawazaki, 1982).

In rice, Umamaheshwar (1983) studied the effect of four production locations on seed quality attributes of three varieties. There were no significant differences with respect to germination, field emergence, speed of germination and root-shoot growth.

Kant et al. (1983) observed higher germination in the pea seeds developed and matured at cool temperature (mean 17.5 C) at Lahaul than those produced at warmer temperature (mean 24.5C) at Delhi. They also observed significant differences among the varieties produced from Lahaul alone for per cent germination. The varieties P 269, P 989 and

P 190 which required more than 70 days to flower, recorded higher germination than P 1069 and P 200 which took 68 and 64 days to flower respectively.

Vanagmudi and Karivaratharaju (1985) collected seed samples of C53541 sorghum from Coimbatore, North Arcot and Madurai to study the effect of provenance of production on seed quality. They observed the highest germination of seeds (65%) from Coimbatore followed by those of Madurai and the lowest was from seeds of North Arcot (49%). The seedling vigour levels also followed the same trend though the provenance of production did not influence the root and shoot length.

Wheat seed produced from poor wheat growing areas were low in quality as compared to those produced in good sites (Kovav, 1988). Odiemah (1988) obtained seed samples from six locations and reported that seed vigour was greater in 1982 than in 1983 which had a high temperature and low precipitation. On the contrary, Morgapuram (1989) reported that maize seed lots produced in different years had similar standard germination, field emergence and vigour.

Thiagarajan (1990) observed variability in both germinability (23%) and seedling vigour (24%) which was almost equal across ten locations of Cauvery delta zone, irrespective of rice varieties.

Thousand-seed weight of early varieties differed in all locations (Hyderabad, Maruteru, Chinsurah, Kankanadi and Mandya) inferring varied degrees of seed filling interacting with the varied environments at the respective locations (DRR., 1990). Yogeesha (1991) recorded significant variation in the test weight of six rice varieties produced from 4 locations viz., Mandya, Hebbal, Mudigere and Honnavile.

Dharmalingam (pers. Comm.) also noticed variation in per cent germination, root-shoot length, seedling vigour and electrical conductivity of seed leachate of rice genotypes in various locations of Tamilnadu.

Totally 22 certified seed lots of maize produced by Karnataka State Seed Corporation in six different agroclimatic zones were tested by Kurdikeri (1991) for various seed quality parameters. Germination percentage and test weight differed significantly among seed lots and locations but vigour index did not vary. Seeds from north dry zone proved to be better followed by north eastern dry zone and southern transitional zone. Electrical conductivity of seed leachate from different provenance did not differ significantly. However, it was less in north dry zone and more in north transitional zone.

2.1.2 Influence of season and weather at maturity on seed quality

Fernandes et al. (1980) observed that germination was not significantly affected by sowing date in rice for any of the varieties studied. But some of them recorded higher germination in summer than in late Kharif. He also noticed significant differences among the varieties for root-shoot length and vigour from summer crop than from Kharif crop.

Saini et al. (1980) reported from their study with soybean cultivars that crops produced from Rabi recorded higher germination and maintained greater vigour and viability than did the Kharif seeds. Varieties differed in their seed quality within and between seasons.

Higher number of normal seedlings (94%) was observed from summer seed than from rabi crop seed (77%) in hybrid bajra (Rajarao, 1981).

Kant et al. (1983) observed that the pea seeds developed and matured at cool temperature (mean 17.5 C) at Lahaul recorded germination higher than seeds produced from warmer temperature (Mean 25 C) at Delhi.

Hegde et al. (1983) observed the flower, foliar injury and decline in seed quality due to rains during flowering, seed development and maturity. Palanisami et al. (1986) reported higher 1000-seed weight, vigour and dry weight of seedlings from Kharif or early Kharif in Bhendi.

High temperature and long day light treatment of high humidity during seed maturation resulted in strong dormancy in rice as a result of the accumulation of germination inhibitors in the seed. High temperature during seed maturation also increased shoot and root length and mesocotyl elongation but reduced coleoptile elongation (Iakahashi et al., 1987).

Sessouma (1987) reported that sorghum seeds harvested from the crop which experienced higher relative humidity (90%) at seed maturation were less viable and more susceptible to stress conditions, when compared to seeds from 40 per cent relative humidity as tested by 2, 3, 5 tetrazolium chloride and germination tests.

Rain damaged seeds of rice (cv. Tellahamsa could) exhibit better germination and would be stored only for shorter period (Saibabu et al., 1987). Rain affected rice seeds from two sites registered lower thousand seed weight (Katano et al., 1988). Promila Kumari et al. (1992) noticed significant differences in standard germination but root shoot length and 1000-seed weight between the control and rain damaged seed were not-significant. Electrical conductivity of rain damaged seed lots were higher as compared to the control indicating the loss of membrane permeability.

2.1.3 Presence of seed borne pathogens as influenced by production location and weather

Blotter and agar plating techniques revealed the presence of 16 fungal species in and on the grain cultivars of rice. Curvularia lunata, Fusarium moniliforme, Macrophomina phaseolina and Drechslera oryzae were predominant on cv. Sakoli-6, while C. lunata, F. moniliforme, M. phaseolina, A. niger and A. flavus were predominant on cv. Syndewaki-75. The latter cultivar carried more fungal forms and was more susceptible (Parate and Lanjewar, 1987).

Indira Kalyanasundaram and Rao (1988) reported that, out of 148 South Indian rice samples analysed, 84 per cent harboured storage fungi internally. The fungi included several Aspergillus spp. and some Penicillium spp. Statistical analysis revealed that the extent of invasion was correlated with the source of the sample (regions), nature of grain and varietal groups.

Chandrashekarappa et al. (1989) collected 207 seed samples belonging to 61 different cultivars from various regions of Karnataka and tested for kernel smut incidence. The percentage incidence ranged from 0.1 to 0.3. The kernel smut of paddy had been earlier reported from the coastal district of Karnataka. Later it was detected even in other

districts viz., Raichur, Shimoga and Uttar Kannada. Forty per cent of the samples recorded surface borne inoculum. Different varieties from the same location and the same varieties from various locations varied in their per cent infection and inoculum load.

Three paddy cultivars viz., Rajamudi, Rajkayame and IR20 collected from different agroclimatic regions of Karnataka were subjected to seed health testing by standard blotter method to determine fungal incidence. Different fungi like Drechslera, Trichoconiella padwickii, F. mohilliforme, Curvularia and Cladosporium. Spp. were detected (Shubha Krishnamurthy et al., 1989).

Discoloured seeds from four locations viz., Ambarpet, Faizabad, Ghagharghat and Moncombu, were subjected to testing. The predominant fungi identified were Drechslera spp. Alternaria Spp. Curvularia Spp. and Fusarium spp. (DRR., 1990).

Sharma et al. (1990) reported varying degree of discolouration and fungi incidence in 163 rain damaged samples of paddy from different districts of Punjab.

2.2 Seed Storability

In stored seeds, ageing is an universal physiological phenomenon followed by deterioration resulting in loss of viability. Usually it progresses at a faster rate under

stress or unfavourable environment and its effect poses problem in modern agricultural production. The mechanism of deterioration which is the final stage of ageing process is still an enigma. A brief review of seed longevity and their possible causes of loss of viability and consequences of deterioration are presented below.

2.2.1 The life span of seed

On the basis of duration of life of seed under optimum conditions, seeds can be classified into i) microbiotic seeds with a life span of three years, ii) mesobiotic seeds with a life span of 3 to 15 years and iii) macrobiotic seeds with a life span of 15 to over 100 years. According to Simon (1958) the viability of oats, maize and barley was found to be 23, 12 and 11 years, respectively.

The seeds of major tropical and sub-tropical crops have been classified as good, intermediate and poor storers under ambient conditions of warm-humid places (Delouche et al., 1973). According to that the seeds of maize, sorghum are intermediate storers, paddy is a good storer and groundnut, and soybean are poor storers.

2.2.2 Factors influencing longevity of seed

It is still not clear what the critical factors are and by which mechanism loss of viability occurs. Seeds go through a series of changes before they finally lose

viability. Roberts (1972) postulated loss of viability theory into intrinsic and extrinsic, based on internal and external agents causing loss of viability.

i) Production location

Very little information is available on the effect of location of production on seed viability and apparently non-relating location directly to storability of seeds.

Mackay and Tonkin (1967) compared the time required for seeds of four forage to deteriorate to 80 per cent germination. Red clover seed grown in Canada required four years compared to three years for England and New Zealand grown seeds; Perennial ryegrass seed grown in Ireland and New Zealand required four years; American grown meadow fescue required nearly seven years and Irish-grown crested dogtail seed required six years compared with three years for New Zealand grown seeds.

ii) Weather

The obvious preharvest factor affecting seed viability and storability is weather, especially seasonal changes. Farmers and seedsman alike know the perils and risks of excessive moisture and alternate wetting and drying temperature during the later stages of seed maturation and post-maturation stand in the field.

Mackay and Tonkin (1967) showed positive correlations between weather conditions during ripening and harvesting of barley, oats and wheat and the number of years required for the seed to deteriorate to either below 80 per cent or below 50 per cent germination. Haferkamp et al. (1953) concluded from his study that the healthy matured seed stored and harvested in dry weather is a pre-requisite for long storage life. Harrington and Thompson (1952) found that the region where lettuce seed was grown significantly affected its germination at between 24^o to 30^o C. They established a highly positive correlations between germination and temperature 10 to 30 days preceding harvest. Saibabu et al. (1987) reported the short term storability of rain damaged paddy seeds (8 to 10 months). Such results are also reported by Moss et al. (1972) and Promila Kumari et al. (1992).

iii) Genotype Factors

Some kinds of seeds are inherently long lived, others are short lived, while some others have an intermediate life span.

iv) Species character

Differences in storability extend even to the species. Under open storage conditions, seeds of different species differed in viability; seeds of maize, paddy, sorghum, soybean and wheat maintained viability 85, 88, 78, 90 per

cent respectively at the end of 30 months storage (Delouche, 1973). Among cereal seeds, bajra deteriorated faster followed by maize, sorghum, paddy and ragi in all storage conditions like warehouse, flat ventilated and air conditioned (Jawaregowda and Bhole, 1989).

v) Varietal character

Varietal differences in storability of paddy seeds have been reported under ambient storage conditions, seeds of dwarf Ponlais recorded less than 40 per cent germination after one year storage when compared with better storer, i.e., dwarf indica (80 %) varieties (Sikdar, 1988).

Gomez et al. (1986) reported that not all varieties of paddy studied maintained their viability to the same degree after prolonged storage.

vi) Initial seed quality

The storage potential of a seed is greatly affected by seed quality at the time it enters storage or its prestorage history. Seed lot of a given kind, variety, chronological age and germination do not maintain viability equally well in storage, even under identical conditions Gomez et al. (1986) reported that storability of 5 lots of paddy seed produced in the same season and area differed although they were similar in initial germination (79 %). Seed lots of a cultivar with the same initial germination differed greatly

in the rate of decrease in germinability during storage under the same conditions and it was influenced by their pre-storage history (Delouche, 1990).

vii) Other factors

Several other factors have been related to storability of seeds. They are moisture content of seed at harvest in paddy and other cereals (Saibabu et al., 1983), maturity status in corn (Deshpande et al., 1991), season of seed production in paddy (Prabhakar and Mukherjee, 1980), seed size in sorghum (Singh, 1988) and storage containers in paddy (Saibabu et al., 1983).

viii) Relative humidity and temperature

Relative humidity and temperature in storage are the principal external factors that influence seed longevity. Most crops lose viability rapidly at relative humidity approaching 80 per cent, and temperature of 25^o to 30^o, but can be kept up to 10 years at the relative humidity of 50 per cent or less and temperature of 5^o C or lower (Toole, 1950). According to Harrington (1960), the sum of the per cent relative humidity plus the temperature in degree fahrenheit should not exceed 100 for storage. Another report indicates that, for safe storage for one to three years this combined total may be as high as 120 as long as the temperature contributes not more than half the total (Bass, 1967).

Grains of eight lines or hybrids were stored in environments using incubators, desiccators and sulfuric acid treatments. Grain moisture, germination percentages, germination rate and vigour index were affected by genotypes, storage treatment and interaction. All genotypes stored well at less than 20^o C and 30 to 50 per cent relative humidity. The hybrid CSH 6 and its parents 2219 R and CS 3541, maintained a satisfactory minimum germination rate (80 %) up to 80 per cent relative humidity. High temperature was detrimental to all genotypes (Singh, 1987).

ix) Seed moisture content

Under ambient storage conditions, due to hygroscopic nature of seeds, seed moisture content fluctuates and maintains moisture equilibrium with the prevailing relative humidity. Jalote and Vaish (1976) reported that seeds with high moisture content (14 to 16%) deteriorated rapidly within three to six months of storage in gunny bags, the viability fell below 80 per cent, while the seeds with low moisture content (10 to 12%) retained more than 80 per cent viability for 12 to 15 months. Nagarajan and Karivaratharaju (1976) opined that maize seeds with an initial moisture content of 7.63 per cent gained 4.47 per cent over initial moisture after nine months of storage and this increase in moisture was related to the rapid loss of viability of seeds. The rate of decline in viability was observed to be vary

rapid when moisture reached 14 per cent (Khanna and Yadav, 1979) in maize.

Drastic decline in germination of stored paddy (Tellahamsa) in polythene bags with 15 and 13 per cent seed moisture between 10 and 12 months was observed by Saibabu et al. (1983). He further stated that seeds with initial moisture of 11 per cent could be stored for longer time.

2.2.3 Seed deterioration and loss of viability

Many researchers agreed that seed deterioration is a progressive process which has far reaching consequences (Ellis and Roberts, 1981; Ghosh et al., 1981). Generally seed viability and vigour are at maximum at the time of physiological maturity. After this stage seeds begin to deteriorate at varying rates depending on the conditions of storage environment (Roberts and Ellis, 1980).

Delouche (1973) defined seed deterioration as 'Summation of all physical, physiological and biochemical changes occurring in a seed which ultimately leads to its death'. He also characterised seed deterioration as inexorable, irreversible, minimal at the time of physiological maturity and variables among seed kinds, varieties, seed lots of the same variety and among individuals.

2.2.4 Biochemical manifestations of seed deterioration

Delouche (1973) and Copeland (1988) highlighted the consequences of deteriorative changes in seed which include membrane degradation, accumulation of toxic metabolites, decreased enzymatic activity, lipid autoxidation, failure of repair mechanism, genetic degradation, reduced yield, finally loss of germination or death. Some of the major physiological and biochemical events of deterioration are reviewed here.

i) Membrane degradation

It is widely accepted that loss in membrane permeability is one of the causes for loss of viability. Presumably, loss of membrane permeability under unfavourable conditions of storage leads to increased leaching out of seed constituents and thus loss in viability (Ching and Schoolcraft, 1968; Sen, 1977). The leachate exudates as measured by electrical conductivity (Bradnok and Mathews, 1970) was shown to be associated with the loss of vigour and viability. Increased leachate was related to low metabolic activity of seed (Abdul-Baki and Anderson, 1972).

Evidences from ultrastructure and cytochemical investigation in increased membrane aberrations in age of paddy seeds strongly support the loss of viability during storage (Berjak and Villiers, 1972). Krishnaveni and

Ramasamy (1985) reported that, in general the electrical conductivity and leaching of free amino acids and sugars significantly increased with increasing periods of maize seeds storage which was ascribed to the membrane aberrations increasing with increasing age of seed. Similarly Kurdikeri (1991) stated that electrolyte leakage increased with storage period. Such reports were also made by Ghose et al. (1981) in rice.

ii) Enzymatic activity

Loss of viability of seeds in storage has been related to enzymatic activity. Kalpana Sur and Basu (1986) reported high activity of alpha amylase, dehydrogenase and polyphenyl oxidase enzymes in high vigorous and fresh seeds of paddy. The enzyme activity was reduced in aged seeds.

A decreased activity of amylase (Ray et al., 1990; Shenoy et al., 1990; Dhaliwal et al., 1991), ATPase (Paul et al., 1970), catalase (Paul and Mukherji, 1992), glutamic acid decarboxylase (Islam and Delouche, 1973) and increased activity of lipase and oxidase due to seed age is reported by Dhaliwal et al. (1991) and Mukhopadhyaya (1983).

iii) Reduced metabolic activity

Metabolic activity of the seeds was reported to be low in nonviable seeds than in viable seeds. Decrease in ability to form nucleic acid and free nucleotides during long term storage was noticed by Sedenka (1975). Nagashima and

Ota (1986) reported that both ATP content and per cent germination of paddy seeds decreased with increase in storage duration (deterioration).

iv) Free radical damage

Ageing has been partially attributed to the accumulation of free radicals produced by metabolic process (Tappel, 1973). Pammenter et al. (1974) observed free radical damage leading to the deterioration in aged seeds.

v) Chromosome aberrations

Tomar and Singh (1986) related the degree of deterioration or ageing to the spectrum of chromosome aberrations in paddy seeds. Similar reports have been made by Khristov and Khristova (1978) in maize and Rao et al. (1987) in lettuce. The frequency of chromosomal aberrations can be estimated by examining a large number of cell divisions and by evaluating the relative frequency of anaphases showing abnormalities. These abnormalities include bridges, fragments and rings which result from breakage of chromosomes rather than chromatids. These aberrations are most common in meristematic cells of seedling roots and to a lesser extent in shoot tip meristematic cells. This damage allows to evaluate the genetic change potentially altering the genetic integrity of seeds in storage.

vi) Lipid peroxidation

These are two possible changes which could result in membrane deterioration viz., i) the formation of free radicals by peroxidation and ii) changes in the amount of membrane phospholipids due to hydrolysis. Free radicals are highly reactive in species whose action results in the inactivation of enzymes, denaturation of proteins and destruction of DNA and RNA (Mead, 1976). Their activity makes them difficult to detect as they are short lived (Prestley and Leopold, 1979); it has been shown that free radicals of lipid peroxides damage cytochrome C by changing its physical and catalytic properties, suggesting that free radicals attack themselves to the protein by covalent linkages. The analysis of the products of peroxidation has shown an increase in Malonaldehyde (MDG) in nonviable aged seeds of rice (Ray et al., 1990; Ramegowda, 1992).

vii) Accumulation of toxic substances during deterioration

One of the most popular theories has been that loss of viability is due to the accumulation of various substances to toxic levels. Rice provides a good example in which most of the potentially toxic compounds which have been investigated have been claimed to be responsible at various times for loss of viability, eg. Indole acetic acid (IAA) and various other indole derivatives (Sircar and Biswas, 1960), Phenolics including coumarin and ferulic acid. Further, this has been proved by Floris (1970).

2.2.5 Occurrence of storage pests, their effect on seed quality and control

i. Storage pests

The incidence of 10 species of storage paddy insects has been reported by Oliveira et al. (1990). In descending order of frequency these were Rhizopertha dominica, Oryzaephilus surinamensis, Laemophloeus fenugineus, Sitophilus oryzae, Corcyra cephalonica, Tribolium castaneum and Sitotroga cerealella. Similar reports were also made by Sukprakaran (1985) and Sauphanor (1988).

Uttam et al. (1985) observed the percentage of damaged seed and loss in weight in all varieties of paddy seed increased significantly with an increase in population of R. dominica. The varieties IR 8, Jaya and Madhu were found comparatively resistant, while Mahsuri, Sona and P 23 as most susceptible. Such reports were also made by Nigam et al. (1987).

Prakash and Kuraw (1983) observed losses in viability ranging from 3.67 to 41.0 per cent in paddy with infection ranging from 1.43 to 4.05 per cent over a period of three to nine months of storage.

Reduction in germination percentage ranging from 7.0 to 2.6 was noticed in eight paddy varieties during six months storage (Subhakar, 1992). Maximum loss in germination was observed in the variety Intan and minimum in Mandya Vani.

Varieties differed significantly for loss in viability and vigour due to attack of R. dominica. In other cereals, similar reports have been made by Karan Singh et al. (1975) in wheat and maize due to S. oryzae and Girish et al. (1975) in wheat due to Trogoderma granarium.

Investigation of Girish et al. (1990) revealed that malathion gave 40 per cent mortality after 15 days of treatment against R. dominica infesting wheat.

ii) Storage fungi

Paddy is known to suffer from many fungal and other seed borne disease as listed by Agrawal and Sinklare (1987). Seventeen fungal species were isolated from discoloured seeds (Sharma et al., 1987).

Ahuja and Ahuja (1982) observed decline in germination and seedling vigour due to discolouration. Varieties varied for their viability against infection. Neelakant (1982) studied the quality attribute of rice seeds of the varieties 'Prakash' as influenced by Drechslera oryzae infection. Germination percentage drastically decreased from 85 to 30 per cent as infection percentage increased. Seedling vigour followed the same trend.

The beneficial effect of seed treatment with fungicides on germination was also reported by Sivaprakasam et al. (1976).

Vyas and Neme (1975) observed the better germinability of treated sorghum seeds over untreated control stored at different relative humidities. However, viability declined with increase in storage period (Deshpande, 1988). Asokan et al. (1980) treated the rice seeds with Ceresan and Agrosan. They recorded higher germination of treated seeds as compared to control.

Out of ten fungicides treated, Ceresan followed by Captan and Bavistin were best to inhibit the majority of fungi (Anahosur and Hegde, 1980) in sorghum. Neelakant (1982) observed that fungicides like Dithane M45 and Parasan were proved to be better than the rest by exhibiting higher germinability against infection by P. oryzae. Similar opinion was expressed by Sathyanarayan and Ranganathaiah (1988) against T. padwicki.

Pawar et al. (1985) observed significant improvement in germination, seedling length when treated with Dithane M45. Captan treated seeds recorded the highest germination of 96 per cent after eight months of storage (Mathur et al., 1982). Sharma et al. (1990) reported the superiority of Dithane M45, Thiram and Captan against rain damaged and discoloured rice seeds.

2.3 Feasibility of Vegetative Propagation in Varieties and Rice Hybrids

The major constraints for the commercialization of rice hybrid in India is the problem associated with hybrid seed

production. The seed yields in hybrid seed production are discouragingly low. In this background, the vegetative propagation of rice offer scope both to increase cropping intensity under rainfed areas and also to commercialise rice hybrids. Rice, being a member of the grass family, is amenable for vegetative propagation. Ratooning, stubble planting, and tiller separation and planting are the vegetative propagation methods possible in rice, although ratooning is the common method commercially adopted.

2.3.1 Rice ratooning

Ratoon cropping usually referred to as 'second crop' or pruned crop in literature, is realised on regeneration of stubble i.e., tillers developing from the base or crown of the plant after the harvest of crop of previous season. Ratooning has the following advantages:

1. Ensures maximum use of a growing season that may be too short for two sown crops in succession.
2. Difficulties such as poor germination or slow seedling growth due to low temperature at the time of raising nurseries and problem of rains at harvesting can be easily avoided.
3. Ratoon crop cultivation is very cheap, hence, the low cost of cultivation per unit land area.
4. The irrigation water requirement of a ratoon crop is much lower to that of newly planted second crop.
5. Many times, ratoon crop yields as much as or some times more than that of a main crop in a given period of time.

6. In some place, it provides employment in the off-season.
7. Duration of the ratoon crop can be manipulated to some extent according to availability of water and time through altering harvesting time and cutting heights.
8. Possible to maintain genetic purity of variety or hybrid rice through several seasons.
9. In hybrid rice programme, maintenance of parental lines and saving on fresh hybrid seeds is possible through ratooning.

2.3.1.1 Ratoon mechanism and variability

Rice ratooning depends on the ability of dormant buds on the stubble of the first crop to remain viable. The buds exist in various stages of development (Nair and Sahadevan, 1961). Axillary buds that develop at those nodes grow into ratoon tillers. In IR 5 and IR 8, each of the four nodes above the ground has buds with regrowth potential (Prashar, 1970). Tillers regenerated from higher nodes formed more quickly, grew faster and matured earlier.

Different varieties produce ratoon tillers differently (Volkova and Smetanin, 1971). Kuban 3 grew tillers from all nodes of the stubble, whereas Krasnodarskii 424 formed tillers only from lower nodes. Those and similar findings indicate ratoon crops will yield well if main crop stubble is left with two to three nodes. The C:N ratio also varied with the origin of ratoon tillers. Tillers from upper nodes with higher C:N reacted like old seedlings. Tillers from the lower nodes with low C:N ratio have young seedling characters. Therefore, the development of lower tillers should be

encouraged (Iso, 1954). Ratoon tillers from lower nodes have best yielding ability potential (Aubin, 1979). Several studies showed that ratoon tiller development depends on the carbohydrates that remain in the stubble and roots after the main crop is harvested. Thick culms may store more carbohydrates than thin culms; and probably would be reflected in ratoon potential. Origin and time of tiller development were not influenced by culms thickness (Cuevasperez, 1980).

2.3.1.2 Factors influencing ratooning ability

Inherent ratooning ability is important. Tillering is probably the most important genetic factor affecting ratoon performance of grasses (Plucknett et al., 1978). Main crop growth duration has been reported to influence ratooning ability (Cuevasperez, 1980), and early maturing cultivars do not produce a successful second crop (Hodges and Evatt, 1969). However, Chatterjee et al. (1982) harvested a satisfactory but low ratoon yield from a wet season crop of an early maturing variety. Main crop growth duration was correlated with that of the ratoon crop (Mahadevappa, 1979) and ratoon crop yield was correlated with main crop growth duration ($r = 0.803^{**}$). Cutting height of the main crop decides the duration and performance of ratoon crop (Volkova and Smetanin, 1971). Regardless of cutting height, ratoon yields seldom are as high as main crop yield (Bahar and DeDatta, 1977).

Stage of maturity at main crop harvest affects ratooning (Haque, 1975). When the main crop was harvested late, ratoon tillers began to develop soon after the first crop ripened. In this situation, the culms of the growing ratoon tillers were damaged because they elongated within the old leaf sheaths (Szokolay, 1956). Grist (1965) and Parago (1963) have suggested to harvest the main crop when they are still greenish. For good ratooning, stalks should be cut before the main crop is fully matured (Balasubramanian et al., 1970) or at full maturity when the ratoon shoots have just begun to grow (Szokolay, 1956). Votong (1975) reported the decline in ratoon crop growth duration due to delay in main crop harvest for 44 to 56 days after flowering. Ratoon growth duration, weight, height and percentage of ratoon tillers declined if cutting was delayed 10 to 20 days after heading (Ichii and Kuwada, 1981). However, ratoon traits improved slightly with cutting 30 to 40 days after heading. In another study, Reddy et al. (1979) did not observe significant influence on ratoon yields when main crop was harvested 30, 35 and 40 days after flowering. Xiong Hong et al. (1991) reported that main crop cutting at 34 days after heading i.e., when axillary buds began sprouting, resulted in high yields in both the crops and high yield of ratoon crop was attributed to higher number of productive tillers. Cutting time of main crop was significantly correlated with

yield of main crop and the number of axillary buds sprouting, number of productive panicles and ratoon yield.

2.3.1.3 Seed production through ratooning of parents

Patil and Mahadevappa (1988) achieved synchrony of flowering by adjusting the cutting time and frequency of main crop of KMS 1 and Intan mutant when uncut as well as single cut and two times cut tillers were allowed in a single plant. The plant could supply pollen for 22 days which is a plus point for using ratooning in hybrid rice production.

Chauhan (1988) reported the ratooning of male sterile and maintainer lines in the seed multiplication plots, the second flowering in ratoon crop can increase seed yield of male sterile lines whereas ratooning of restorer lines, and male sterile lines in the hybrid seed production plots would increase seed yield per se. This would be an additional advantage at no extra cost. He felt the need for further studies to explore the potentials and problems of ratooning male sterile, maintainer and restorer lines.

Seed production of parents and hybrids in rice is possible through ratooning of parental lines. A considerable seed yield was obtained during ratoon seed production of experimental hybrids. viz., IR 54752A/IR 46 R, IR 54752A/IR 54 R and IR 54752A/ IR 27315 R (UAS., 1989).

2.3.1.4 Ratoon yield

Varietal differences are also enormous in respect of yield and other characters. The yield obtainable from ratoon crop ranged from 6 to 140 per cent of the main crop. While the yield of main crop varied from 0.8 to 7.5 t/ha and the respective ratoon yield ranged from 0.1 to 8.7 t/ha (Mahadevappa et al., 1988). IR 8 recorded maximum of 115.3 per cent of the main crop yield accounting for only 3.5 t/ha against 3.0 t/ha of the main crop yield (Palchamy and Soundarapandian, 1988). Srinivasan (1990) noticed superiority of cv. Bhavani over Ponni in all growth and yield attributes. Bhavani ratoon crop yielded 2.8 t/ha, 50 per cent of its main yield, where Ponni produced 38 per cent of its main crop yield (1.8 t/ha). Ratoonability and ratoon yield of parents and their 30 hybrids were tested in Tamilnadu. Results revealed that all parents except MDU 3 and IET 9293 showed high number of regenerated tillers (Arumugachamy et al., 1991).

2.3.1.5 Seed quality of main crop vs. ratoon crop

The productivity or the viability of the seeds from ratoon crops of a number of rice varieties was not different from that of main crop seeds in comparative studies conducted by Saran and Prasad (1952) and Reddy and Pawar (1959). Even the quality of ratoon crop seeds was graded No.1 in Gulfrose variety of rice (Gay, 1961). In spite of less uniform size,

shape and weight, the protein content of the ratoon crop seed was considerably higher than that of the main crop (Webb et al., 1975). In case of sorghum, ratoon crop seeds recorded higher protein content (Azeredo et al., 1976) and lesser thousand seed weight as stated by Rao and Damodaran (1972) than that of main crop.

Nagaraj (1984), in his study on seed quality of main and ratoon crop seeds, observed higher thousand seed weight in main crop of rice varieties viz., Mangala, Mulliam Puncha, Cold Adakkan 74 and Mingolo than that of ratoon crop except in cold Adakkan 74. High germination per cent was recorded by the main crop seeds of varieties Mangala, Cold Adakkan 27, Mulliam Puncha, Cold Adakkan 74, respectively as against lower values in respective ratoon crop seeds. In all the varieties except Mingolo higher values of speed of germination and vigour indices were seen in the main crop seeds than their ratoon seeds. Higher root-shoot lengths were recorded in the varieties CH 2 and Cold Adakkan in the main crop seeds as compared to ratoon. The varieties Mulliam Puncha, CH2 and Cold Adakkan recorded significantly high dry weight of seedlings when compared to the respective ratoon crop seeds.

In CTH 1 (Mukthi) rice, 1000-seed weight of main crop was higher than that of ratoon crop. Contrary to this the variety KBCP recorded higher 1000-seed weight in ratoon seeds

than main crop (Vasundhara, 1987). She also recorded the higher shoot length and root length in ratoon crop seeds except in CH2. Maximum germination and speed of germination were observed in main crop; vigour index was higher in main crop than in corresponding ratoon crop.

Rosamma et al. (1988) stated that ratoon crop seeds of rice germinated as good as main crop seeds despite lower grain weight. Varietal differences were observed for both the traits. The main crop seeds of the cultivars CTH 1, Mangala and IR 64 had higher test weight and seed density than respective ratoon crop seeds (Vasudev, 1989). He also observed significantly superior 1000-seed volume of the main crop. The seeds of eight varieties from ratoon crop recorded inferior germinability, field emergence and vigour as compared to their respective main crop seeds. The root shoot length and seedling dry weight varied in some of the varieties studied. However, he could not establish a perfect correlation between main and ratoon crop seeds of eight varieties with respect to electrical conductivity of seed leachate.

2.3.2 Tiller separation and planting

Profused tillering during the early phase of vegetative growth in rice offers a great scope for tiller separation and planting them to establish individual plants and to exploit hybrid vigour. The recovery of total number of tillers and their further performance depends on their tillering

ability, growth duration (response to photoperiod), fertility status and age at which tiller separation was done. Richharia (1960) and Richharia et al. (1964) have indicated scope of extending this technique under normal cultural and environmental conditions.

2.3.2.1 Clonal propagation as a trigger mechanism

Richharia et al. (1964) suggested that vegetative propagation (clonal propagation) would probably act as a trigger mechanism in activating the otherwise dormant bud thereby increasing the scope of vegetative multiplication of individual tillers. The vegetative propagation of rice resulted in an increased grain yield of 9.86 per cent and 15 per cent in two experiments over normal planting. Besides the crop planted with vegetative propagation was found to be shorter in height and non-lodging in character. The vegetative splitting one to one-and-half months after planting temporarily arrested the unwanted growth of the crop and induced fresh roots and more tillers which were attributed to increased grain yield. A full pledged crop could be raised from a limited number of stubbles by repeated splits which resulted in higher production. Nine out of 30 varieties did not show increase in yield due to splitting the tillers three weeks after planting.

Richharia et al. (1964) observed that rice varieties differ in their responses in terms of grain yield to vegetative propagation. Varieties of profuse tillering habit

may be used for tiller multiplication. Tiller plants can stand late planting, establish quicker, give uniform stand and complete flowering earlier than the seed plants by about ten days. The mortality of plants in the field was least when vegetatively propagated seedlings were planted. They have also noticed more number of productive tillers and grain weight per unit area. The percentage of sterile spikelets was the least in tiller crop as compared to seed plants. But Sharma et al. (1987) recorded reduced number of effective tillers, reduced length and size of panicles, higher floral sterility as the sequential splitting were increased. So they did not record a proportionate increase in yield.

Jagannathan and Banerjee (1982) opined that the traditional methods of vegetative propagation in rice are time consuming and uneconomical and a new method of multiplication of hybrid planting materials continuously was emphasized. They separated individual culms from a mother plant after 45 days of transplanting and planted at different spacing. They counted the tillers per hill after 45 days. There was a potentiality for high tillering within a very short period. Mean tiller numbers per clump increased with increased spacing from 10 x 10 cm to 20 x 20 cm. The important outcome of their study was that the time involved in other methods of clonal propagation was considerably

reduced as three to four multiplication generations were possible just within 100 to 120 days.

Sharma et al. (1987) found variation in tillering ability among four rice varieties while the rest of the twenty-one varieties gave significantly higher yield. They also felt that this method could help in rapid multiplication of elite and newly developed cytoplasmic male sterile lines for hybrid rice seed production. Tiller separation and planting was also reported by Sateesha Babu (1986), Padmaja Rao (1990) and NSC (1990) they have reported encouraging results.

2.3.2.2 Performance of different tillers

In general, among different tillers, plants developed from primary tillers possessed higher number of high density grains than those from secondary and tertiary tillers. Tertiary tillers exhibited very poor per cent of high density grains. The chaff, partially filled and poor grade grains were found comparatively more in tertiary tillers (Padmaja Rao, 1990).

Sateesha Babu (1986) studied behaviour of primary, secondary and tertiary tillers for vegetative propagation in respect of growth and yield. The treatments did not vary much with regard to field establishment percentage. However, the highest field establishment (90%) was found in primary tillers of the dwarf variety IR 20 and secondary tillers of

medium statured variety (T 18) and Cold Adakkan as compared to secondary tillers. Number of productive tillers and seed yield differed significantly due to different type of tillers planted. Unproductive tillers were least in primary tiller planted crop in all varieties which gave the maximum yield.

2.3.2.3 Seed quality as influenced by type of tiller

Padmaja Rao (1988) grown two early (Rasi and Ratna) and two late (Mahsuri and Swarnadhan) rice cultivars observed the filled grain pattern among primary and tertiary tillers. Grain filling was uniform among the primary tillers, while it was incomplete in tertiary tillers of the early cultures. However, the difference in grain index between primary and tertiary tillers was negligible among the late cultures. In other words, profuse tillering of early cultures seemed to be unproductive. On the other hand, increased vegetative growth of late cultures may be advantageous in obtaining higher grain index from both primary and tertiary tillers (Venkateswaralu et al. 1987).

Mallik et al. (1988) studied the panicle characters in 10 IR rice cultivars, 16 Oryza glaberrima accessions and sixteen upland rice. They obtained the high density grains (Sp. gr more than 1.20) located mainly on primary panicles.

Seed germination in laboratory and field varied markedly between primary and secondary sympodia under different pickings. In general, cotton seeds from balls

borne on primary sympodia had clearly registered seed germination and field emergence higher than those from secondary sympodia (Merwade et al., 1989).

Selvaraj and Subramanian (1989) reported superiority of seeds from primary and secondary tillers over late flowering tillers. Early flowered tillers recorded the highest seed weight per tiller, 1000-seed weight, germination and vigour. The superior quality of early flowered primary tillers was evident in the accelerated ageing test. They also suggested to use large and early flowering tillers or panicles for breeder seed increase.

Thiagarajan (1990) noticed the existence of an inherent heterogeneity in rice seed quality between tillers of a plant and between plants in a population. The variability was higher in seedling vigour (18%) than in germination (8.4%) between the tillers.

2.3.3 Stubble (slip) planting

Nair and Sahadevan (1961) explored the possibility of propagation through stem cuttings after harvest. They observed that practical possibility exists to obtain large number of plants by stem cutting rather than by planting stubbles. Richharia (1961) reported in detail about the vegetative propagation by repeated stubble planting but Jagannathan and Banerjee (1982) objected this type of propagation because stubble planting poses the problem of

time involvement; wherein only after one complete crop generation the propagation is possible.

Azzini and Rutger (1982) reported the reduction in the seed set on vegetatively propagated crop as compared to seeded crop but Yogeeshha and Mahadevappa (1987) showed better seed set on stubble planted Pankhari 203 A. However they observed non-establishment of stubbles in other CMS lines indicating the varietal difference of regeneration.

Mahadevappa et al. (1989) noted the usefulness of stubble planting in commercial exploitation of hybrid vigour in rice since it eliminates the use of fresh hybrid seeds. They observed the multiplication ratio of 1:15. They could get higher grain yields in some of promising experimental hybrids as stubble crop and seedling planted check varieties. They opined that stubble planting is a most 'promising method'.

The only disadvantage with stubble planting as compared to ratoon cropping is that land preparation is needed for transplanting which has to be done in a traditional way for planting the stubble prepared from the previous crop. Experiments at Bangalore on stubble planting with 10 hybrids revealed that the hybrids IR 54752 A/ARC 11353R, IR54752A/IR 46 R and IR 54752A/ IR 54 R have good potential for stubble planting (Mahadevappa et al.,1989). Radhakrishna (1992) also reported the encouraging results for stubble planted crop.

Economic feasibility

Richharia (1960) mentioned that the vegetative propagation might prove to be of great economic importance as the pure varieties can be multiplied and enough seeds can be made available within a comparatively short time.

A rough estimate of the financial outlay has been given by Jagannathan and Banerjee (1982) which was found to be very much comparable with traditional method, but yielding a much higher amounts of the planting material by separating the culms at the end of vegetative phase and replanting them for maximum tillering and repeating this process several times as to generate large amounts of planting material.

2.4 Effect of Planting Ratio, Synchronization and Chemical Spray on Seed Set and Seed Yield

It is the extent of seed set on outcrossing that determines the success and feasibility of hybrid rice programme. Higher seed set depends on agromorphological traits, floral traits and synchronization of flowering between parents, planting ratio of parents (male to female), use of growth regulators and supplementary pollination. Many researchers have reported successful results on these lines which are reviewed here.

2.4.1 Agromorphological traits influencing outcrossing

2.4.1.1 Plant height

Plant height is one of the important traits to be kept in mind while selecting parents in hybrid development and seed production. At the time of flowering, anthers dehisce and pollen grains move in a zigzag manner and gradually settle down, thereby facilitating some of the pollen grains to get deposited on the stigma of the female parent. Hence, it is desirable that the plant height of male parent be more than that of female parent. Use of a recessive gene for tall habit in rice (Rutger and Carnhan, 1981) should also enable the use of even taller R lines with semidwarf CMS lines to develop semidwarf hybrids. This gene produces a near doubling in the length of the upper most internode, a 12 per cent increase in panicle length with little effect on other internodes or plant characters. The tall plant type would be desirable for wind blown pollen dispersal on the semidwarf female parents.

Chinese researchers are using rice restorer lines which are 10 to 20 cm taller than CMS lines (Virmani and Edwards, 1983). Saran and Sahai (1935) reported that the height of maintainer and restorer lines was a few centimeter more than that of CMS lines, which according to them, was conducive to receive more pollens and ultimately set more number of crossed seeds. Taillebois and Guimaraes (1986) also opined that taller male parent would facilitate better pollen dispersal.

2.4.1.2 Flag leaf angle

Flag leaf angle too plays an important role in pollen movement. If the angle is too narrow in the parents it may obstruct the pollen movement. Wider the flag leaf angle, better the dispersal and availability of the pollen grains. The benefit from parents with wide flag leaf angle is being derived profusely in China especially in the seed production of recently commercialised hybrids.

2.4.1.3 Panicle exertion

Virmani et al. (1980a) found that outcrossing percentage was more on Zhen Shan 97A than on V 20 A because of better panicle exertion and good synchronized flowering. Sarma et al. (1982) reported that one-third of the basal florets in V 20A did not set grains because of lack of panicle exertion and physical hindrance to pollination.

Hassan and Siddiq (1984) opined that the 'B' and 'R' lines should have well exerted panicles to resume increased outcrossing. Taillebois and Guinaraes (1986) stated that clear panicle exertion would facilitate pollen dispersal and stigma reception. Considerable variation for panicle exertion among the cultivars of North-East India was noticed by Sasikumar and Sardana (1987).

Rangaswamy et al. (1987) observed that the reduction in height of A lines due to lack of panicle exertion may be

associated with a non-restorer and sterile cytoplasm. Vinod et al. (1990) opined that panicle exertion might be under the control of cytoplasmic genic factors that control male sterility in rice and reported that sterile plants showed poor panicle exertion compared to fertile plants.

2.4.2 Floral characters influencing outcrossing

2.4.2.1 Time of blooming as influenced by environment

Kadam and Patil (1983) observed under Kolaba conditions that the blooming hastened during bright weather, while damp and cloudy conditions checked it. Grist (1965) reported that delay or failure in pollination prolonged the flowering time. Parmar et al. (1979) reported that a majority of early maturing varieties bloom between 10.00 a.m and 10.30 a.m. while late maturing varieties bloom between 10.30 a.m and 12.00 noon. Along With genetic difference among the varieties, weather conditions were also reported to alter the duration of blooming. Delayed and irregular flowering were common during cloudy or rainy days.

2.4.2.2 Duration of glume opening

Varietal difference with regard to duration of flower opening, ranged from 28 to 93 minutes (Virmani and Athawal, 1973). In CMS lines, V 20A, Zhen Shan 97 A, V 41A and Pankhari 203 A, the floretes remained open for more than 200 minutes and two to three times more than corresponding B lines (IRRI, 1981). Virmani and Edwards (1983) reported that

in general, flowers of rice reached their peak opening between 9.00 a.m. and 11.30 a.m. and sunny days. Mallaiah (1985) reported that the period of flowering was about two-and-a-half hours on normal days and a hour more during cloudy and rainy days. Virmani et al. (1986) under Philippines conditions showed that the 'A' lines in general had larger anthesis period ranging from 306 to 435 minutes and duration of opening longer than their maintainers. Delay or failure in pollination was found to prolong flowering and consequently CMS lines exhibited a longer duration of floret opening than did the fertile plants (Virmani, 1986; Sahai et al., 1987; Ramachandra, 1989).

2.4.2.3 Angle of glume opening

Nagao (1951) reported that genetic and environmental factors, especially temperature and humidity were found to affect the blooming behaviour considerably. He also found that position of tillers influenced the degree of glume opening. Parmar et al. (1979) observed that simultaneous protrusion of all anthers would help in increasing the angle of glume opening, which was found to vary from 25° to 30°, depending on the glume type. Short and coarse spikelets with thick anthers exhibited maximum angle of opening, whereas long slender spikelets with narrow anthers exhibited minimum angle of opening of glumes.

The angle of glume opening in the male sterile line Er-Jiu Nan 1 A was similar to that of either the maintainer or

restorer lines (IR 26 and IR 24), which was favourable for acceptance of external pollen (IRRI, 1981). Patil (1937) reported that a higher number of florets opened between 30° to 40° angle during both summer and Kharif seasons. Kato and Namai (1987) observed that the size of angle between lemma and palea was positively associated with protruding stigma percentage.

2.4.2.4 Anther size

Generally small anther (2.0 to 2.5 mm) were observed in cultivated species and big ones in (4.0 to 5.5 mm) in wild species (Sampath, 1962). Virmani and Athawal (1973) reported about variation in anther length and extended study to get an idea on the quantity of pollen per anther in relation to pollen size. Hassan and Siddiq (1984) opined that the 'B' and 'R' lines should have large anthers with abundant fertile pollens to increase outcrossing. Ramchandra (1989) observed that, generally, the male sterile lines had smaller anthers than their respective maintainer lines.

2.4.2.5 Stigma size, exsertion and receptivity

Virmani et al. (1980) studied stigma length, breadth and exsertion. A wide range of variation was noticed among the cultivars for all these characters. Eleven rice cultivars possessing desirable floral traits influencing outcrossing were identified by them. Hung and Hung (1978) correlated exsertion either positively or negatively with spikelet length, width of pollen and spikelet sterility.

In the male sterile lines and their maintainers, stigma exertion was noticed to be 74.5 and 59.5 per cent in V41A and V 41B, respectively. In ErJiuNan 1A and B it was 30 and 22 per cent respectively in summer (HRT., 1981). In general 'A' lines showed higher stigma exertion than their corresponding 'B' lines (IRRI, 1982).

Receptivity of stigma was six to seven days from the date of emasculation and gradually a decline in the receptivity was noticed after the third day (Weeraratna, 1954). He opined that the stigma receptivity duration is a varietal character. Studies conducted at IRRI, Philippines during 1981 and 1982 revealed that the A lines can receive pollen for a longer period than the corresponding B lines (IRRI., 1982).

Venkataramana (1988) observed stigma of three CMS lines being receptive for 3 to 5 days. A high degree of receptivity was observed for the first 3 days and thereafter it started declining. Xu and Shen (1988) studied receptivity of exerted stigmas in three male sterile lines and concluded that seed set was directly proportional to percentage of exerted stigma and was suggested as an index of stigma receptivity.

2.4.3 Days to 50 per cent flowering

Mahadevappa (1985) found that some of the CMS lines exhibited differences between 'A' and 'B' lines in vigour,

days to 50 per cent flowering. Ramachandra (1989) observed 1 to 10 days difference in days to 50 per cent flowering between 'A' and 'B' lines. Sivasubramanian et al. (1989) studied the performance of five CMS lines along with V 20 A. They reported that heading difference between 'A' and 'B' lines was two or three days in all the lines tested.

2.4.4 Outcrossing rate on male sterile lines

Carnahan et al. (1972) observed seed set of 0.5 to 44 per cent on Oryza glaberrima derivatives, while the seed set ranged from 6 to 31 per cent in 'Birco derivatives'. Twenty-four per cent seed set on male sterile plants by open anemophily was noticed by Mahadevappa (1973). Mazur et al. (1978) in their experiment on seed setting found that atmospheric humidity considerably influenced the extent of seed set during hybridization and the optimum humidity proved to be 70 to 80 per cent.

Virmani et al. (1980a) recorded higher outcrossing (35 to 40 % seed set) on male sterile line Zhen Shan 97A than on V 20A because of its better panicle exertion and synchronized flowering. The higher seed set was observed on the male sterile plant planted across the wind direction. Silitonga (1985) observed that the bagged panicles of V 20A set no seed, while seed set on uncovered panicles varied with distance and direction of pollen source and attributed the low seed setting percentage (5 to 8%) to poor panicle exertion of V 20 A.

The Chinese cytoplasmic male sterile lines V 20A and Zhon Shan 97 A and their corresponding maintainers were evaluated for outcrossing ability. Seed set on A line due to cross pollination ranged from 2 to 10 per cent in the wet season and 21 to 43 per cent in the dry season (BuiBaBonga et al., 1986).

2.4.5 Male to female ratio

To find out the cause for low seed set on male sterile plants, Carnahan et al. (1972) conducted an experiment with 1:5 ratio of pollinator to male sterile plants. They observed zero to five per cent selfed seed set under bag pollination and seed set ranged from 0.5 to 44.0 per cent under natural pollination. Azzini and Rutger (1982), in an experiment to study the amount of outcrossing on three short statured male sterile lines, planted in alternate rows with pollinators, which constituted a mixture of tall varieties, seed set on 'calady ; and earlirose genetic male steriles was very poor and neither of them was considered useful in hybrid seed production or population improvement. The 'birco' cytoplasmic male sterile source showed average seed set of 5.4 per cent in 1978 and 32.5 per cent in 1979. Higher seed set in 1979 was due to better synchrony of parents.

In other experiment V 20 B and A were planted in proportion of 1:2 and 1:4 in east-west direction. Seed set was higher (22.4%) in CMS lines grown in north-south rows 20 cm to the east of V20 B; the seed set percentage

decreased with increase distance from V 20A (Kumar and Sharma, 1984). The recommended the planting of CMS lines and maintainers in north - south rows for hybrid seed production.

Sahai and Chaudhary (1985) reported that in hybrid seed production, the best combination was one row of restorer line at 10 x 10 cm spacing and six rows of A line at 20 x 15 cm spacing. In the CMS seed production, the best combination was four rows of A line at 10 x 10 cm and two rows of B lines at 15 x 10 cm.

Patil (1983) studied seed set on KMS 1 with Pushpa and Intan mutant as pollinators. The best male to female ratio was 1:5 resulting in 12.75 per cent seed set in both season, in contrast to 1:6 and 1:7 ratios. Pradhan and Ratho (1987) indicated that row ratios 1:1 and 1:2 of V 20 B to V 20 A gave higher seed set of 30 to 35 per cent in contrast to the row ratio of 1:4 which gave seed set of only 10 to 15 per cent.

On the basis of the results of 74 crosses behaviour elite cultivars and three CMS lines, 23 restorers, 22 partial restorers and 16 non-restorers of cytoplasmic male sterile were identified (Sahai et al., 1987). They found that the best planting combination was to be one row of restorer line at 10 x 10 cm spacing and six rows of CMS lines at 20 x 15 cm spacing.

Out of six planting ratios examined by Djeacoumar (1988), 2:6 male to female ratio followed by 1:5 recorded the maximum seed set (25.9 %). The higher seed set was due to better synchronization of parental lines. Rangaswamy and Sreerangasamy (1988) evaluated different row ratios for seed production of Zhen shan 97A using Zhenshan 97B as pollinator. Among different male to female row ratios tried (1:1, 1:2, 1:3, 1:4, 1:5 and 1:6) seed set on A line was high with 1:1 row ratio and low with 1:6 .

Among the three ratios tested in Indonesia, seed yields of 1B:4A, 1B:2A were significantly higher than that of 2B:4A. Seed set was not significantly different among the ratios (Satato and Sukamandi, 1989). Out of the five planting ratios studied by Ramachandra (1939), 2:6 ratio recorded the highest yield (416.6 kg) with 9.39 per cent seed set. The ratio 1:6 registered 263.6 kg seed yield per hectare. The lower seed set on V 20A A was due to non-synchrony of parents.

2.3.6 Synchronisation of flowering and seed set

Virmani et al. (1980a) reported that the outcrossing percentage was more on Zhen Shan 97A than on V20 A when planted along with their maintainer lines. They attributed more outcrossing of Zhen Shan 97 A to better panicle exsertion and synchronization of flowering.

Azzini and Rutger (1982) recorded a Seed set of 5.4 per cent in 1978 and 32.5 per cent in 1979 on Birco CMS line. The higher seed set in 1979 apparently was due to better synchronization of flowering of male and female plants.

Liu et al. (1984) suggested some technical measures for increasing seed production of hybrid rice. They stressed that steps be taken to shorten the tillering period of the pollen parent by raising strong seedlings by early application of fertilizers. At the same time the male parents should be transplanted on 3 dates with an intervals of 11 days between first and third instead of transplanting on two dates at eight days intervals to prolong the full flowering period, sowing on three dates increased the seed yield by 35, 47 and 79 per cent respectively, over sowing on three possible combinations.

Mohammad et al. (1984) studied flowering of tillers in different cultivars. They indicated that in breeding programme, the cultivars should be planted at different time in order to get synchronized flowering and crossing.

Staggered sowing of 'B' Plants in different dates gave a higher seed set on A plants. The earliness or lateness and the time gap required varied with the lines studied (Meghachandra Singh, 1986).

Rangaswamy and Sreerangasamy (1988) reported that perfect synchronization of flowering was achieved by pruning the alternate hills of Zhen Shan 97B (male) line. 25 days after planting during multiplication of Zhen Shan 97A/B. Pruned hills flowered one week later to unpruned hills and supplied continuous pollens.

Seed setting percentage was low on Intan mutant A (6.97 %) due to poor synchronization of Intan mutant A with IR 27315 R (restorer line), thereby indicating scope for further improvement of the technique for higher seed set on A line through precise staggering between two parents (Ranachandra, 1989). The lower seed set and yield were also realised on V 20 A (V 20A / IR 36) because flowering dates of female and male parents did not synchronize properly. Similar opinion was expressed by Shanbhogue and Mahadevappa (1991), while studying seed production in promising hybrid Intan Mutant A/ARC 11353 and seed multiplication of Madhu A/B.

2.4.7 Effect of chemical spray to increase seed set and yield

Some of the causes reported for poor seed set are improper synchrony of flowering between male and female parents, short lived pollen viability resulting in improper pollination, competition for nutrients among developing florets, deficiency of secondary and micronutrients and growth hormones. The role of growth regulators in the

transport of metabolites from source to sink in rice has been well documented (Chatterjee et al., 1976).

The growth regulator gibberellic acid (GA3) is used in hybrid rice seed production in China to increase panicle exertion, stigma protrusion, plant height and also to achieve synchrony between primary and secondary tillers. But GA3 is expensive in countries outside China, when applied at 150 g per hectare costs more. It also increase plant height, leading to lodging. The extra exerted panicles can break during the wet season under torrential rains and strong winds (Prasad et al., 1988).

Search for a suitable less expensive substitute for GA3 is being made. Hybrid seed production experiments with sorghum and pearl millet have shown the effectiveness of urea and boric acid sprays in increasing hybrid seed yields and these are available at low cost throughout the world. Besides major nutrients, the micro element boron appears to have a special role in influencing seed filling. Boron plays an important role in increasing pollen germination and viability and results in higher seed set.

2.4.7.1 Effect of gibberellic acid on agronomic characters, floral traits, seed set and yield

Im (1961) obtained early heading in barley by four to 5 days with gibberellic acid treatment. GA3 produced irregular divisions at the apex, which reduced the number of

tunica layers and thus resulted in earlier flowering. Nicholas and May (1964) stated that applied gibberellic acid decisively increased level of endogenous gibberellin and helped in floral initiation. Takahashi et al. (1972) suggested that gibberellic acid treatment in rice triggered the metabolic activity involved in cell division and cell elongation in internodes which are normally accelerated at panicle initiation. Application of GA3 at 50 and 500 ppm to rice at transplanting and at panicle initiation resulted in increased number of cells, more lignified and round parenchyma cells, enlarged air cavities and narrower conductive vessels (Kumar Perumal and Choudhari, 1973).

Increased plant height and drymatter production was observed in corn due to gibberellic acid spray (Kalina, 1963). Similar results are reported by Vasundhara (1987).

Using higher dosage of GA3 (75 g/ha) to make the whole panicle grow taller than flag leaf to avoid leaf clipping (Lin and Yuan, 1980). Spraying of GA3 more time (3-4) at a higher concentration at early heading increased the seed set on female parent up to 65 per cent. Similar report is also stated by Joshi (1976) in Sorghum.

Ray and Choudhari (1981) observed the function of growth hormones in improving grain filling in rice which was attributed to an increase in longevity of leaves thereby

prolonging period of mobilization of metabolites from leaves to grains. Studies of Kaur and Singh (1986) have indicated increase in the number of vascular bundles and size of the phloem area in young peduncles, which facilitated better translocation of metabolites from source to sink. This in turn increased the per cent filled spikelets and 1000-grain weight.

Vasundhara (1987) did not notice any significant difference in number of productive tillers and panicle length with GA3 spray (30 ppm), while Djeaccoumar (1988) recorded higher seed set (26.9 %) on IR 54752A (IR 5452A/ IR46) with spraying of 60 ppm GA3 along with supplementary pollination. But he did not notice any difference in seed set percentage on Intan Mutant A (Intan mutant A/IR 54R) seed production with 30-60 ppm GA3; higher yield was also recorded (14.3 g/plant) with GA3 than control (12.0 g). Similar findings were also reported by Sahai et al. (1987), Prasad et al. (1988) and Yakshengqui (1988) in hybrid seed production. Xu Shijue and Li Bihu (1988) and Shanbhogue and Mahadevappa (1991) observed increased panicle exertion and higher outcrossing in hybrid seed production.

Dharmarajan (1990) observed better panicle exertion (65.5%) by spraying Triacantanol (1 ppm). Foliar application of GA3 to CMS lines of two rice hybrids at the initiation of

ear emergence significantly increased ear extension from flag leaf sheath and significantly increased the cross pollinated seed set and yield (Duan and Ma, 1992). Seed yield reached the maximum in the treatment of 180g GA3 per hectare in two hybrids. Further increase in GA3 concentration showed adverse effects.

2.4.7.2 Effect of boron on pollen viability and seed set

Shatilov and Ikonnikov (1970) found that boron increased the pollen viability, the fertilizing capacity of pollen, the fat content of the seed weight and decreased the number of wilted achenes and percentage of empty achenes of sunflower. Study of Petrov (1970) reported that the increase in pollen germination and per cent seed set due to boron and calcium.

Garg et al. (1980) found the improvement in germination capacity, size and fertility of pollen grains of rice as a result of boron application at 2.5 ppm concentration. Besides these, the grain yield per plant, number of grains per panicle and 1000-seed weight also exhibited virtually the same trend. They also reported that inclusion of boron in nutrient solution with optimum level induced some stimulatory effects on pollen viability and thereby improved the grain yield of rice. Boron stimulated the enzymatic activity and nitrogen metabolism which may be linked with improvement in pollen fertility and growth. Takkar and Randhwa (1978) also

expressed similar opinion and they further stated that boron helps in biosynthesis of protein and carbohydrates in plants.

Agrawal et al. (1981) noticed that boron deficiency resulted in reduced activity of enzyme like catalase, acid phosphatases and invertase but increase in activity of ribonuclease and amylase. Prasad et al. (1988) reported that spraying boric acid (1.5 %) at full booting, initial heading or 20 per cent heading was as effective as GA3. It did not increase plant height. They also obtained the maximum yield from boric acid spraying. Donaire (1991) observed the importance of boron in maintaining acid pH during germination.

2.4.7.3 Effect of urea, potassium nitrate and flower synchrony, on seed set and yield

Joshi (1976) observed hastening of female flowering to achieve synchrony in CSH 5 sorghum by foliar application of urea at 40 to 50 days after planting.

Spraying of urea (2 %) at full booting recorded high yield of 621 kg per hectare on IR 54752A (Prasad et al. 1988) when compared to spraying the same at initial heading (511 kg/ha) and 20 per cent heading (565 kg/ha).

2.4.8 Seed yield

At IIRRI, hybrid seed yields of 1.32 to 1.68 t/ha have been obtained during dry season in an experimental seed production plot (Virmani et al., 1981). Hung et al. (1984)

reported that Zhen Shan 97 A at a row ratio of 4:1 or 6:1 gave a seed set more than 30 per cent producing 1228 kg per ha. In Fujian, average yield was 614 kg of CMS line seed and 1962 kg of hybrid seed per hectare; and Hunan average yields were 1256 kg of CMS line seed and 1352 kg hybrid seed per hectare (Heguiting et al., 1984).

Of the three new hybrid rices evaluated in Changsha in 1986, II-32 A /MM 63 performed well because of the floral traits of CMS line II-32 A such as large stigma good panicle and stigma exertion facilitated a high natural outcrossing rate and seed yield (Xie Fangming, 1986). Singh and Sinha (1987) obtaining a hybrid seed yield of 806 kg per hectare, on the CMS line V 20 A at 2:1 planting ratio and supplemented with other cultural practices and supplementary pollination. In 1983, yields were more than 1.5 t/ha; by 1985, average yield was 2.07 t/ha and maximum yield was 5.4 t/ha. With this, total area devoted to hybrid seed production has been reduced by 2/3 while yield has doubled (Xu Shijue and Li Bihu, 1988). In a study at Bangalore, the treatment clipping with supplementary pollination accounted for the highest seed yield (Dharmarajan, 1990) per plot (0.9 kg) followed by only clipping (0.83 kg) and GA3 60 ppm (0.81 kg).

2.4.9 Seed quality

Higher concentration of GA3 showed adverse effect on seed quality of F₁ hybrids. The seed weight slightly decreased; significant reduction in storability of hybrid seeds was observed though the freshly harvested seeds showed high germination before storage as compared to control (Duan and Ma, 1992).

Tufail Ahmedkhan et al. (1990) reported that dusting sunflower heads with borax gave significantly higher germination (96%) and vigour than the control (84%).

MATERIAL AND METHODS

III. MATERIAL AND METHODS

The study involved five laboratory and nine field experiments conducted with rice genotypes to understand i) The influence of production location and season on initial seed quality, ii) storability as influenced by location and seed treatment at ambient condition, iii) seed production of hybrids through seedling transplanted (main) and ratoon crop and their seed quality, iv) feasibility of vegetative propagation through tiller separation and stubble planting. v) determination of optimum planting ratio, synchronization of flowering and chemical sprays to increase outcrossing, seed yield and seed quality.

Details of the materials and technique adopted during the course of investigations are described in this chapter.

3.1.1 General Description

The laboratory and field experiments were conducted at the Department of Seed Technology, GKVK and the Main Research Station (MRS), Hebbal, Bangalore. This is situated at an altitude of 899 m above mean sea level, 13° North latitude and 77° 31' East longitude. The station lies in southern zone which consists of sandy loam soils with a pH of 6.5.

3.1.2 Climatic conditions

The monthly weather data during crop growth period recorded at the Meteorological Observatory, MRS, Hebbal, Bangalore are presented in Appendix I.

The average rainfall at MRS is 829 mm per annum fairly distributed over five to six months from May to October. The minimum and maximum temperature during the course of investigation ranged from 16^o C to 28.9^o C during 1989, 12.4^o - 34.9^o C during 1990, 15.5^o C - 34.1^o C during 1991 and 12.1^o C to 34.1^o C to 34.0^o C during 1992. The maximum rainfall was during July to October 1989 and May to July 1992. Very less or negligible rainfall was registered during December to April in all the years of crop growth. Maximum relative humidity (RH) ranged from 79 to 96 per cent and minimum ranged from 25 to 71 per cent during the investigation.

Experimental Details

1. Study on Influence of Provenance, Season on Seed Quality Attributes of Some Rice Genotypes

3.2 EXPERIMENT 1: Study on Initial Seed Quality

The fresh seeds of V 20 B, IR 54752 B, Improved sona B, Madhu B, Mangala B, Pushpa B, Intan mutant B and Pragathi B were obtained from four different locations of Karnataka State namely, Main Research Station (MRS), Hebbal, Bangalore; V.C. Farm, Mandya; Regional Research Station (RRS), Mudigere and Agricultural Research Station (ARS), Honnavile, Shimoga, over two seasons viz., 1989 WS and 1990 DS. The geographical situation and the climatic conditions during 1989 WS and 1990 DS as recorded in the respective research stations are given in Appendix II and III.

The details of the treatments are given below:

A. Genotypes

| | |
|----------------------|---------------------|
| G1 - V 20 B | G5 - Pushpa B |
| G2 - Madhu B | G6 - Mangala B |
| G3 - IR 54752 B | G7 - Intan Mutant B |
| G4 - Improved Sona B | G8 - Pragathi B |

B. Locations

L1 - Main Research Station, Hebbal, Bangalore
 L2 - V.C. Farm, Mandya.
 L3 - Agricultural Resrearch Station, Honnavile, Shimoga.
 L4 - Regional Research Station, Mudigere.

C. Seasons

S1 - 1989 Wet season (WS)
 S2 - 1990 Dry season (DS)

Total treatment combinations: 64

The moisture content of freshly harvested seeds was brought down to 10.0 per cent. The various initial seed quality parameters were studied before keeping the material for storage.

3.2.1 Observations recorded on initial seed quality

Pure seed fractions of freshly harvested seeds were used to record the following observations.

- i. Test weight (g)
- ii. Seed volume (cc)

- iii. Seed density (g/cc)
- iv. Germination (%)
- v. Speed of germination
- vi. Field emergence (%)
- vii. Seedling length (cm)
- viii. Vigour index.
- ix. Electrical conductivity (u mhos/cm)
- x. Seed microflora
- xi. Moisture content (%)
- xii. Accelerated ageing

i. **Test weight:** : Thousand-seed weight of each genotype was recorded (in grams) as per the procedure outlined by ISTA (1985).

ii. **Seed volume:** The seeds selected for determining 1000-seed weight were immersed in toluene and the volume of displacement was recorded and expressed in cc.

iii. **Seed density:** The seeds randomly drawn for 1000-seed weight determination were immersed in toluene having a density of 0.0357 g per ml and the volume of displacement was recorded. The density was recorded by using the formula

$$\text{Seed density (g / cc)} = \frac{\text{Seed weight (g)}}{\text{Volume displaced by seed (cc)}}$$

iv. **Standard germination test:** For this test 'Between paper method' described by ISTA (1985) was followed. Germination test was conducted in four replications of 100 seeds each.

The germination counts on 5th and 14th day were taken on normal seedlings and total germination percentage was calculated.

v. Speed of germination: Four hundred seeds from each sample were counted randomly. Hundred seeds were put on surface of sand taken in each box. The seeds were covered with sand by two centimeter thickness and adequate moisture was maintained. Daily count of emerged seedlings was recorded. The speed of germination was calculated by means of the formula described by Malvika Dadlani (1982).

$$SG = \frac{N_1}{D_1} + \frac{N_2}{D_2} + \dots + \frac{N_n}{D_n}$$

Where, SG = Speed of germination.

N : N₁ N_n = Number of emerged seedlings on 1, 2 and n th days after sowing.

D ; D₁ D_n = Number of days after sowing

vi. Seedling length: Ten normal seedlings randomly selected from top one third portion of germination paper during standard germination test on 14th day were taken to measure the root and shoot length. It was measured from the tip of the primary root to the tip of the primary leaf, and mean length was expressed in centimeters (Nandisha and Mahadevappa, 1984)

vii. Dry weight of seedlings: Ten seedlings selected for seedling length measurement were kept in an oven at 85 ± 2 °C for 24 hours. After drying, the seedlings were kept in a

desiccater for cooling. The mean weight of dried seedlings was recorded using a top pan precision balance. Mean weight of ten seedlings was calculated and expressed in milligrams or grams per 10 seedlings.

viii. **Field emergence:** Four replications of 50 seeds were sown at 3 - 4 cm depth with a spacing of 10 x 2 cm. The emergence was recorded on 14th day after sowing. The seedlings with more than 3 cm in length from the soil surface were counted as emerged and expressed in percentage.

ix. **Vigour index:** Vigour index was calculated using the following parameters and expressed as number (Abdual Baki and Anderson, 1973).

$$\text{Vigour Index} = \frac{\text{Germination}}{\text{per cent}} \times \frac{\text{Mean total}}{\text{length of seedlings (cm)}}$$

x. **Electrical conductivity of seed leachate (EC):** Four replications of 5 g seeds of each genotype were weighed up to two decimal places. The seeds were treated with acetone for half minute and were thoroughly washed in distilled water for several times. The seeds were soaked in 25 ml distilled water. Flasks were placed in an incubator at constant temperature at $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$ for 24 hours. The EC of the leachate was measured in the digital conductivity meter model (Sensitive conductivity cell-CCS-811). After subtracting the EC of distilled water from the values obtained from the seed leachate, the actual EC due (the

leached) to electrolytes was measured and expressed in μ mhos/cm at $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$.

xi. Seed health test for seed borne fungi: Detection of seed borne fungi was done by "Blotter paper" method as recommended by ISTA (1985). Twenty-five seeds in each of 4 replications were placed equidistantly in circles in glass petri dishes of 9 cm diameter containing three moist blotters. The blotters were dipped in 0.2 per cent 2,4-D solution to prevent germination of seeds. Sufficient moisture was maintained by adding 0.2 per cent 2,4-D solution. The seeds were incubated for seven days in an incubator at $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$ with 12 hours light and 12 hours dark alternate cycles. After seven days, the seeds were examined by a low power stereobinocular microscope and the different seed borne fungi found on the seed were recorded.

xii. Moisture content (MC): Moisture content of the seeds was determined by high constant temperature method as per the ISTA (1985). Moisture content on wet basis was determined and expressed in percentage using the following formula .

$$\text{Moisture content} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where, W_1 = Weight of dish (g)
 W_2 = Weight of dish with seed sample before drying (g)
 W_3 = weight of dish with seed sample after drying (g)

xiii. Accelerated ageing test: The seeds of each genotype were subjected for accelerated ageing by exposing the seeds to $40\text{ C} \pm 1\text{ C}$ at 98 ± 2 per cent RH (Delouche and Baskin, 1973) up to six days in an ageing chamber. The seeds were removed and dried under shade for 48 hours. The accelerated seeds were subjected to standard germination test to know their germinability.

II. Storability of Rice Genotypes as Influenced by Provenance and Seed Treatment

3.3 EXPERIMENT 2

Two kg of cleaned seeds were treated by using a drum mixer with Thiram at the rate of 2 g per kg of seeds. The seeds and chemicals were placed in the drum and was rotated slowly until all the seeds were covered uniformly. The treater was cleaned before taking up another treatment.

Storage procedure

Thoroughly dried and treated seeds were bagged in cloth bag and the same quantity of untreated seeds of all the 8 genotypes were stored up to 19 months (Jan. 1990 to July, 1991) under ambient conditions in the laboratory of Seed Technology Department, UAS, GKVK, Bangalore.

Treatment details for storage study

The storage study was composed of seeds of eight genotypes produced from four locations and seed treatment along with control. The details are as follows:

A. Genotypes

| | |
|----------------------|---------------------|
| G1 - V 20 B | G5 - Pushpa B |
| G2 - Madhu B | G6 - Mangala B |
| G3 - IR 54752 B | G7 - Intan Mutant B |
| G4 - Improved Sona B | G8 - Pragathi B |

B. Provenance

- L1 - Main Research Station, Hebbal, Bangalore
- L2 - V.C. Farm, Mandya.
- L3 - Agricultural Research Station, Honnavile, Shimoga.
- L4 - Regional Research Station, Mudigere.

Seed treatment :

T - Treated seeds with Thiram (2g/kg)

1

T - Untreated control

2

The following observations were taken bimonthly on randomly drawn samples adopting procedure mentioned in 3.2.1

- i. Germination (%)
- ii. Field emergence (%)
- iii. Seedling length (cm)
- iv. Vigour index
- v. Electrical conductivity of seed leachate (u mhos/cm)
- vi. Moisture content (%)

During the storage period the actual weather data on mean temperature (°C) and relative humidity (%) of storage room were recorded (Appendix IV).

Inside the storage room, temperature was maximum (29.5 C) in the month of March 1991 and minimum (21.3 C) in the month of December 1990. The relative humidity was maximum (62.0%) in August 1990 and minimum (33.0%) in March 1991).

III. Study on Feasibility of Hybrid Seed Production Through Ratooning of Parents (A/R)

3.4 EXPERIMENT 3

Hybrid seed production through main and ratoon crops of parents

The main crop was raised during 1990 DS with the aim of producing five hybrids and subsequently using them for ratoon purpose (Plate 1). The following were the parents of the hybrids and the staggering time given.

i) IR 54752A /ARC 11353 R

Sowing of female IR 54752A - 0th day
Male ARC 11353 - 2 and 5 days before female sowing.
Date of transplanting : 12.1.1991

ii) IR 54752A /IR 54 R

Sowing of female IR 54752A = 0th day
Male IR 54 R = 2 and 5 days before female
Date of transplanting : 13.1.1991

iii) IR 54752A/ IR 46 R

Sowing of female, IR 54752A = 0th day
Male, IR 46R = 2nd and 4th day before sowing of female
Date of transplanting 13.1.1991

iv) Intan mutant A/ IR27315 R

Sowing of female, Intan mutant A = 0th day
Male, IR 27315 = 12 and 16 days before sowing female
Date of transplanting 14.1.1991



Plate 1: Hybrid seed production through ratooning of parents

v) Intan mutant A/ IR 15324 R

Sowing of female, Intan mutant A = 0th day
Male IRI 15324 = 12 and 16 days before sowing female
Date of transplanting 15.1.1991

For the hybrid seed production the male parents were staggered as per days to 50 per cent flowering. The common planting ratio was 1:3 (male to female). The seedlings aged 30 days old were transplanted with the spacing of 20 x 10 cm, the plot size was 10.44 m².

Isolation: Isolation distance for paddy is 3.0 m for pure lines and 100 m for CMS line maintenance and hybrid seed production. Isolation distance could not be practised during the investigation because of many other experiments on the experimental site. Hence, pollen barriers were used by erecting polythene sheets of 1.50 m high all around the experimental plots to avoid pollen contamination from the neighbouring plots.

All agronomic practices and plant protection measures were followed as per package of practice (UAS, 1989a) and when required. Supplementary pollination was done at peak anthesis time by beating with bamboo stick. Both the parents were cut (harvested) at 10 cm stubble height as required to adjust the date of flowering for synchronisation of parents in ratoon crop.

Seed production through ratooning of parents

The main crop cutting of the parents was done to synchronise the flowering of both the parents in ratoon crop. Immediately after ratooning, the plot was cleaned and fertilized at the rate of 50 kg nitrogen, 20 kg P₂O₅ 40 kg K₂O per hectare and plant protection measures were taken as and when required.

The following observations were recorded for both the main and ratoon crops: plant height, productive tillers number, days to 50 per cent flowering, panicle length, total number of spikelets per panicle, filled spikelets per panicle, seed set (%), seed yield per plant and yield per hectare. The procedure for recording above observations is as follows.

3.4.1 Field observations

Ten plants were randomly selected in each replication and labelled.

i) Regeneration per cent : The ratio of number of plants regenerated to the total number of plants in the plot and expressed as percentage.

$$\text{Regeneration (\%)} = \frac{\text{No. of plants regenerated}}{\text{Total No. of plants}}$$

ii) Ratooning ability (RA): RA was determined as the ratio between ratoon tillers and main crop tillers.

$$RA = \frac{\text{Ratoon tillers}}{\text{Main crop tillers}}$$

iii) Plant height: The plant height at the time of maturity was recorded in centimeters measured from the base of the stem at ground level to the tip of the main panicle. The average plant height was then worked out.

iv) Number of tillers per plant: The total number of tillers was counted from the labelled plants to calculate the mean tillers per plant.

v) Number of productive tiller per plant: All the ear bearing tillers (with fertile spikelets) were counted from the labelled plants to calculate the mean productive tillers per plant.

vi) Days to 50 per cent flowering: Number of days elapsed from seeding date to the date when 50 per cent of plants in a row exerted their panicles was expressed in days to 50 per cent flowering.

vii) Panicle length: Length of the panicle was measured in centimeters from the tip of the panicle to the ciliate ring at base.

viii) Panicle exertion: The distance between the ciliated ring and the base of the flag leaf, length of panicle from the ciliate to the tip of the panicle were measured in terms of percentage or centimeter and calculated as per cent panicle exertion.

ix) Number of spikelets per panicle: The number of filled and unfilled spikelets per panicle was counted.

x) Number of filled spikelets per panicle : The total number of filled spikelets per panicle was counted and expressed in number.

xi) Per cent seed set or per cent filled spikelets: The seed set was calculated by using the following formula and expressed as per cent seed set.

$$\text{Per cent seed set} = \frac{\text{No. of filled spikelets}}{\text{No. of filled + unfilled spikelets}} \times 100$$

xii) Seed yield per plant: Total weight of the sun-dried seeds was recorded from the labelled plants to estimate the mean seed yield per plant in gram.

xii) Seed yield per hectare: Seeds from the corresponding net plots were sun-dried and the weight of seeds per net plot was recorded in kg or gram and seed yield per hectare was directly computed.

3.5 EXPERIMENT 4 : Quality of seeds harvested from main and ratoon crops

The F₁ hybrid seeds obtained from the transplanted main and ratoon crops were cleaned and dried to constant moisture content. The following seed quality parameters were recorded to compare their quality viz., test weight, 1000-seed volume, seed density, speed of germination, germination per cent,

field emergence, root length, shoot length, vigour index, seedling dry weight and electrical conductivity of seed leachate. The procedure for recording above parameter are mentioned elsewhere in this chapter (3.2.1).

IV. Vegetative Propagation with Tiller and Stubble/slip planting of Parents, Hybrids and Varieties

3.6. EXPERIMENT 5

Evaluation of some CMS lines, maintainer lines, restorers, hybrids and varieties for their response to vegetative propagation through tiller separation and planting

The experiment was conducted during 1990 DS with 36 genotypes as main crop and their respective tiller propagated plants in split plot design. The plot size was 2.25 m².

Main plot: Propagation method: M = Main crop; T = Tiller crop;

Sub plot: Genotypes.

| A lines | B lines |
|----------------------|-----------------------|
| G1 - V 20A | G10 - V 20 B |
| G2 - Improved Sona A | G11 - Improved Sona B |
| G3 - Mangala A | G12 - Mangala B |
| G4 - Pragathi A | G13 - Pragathi B |
| G5 - IR 54752 A | G14 - IR 54752 B |
| G6 - Pushpa A | G15 - Pushpa B |
| G7 - ES 18 A | G16 - ES 18 B |
| G8 - Madhu WA | G17 - Madhu B |
| G9 - Intan mutant A | G18 - Intan mutant B |

Restorer lines

| | |
|----------------|----------------|
| G19- IR 29723 | G20 - IR 54 |
| G21- IR 46 | |
| G22- ARC 11353 | G23 - IR 20 |
| G24- IR 36 | G25 - IR 15324 |

Hybrids

G26 - Intan mutant A/ARC 11353 R
 G27 - Madhu WA/IR 46 R
 G28 - IR 54752 A/IR 46 R.
 G29 - V 20 A/IR 36 R
 G30 - Madhu WA/IR 15324 R
 G31 - IR 54752 A/IR 27315 R
 G32 - IR 54752 A/ARC 11353 R
 G33 - IR 54752 A/IR 54 R .

Checks

G34 - Jaya
 G35 - Mukthi (CTH 1)
 G36 - Rasi

Nursery preparation: Nursery was well puddled and prepared to fine tith. Basal fertilizer of 1.0 kg N, 0.4 kg P₂O₅ 0.5 kg K₂O / 1000 sq ft) was applied. The pregerminated seeds were sown sparsely and covered with compost. In seedling nursery, standing water was avoided before two leaf stage. At three leaf stage top dressing was made and water level maintained. Thirty and forty days after sowing second top dressing was done with nitrogen. Nursery was kept weed free and plant protection measures were taken as required.

Tranaplanting: Twenty-eight days old seedlings were transplanted to main field and maintained as control. After 52 days of sowing seedlings were uprooted from the same nursery and individual tillers were separated and transplanted in the main field in three replications.

The observations on number of tillers recovered per plant, field establishment per cent, plant height, number of productive tillers, total spikelets per panicle, filled spikelets per panicle, filled spikelets per cent and grain yield were recorded.

Number of tiller recovered per mother plant: The total number of tillers were counted after uprooting the mother plant and separated by splitting and expressed as number.

Procedure for recording other observations is mentioned elsewhere in this chapter (3.4.1).

3.7 EXPERIMENT 6: Field Performance of Tiller Planted Crop as Influenced by Age of Tiller

The experiment consisted of eight entries laid out in split plot design during 1990 WS with three replications. Plot size was 6.48 sq. m treatment. The other details are as follows.

Main plot: Age of tiller

- T0 - Control (Main crop) No tiller separation.
 T1 - Tiller separation after 50 days of sowing.
 T2 - Tiller separation after 70 days of sowing.

Subplot:

- V1 - ARC 11353 R
 V2 - IR 46 R
 V3 - Maihu WA/IR 15324 R
 V4 - IR 54752 A/ARC 11353 R
 V5 - IR 54752 A/IR 54 R
 V6 - IR 54752 A / IR 27315
 V7 - V 20 B
 V8 - ES 18 B

| | | |
|---------------------------------------|---|-----------|
| Date of sowing of control | : | 17.7.1990 |
| Date of transplanting of control: | | 15.8.1990 |
| First tiller separation and planting | : | 6.9.1990 |
| Second tiller separation and planting | : | 26.9.1990 |

Seedling nursery was prepared and vigorous seedlings were raised as described in the experiment 5. Fifty (T1) and seventy (T2) days old seedlings were uprooted and tillers separation was made. Then individual tillers were transplanted in the main field. Twenty eight days old seedlings (T0) transplanted in the main field served as control.

The recommended agronomic and plant protection measures were followed to raise the experiment observations on number of tillers obtained per mother plant during T1 and T2., Plant height, number of total and productive tillers, filled

spikelet (%), grain yield, days to 50 per cent flowering and maturity were recorded.

3.8 EXPERIMENT 7: Seed Quality as Influenced by Type of Tillers

During 1990 DS two restorers viz. IR 46 (G1) and ARC 11353 (G2) were grown under normal practices. At the time of panicle emergence, the tillers were tagged and numbered periodically as the tillers reached maturity. The seeds of particular tiller from 15 plants were subjected to test in order to record various seed quality attributes viz, test weight, germination per cent and vigour before and after ageing. The procedure for recording, above parameters is mentioned elsewhere in this chapter (3.2.1).

3.9 EXPERIMENT 8: Seed Production Through Stubble Cropped Parents and Field Performance of Stubble Planted hybrids

Main crop of 4 A/B of 1990 DS was cut at 10 cm stubble height from the base and stubble were allowed to regenerate. After 12 days of cutting the regenerated were separated into individuals and then planted in puddled plot.

The stubbles of 4 (A/B lines) were planted in 1:1 ratio in 4.2 m² plot and replicated three times during 1990 WS. The plots were isolated by artificial plastic barriers to provide isolation. In the same season four hybrids along with three checks were stubble planted. The recommended agronomic practices were followed.

| <u>Entries:</u> | <u>'A' Lines</u> | <u>'B' Lines</u> |
|-----------------|-----------------------|------------------|
| | V 20 | V 20 |
| | IR 54752 | IR 54752 |
| | ES 18 | ES 18 |
| | Intan mutant | Intan mutant |
| | <u>Hybrids</u> | <u>Checks</u> |
| | Madhu WA/IR 46 | Rasi |
| | V 20 A/IR 36 | IR 20 |
| | Madhu WA/IR 15324 | ARC 11353 |
| | IR 54752A / ARC 11353 | |

Observations recorded:

Number of stubbles obtained from single mother plant

The stubbles were split and separated into individuals from a single mother plant and counted to express as number.

Field establishment of stubbles

The total number of stubbles established 15 days after planting were counted and expressed in percentage.

Plant height, tiller number per plant, productive tillers per plant, yield per plant and hectare were also recorded as stated elsewhere in this chapter (3.4.1).

3.10 EXPERIMENT 9: Performance of Stubble Crop as Influenced by Time of Main Crop Harvest

The main crop was raised during 1990 WS and was cut 3 times as per treatments and was allowed to ratoon. After 12 days, the regenerated stubbles were uprooted, tillers separated and planted in 6.96 m² plot. The experimental design was split plot replicated 3 times. The treatments are as below.

Main plots: Harvesting time

- H1 - Stubbles obtained from harvesting main crop at physiological maturity.
- H2 - Harvesting one week after physiological maturity
- H3 - Harvesting two weeks after physiological maturity.

Sub plots: Varieties

- V1 - Good ratooner - ARC 11353
- V2 - Poor ratooner - Pushpa
- V3 - F₁ Hybrid - IR 54752 A/ ARC 11353

Observations recorded:

Number of plants regenerated per plot, number of regenerated tillers per plant, field establishment per cent in the main field after planting, height of the plant, number of productive tillers, panicle length, filled spikelets per panicle, yield per plant and hectare. The procedure for recording above parameters is described in Chapter 3.4.1.

3.11 EXPERIMENT 10: Performance of Stubble Crops as Influenced by Stubble Root Dipping

The stubble of the hybrid IR 54752A/ IR 46 R were obtained from the main crop raised during 1990 WS. The stubbles were separated from mother plant and roots were dipped for 25 minutes as per treatment schedule. Then the individual stubble was planted during 1991 DS in the main plot of 2.0m². The experiment design was randomised block design and replicated thrice. The treatment were as follows.

Hybrid - IR 54752A/ IR 46 K

Chemicals - T1 - Emissan (0.1%)
 T2 - Rogar (0.1%)
 T3 - Diammonium phosphate [DAP (3.0%)]
 T4 - Emissan + Rogar
 T5 - Rogar + DAP
 T6 - Emissan + DAP
 T7 - Control
 T8 - Seedling planted check

The following observations viz., field establishment plant height, productive tillers per plant, panicle length, filled spikelets (%) and grain yield. The procedure for recording these parameters are mentioned elsewhere in this chapter (3.4.1).

V. Influence of Planting Ratio, Synchronization of Flowering and Foliar Spray of Chemicals on Seed Set, Seed Yield and Quality in Hybrid Seed Production

3.12 EXPERIMENT 11(1): Determination of Optimum Planting Ratio for Parental Seed Production of IR 62829 A / B

The female and male parents i.e., IR 62829 A and B were planted with eight ratios as follows:

Planting ratio (male to female) :

| | |
|----------|-----------|
| T1 - 1:2 | T5 - 2:4 |
| T2 - 1:3 | T6 - 2:6 |
| T3 - 1:4 | T7 - 2:8 |
| T4 - 1:5 | T8 - 2:10 |

The experimental design was RCBD with 3 replications. The plot size was 14 m^2 . Since 'B' line flower earlier than 'A' line, two staggering of B lines was done by sowing 4 and 8 days later. The transplanting was done on 21.2.1992. Isolation was created by erecting polythene sheets as described earlier. Recommended agronomic practices were followed during the crop growth. Thorough roguing was done in both male and female plants at vegetative stage, flowering and harvest. GA₃ (60 ppm) was sprayed at 5 per cent panicle emergence and supplementary pollination was done by rope pulling at peak anthesis only one time. At physiological maturity, the male parents was harvested first and then the female.

Observations were recorded:

Number of productive tillers per plant, panicle length, total spikelets per panicle, filled spikelets per panicle, seed set per cent, seed yield per plant and per hectare.

3.12.1 EXPERIMENT 11(ii) : Determination of Optimum Planting Ratio for Hybrid Seed Production of IR 62829 A/ IR 9761 -19-1 R

The experiment was carried out during 1992 DS, involving IR 6289A as female and IR 9761-19-1 R as male parent. The design was RCBD with 3 replications having the plot size of 14 m^2 . Treatments composed of 8 planting ratios as described in experiment 11 (i). All the agronomic, seed

technological practices followed and observations recorded were as mentioned in the experiment 11 (i).

3.13 EXPERIMENT 12 (i): Synchronization of Flowering in Maintenance of IR 62829 A/B

The experiment was laid out during 1992 DS involving the following parental lines.

| | | | |
|-----|-----------|---|----------------------|
| | Female | - | IR 62829 A |
| | Male | - | IR 62829 B |
| | Row ratio | - | 2:4 male to female |
| D/S | Female | - | 14.2.1992 |
| | Male | - | 16.2.1992, 18.2.1992 |
| | | | 20.2.1992, 22.2.1992 |
| D/P | | - | 17.3.1992 |

The experimental design was randomised block and replicated 3 times. The plot size was 11.25m² with the following staggering treatments with a row ratio of 2:4.

Treatments:

- T1 - 2 (sowing male 2 days after female)
- T2 - 4 (sowing male 4 days after female)
- T3 - 6 (sowing male 6 days after female)
- T4 - 8 (sowing male 8 days after female)
- T5 - 2,8 (out of 2 male rows, : one row was sown as in T1 and second as in T4)
- T6 - 4,6 (out of 2 male rows, : one row was sown as in T2 and other as in T3)
- T7 - 6,8 (out of 2 male rows, : one row was sown as in T3 and other as in T4)
- T8 - 4,8 (out of 2 male rows, : one row was sown as in T2 and other as in T4)

3.13.1 Experiment 12 (ii) Synchronization of flowering in hybrid seed production of IR 62829 A/IR 9761-19-1R

The experiment was laid out during 1992 DS involving IR 62829 A as female and IR 9761-19-1R as male.

| | | | |
|-----|--------|---|----------------------------------------------|
| D/S | Female | - | 14.1.1992 |
| | Male | - | 21.1.1992, 23.1.1992 25.1.1992, 27.1.1992 |
| D/P | | - | 25.2.1992 |

The experiment was laid out in RCBD with 3² replications. The plot size was 13.5 m with the following treatment combinations (staggering of male parent) and a common row ratio of 2:4 (male to female) was adopted.

Treatment:

T1 - 7 (sowing male 7 days after female sowing)
 T2 - 9 (sowing male 9 days after female sowing)
 T3 - 11 (sowing male 11 days after female sowing)
 T4 - 13 (sowing male 13 days after female sowing)
 T5 - 7,9 (out of 2 male rows, one row sown as in T1 and second sown as in T2)
 T6 - 9,11 (As in T2 and T3)
 T7 - 9,13 (As in T2 and T4)
 T8 - 11,13 (As in T3 and T4)

In case of IR 62829 A/IR 62829 B the male parent 'B' line flowers earlier to female. In hybrid seed production of IR 62829 A/ IR 9761-19-1 R the male parent was staggered 4 times by sowing after female. At boot leaf stage flag clipping and spraying GA (60 ppm) was done. The following observations were common in both the experiments

12(i) and 12(ii) viz., flowering behaviour, number of productive tillers, filled spikelets per panicle, seed set per cent, seed yield per plant and per hectare. The procedure for recording the above observations is mentioned elsewhere in this chapter (3.4.1)

3.14 Experiment 13: Effect of Foliar Chemical Spray on Outcrossing and Seed Yield

The experiment was laid out during 1990 WS , involving IR 54752 A and maintainer IR 54752 B.

D/S: A line : IR 54752 A - 8.7.1990
 B line : IR 54752 B - 10.7.1990 and 12.7.1990

D/P: 9.8.1990

Row ratio 1:3 (male to female)

Treatments:

T1 - Control
T2 - Gibberellic acid (GA₃) 60 ppm
T3 - Urea (1.5%)
T4 - Urea (2.0%)
T5 - KNO₃ (1.0%)
T6 - KNO₃ (1.5%)
T7 - Boric acid (0.5%)
T8 - Boric acid (1.0%)

The experiment was laid out in RCDB with 3₂ replications and a plot size of 7.02 m². Since the maintainer line (IR 54752 R) comes to flowering early by 4 days, 50 per cent of seeds were sown two days and four days after sowing of the female parent. Chemicals were sprayed as per treatment at booting stage and two per cent flowering both the parents. The following observations viz., plant height,

number of productive tiller per plant, panicle exertion, panicle length, filled spikelets per plant, seed set per cent, seed yield, yield per plant, per hectare and test weight were recorded as per the procedure described in 3.4.1.

3.15 EXPERIMENT 14: Seed Quality as Influenced by Foliar Chemical Spray

The seeds harvested from the female line of the experiment 13 were cleaned and dried to safe moisture content (12 %) and subjected to following observations. viz., germination per cent, field emergence per cent, shoot-root length, vigour index, seedling dry weight and AA test response. Procedure for recording above parameters is mentioned in 3.2.1.

3.16 Statistical Analyses

The experimental data were analysed statistically by following the analyses of variance technique appropriate to design outlined by Cochran and Cox (1965), Sundararaj et al. (1972). The 'F' test critical differences, standard error of means, have been provided. The results and discussion are based at probability level of 5 per cent. Some of the data in percentage were transformed in to arcsin root transformation before analysis.

EXPERIMENTAL RESULTS

EXPERIMENTAL RESULTS

The present investigation involved both field and laboratory experiments in order to generate required results to meet the objectives. The results of these experiments are presented in this chapter.

EXPERIMENT -1

4.1 Seed Quality as Influenced by Genotype, Provenance and Season

The seed quality of eight genotypes (maintainer lines) viz., V 20 B (G1), Madhu B (G2), IR 54752 B (G3), Improved sona B (G4), Pushpa B (G5), Mangala B (G6), Intan mutant B (G7) and Pragathi B (G8) produced from four locations viz., Bangalore (L1), Mandya (L2), Shimoga (L3) and Mudigere (L4) during two seasons viz., Wet season (S1) and Dry season (S2) was assessed in the laboratory experiment. The results recorded with respect to the following seed characteristics and seed quality attributes as influenced by genotype, location, season and their interactions are presented herein.

4.1.1 Seed Characteristics

4.1.1.1 Test weight

Data on test weight as influenced by genotype, production location, season and their interactions are presented in Table 1 and Fig. 1.

Genotypes differed significantly for test weight. G1 registered the highest test weight (25.92 g) followed in order by G3 (24.28 g), G8 (23.04 g) and G6 (22.85 g). The lowest weight was shown by G5 (19.04 g).

Significant differences were noticed among the locations for test weight. L2 recorded the highest weight (22.97 g) followed in order by L1 (22.77 g), L3 (22.03g) and the lowest by L4 (21.15 g). Statistical analysis did not indicate significant difference between the two seasons for test weight.

Interaction effects between genotype and production location was found to be significant in respect of test weight. G1L1 registered the highest value being on par with G1L2, and it differed significantly from G1L3 and G1L4; G3L2 and G3L1 were on par. Though the genotypic differences existed, the same genotype registered values in a declining trend from L1 or L2 to L3 and L4.

Interaction between genotype and season was significant for test weight. The genotypes G1, G3 and G8 from S2 season recorded higher test weight than their respective values in S1. But the rest of the genotypes showed reverse trend. The interaction between location and season registered significant difference, except in L1. Genotypes from the rest of the locations produced in S2 recorded higher mean values than those produced in S1. The interaction effects among G x L x S were not statistically significant.

Table 1 . Initial test weight (g) as influenced by genotype, location, season and their interaction effects in rice

| Genotypes | Location / season (G x L x S) | | | | | | | | Mean (G x S) | | | | Location (G x L) | | | | | | | | |
|-----------|-------------------------------|-------|-------|-------|-------|-------|-------|-------|----------------|-------|-------|-------|------------------|-------|-------|----|----|----|----|----|--|
| | L1 | | L2 | | L3 | | L4 | | S1 | | S2 | | L1 | | L2 | | L3 | | L4 | | |
| | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | |
| G1 | 26.87 | 26.75 | 26.88 | 26.70 | 24.75 | 26.72 | 23.98 | 24.75 | 25.62 | 26.23 | 25.92 | 26.81 | 26.79 | 25.73 | 24.36 | | | | | | |
| G2 | 20.97 | 21.23 | 21.50 | 21.25 | 20.07 | 19.74 | 20.08 | 19.59 | 20.65 | 20.45 | 20.55 | 21.10 | 21.37 | 19.90 | 19.83 | | | | | | |
| G3 | 25.22 | 26.13 | 25.43 | 26.00 | 23.98 | 23.32 | 22.19 | 22.00 | 24.20 | 24.36 | 24.28 | 25.67 | 25.71 | 23.65 | 22.09 | | | | | | |
| G4 | 20.59 | 20.61 | 20.95 | 20.15 | 20.26 | 20.22 | 19.43 | 19.49 | 20.30 | 20.36 | 20.33 | 20.60 | 21.05 | 20.24 | 19.46 | | | | | | |
| G5 | 19.32 | 19.30 | 19.09 | 19.10 | 19.01 | 18.96 | 19.00 | 18.56 | 19.10 | 18.98 | 19.04 | 19.31 | 19.09 | 18.98 | 18.78 | | | | | | |
| G6 | 23.35 | 22.33 | 23.41 | 23.66 | 22.93 | 23.23 | 22.10 | 21.84 | 22.94 | 22.76 | 22.85 | 22.84 | 23.53 | 23.08 | 21.97 | | | | | | |
| G7 | 22.60 | 21.13 | 22.46 | 22.08 | 21.82 | 22.09 | 21.19 | 21.12 | 22.02 | 21.60 | 21.81 | 21.86 | 22.27 | 21.95 | 21.15 | | | | | | |
| G8 | 23.90 | 24.11 | 23.82 | 24.09 | 22.52 | 22.85 | 21.02 | 22.06 | 22.81 | 23.27 | 23.04 | 24.00 | 23.95 | 22.68 | 21.54 | | | | | | |
| Mean | 22.85 | 22.69 | 22.94 | 23.00 | 21.91 | 22.14 | 21.12 | 21.17 | 22.20 | 22.25 | 22.77 | 22.97 | 22.03 | 21.15 | | | | | | | |

G L S GxL GxS LxS GxLxS

S.E.M.
C.D. at 5%

0.04 0.03 0.02 0.08 0.06 0.04 0.11
0.11 0.08 NS 0.22 0.15 0.11 0.31

G1 = V20B; G2 = Madhu B; G3 = IR54752 B; G4 = Improved Sona B; G5 = Pustpa B; G6 = Mangala B;
G7 = Intan Mutant B; G8 = Pragathi B; L1 = Bangalore; L2 = Mandya; L3 = Shivnoga; L4 = Mudigere
S1 = Wet season; S2 = Dry season; NS = Not-significant

4.1.1.2 Seed volume

The observations pertaining to thousand seed volume as influenced by genotype, production location season and their interactions are given in Table 2.

Seed volume differed significantly among the selected genotypes, G1 recorded the highest (18.11 cc) seed volume followed in order by G3 (17.68 cc), G8 (17.31 cc) and G7 (16.43 cc). G5 recorded the lowest seed volume (13.96 cc). Locations differed significantly for seed volume. L1 (16.50 cc) recorded the highest and was on par with L2 (16.46 cc) and these two were significantly superior to L3 (16.18 cc) and L4 (15.98 cc). Season S1 and S2 were on par with each other due to seed volume, irrespective of genotype and location.

Interaction between genotype and location was significant. L2G1 combination was superior to the rest and was followed in order by L1G3, L2G3 and L1G1. Significant interaction effect was observed due to genotype and season. Genotypes produced in S1 recorded significantly higher values for seed volume than in S2. G1S1 topped the list followed in order by G3S1, G1S2 and G5S2.

Genotype produced in S1 recorded significantly higher 1000-seed volume than in S2 in all locations. Among the combinations L1S1 registered the highest value but was on par with L2S1 followed by L3S1, L1S2 and L2S2. The

Table 2 . Initial 1000-seed volume (cc) as influenced by genotype, location, season and their interaction effects in rice

| Genotypes | Location / season (G x L x S) | | | | | | | | | | | | | | | | | | |
|--------------|-------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------------|-------|-------|-------|----|----|----|----|
| | L1 | | | L2 | | | L3 | | | L4 | | | | | | | | | |
| | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | | | | | | | |
| Mean (G x S) | | | | | | | | | | | | Mean (G x L) | | | | | | | |
| | | | | | | | | | | | | S1 | S2 | (G) | | L1 | L2 | L3 | L4 |
| G1 | 18.90 | 18.10 | 18.95 | 17.85 | 17.70 | 18.10 | 17.50 | 17.85 | 18.26 | 17.97 | 18.11 | 18.50 | 18.40 | 17.90 | 17.67 | | | | |
| G2 | 15.40 | 15.65 | 15.60 | 15.40 | 15.05 | 15.00 | 15.00 | 14.85 | 15.26 | 15.22 | 15.24 | 15.52 | 15.50 | 15.02 | 14.92 | | | | |
| G3 | 18.65 | 17.95 | 18.70 | 17.80 | 17.95 | 16.95 | 16.80 | 16.70 | 18.02 | 17.35 | 17.68 | 18.30 | 18.25 | 17.45 | 16.75 | | | | |
| G4 | 15.15 | 15.60 | 15.35 | 15.55 | 14.95 | 15.10 | 14.70 | 15.15 | 15.03 | 15.35 | 15.19 | 15.37 | 15.45 | 15.02 | 14.92 | | | | |
| G5 | 14.25 | 14.15 | 14.00 | 14.10 | 14.10 | 13.50 | 14.05 | 13.60 | 14.10 | 13.83 | 13.96 | 14.20 | 14.05 | 13.80 | 13.82 | | | | |
| G6 | 16.95 | 15.00 | 17.00 | 15.35 | 16.75 | 16.50 | 16.80 | 16.10 | 16.87 | 15.73 | 16.30 | 15.97 | 16.17 | 16.62 | 16.45 | | | | |
| G7 | 17.10 | 15.60 | 16.85 | 15.90 | 17.25 | 16.10 | 17.07 | 15.60 | 17.06 | 15.80 | 16.43 | 16.35 | 16.37 | 16.67 | 16.33 | | | | |
| G8 | 17.95 | 17.65 | 17.65 | 17.40 | 17.10 | 16.80 | 16.90 | 17.10 | 17.40 | 17.23 | 17.31 | 17.80 | 17.52 | 16.95 | 17.00 | | | | |
| Mean | 16.79 | 16.21 | 16.76 | 16.16 | 16.35 | 16.00 | 16.10 | 15.86 | 16.50 | 16.06 | 16.50 | 16.46 | 16.18 | 15.98 | | | | | |

G L S GxL LxS GxLS

S.E.m
C.D. at 5%

0.04 0.03 0.02 0.07 0.05 0.04 0.11
0.11 0.07 0.06 0.21 0.15 0.11 0.29

G1 = V20B; G2 = Nadhu B; G3 = IR54752 B; G4 = Improved Sona B; G5 = Pustpa B; G6 = Mangala B;
G7 = Intan Mutant B; G8 = Pragathi B; L1 = Bangalore; L2 = Mandya; L3 = Shimoga; L4 = Mudigere
S1 = wet season; S2 = Dry season;

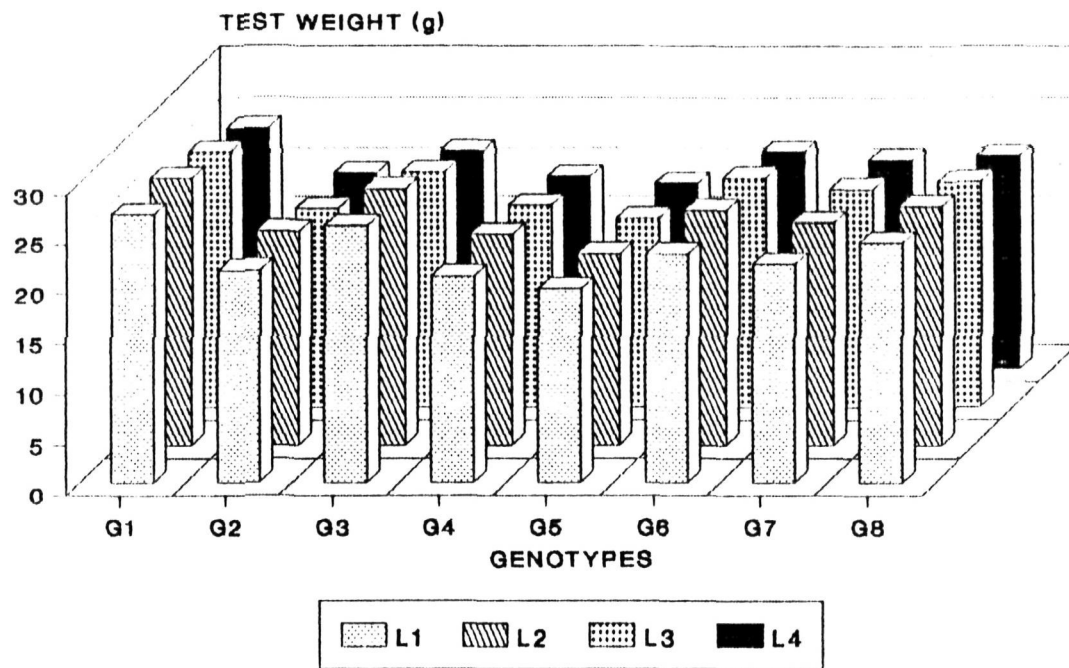


FIG 1. INITIAL TEST WEIGHT (g) AS INFLUENCED BY GENOTYPE AND LOCATION.

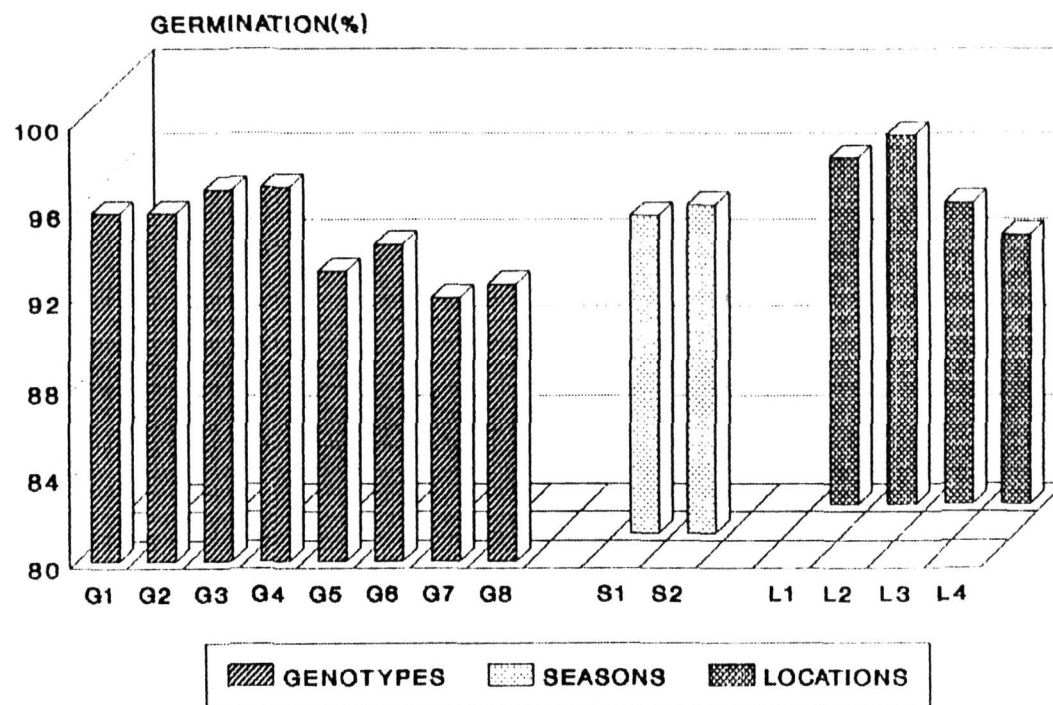


FIG 2. INITIAL GERMINATION AS INFLUENCED BY GENOTYPE, LOCATION AND SEASON.

interactions among genotype, location and season were found to be not significant.

4.1.1.3 Seed density

The data on density of seeds as influenced by genotype, location, season and their interactions are presented in Table 3.

Significant difference was observed for seed density among the genotypes. G1 recorded significantly the highest value (1.43 g/cc) followed in order by G6 (1.40 g/cc), G3 (1.37 g/cc). The lowest density was observed in G7 (1.32 g/cc) and G8 (1.32 g/cc). Results indicated significant differences in seed density due to production locations. L2 (1.39 g/cc) registered the highest followed by L1 (1.37g/cc), L3 (1.36 g/cc) and L4 (1.32 g/cc).

Season S2 recorded significantly higher density (1.38 g/cc) than S1 (1.34 g/cc) irrespective of genotype and location.

The interaction effects between genotype and location were found to be negligible. However, high values for seed density were recorded by G6L2, G1L1, G1L2, G1L3 and G6L1 over the rest of the combinations.

Genotype and season interaction was found to be statistically significant for seed density. G1S2 topped the list followed by G6S2, G1S1 and G3S2. The combinations

Table 3 . Initial seed density (g/cc) as influenced by genotype, location, season and their interaction effects in rice

| Genotypes | Location / season (G x L x S) | | | | | | | | | | | | | | | |
|-------------------------|-------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|----|
| | L1 | | | | L2 | | | | L3 | | | | L4 | | | |
| | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 |
| Mean (G x S) | | | | | | | | | | | | | | | | |
| Mean (G) | | | | | | | | | | | | | | | | |
| Location (G x L) | | | | | | | | | | | | | | | | |
| L1 | | | | | | | | | | | | | | | | |
| L2 | | | | | | | | | | | | | | | | |
| L3 | | | | | | | | | | | | | | | | |
| L4 | | | | | | | | | | | | | | | | |
| G1 | 1.42 | 1.48 | 1.42 | 1.49 | 1.40 | 1.48 | 1.37 | 1.36 | 1.40 | 1.46 | 1.43 | 1.45 | 1.45 | 1.44 | 1.38 | |
| G2 | 1.36 | 1.36 | 1.38 | 1.38 | 1.33 | 1.32 | 1.33 | 1.32 | 1.33 | 1.34 | 1.34 | 1.36 | 1.38 | 1.32 | 1.32 | |
| G3 | 1.35 | 1.46 | 1.36 | 1.46 | 1.34 | 1.38 | 1.32 | 1.32 | 1.34 | 1.40 | 1.37 | 1.40 | 1.41 | 1.36 | 1.32 | |
| G4 | 1.36 | 1.34 | 1.36 | 1.38 | 1.35 | 1.34 | 1.32 | 1.29 | 1.34 | 1.33 | 1.34 | 1.35 | 1.37 | 1.34 | 1.30 | |
| G5 | 1.36 | 1.36 | 1.36 | 1.35 | 1.35 | 1.40 | 1.35 | 1.36 | 1.35 | 1.36 | 1.36 | 1.36 | 1.35 | 1.37 | 1.35 | |
| G6 | 1.38 | 1.48 | 1.38 | 1.54 | 1.37 | 1.41 | 1.30 | 1.36 | 1.35 | 1.44 | 1.40 | 1.43 | 1.46 | 1.39 | 1.33 | |
| G7 | 1.32 | 1.35 | 1.33 | 1.39 | 1.27 | 1.37 | 1.25 | 1.35 | 1.29 | 1.36 | 1.32 | 1.33 | 1.36 | 1.32 | 1.30 | |
| G8 | 1.33 | 1.36 | 1.35 | 1.38 | 1.32 | 1.36 | 1.24 | 1.29 | 1.31 | 1.34 | 1.32 | 1.34 | 1.36 | 1.34 | 1.26 | |
| Mean | 1.36 | 1.39 | 1.36 | 1.42 | 1.34 | 1.38 | 1.31 | 1.33 | 1.34 | 1.38 | 1.34 | 1.37 | 1.39 | 1.36 | 1.32 | |
| G L S GxL GxS LxS GxLxS | | | | | | | | | | | | | | | | |
| S.E.m. | | | | | | | | | | | | | | | | |
| C.D. at 5% | | | | | | | | | | | | | | | | |

G1 = V20B; G2 = Vachhu B; G3 = IR54752 B; G4 = Improved Sona B; G5 = Pustpa B; G6 = Mangala B;
G7 = Intan Mutant B; G8 = Pragathi B; L1 = Bangalore; L2 = Nandyala; L3 = Shingoga; L4 = Mudigere
S1 = wet season; S2 = Dry season; NS = Not-significant

G1S2, G3S2, G6S2, G7S2 and G8S2 recorded significantly higher seed density than their respective values in S1. But G2S2 and G4S2 registered lower values than their respective values in S1. The interaction between location and season was not significant. The same was also true for G x L x S.

4.1.2 Seed Quality

4.1.2.1 Germination

Initial germination percentage as influenced by genotype, location, season and their interaction effects are presented in Table 4 and Fig 2 and 3.

Genotypes differed significantly for germination per cent. G1 recorded the highest germination (96.0 %) followed by G5 (95.7 %) and G6 (95.5%). The lowest germination was registered by G3 (93.3 %). Significant variation in germination per cent was noticed among the locations. Genotypes from Mandya recorded the highest germination (97.0 %) followed by those from Bangalore (95.8 %) and Shimoga, (93.7 %) and the lowest was recorded by the seeds from Mudigere (92.2 %). Genotypes produced in dry season registered significantly higher germination (94.9%) than those produced in wet season (94.4 %) irrespective of genotype and location.

Interaction effects between genotype and location indicated significant differences. G1L2 registered the

Table 4 . Initial germination (%) as influenced by genotype, location, season and their interaction effects in rice

| Genotypes | Location / season (G x L x S) | | | | | | | | Mean (G x S) | | | | Mean (G x L) | | | | | | | | | |
|-----------|-------------------------------|------|------|------|------|------|------|------|--------------|------|------|------|--------------|------|------|------|------|----|-------|----|------|--|
| | L1 | | L2 | | L3 | | L4 | | S1 | | S2 | | L1 | | L2 | | L3 | | L4 | | | |
| | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | | |
| G1 | 97.5 | 98.0 | 99.0 | 98.2 | 94.5 | 97.5 | 93.5 | 89.5 | 96.1 | 95.8 | 96.0 | 97.8 | 96.0 | 97.8 | 96.6 | 96.0 | 91.5 | | | | | |
| G2 | 96.0 | 96.7 | 97.2 | 97.5 | 93.0 | 95.0 | 92.0 | 94.2 | 94.6 | 95.8 | 95.2 | 96.4 | 95.2 | 96.4 | 97.4 | 94.0 | 93.1 | | | | | |
| G3 | 94.2 | 92.7 | 94.5 | 94.7 | 94.0 | 93.0 | 92.2 | 91.2 | 93.7 | 92.9 | 93.3 | 93.4 | 93.3 | 93.4 | 94.6 | 93.5 | 91.7 | | | | | |
| G4 | 94.5 | 95.2 | 96.0 | 96.0 | 90.5 | 90.0 | 90.8 | 91.2 | 93.0 | 93.1 | 93.0 | 94.8 | 93.0 | 94.8 | 96.0 | 90.2 | 91.0 | | | | | |
| G5 | 97.2 | 96.8 | 98.2 | 97.8 | 94.5 | 95.0 | 92.5 | 93.8 | 95.6 | 95.8 | 95.7 | 97.0 | 95.7 | 97.0 | 98.0 | 94.8 | 93.2 | | | | | |
| G6 | 97.0 | 96.8 | 98.9 | 97.3 | 94.2 | 93.9 | 92.5 | 93.0 | 95.7 | 95.3 | 95.5 | 96.9 | 95.5 | 96.9 | 98.1 | 94.1 | 92.8 | | | | | |
| G7 | 94.9 | 94.6 | 95.3 | 95.5 | 92.5 | 94.7 | 92.3 | 93.7 | 93.8 | 94.7 | 94.2 | 94.8 | 94.2 | 94.8 | 95.4 | 93.6 | 93.0 | | | | | |
| G8 | 95.0 | 95.7 | 96.2 | 99.0 | 91.5 | 96.2 | 89.5 | 93.5 | 93.1 | 96.1 | 94.6 | 95.4 | 94.6 | 95.4 | 97.6 | 93.8 | 91.5 | | | | | |
| Mean | 95.8 | 95.8 | 96.9 | 97.0 | 93.1 | 94.4 | 91.9 | 92.5 | 94.4 | 94.9 | 94.9 | 95.8 | 94.9 | 95.8 | 97.0 | 93.7 | 92.2 | | | | | |
| | G | | | | | | | | L | | S | | GxL | | GxS | | LxS | | GxLxS | | | |
| | S.Br+ | | | | | | | | 0.21 | | 0.14 | | 0.10 | | 0.41 | | 0.29 | | 0.21 | | 0.58 | |
| | C.D. at 5% | | | | | | | | 0.57 | | 0.40 | | 0.28 | | 1.14 | | 0.80 | | 0.57 | | 1.60 | |

G1 = V20B; G2 = Madhu B; G3 = IR54752 B; G4 = Improved Sona B; G5 = Pustpa B; G6 = Mangala B; G7 = Intan Mutant B; G8 = Pragathi B; L1 = Bangalore; L2 = Mandya; L3 = Shimoga; L4 = Mudigere S1 = Wet season; S2 = Dry season

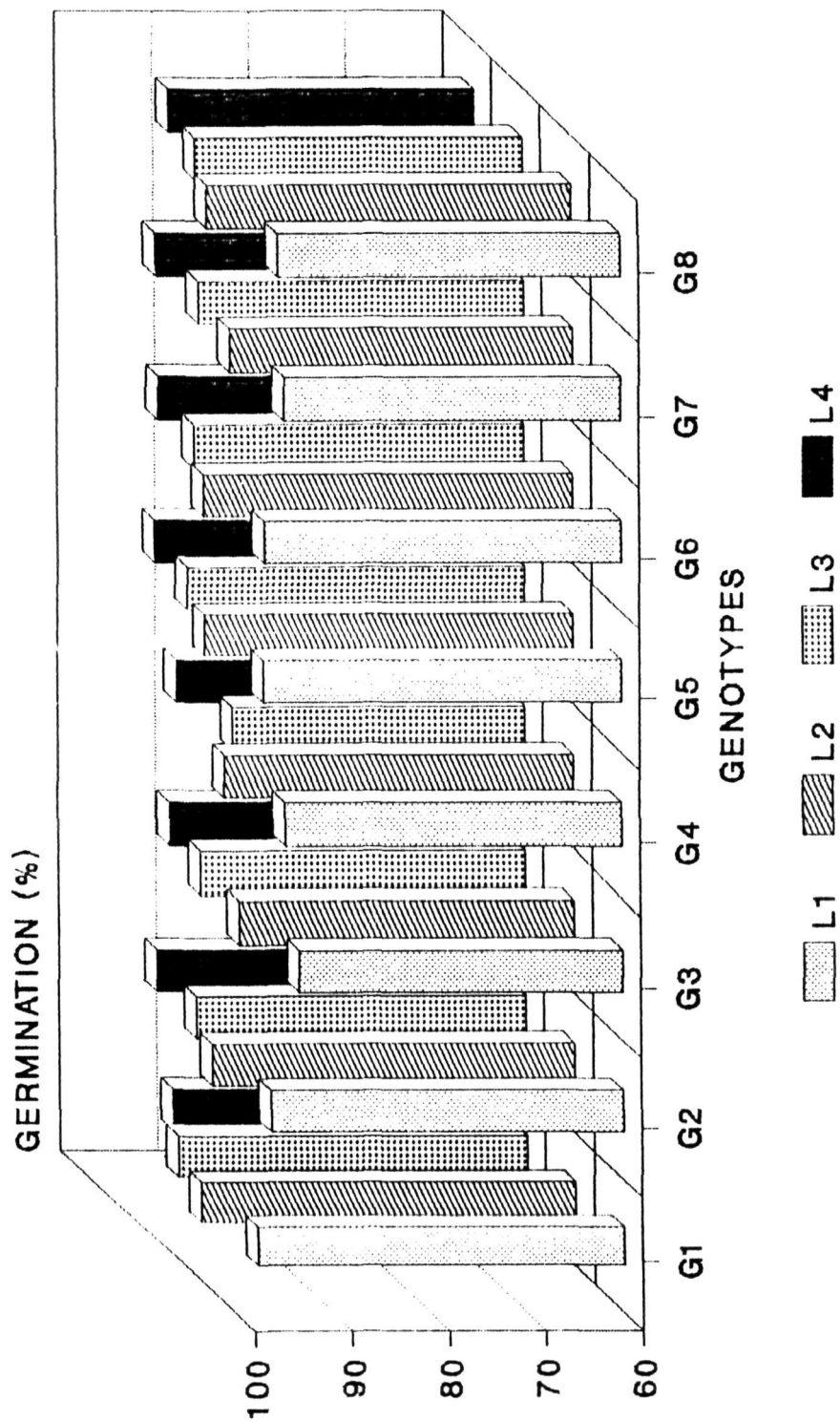


FIG 3. INITIAL GERMINATION (%) AS INFLUENCED BY INTERACTION BETWEEN GENOTYPE AND LOCATION.

highest germination value (98.6%) which was on par with G1L1 (97.8%) and significantly above G1L3 (96.0%) and G1L4 (91.5%). Interaction between genotype and season was significant. G1S1, G3S1 and G2S2, G7S2 and G8S2 recorded significantly higher germination but G4S1 and G4S2, G5S1 and G5S2, and G6S1 and G6S2 were on par with each other. L3S2 and L4S2 differed significantly from L3S1 and L3S2. But these two locations were on par with each other. The interactions among G x L x S were found to be significant with respect to germination.

4.1.2.2 Speed of germination

Speed of germination as influenced by genotypes, season and their interactions are presented in Table 5.

Genotypes differed significantly for speed of germination. Genotype G1 recorded the highest speed of germination (31.6) followed by G5 (30.3) and G8 (30.1). The lowest was registered by G4 (29.0). Significant differences were noticed among the four locations due to speed of germination. The L2 recorded the significantly higher value (33.0) followed by L1 (31.4), L3 (29.1) and L4 (26.0). S2 season recorded significantly higher speed of germination (30.3) than S1 (29.5), irrespective of genotype and location.

Interaction between genotype and location caused for significant differences in respect of their characters. G1L2 registered the highest speed of germination (34.6) which was

Table 5 . Initial speed of germination as influenced by genotype, location, season and their interaction effects in rice

| Genotypes | Location / season (G x L x S) | | | | | | | | Mean (G x S) | | Location (G x L) | | | |
|-----------|-------------------------------|------|------|------|------|------|------|------|--------------|------|------------------|------|------|------|
| | L1 | | L2 | | L3 | | L4 | | S1 | S2 | L1 | L2 | L3 | L4 |
| | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | | | | | | |
| G1 | 33.7 | 33.7 | 35.2 | 33.9 | 29.5 | 31.6 | 27.5 | 27.5 | 31.5 | 31.7 | 33.7 | 34.6 | 30.6 | 27.5 |
| G2 | 30.8 | 32.8 | 30.5 | 33.9 | 29.1 | 29.9 | 24.6 | 28.1 | 28.8 | 31.2 | 31.8 | 32.2 | 29.5 | 26.4 |
| G3 | 31.5 | 29.9 | 35.2 | 30.0 | 32.0 | 26.3 | 26.4 | 27.1 | 31.3 | 28.3 | 30.7 | 32.6 | 29.2 | 26.8 |
| G4 | 29.5 | 33.1 | 31.6 | 34.1 | 26.8 | 28.6 | 23.4 | 24.6 | 27.8 | 30.1 | 31.3 | 32.8 | 27.7 | 24.0 |
| G5 | 32.0 | 31.3 | 34.5 | 32.8 | 29.4 | 30.8 | 21.2 | 30.2 | 29.3 | 31.3 | 31.6 | 33.6 | 30.1 | 25.7 |
| G6 | 28.9 | 30.1 | 32.3 | 31.5 | 27.9 | 28.1 | 26.5 | 26.8 | 28.9 | 29.1 | 29.5 | 31.9 | 28.0 | 26.6 |
| G7 | 30.5 | 31.5 | 33.8 | 34.3 | 27.0 | 29.7 | 23.7 | 24.5 | 28.8 | 30.0 | 31.0 | 34.1 | 28.4 | 24.1 |
| G8 | 31.2 | 31.9 | 31.6 | 32.6 | 29.5 | 30.1 | 26.4 | 27.7 | 29.7 | 30.6 | 31.6 | 32.1 | 29.8 | 27.1 |
| Mean | 31.0 | 31.8 | 33.1 | 32.9 | 28.9 | 29.4 | 25.0 | 27.1 | 29.5 | 30.3 | 31.4 | 33.0 | 29.1 | 26.0 |

| | G | L | S | GxL | GxS | LxS | GxLxS |
|--------------------|------|------|------|------|------|------|-------|
| S.E.m ⁺ | 0.24 | 0.17 | 0.12 | 0.47 | 0.33 | 0.24 | 0.67 |
| C.D. at 5% | 0.65 | 0.46 | 0.33 | 1.31 | 0.92 | 0.65 | 1.84 |

G1 = V20B; G2 = Machu B; G3 = IR54752 B; G4 = Improved Sona B; G5 = Pustpa B; G6 = Mangala B;
 G7 = Intan Mutant B; G8 = Pragathi B; L1 = Bangalore; L2 = Mandya; L3 = Shimoga; L4 = Mudigere
 S1 = Wet season; S2 = Dry season

on par with G1L1 (33.7) and significantly above G1L3 and G1L4 (27.5). Similar trend was recorded by other genotypes in interaction with other locations.

Interaction effects between genotype and season were significant. G2S2, G4S2, G5S2, G7S2 were highly significant and G1S2, G6S2, G8S2 were on par with the same genotypes from wet season (S1) with respect to speed of germination. The interaction between location and season was found to be significant. L2S1 (33.1) recorded the highest during S1 and L2S1 (32.9) during S2 over other interactions of LxS in respective seasons. The interactions due to GxLxS were also found to be significant.

4.1.2.3 Field emergence

Field emergence percentage as influenced by genotype, location, season and their interactions are presented in Table 6.

Field emergence was found to differ significantly among the genotypes. G1 (92.6%) was significantly superior to G5 (90.3%), G2 (90.1%) and G6 (89.3%). The significantly low per cent field emergence was registered by G8 (87.7%). G5 was on par with G2 and G3 with G4 and G7. Significant difference was noticed among locations for per cent field emergence. L2 recorded the highest (93.3%) followed by L1 (91.5%) and L3 (87.5%). The lowest value was registered by L4 (84.9%) for field emergence percentage. Very

Table 6 . Initial field emergence (%) as influenced by genotype, location, season and their interaction effects in rice

| Genotypes | Location / season (G x L x S) | | | | | | | | Mean (G x S) | | Location (G x L) | | | | |
|-----------|-------------------------------|------|------|------|------|------|------|------|--------------|-------|------------------|------|------|------|------|
| | L1 | | L2 | | L3 | | L4 | | S1 | S2 | L1 | L2 | L3 | L4 | |
| | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | | | | | | | |
| G1 | 93.2 | 95.8 | 97.2 | 97.0 | 90.0 | 94.2 | 87.5 | 86.2 | 92.0 | 93.3 | 92.6 | 94.5 | 97.1 | 92.1 | 86.8 |
| G2 | 91.0 | 91.5 | 93.2 | 93.5 | 87.2 | 90.0 | 86.5 | 87.8 | 89.5 | 90.7 | 90.1 | 91.2 | 93.4 | 88.6 | 87.2 |
| G3 | 90.0 | 88.2 | 90.8 | 89.8 | 88.2 | 88.2 | 84.8 | 88.5 | 88.4 | 87.7 | 88.1 | 89.1 | 90.1 | 88.2 | 84.6 |
| G4 | 90.2 | 91.7 | 92.5 | 93.3 | 85.5 | 86.0 | 83.5 | 84.0 | 87.9 | 88.8 | 88.3 | 91.0 | 92.9 | 85.8 | 83.8 |
| G5 | 94.0 | 93.0 | 95.8 | 93.2 | 86.5 | 87.8 | 87.0 | 85.2 | 90.8 | 89.8 | 90.3 | 93.5 | 94.5 | 87.2 | 86.1 |
| G6 | 93.0 | 89.0 | 95.2 | 92.5 | 88.0 | 87.2 | 85.0 | 84.7 | 90.3 | 88.4 | 89.3 | 91.0 | 93.8 | 87.6 | 84.8 |
| G7 | 90.0 | 91.2 | 93.0 | 92.0 | 83.8 | 86.2 | 82.5 | 85.4 | 87.3 | 88.7 | 88.0 | 90.6 | 92.5 | 85.0 | 85.9 |
| G8 | 91.2 | 91.5 | 92.0 | 92.0 | 84.8 | 86.5 | 80.8 | 83.0 | 87.2 | 88.2 | 87.7 | 91.4 | 92.0 | 85.6 | 81.9 |
| Mean | 91.6 | 91.5 | 93.7 | 92.9 | 86.7 | 88.2 | 84.7 | 85.1 | 89.2 | 89.4 | 91.5 | 93.3 | 87.5 | 84.9 | |
| | G | | L | | S | | GxL | GxS | LxS | GxLxS | | | | | |
| | S.E.m ^t | | 0.21 | 0.15 | 0.11 | 0.42 | 0.30 | 0.21 | 0.60 | | | | | | |
| | C.D. at 5% | | 0.60 | 0.42 | NS | 1.16 | 0.63 | 0.60 | 1.66 | | | | | | |

G1 = V20B; G2 = Madhu B; G3 = IR54752 B; G4 = Improved Sona B; G5 = Pushpa B; G6 = Mangala B; G7 = Intan Mutant B; G8 = Pragathi B; L1 = Bangalore; L2 = Mandya; L3 = Shimoga; L4 = Mudigere
 S1 = wet season; S2 = Dry season; NS = Not-significant

insignificant difference was noticed between seasons for per cent field emergence.

Interaction effects between genotype and location were significant. G1L2 was significantly superior to G1L1, G1L3 and G1L4. The genotype G5 from L2, G2L2 showed the same trend of emergence. Irrespective of location, the interaction between genotype and season was significant for per cent field emergence. G1S2, G2S2, G4S2, G7S2, G8S2 were significantly superior to the same genotype from S1 season while G3S2, G5S2, G6S2 were inferior. The interaction due to location and season was significant. For the particular season S1, L2S1 recorded the highest value followed by L1S1, L3S1 and L4S1. For the season S2 also, similar trend was observed. The interaction effects due to GxLxS were found to be significant for field emergence per cent.

4.1.2.4 Seedling length

The data on seedling length as influenced by genotype, location, season and their interaction effects are presented in Table 7.

Genotypes differed significantly for seedling length. G1 recorded the highest length (27.3 cm) followed by G8 (26.4 cm), G5 (25.1 cm) and G6 (24.1 cm). The lowest seedling length was observed in G7 (20.2 cm). Significant differences were noticed among the locations due to seedling

Table 7 . Initial seedling length (cm) as influenced by genotype, location, season and their interaction effects in rice

| Genotypes | Location / season (G x L x S) | | | | | | | | Mean (G x S) | | | | Location (G x L) | | | | | | | | |
|-----------|-------------------------------|------|------|------|------|------|------|------|--------------|------|------|------|------------------|------|------|----|----|----|----|----|--|
| | L1 | | L2 | | L3 | | L4 | | S1 | | S2 | | L1 | | L2 | | L3 | | L4 | | |
| | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | L1 | L2 | L3 | L4 | L1 | L2 | L3 | L4 | |
| G1 | 27.6 | 28.2 | 29.2 | 29.4 | 26.2 | 27.4 | 25.1 | 25.8 | 27.0 | 27.7 | 27.3 | 27.9 | 29.2 | 26.8 | 25.4 | | | | | | |
| G2 | 24.4 | 25.1 | 26.5 | 26.8 | 22.8 | 22.1 | 20.1 | 20.0 | 23.4 | 23.5 | 23.5 | 24.7 | 26.6 | 22.5 | 20.1 | | | | | | |
| G3 | 24.1 | 24.5 | 25.5 | 26.0 | 23.5 | 24.4 | 22.1 | 22.1 | 23.8 | 24.3 | 24.0 | 24.3 | 25.8 | 23.9 | 22.1 | | | | | | |
| G4 | 21.6 | 20.9 | 21.0 | 22.0 | 23.1 | 23.0 | 19.9 | 20.0 | 21.4 | 21.5 | 21.4 | 21.2 | 21.5 | 23.1 | 19.9 | | | | | | |
| G5 | 27.1 | 27.0 | 27.3 | 26.2 | 26.7 | 24.9 | 21.4 | 21.1 | 25.5 | 24.8 | 25.1 | 27.0 | 26.7 | 25.5 | 21.3 | | | | | | |
| G6 | 25.2 | 26.1 | 26.3 | 25.8 | 22.7 | 23.0 | 22.0 | 22.0 | 24.0 | 24.2 | 24.1 | 25.6 | 26.1 | 22.8 | 22.0 | | | | | | |
| G7 | 19.6 | 19.7 | 19.9 | 21.0 | 20.1 | 21.0 | 20.4 | 20.1 | 20.0 | 20.4 | 20.2 | 19.6 | 20.5 | 20.6 | 20.3 | | | | | | |
| G8 | 26.1 | 28.8 | 27.8 | 28.2 | 26.3 | 25.7 | 22.9 | 23.4 | 26.3 | 26.5 | 26.4 | 28.4 | 28.0 | 26.0 | 23.1 | | | | | | |
| Mean | 24.7 | 25.0 | 25.4 | 25.7 | 23.8 | 23.9 | 21.7 | 21.8 | 23.9 | 24.1 | 24.8 | 25.5 | 23.9 | 21.8 | 21.8 | | | | | | |

| | G | L | S | GxL | GxS | LxS | GxLxS |
|------------|------|------|------|------|------|------|-------|
| S.E.m | 0.16 | 0.12 | 0.08 | 0.32 | 0.22 | 0.16 | 0.49 |
| C.D. at 5% | 0.45 | 0.31 | NS | 0.90 | 0.62 | 0.45 | 1.38 |

G1 = V20E; G2 = Madhu B; G3 = IR64752 B; G4 = Improved Sona B; G5 = Pustpa B; G6 = Mangala B;
 G7 = Intan Mutant B; G8 = Pragathi B; L1 = Bangalore; L2 = Mandya; L3 = Shimoga; L4 = Mudigere
 S1 = Wet season; S2 = Dry season; NS = Not-significant

length. L2 was superior (25.5 cm) to L1 (24.8 cm), L3 (23.9 cm) and L4 (21.8 cm). Seedling length did not differ significantly due to season. However, S2 (24.1 cm) recorded numerically greater seedling length than S1 (23.9 cm).

Interaction effects between genotype and location were found to be significant for seedling length. All genotypes from L2 registered higher values except G5, G7 and G8. All the genotypes from L3 were inferior except G7 for seedling length. Interactions between genotype and season was significant. Except the interaction G1S2, all the combinations were on par with respective genotypes in S1 season. Significant interaction was observed between location and season for seedling length. The genotypes produced from L2S1 were superior to those produced from other locations in the same season, but L4S1 was inferior. Genotypes from same location produced in different seasons were on par with each other though numerically higher values were recorded in S2 season. The interactions between genotype, location and season were found to be significant for seedling length.

4.1.2.5 Vigour index

The data on vigour index as influenced by genotype, production location, season and their interactions are given in Table 8 and Fig. 4 and 5.

Genotypes differed significantly for vigour index irrespective of location and season. Genotype G1 recorded

Table 8 . Initial vigour index as influenced by genotype, location, season and their interaction effects in rice

| Genotypes | Location / season (G x L x S) | | | | | | | | Mean (G x S) | | Location (G x L) | | | | |
|-----------|-------------------------------|------|------|------|------|------|------|------|--------------|------|------------------|------|------|------|------|
| | L1 | | L2 | | L3 | | L4 | | S1 | S2 | L1 | L2 | L3 | L4 | |
| | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | | | | | | | |
| G1 | 2688 | 2758 | 2886 | 2882 | 2474 | 2667 | 2346 | 2309 | 2598 | 2654 | 2626 | 2723 | 2884 | 2570 | 2327 |
| G2 | 2338 | 2429 | 2577 | 2608 | 2120 | 2101 | 1852 | 1884 | 2222 | 2255 | 2239 | 2383 | 2592 | 2110 | 1868 |
| G3 | 2273 | 2473 | 2409 | 2462 | 2209 | 2267 | 2037 | 2019 | 2232 | 2306 | 2269 | 2373 | 2435 | 2238 | 2028 |
| G4 | 2037 | 1989 | 2011 | 2112 | 2090 | 2070 | 1803 | 1824 | 1985 | 1999 | 1992 | 2013 | 2061 | 2080 | 1813 |
| G5 | 2634 | 2608 | 2683 | 2557 | 2472 | 2361 | 1981 | 1979 | 2442 | 2376 | 2409 | 2621 | 2620 | 2416 | 1980 |
| G6 | 2442 | 2516 | 2601 | 2510 | 2134 | 2160 | 2033 | 2046 | 2302 | 2308 | 2305 | 2480 | 2555 | 2147 | 2039 |
| G7 | 1856 | 1866 | 1901 | 2005 | 1863 | 1988 | 1887 | 1883 | 1877 | 1935 | 1906 | 1861 | 1953 | 1925 | 1885 |
| G8 | 2664 | 2757 | 2679 | 2793 | 2408 | 2470 | 2051 | 2184 | 2450 | 2551 | 2501 | 2710 | 2736 | 2439 | 2117 |
| Mean | 2366 | 2425 | 2468 | 2491 | 2221 | 2260 | 1999 | 2016 | 2264 | 2298 | 2355 | 2479 | 2240 | 2007 | |

| | G | L | S | GxL | GxS | LxS | GxLxS |
|------------|------|------|------|-------|------|------|-------|
| S.E.D. | 24.8 | 17.6 | 12.4 | 49.6 | 35.1 | 24.8 | 70.2 |
| C.D. at 5% | 68.8 | 48.6 | NS | 137.6 | NS | NS | NS |

S.E.D.
C.D. at 5%

G1 = V20B; G2 = Madhu B; G3 = IR64752 B; G4 = Improved Sona B; G5 = Pustpa B; G6 = Mangala B;
G7 = Intan Mutant B; G8 = Pragathi B; L1 = Bangalore; L2 = Mandya; L3 = Shironga; L4 = Mudigere
S1 = wet season; S2 = Dry season; NS = Not-significant

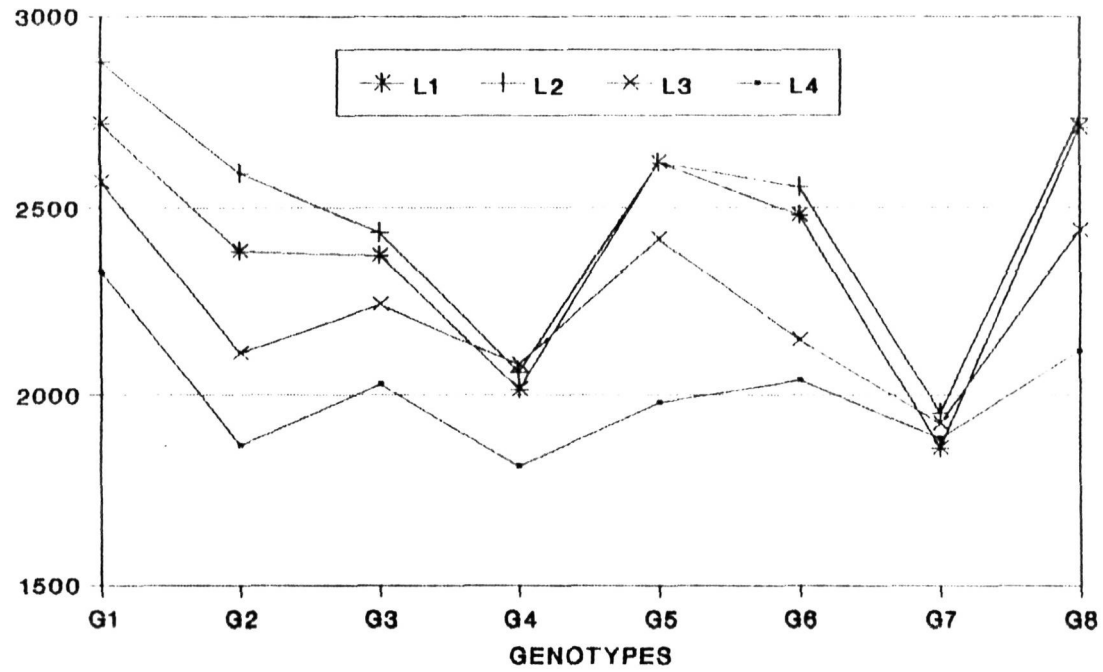


FIG 4. INITIAL VIGOUR INDEX AS INFLUENCED BY GENOTYPE AND LOCATION.

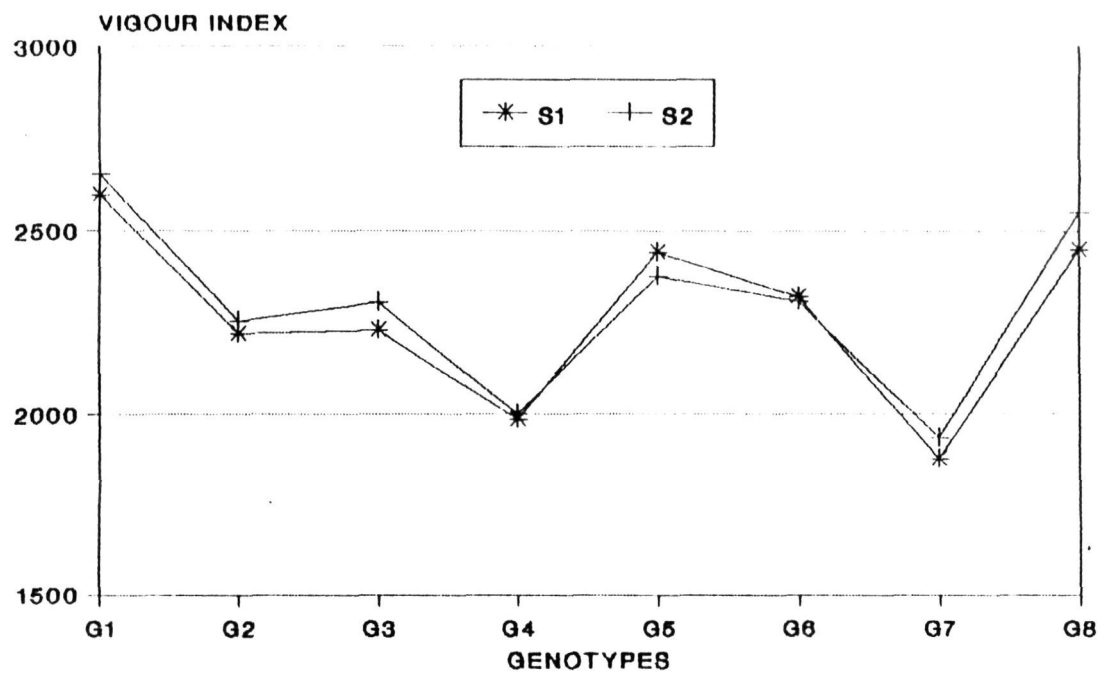


FIG 5. INITIAL VIGOUR INDEX AS INFLUENCED BY INTERACTION OF GENOTYPE AND SEASON.

the highest vigour index (2626) followed by G8 (2501) and G5 (2409). The lowest vigour index was registered by G7 (1906). The genotype G2 and G3, G4 and G7 were all on par. Vigour index differed significantly due to locations. The location L2 registered the highest vigour index (2479) followed in order by L1 (2395), L3 (2240) and the lowest by L4 (2007). Significant difference was not observed between the two seasons S1 (2264) and S2 (2298) for vigour index.

The interaction between genotype and location was significant for vigour index. G1L2 was superior to the rest of the locations with G1 combinations. This was closely followed by G7L2 and G5L2.

Genotype and season interactions at various locations were not significant. The interaction between i) location and season and ii) genotype, location and season were not significant for vigour index.

4.1.2.6 Electrical conductivity of seed leachate (EC)

The data on electrical conductivity of seed leachate as influenced by genotype, location, season and their interactions are given in Table 9.

Significant differences were observed among the genotypes due to EC. The genotype G1 (146 μ mhos/cm) recorded the lowest EC and was on par with G6 (147 μ mhos/cm). This was followed by G5 (148 μ mhos / cm). The highest EC was recorded by G8 (165 μ mhos / cm) followed by G7 (159 μ mhos/cm).

Table 9 . Initial electrical conductivity (μ mhos/cm) as influenced by genotype, location, season and their interaction effect in rice

| Genotypes | Location / season (G x L x S) | | | | | | | | Mean (G x S) | | | | Location (G x L) | | | | | | | | |
|-----------|-------------------------------|-----|-----|-----|-----|-----|-----|-----|--------------|-----|-----|-----|------------------|-----|-----|----|----|----|----|----|--|
| | L1 | | L2 | | L3 | | L4 | | S1 | | S2 | | L1 | | L2 | | L3 | | L4 | | |
| | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | L1 | L2 | L3 | L4 | L1 | L2 | L3 | L4 | |
| G1 | 146 | 140 | 133 | 126 | 152 | 149 | 165 | 162 | 149 | 144 | 146 | 143 | 129 | 150 | 163 | | | | | | |
| G2 | 151 | 150 | 137 | 133 | 158 | 155 | 165 | 166 | 152 | 151 | 152 | 150 | 135 | 156 | 165 | | | | | | |
| G3 | 150 | 152 | 148 | 141 | 169 | 159 | 173 | 165 | 160 | 154 | 157 | 151 | 144 | 164 | 169 | | | | | | |
| G4 | 153 | 150 | 144 | 142 | 163 | 159 | 165 | 161 | 156 | 153 | 154 | 151 | 143 | 161 | 163 | | | | | | |
| G5 | 150 | 153 | 138 | 143 | 150 | 152 | 150 | 150 | 147 | 149 | 148 | 151 | 140 | 151 | 151 | | | | | | |
| G6 | 145 | 150 | 130 | 130 | 150 | 150 | 162 | 158 | 146 | 147 | 147 | 147 | 130 | 150 | 160 | | | | | | |
| G7 | 158 | 154 | 149 | 152 | 165 | 162 | 167 | 166 | 160 | 158 | 159 | 156 | 150 | 164 | 167 | | | | | | |
| G8 | 161 | 160 | 158 | 155 | 172 | 168 | 176 | 170 | 166 | 163 | 165 | 160 | 156 | 170 | 173 | | | | | | |
| Mean | 152 | 151 | 142 | 140 | 160 | 156 | 166 | 163 | 155 | 153 | 152 | 141 | 158 | 164 | | | | | | | |

| S.E.M. C.D. at 5% | G | | L | | S | | G x L | | L x S | | G x L x S | | |
|----------------------|------|------|------|------|------|------|-------|------|-------|------|-----------|------|------|
| | 0.54 | 0.38 | 0.27 | 1.08 | 1.76 | 0.54 | 1.53 | 1.50 | 1.06 | 0.75 | 3.00 | 2.12 | 1.50 |

G1 = V20B; G2 = Madni B; G3 = IR64752 B; G4 = Improved Sona B; G5 = Pushpa B; G6 = Mangala B;
 G7 = Intan Mutant B; G8 = Pragathi B; L1 = Bangalore; L2 = Mandya; L3 = Shiroga; L4 = Mudigere
 S1 = Wet season; S2 = Dry season

EC differed significantly among the locations under the study. L2 (141 μ mhos/cm) registered the lowest EC followed by L1 (152 μ mhos/cm), and L3 (158 μ mhos/cm). The highest EC was recorded in L4 (164 μ mhos/cm). Significant difference was noticed between the seasons in EC. Seeds produced in dry season recorded significantly lower EC value (153 μ mhos/cm) than that produced in wet season (155 μ mhos/cm).

The interactions due to genotype and location were significant. All the genotypes produced from the L2 registered the lowest EC followed by L1, L3 and L4. The interaction G1L2 recorded the lowest EC followed by G6L2, G2L2, G5L2, G1L1 and G4L2. The highest EC was observed in G8 in all locations. Significant differences were also observed due to interaction between genotype and season. The combinations G1S2, G2S2, G3S2, G4S2 and G8S2 showed significantly lower EC as compared to their respective data in S1. Genotype G8 recorded highest EC in both the seasons. The interaction between location and season was significant. The seeds from S2 in L2, L3 and L4 showed significantly lower EC than S1 but seeds from season S2 of L1 were on par with S1 in EC. The interactions due to G x L x S were also significant.

4.1.2.7 Accelerated ageing response (AA)

The data on germination per cent due to AA response as influenced by genotype, production location, season and their interactions are presented in Table 10.

Table 10 . Germination (%) as influenced by genotype, location, season and their interaction effects in rice after accelerated ageing

| Genotypes | Location / season (G x L x S) | | | | | | | | | | | | | | | |
|----------------------------------------------|-------------------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| | L1 | | | | L2 | | | | L3 | | | | L4 | | | |
| | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 | S1 | S2 |
| Mean (G x S) | | | | | | | | | | | | | | | | |
| Mean (G) | | | | | | | | | | | | | | | | |
| Location (G x L) | | | | | | | | | | | | | | | | |
| L1 | | | | L2 | | | | L3 | | | | L4 | | | | |
| G1 | 83.2 | 85.4 | 86.4 | 87.8 | 80.6 | 79.3 | 76.2 | 74.4 | 81.6 | 81.7 | 81.7 | 81.7 | 84.3 | 87.1 | 80.0 | 75.3 |
| G2 | 84.6 | 82.1 | 83.7 | 84.8 | 82.2 | 80.1 | 72.4 | 76.6 | 80.7 | 80.9 | 80.8 | 80.8 | 83.4 | 84.2 | 81.2 | 74.5 |
| G3 | 74.8 | 76.2 | 76.4 | 75.6 | 68.2 | 70.2 | 60.4 | 65.2 | 70.0 | 71.8 | 70.9 | 70.9 | 75.5 | 76.0 | 69.2 | 62.8 |
| G4 | 80.1 | 78.4 | 79.2 | 80.2 | 70.1 | 68.0 | 63.1 | 65.0 | 73.1 | 73.2 | 73.1 | 73.1 | 79.2 | 79.9 | 69.1 | 64.6 |
| G5 | 85.2 | 87.4 | 86.8 | 89.2 | 81.6 | 82.8 | 78.2 | 76.6 | 85.4 | 84.0 | 83.7 | 83.7 | 86.3 | 89.0 | 82.2 | 77.4 |
| G6 | 87.0 | 84.4 | 86.2 | 85.6 | 79.8 | 81.1 | 76.4 | 76.2 | 82.4 | 81.8 | 82.1 | 82.1 | 85.7 | 85.9 | 80.4 | 76.3 |
| G7 | 75.4 | 74.2 | 77.6 | 76.2 | 66.1 | 69.4 | 61.2 | 67.3 | 70.1 | 71.8 | 70.9 | 70.9 | 74.8 | 76.9 | 67.8 | 64.2 |
| G8 | 88.6 | 86.2 | 89.0 | 88.6 | 78.8 | 81.2 | 78.1 | 79.2 | 83.6 | 83.8 | 83.7 | 83.7 | 87.4 | 88.8 | 80.0 | 78.6 |
| Mean | 82.3 | 81.8 | 83.4 | 83.5 | 75.9 | 76.5 | 70.7 | 72.7 | 78.1 | 78.6 | 78.1 | 78.6 | 82.1 | 83.4 | 76.2 | 71.7 |
| G L S GxL LxS GxLxS | | | | | | | | | | | | | | | | |
| S.E.M. | | | | | | | | | | | | | | | | |
| C.D. at 5% | | | | | | | | | | | | | | | | |

G1 = V20B; G2 = Madh; L; G3 = Improved Sona B; G4 = Improved Sona B; G5 = Pustpa B; G6 = Mangala B;
 G7 = Intan Mutant B; G8 = Pragathi B; L1 = Bengalore; L2 = Mandya; L3 = Shimoga; L4 = Mudigere
 S1 = Wet season; S2 = Dry season; NS = Not-significant

Seeds differed significantly for germination after AA. G5 (83.7 %) and G8 (83.7 %) recorded the highest and equal germinability followed by G6 (82.1%) and G1 (81.7%). The lowest germinability was observed in G3 (70.9%) and G7(70.9%). Results indicated significant differences among the locations for germination after AA. L2 (83.4%) registered the highest germination followed by L1 (82.1 %), L3 (76.2%) and L4 (71.7%). Accelerated ageing response of seeds did not differ significantly between two seasons.

Interaction between genotype and location was significant for germinability after AA. All the genotypes from L2 recorded comparatively the higher germination per cent followed by L1. The lowest germinability was registered by seeds produced at L4. The combination G5L2 showed the highest germination per cent followed by G8L2, G8L1 and G1L2. Interaction effects observed due to genotype and season were negligible for AA response. Location and season due to their interaction showed significant differences for germinability due to AA. In L1 and L2 the interaction means were on par with each other between S1 and S2. A significant difference was observed in S2 season over S1 in L4 location. The interactions between Gx L x S were not significant.

4.1.2.8 Seed borne fungi

Among the eight genotypes studied, the maximum number of seed borne fungi were detected on IR 54752B followed by Improved Sona B and Intan mutant B (Table 11). Seed produced

Table 11. Seed borne fungi detected in the seeds of 8 rice genotypes produced at four locations during initial period of storage

| Genotype | Location | Pathogens | | | | | |
|-----------------|----------|-----------|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 |
| V 20 B | L1 | + | - | + | - | - | + |
| | L2 | - | - | + | - | - | - |
| | L3 | - | - | + | + | - | - |
| | L4 | + | + | + | - | + | + |
| Madhu B | L1 | - | + | - | + | - | - |
| | L2 | - | - | - | - | - | - |
| | L3 | + | - | + | - | + | - |
| | L4 | - | - | + | + | - | + |
| IR 54752 B | L1 | + | - | - | - | - | + |
| | L2 | - | + | + | - | - | - |
| | L3 | + | + | + | + | + | + |
| | L4 | + | + | + | + | + | + |
| Improved Sona B | L1 | + | - | - | + | - | + |
| | L2 | - | + | - | - | + | - |
| | L3 | + | + | - | - | - | + |
| | L4 | + | + | + | - | + | + |
| Pushpa B | L1 | - | - | + | + | - | - |
| | L2 | + | - | + | - | - | + |
| | L3 | - | + | - | + | - | - |
| | L4 | + | - | - | + | + | - |
| Mangala B | L1 | - | + | - | - | - | + |
| | L2 | - | + | - | - | - | - |
| | L3 | - | - | - | - | - | + |
| | L4 | + | + | + | + | + | + |
| Intan mutant B | L1 | - | - | - | - | + | - |
| | L2 | + | - | + | - | - | - |
| | L3 | + | + | - | - | + | - |
| | L4 | + | + | + | - | + | + |
| Pragathi B | L1 | - | + | - | - | - | - |
| | L2 | + | - | + | + | - | - |
| | L3 | - | + | - | - | - | + |
| | L4 | + | + | - | + | - | - |

1) Alternaria alternata 2) Alternaria longissima
 3) Curvularia lunata 4) Helminthosporium oryzae
 5) Fusarium spp. 6) Trichoconis padwickii
 L1 = Bangalore; L2 = Mandya; L3 = Shimoga; L4 = Mudigere

at Mudigere recorded the maximum incidence followed by Shimoga, Bangalore and Mandya. Irrespective of genotype and location, the incidence of A. alternata, A. longissima and C. lunata was more and on par as compared to H. oryzae, Fusarium Spp. and T. padwickii.

EXPERIMENT-2

4.2 Seed Storability as Influenced by Genotype, Production Location and Seed Treatment

The storability of eight genotypes viz., V 20 B (G1), Madhu B (G2), IR 54752 B(G3), Improved sona B (G4), Pushpa B (G5), Mangala B (G6), Intan Mutant B(G7) and Pragathi B (G8) produced from four locations viz., Bangalore (L1), Mandya (L2), Shimoga (L3) and Mudigere (L4) and with seed treatment (T1) and without (T2) was studied in this experiment for 19 months (1990 January to 1991 July). The data recorded with respect to the following attributes were studied by drawing bimonthly intervals and the results are presented below.

4.2.1 Germination

The data on germination percentage during storage as influenced by genotype, location, seed treatment and their interaction effects are presented in Tables 12, 13 and 14 and Fig. 6, 7 and 8.

Irrespective of genotype, location and seed treatment, a steady decline in germination (94.7 - 81.8%) was observed with progressive increase in storage period. The germination

percentage differed significantly among the genotypes in all the months of storage (Table 12). The germination percentage was found to decline as follows G1: 96.0 to 84.1; G2: 95.2 to 84.2; G3: 93.3 to 77.9; G4: 93.0 to 79.0; G5: 95.7 to 84.7; G6: 95.5 to 84.0; G7: 94.2 to 77.8; and G8: 94.6 to 82.9. at the end of 19th month after storage. Among the genotypes V 20 (G1) recorded the highest germination percentage throughout the storage period, except for 17th and 19th month, while Improved sona (G4) recorded the lowest from initial to 15 month and IR 54752 (G3) from 17th month onwards up to the end of the storage period.

The germination percentage was found to differ significantly among the location throughout the storage period. The seeds produced from Mandya were significantly above the other locations throughout the storage period. The germination percentage of seeds produced from Mandya declined from initial 97.0 to 86.8 per cent at the end, followed by those produced at Bangalore (95.8 to 85.6 %), Shimoga (93.8 to 78.8 %) and Mudigere (92.2 to 76.2 %). Treated seeds registered the higher germination percentage (94.3 to 85.8%) than untreated seeds (94.0 to 78.2%) throughout the storage period (Table 13).

Interactions between the genotype and location were found to be significant for germination throughout the storage period (Table 13). Genotypes G5, G1, G6, G2 and G8 exhibited better germination till the end of storage period

Table 12. Germination (%) as influenced by genotype, location and seed treatment during storage

| Treatments | Month after storage | | | | | | | | | |
|-----------------------|---------------------|------|------|------|------|------|------|------|------|------|
| | 1 | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 17 | 19 |
| Genotypes | | | | | | | | | | |
| G1 | 96.0 | 95.9 | 95.4 | 94.9 | 94.5 | 93.3 | 92.0 | 89.6 | 87.3 | 84.1 |
| G2 | 95.2 | 94.5 | 93.7 | 93.4 | 92.9 | 91.8 | 90.7 | 88.9 | 87.1 | 84.2 |
| G3 | 93.3 | 93.1 | 92.4 | 91.7 | 90.9 | 89.5 | 87.7 | 85.3 | 82.1 | 77.9 |
| G4 | 93.0 | 92.0 | 91.8 | 90.8 | 90.0 | 88.8 | 87.4 | 85.2 | 82.4 | 79.0 |
| G5 | 95.7 | 95.5 | 94.5 | 94.5 | 93.8 | 92.7 | 91.3 | 89.6 | 87.6 | 84.7 |
| G6 | 95.5 | 95.5 | 95.0 | 94.4 | 94.0 | 92.7 | 91.2 | 89.4 | 87.1 | 84.0 |
| G7 | 94.2 | 93.2 | 92.5 | 91.7 | 90.7 | 89.4 | 87.7 | 84.9 | 82.0 | 77.8 |
| G8 | 94.6 | 93.7 | 93.2 | 92.5 | 91.9 | 90.9 | 89.5 | 87.8 | 85.6 | 82.9 |
| Mean | 94.7 | 94.2 | 93.6 | 93.0 | 92.3 | 91.1 | 89.7 | 87.6 | 85.2 | 81.8 |
| S.E.m+ | 0.21 | 0.18 | 0.30 | 0.26 | 0.17 | 0.19 | 0.18 | 0.19 | 0.21 | 0.21 |
| C.D. $\bar{5}$ % | 0.57 | 0.48 | 0.82 | 0.71 | 0.46 | 0.53 | 0.51 | 0.53 | 0.57 | 0.56 |
| Locations | | | | | | | | | | |
| L1 | 95.8 | 95.7 | 94.9 | 94.9 | 94.0 | 93.1 | 91.7 | 90.3 | 88.2 | 85.6 |
| L2 | 97.0 | 97.0 | 95.7 | 95.7 | 95.4 | 94.4 | 93.0 | 91.6 | 90.1 | 86.8 |
| L3 | 93.8 | 92.6 | 92.2 | 91.1 | 90.6 | 89.3 | 88.0 | 84.6 | 82.0 | 78.8 |
| L4 | 92.2 | 91.4 | 91.6 | 90.3 | 89.3 | 87.7 | 86.2 | 83.8 | 80.3 | 76.2 |
| Mean | 94.7 | 94.2 | 93.6 | 93.0 | 92.3 | 91.1 | 89.7 | 87.5 | 85.1 | 81.8 |
| S.E.m+ | 0.15 | 0.12 | 0.21 | 0.18 | 0.12 | 0.14 | 0.13 | 0.14 | 0.15 | 0.14 |
| C.D. $\bar{5}$ % | 0.40 | 0.34 | 0.58 | 0.50 | 0.32 | 0.38 | 0.36 | 0.37 | 0.41 | 0.40 |
| Seed treatment | | | | | | | | | | |
| T1 | - | 94.3 | 93.9 | 93.4 | 93.1 | 92.4 | 91.4 | 89.8 | 88.0 | 85.8 |
| T2 | - | 94.0 | 93.3 | 92.6 | 91.6 | 89.9 | 88.0 | 85.4 | 82.3 | 78.2 |
| Mean | - | 94.2 | 93.6 | 93.0 | 92.4 | 91.2 | 89.7 | 87.6 | 85.2 | 81.8 |
| S.E.m+ | - | 0.09 | 0.15 | 0.13 | 0.08 | 0.10 | 0.09 | 0.10 | 0.10 | 0.10 |
| C.D. $\bar{5}$ % | - | 0.24 | 0.41 | 0.36 | 0.23 | 0.27 | 0.25 | 0.26 | 0.29 | 0.28 |

G1 = V20B; G2 = Madhu B; G3 = IR 54752; G4 = Improved Sona B; G5 = Pushpa B; G6 = Mangala B; G7 = Intan mutant B; G8 = Pragathi B; L1 = Bangalore; L2 = Mandya; L3 = Shimoga; L4 = Mudigere, T1 = Treated; T2 = Untreated.

Table 13 . Germination (%) as influenced by interaction of genotype and location during storage

| Genotypes | Month after storage | | | | | | | | | |
|------------------------|---------------------|------|------|------|------|------|------|------|------|------|
| | 1 | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 17 | 19 |
| Location 1 (Bangalore) | | | | | | | | | | |
| G1 | 97.7 | 98.1 | 97.9 | 97.6 | 96.8 | 96.0 | 94.8 | 93.5 | 91.4 | 88.7 |
| G2 | 96.3 | 96.0 | 96.0 | 95.5 | 94.5 | 93.6 | 92.7 | 91.7 | 90.6 | 88.7 |
| G3 | 93.4 | 93.6 | 93.2 | 92.3 | 91.6 | 90.4 | 88.5 | 87.0 | 84.5 | 80.8 |
| G4 | 94.8 | 93.2 | 93.5 | 92.3 | 91.6 | 90.6 | 89.1 | 87.8 | 85.0 | 82.2 |
| G5 | 97.0 | 97.8 | 97.5 | 97.0 | 96.2 | 95.4 | 94.2 | 93.0 | 91.6 | 89.8 |
| G6 | 96.9 | 97.0 | 97.1 | 96.1 | 95.1 | 94.2 | 92.5 | 91.4 | 89.4 | 87.4 |
| G7 | 94.8 | 93.8 | 93.9 | 93.0 | 91.7 | 90.6 | 89.0 | 87.1 | 84.3 | 80.0 |
| G8 | 95.3 | 96.2 | 96.2 | 95.4 | 94.9 | 93.8 | 92.5 | 91.2 | 88.8 | 87.0 |
| Mean | 95.8 | 95.7 | 95.7 | 94.9 | 94.1 | 93.1 | 91.7 | 90.4 | 88.2 | 85.6 |
| Location 2 (Mandya) | | | | | | | | | | |
| G1 | 98.6 | 98.8 | 97.2 | 97.0 | 97.2 | 96.3 | 94.8 | 93.4 | 92.0 | 89.6 |
| G2 | 97.4 | 97.2 | 95.0 | 95.4 | 95.8 | 94.6 | 93.4 | 92.3 | 91.2 | 88.6 |
| G3 | 94.6 | 94.3 | 93.2 | 93.3 | 92.5 | 91.4 | 89.6 | 88.0 | 85.6 | 82.0 |
| G4 | 96.0 | 95.1 | 92.3 | 93.2 | 93.3 | 92.2 | 90.6 | 89.5 | 87.7 | 84.5 |
| G5 | 98.0 | 98.4 | 96.1 | 97.1 | 96.8 | 96.0 | 94.4 | 93.3 | 92.0 | 89.4 |
| G6 | 98.1 | 99.1 | 97.2 | 98.0 | 97.6 | 96.6 | 95.1 | 94.0 | 92.6 | 89.1 |
| G7 | 95.4 | 96.2 | 93.9 | 95.2 | 94.3 | 93.2 | 91.6 | 89.7 | 87.7 | 82.9 |
| G8 | 97.6 | 96.8 | 94.7 | 96.3 | 95.9 | 95.1 | 94.2 | 93.1 | 91.9 | 88.7 |
| Mean | 97.0 | 97.0 | 95.0 | 95.7 | 95.4 | 94.4 | 93.0 | 91.7 | 90.1 | 86.8 |
| Location 3 (Shimoga) | | | | | | | | | | |
| G1 | 96.0 | 93.7 | 93.2 | 92.8 | 92.6 | 91.2 | 90.0 | 86.2 | 83.8 | 80.7 |
| G2 | 94.0 | 93.0 | 91.9 | 91.6 | 91.1 | 90.0 | 88.8 | 86.1 | 83.7 | 81.2 |
| G3 | 93.5 | 93.0 | 91.7 | 91.1 | 90.7 | 89.3 | 87.8 | 83.6 | 80.1 | 76.1 |
| G4 | 90.3 | 89.6 | 89.0 | 88.0 | 87.1 | 85.8 | 84.6 | 81.1 | 78.3 | 75.0 |
| G5 | 94.8 | 93.8 | 92.5 | 92.3 | 91.7 | 90.7 | 89.3 | 86.3 | 84.3 | 81.4 |
| G6 | 94.1 | 95.0 | 93.5 | 93.2 | 93.0 | 91.8 | 90.7 | 87.6 | 85.6 | 82.0 |
| G7 | 93.6 | 91.4 | 90.2 | 89.5 | 88.7 | 87.3 | 85.4 | 81.0 | 77.7 | 74.4 |
| G8 | 93.8 | 91.5 | 90.4 | 90.6 | 89.8 | 88.6 | 87.1 | 84.4 | 82.0 | 79.3 |
| Mean | 93.8 | 92.6 | 91.6 | 91.1 | 90.6 | 89.3 | 88.0 | 84.5 | 81.9 | 78.8 |
| Location 4 (Mudigere) | | | | | | | | | | |
| G1 | 91.5 | 93.1 | 93.3 | 92.2 | 91.3 | 89.8 | 88.3 | 85.4 | 82.0 | 77.6 |
| G2 | 93.1 | 92.0 | 92.0 | 91.2 | 90.2 | 89.0 | 87.7 | 85.6 | 82.7 | 78.5 |
| G3 | 91.7 | 91.4 | 91.3 | 90.3 | 88.8 | 86.8 | 85.1 | 82.2 | 78.0 | 72.5 |
| G4 | 91.0 | 90.1 | 92.4 | 89.8 | 88.1 | 86.7 | 85.1 | 82.8 | 78.6 | 74.1 |
| G5 | 93.1 | 92.0 | 93.5 | 91.6 | 90.3 | 88.7 | 87.4 | 85.7 | 82.4 | 78.3 |
| G6 | 92.8 | 91.1 | 91.8 | 90.3 | 90.1 | 88.0 | 86.6 | 84.6 | 80.8 | 77.9 |
| G7 | 93.0 | 91.4 | 92.0 | 89.2 | 88.3 | 86.8 | 84.7 | 81.9 | 78.2 | 74.0 |
| G8 | 91.5 | 90.3 | 91.6 | 87.7 | 87.0 | 86.2 | 84.3 | 82.4 | 79.8 | 76.6 |
| Mean | 92.2 | 91.4 | 92.2 | 90.3 | 89.3 | 87.7 | 86.2 | 83.8 | 80.3 | 76.2 |
| S.E.m+ | 0.41 | 0.35 | 0.59 | 0.52 | 0.33 | 0.39 | 0.36 | 0.38 | 0.41 | 0.41 |
| C.D.5% | 1.14 | 0.97 | 1.64 | 1.42 | 0.92 | 1.07 | 1.01 | 1.06 | 1.14 | 1.12 |

G1 = V20B; G2 = Madhu B; G3 = IR 54752B; G4 = Improved Sona B; G5 = Pushpa B; G6 = Mangala B; G7 = Intan mutant B; G8 = Pragathi B;

Table 14 . Germination (%) as influenced by interaction of (1) genotype and seed treatment (2) location and seed treatment during storage

| Genotypes | Month after storage | | | | | | | |
|---------------------|---------------------|------|------|------|------|------|------|------|
| | 13 | | 15 | | 17 | | 19 | |
| | T1 | T2 | T1 | T2 | T1 | T2 | T1 | T2 |
| G1: V20 B | 93.4 | 90.6 | 91.6 | 87.6 | 90.1 | 84.6 | 87.8 | 80.5 |
| G2: Madhu B | 92.2 | 89.2 | 90.8 | 87.1 | 89.5 | 84.6 | 87.6 | 81.0 |
| G3: IR 54752 B | 89.4 | 86.1 | 87.3 | 83.0 | 84.9 | 79.2 | 81.6 | 74.1 |
| G4: Improved Sona B | 89.3 | 85.4 | 87.7 | 82.9 | 85.2 | 79.5 | 82.4 | 75.6 |
| G5: Pushpa B | 92.8 | 89.8 | 91.3 | 87.8 | 89.7 | 85.4 | 87.6 | 81.8 |
| G6: Mangala B | 93.0 | 89.5 | 91.6 | 87.2 | 90.0 | 84.2 | 88.0 | 80.2 |
| G7: Intan Mutant B | 90.2 | 85.0 | 87.9 | 81.9 | 85.8 | 78.1 | 82.2 | 73.4 |
| G8: Pragathi B | 91.2 | 87.8 | 89.8 | 85.8 | 88.5 | 82.7 | 86.4 | 79.3 |
| Mean | 91.4 | 88.0 | 89.8 | 85.4 | 89.0 | 82.3 | 85.4 | 78.2 |
| S.E.m ⁺ | 0.26 | | 0.27 | | 0.29 | | 0.28 | |
| C.D. at 5% | 0.71 | | 0.75 | | 0.81 | | 0.80 | |
| Location | | | | | | | | |
| L1 : Bangalore | 93.5 | 89.8 | 92.4 | 88.3 | 90.8 | 85.6 | 88.6 | 82.5 |
| L2 : Mandya | 94.5 | 91.4 | 93.6 | 89.8 | 92.4 | 87.5 | 89.9 | 83.8 |
| L3 : Shimoga | 89.8 | 86.1 | 87.0 | 82.1 | 85.1 | 78.8 | 82.7 | 74.3 |
| L4 : Mudigere | 87.9 | 84.4 | 86.1 | 81.5 | 83.5 | 77.1 | 80.5 | 71.8 |
| Mean | | | | | | | | |
| S.E.m + | 0.18 | | 0.19 | | 0.21 | | 0.20 | |
| C.D. 5 % | NS | | 0.53 | | 0.57 | | 0.56 | |

T1 = Treated; T2 = Untreated

NOTE: 1 to 13 months of storage interaction was not significant

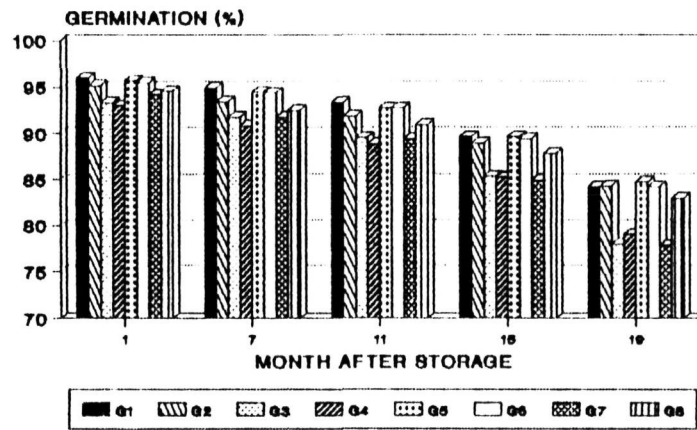


FIG 6. GENOTYPIC VARIATION FOR GERMINATION DURING STORAGE.

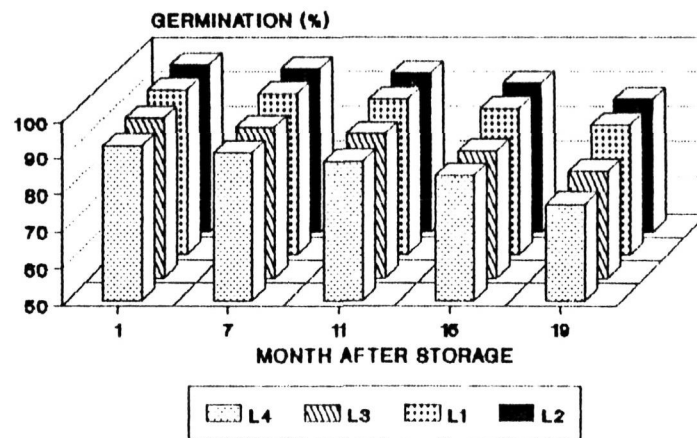


FIG 7. GERMINATION (%) AS INFLUENCED BY LOCATION DURING STORAGE.

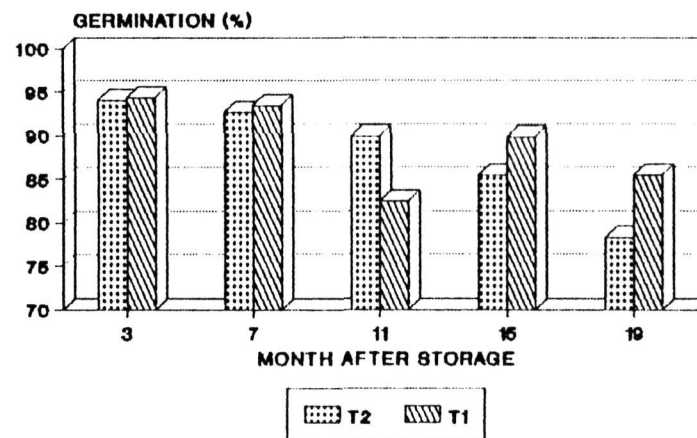


FIG 8. EFFECT OF SEED TREATMENT ON GERMINATION DURING STORAGE.

than the rest of the genotypes under the study viz., G3, G4, G7 in all locations. Significant differences were observed for interaction between genotype and seed treatment, only from 15th month onwards up to the end of the storage period (Table 14). The treated seeds of genotypes G1, G6, G5 and G2 maintained better germination than G7, G3 and G4. Untreated seeds of all the genotypes were inferior to the treated seeds from all the chosen locations. Irrespective of seed treatment, seeds produced from Mandya maintained a higher viability than seeds of other locations. The interaction effects among the genotypes, locations and seed treatment were found not significant.

4.2.2 Field emergence

The data on field emergence percentage as influenced by genotype, location, seed treatment and their interactions during storage are presented in Tables 15 and 16. In general a steady decline in field emergence percentage (89.3 to 74.8%) was observed as the storage period advanced.

The per cent emergence differed significantly in all the months of storage. Irrespective of location and seed treatment, a steady decline in emergence percentage was observed in all the genotypes under storage in the present study (Table 15). At the end of 19 months of storage, G1 maintained maximum field emergence (77.4%) which was statistically on par with G5 (77.2%), G8 (77.2%), G6 (76.8%) and G2 (76.3%). The minimum field emergence was noticed in G7 (70.3%).

Table 15. Field emergence (%) as influenced by genotype, location and seed treatment during storage

| Treatments | Month after storage | | | | | | | | | |
|-----------------------|---------------------|------|------|------|------|------|------|------|------|------|
| | 1 | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 17 | 19 |
| Genotypes | | | | | | | | | | |
| G1 | 92.6 | 91.5 | 90.4 | 90.1 | 89.2 | 87.4 | 85.9 | 83.7 | 81.9 | 77.4 |
| G2 | 90.1 | 89.1 | 88.4 | 87.7 | 86.9 | 85.8 | 84.1 | 81.9 | 79.5 | 76.3 |
| G3 | 88.1 | 88.2 | 87.2 | 86.3 | 85.4 | 83.9 | 81.8 | 78.9 | 75.9 | 71.1 |
| G4 | 88.3 | 87.7 | 86.9 | 86.2 | 85.3 | 83.8 | 81.9 | 79.3 | 76.4 | 71.8 |
| G5 | 90.3 | 90.4 | 89.7 | 88.9 | 88.1 | 86.8 | 85.6 | 83.4 | 80.6 | 77.2 |
| G6 | 89.3 | 90.2 | 89.5 | 88.9 | 87.9 | 86.6 | 84.9 | 82.6 | 80.1 | 76.8 |
| G7 | 88.0 | 86.6 | 85.8 | 85.1 | 84.1 | 82.8 | 80.7 | 77.9 | 74.5 | 70.3 |
| G8 | 87.7 | 88.5 | 88.4 | 87.9 | 86.8 | 85.7 | 84.4 | 82.3 | 80.7 | 77.2 |
| Mean | 89.3 | 89.0 | 88.3 | 87.6 | 86.7 | 85.3 | 83.7 | 81.2 | 78.6 | 74.8 |
| S.E.m ₊ | 0.21 | 0.22 | 0.25 | 0.21 | 0.33 | 0.56 | 0.29 | 0.29 | 0.77 | 0.91 |
| C.D.5 % | 0.59 | 0.60 | 0.69 | 0.59 | 0.92 | 1.60 | 0.81 | 0.79 | 2.12 | 2.50 |
| Locations | | | | | | | | | | |
| L1 | 91.5 | 91.8 | 91.0 | 90.3 | 89.4 | 87.2 | 86.6 | 84.8 | 82.7 | 77.9 |
| L2 | 93.3 | 93.3 | 92.7 | 92.2 | 91.2 | 89.7 | 88.3 | 86.5 | 83.1 | 80.9 |
| L3 | 87.5 | 86.4 | 85.7 | 85.0 | 84.1 | 83.5 | 81.1 | 77.9 | 74.9 | 72.5 |
| L4 | 84.9 | 84.6 | 83.8 | 83.1 | 82.2 | 81.0 | 78.7 | 75.8 | 73.7 | 67.8 |
| Mean | 89.3 | 89.0 | 88.3 | 87.6 | 86.7 | 85.3 | 83.7 | 81.2 | 78.6 | 74.8 |
| S.E.m ₊ | 0.15 | 0.15 | 0.18 | 0.15 | 0.24 | 0.40 | 0.21 | 0.20 | 0.54 | 0.64 |
| C.D.5 % | 0.42 | 0.42 | 0.49 | 0.41 | 0.65 | 1.10 | 0.57 | 0.56 | 1.50 | 1.77 |
| Seed treatment | | | | | | | | | | |
| T1 | - | 89.2 | 88.7 | 88.2 | 87.5 | 86.2 | 85.5 | 83.7 | 80.4 | 77.1 |
| T2 | - | 88.8 | 87.9 | 87.1 | 85.9 | 84.5 | 81.8 | 78.8 | 76.9 | 72.5 |
| Mean | - | 89.0 | 88.3 | 87.6 | 86.7 | 85.4 | 83.7 | 81.2 | 78.6 | 74.8 |
| S.E.m ₊ | - | 0.11 | 0.13 | 0.11 | 0.17 | 0.28 | 0.15 | 0.14 | 0.38 | 0.45 |
| C.D.5 % | - | 0.30 | 0.35 | 0.29 | 0.46 | 0.78 | 0.41 | 0.40 | 1.06 | 1.25 |

G1 = V20B; G2 = Madhu B; G3 = IR 54752B; G4 = Improved Sona B; G5 = Pushpa B;
 G6 = Mangala B; G7 = Intan mutant B; G8 = Pragathi B; L1 = Bangalore; L2 = Mandya
 L3 = Shimoga; L4 = Mudigere, T1 = Treated; T2 = Untreated.

Table 16. Field emergence (%) as influenced by interaction of genotype and location during storage

| Genotypes | Month after storage | | | | | | | | | |
|------------------------|---------------------|------|------|------|------|------|------|------|------|------|
| | 1 | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 17 | 19 |
| Location 1 (Bangalore) | | | | | | | | | | |
| G1 | 94.5 | 93.1 | 92.0 | 91.5 | 90.8 | 88.5 | 87.7 | 85.9 | 83.9 | 79.1 |
| G2 | 91.2 | 91.3 | 90.3 | 89.4 | 88.7 | 87.3 | 86.3 | 84.4 | 82.5 | 78.4 |
| G3 | 89.1 | 91.4 | 89.5 | 88.6 | 87.7 | 85.8 | 84.4 | 82.3 | 79.3 | 73.8 |
| G4 | 91.0 | 90.8 | 89.7 | 88.9 | 86.4 | 86.1 | 85.1 | 82.8 | 80.2 | 75.1 |
| G5 | 93.5 | 93.8 | 93.2 | 92.6 | 91.8 | 88.9 | 89.6 | 88.1 | 86.2 | 80.9 |
| G6 | 91.0 | 93.1 | 92.5 | 91.8 | 90.3 | 88.7 | 87.8 | 86.2 | 84.4 | 80.2 |
| G7 | 90.6 | 89.6 | 88.9 | 88.3 | 87.3 | 85.1 | 84.1 | 82.1 | 79.3 | 74.3 |
| G8 | 91.3 | 91.6 | 92.1 | 91.6 | 90.3 | 87.4 | 86.1 | 86.6 | 84.9 | 81.9 |
| Mean | 91.5 | 91.8 | 91.0 | 90.3 | 89.4 | 87.2 | 86.6 | 84.8 | 82.7 | 78.0 |
| Location 2 (Mandya) | | | | | | | | | | |
| G1 | 97.1 | 96.1 | 94.2 | 94.8 | 93.8 | 91.8 | 90.8 | 89.1 | 86.4 | 83.7 |
| G2 | 93.4 | 92.6 | 92.0 | 91.5 | 90.6 | 89.1 | 87.5 | 85.9 | 83.2 | 81.5 |
| G3 | 90.1 | 90.0 | 89.4 | 88.6 | 87.7 | 86.5 | 84.2 | 82.4 | 79.2 | 75.8 |
| G4 | 92.9 | 92.1 | 91.6 | 90.8 | 89.8 | 88.2 | 86.5 | 84.5 | 80.8 | 77.6 |
| G5 | 94.5 | 95.2 | 94.6 | 93.9 | 93.0 | 92.1 | 91.1 | 89.5 | 86.2 | 84.5 |
| G6 | 93.8 | 95.2 | 94.8 | 94.2 | 93.3 | 91.2 | 90.4 | 88.4 | 84.7 | 83.5 |
| G7 | 92.5 | 92.4 | 91.8 | 91.1 | 90.1 | 88.6 | 86.9 | 84.8 | 80.1 | 77.3 |
| G8 | 92.0 | 92.7 | 92.9 | 92.5 | 91.0 | 90.5 | 89.1 | 87.5 | 84.2 | 83.2 |
| Mean | 93.3 | 93.3 | 92.7 | 92.2 | 91.2 | 89.8 | 88.3 | 86.5 | 83.1 | 80.9 |
| Location 3 (Shimoga) | | | | | | | | | | |
| G1 | 92.1 | 89.6 | 88.8 | 88.1 | 87.2 | 85.8 | 83.9 | 81.0 | 78.4 | 75.8 |
| G2 | 88.6 | 86.8 | 86.4 | 85.7 | 84.7 | 85.2 | 82.1 | 75.5 | 77.2 | 74.8 |
| G3 | 88.2 | 87.8 | 87.0 | 86.0 | 85.1 | 83.5 | 81.5 | 77.5 | 74.1 | 70.3 |
| G4 | 85.8 | 85.0 | 84.1 | 83.4 | 82.5 | 81.5 | 79.1 | 76.0 | 72.8 | 70.0 |
| G5 | 87.2 | 86.1 | 85.3 | 84.6 | 83.7 | 84.0 | 81.2 | 78.1 | 75.1 | 73.4 |
| G6 | 87.6 | 87.7 | 87.1 | 86.4 | 85.6 | 84.9 | 82.4 | 79.2 | 76.3 | 74.4 |
| G7 | 84.0 | 82.8 | 82.1 | 81.6 | 80.5 | 79.8 | 77.5 | 73.8 | 70.1 | 67.3 |
| G8 | 85.7 | 85.3 | 84.9 | 84.2 | 83.4 | 83.2 | 80.6 | 78.1 | 75.8 | 73.8 |
| Mean | 87.5 | 86.4 | 85.7 | 85.0 | 84.1 | 83.5 | 81.1 | 77.9 | 75.0 | 72.5 |
| Location 4 (Mudigere) | | | | | | | | | | |
| G1 | 86.8 | 87.3 | 86.6 | 86.0 | 85.1 | 83.6 | 81.4 | 78.8 | 78.8 | 71.1 |
| G2 | 87.2 | 85.7 | 84.9 | 84.3 | 83.6 | 81.7 | 80.4 | 77.9 | 75.1 | 70.7 |
| G3 | 84.6 | 83.6 | 82.8 | 82.1 | 81.2 | 79.8 | 76.9 | 73.4 | 70.8 | 64.5 |
| G4 | 83.8 | 83.1 | 82.1 | 81.5 | 80.6 | 79.5 | 76.9 | 73.6 | 71.8 | 64.5 |
| G5 | 86.1 | 86.2 | 85.6 | 84.7 | 83.8 | 82.3 | 80.5 | 77.9 | 74.8 | 70.2 |
| G6 | 84.8 | 85.0 | 83.8 | 83.2 | 82.4 | 81.5 | 79.3 | 76.7 | 74.1 | 69.3 |
| G7 | 84.0 | 81.5 | 80.5 | 79.5 | 78.5 | 77.8 | 74.2 | 70.9 | 68.6 | 62.4 |
| G8 | 81.9 | 84.4 | 83.8 | 83.4 | 82.6 | 81.6 | 79.8 | 77.1 | 75.4 | 70.1 |
| Mean | 84.9 | 84.6 | 83.8 | 83.1 | 82.2 | 80.9 | 78.7 | 75.8 | 73.7 | 67.8 |
| S.Em+ | 0.42 | 0.43 | 0.50 | 0.42 | 0.67 | 1.12 | 0.59 | 0.59 | 1.53 | 1.81 |
| C.D.5% | 1.16 | 1.19 | 1.38 | 1.17 | 1.84 | NS | 1.62 | 1.58 | 4.20 | 5.00 |

G1 = V20B; G2 = Madhu B; G3 = IR 54752B; G4 = Improved Sona B; G5 = Pushpa B; G6 = Mangala B; G7 = Intan mutant B; G8 = Pragathi B;

The field emergence percentage was found to be significant among the locations throughout the storage period (Table 15). The seeds produced from Mandya maintained significantly higher emergence per cent until the end of the storage period (93.3 to 80.9%), closely followed by that produced at Bangalore (91.5 to 77.9%) and Shimoga (87.5 to 72.5%). The seeds from Mudigere were found to be inferior to the rest of the locations for their storability (84.9 to 67.8%). Treated seeds registered the maximum field emergence percentage (Table 15) from the beginning to the end of storage period (89.2 to 77.1%) as compared to the untreated (88.8 to 72.5%).

Per cent field emergence differed significantly between the chosen genotypes and location (Table 16). Genotypes, G1, G2, G8 and G5 have better emergence ability than G3, G7 and G4 in all locations. Other interactions due to field emergence were not significant.

4.2.3 Seedling length

The data on seedling length as influenced by genotype, location, seed treatment and their interactions during storage are presented in Tables 17 and 18. In general a linear reduction in seedling length (23.8 to 21.9 cm) was noticed with progressive increase in storage period.

The seedling length differed significantly among the genotypes throughout the storage period. It was found to

decline (Table 17) as follows in G1: 27.0 to 25.1; G2: 23.4 to 22.4; G3: 23.8 to 21.3; G4: 21.4 to 19.0; G5: 25.5 to 23.2; G6: 24.0 to 22.2; G7: 20.0 to 17.6 and G8: 25.3 to 23.8 cm after 19 months of storage. Among the genotypes G1 recorded the maximum seedling length in all the period of storage, while G7 registered the minimum. The seedling length was found to differ significantly among the locations (Table 17). The seeds from Mandya registered the maximum seedling length throughout the storage period (25.4 to 23.7 cm) followed by Bangalore (24.7 to 22.9 cm) and Shimoga (23.9 to 21.4 cm). The minimum seedling length was recorded by Mudigere (21.9 to 19.4 cm).

Treated seeds maintained the maximum seedling length (23.9 to 22.4 cm) as compared to untreated control (23.8 to 21.2 cm) from beginning to the end of storage period, though the initial (up to 5 months) differences were not significant (Table 17).

Interaction effects due to genotype and location indicated significant differences in all the months of storage period (Table 18). On the whole, the genotypes G1, G8, G5 and G2 in all the locations throughout the storage period maintained better seedling length as compared to other genotypes viz., G7, G3 and G4. Significant differences were noticed for the interaction between genotypes and seed treatment and also due to location and seed treatment. The

Table 17. Seedling length (cm) as influenced by genotype, location and seed treatment during storage

| Treatments | Month after storage | | | | | | | | | |
|-----------------------|---------------------|------|------|------|------|------|------|------|------|------|
| | 1 | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 17 | 19 |
| Genotypes | | | | | | | | | | |
| G1 | 27.0 | 27.0 | 26.9 | 26.8 | 26.7 | 26.5 | 26.3 | 25.9 | 25.5 | 25.1 |
| G2 | 23.4 | 24.2 | 24.1 | 24.0 | 23.9 | 23.8 | 23.6 | 23.2 | 22.8 | 22.4 |
| G3 | 23.8 | 23.8 | 23.7 | 23.5 | 23.4 | 23.2 | 23.0 | 22.4 | 21.7 | 21.3 |
| G4 | 21.4 | 21.3 | 21.2 | 21.1 | 21.0 | 20.8 | 20.6 | 20.1 | 19.4 | 19.0 |
| G5 | 25.5 | 25.0 | 24.9 | 24.8 | 24.7 | 24.6 | 24.4 | 24.0 | 23.6 | 23.2 |
| G6 | 24.0 | 24.0 | 23.9 | 23.8 | 23.7 | 23.6 | 23.4 | 23.0 | 22.6 | 22.2 |
| G7 | 20.0 | 20.0 | 19.9 | 19.8 | 19.6 | 19.5 | 19.2 | 18.7 | 18.1 | 17.6 |
| G8 | 25.3 | 25.5 | 25.5 | 25.4 | 25.3 | 25.2 | 25.0 | 24.6 | 24.2 | 23.8 |
| Mean | 23.8 | 23.9 | 23.8 | 23.7 | 23.6 | 23.4 | 23.2 | 22.8 | 22.3 | 21.9 |
| S.E.M _t | 0.16 | 0.10 | 0.07 | 0.04 | 0.02 | 0.09 | 0.05 | 0.07 | 0.03 | 0.04 |
| C.D.5 % | 0.44 | 0.26 | 0.20 | 0.10 | 0.06 | 0.26 | 0.13 | 0.21 | 0.09 | 0.11 |
| Locations | | | | | | | | | | |
| L1 | 24.7 | 24.6 | 24.5 | 24.4 | 24.3 | 24.1 | 23.9 | 23.6 | 23.3 | 22.9 |
| L2 | 25.4 | 25.3 | 25.2 | 25.2 | 25.0 | 24.8 | 24.7 | 24.4 | 24.1 | 23.7 |
| L3 | 23.9 | 23.6 | 23.5 | 23.4 | 23.3 | 23.1 | 22.9 | 22.4 | 21.8 | 21.4 |
| L4 | 21.9 | 21.9 | 21.8 | 21.8 | 21.6 | 21.4 | 21.2 | 20.6 | 19.8 | 19.4 |
| Mean | 23.9 | 23.9 | 23.8 | 23.7 | 23.6 | 23.4 | 23.2 | 22.8 | 22.3 | 21.9 |
| S.E.M _t | 0.11 | 0.07 | 0.05 | 0.03 | 0.02 | 0.07 | 0.03 | 0.05 | 0.02 | 0.03 |
| C.D.5 % | 0.31 | 0.18 | 0.14 | 0.07 | 0.04 | 0.18 | 0.09 | 0.14 | 0.06 | 0.08 |
| Seed treatment | | | | | | | | | | |
| T1 | - | 23.9 | 23.8 | 23.7 | 23.7 | 23.6 | 23.4 | 23.1 | 22.7 | 22.4 |
| T2 | - | 23.8 | 23.7 | 23.6 | 23.4 | 23.2 | 22.9 | 22.4 | 21.7 | 21.2 |
| Mean | - | 23.9 | 23.8 | 23.7 | 23.6 | 23.4 | 23.2 | 22.8 | 22.3 | 21.9 |
| S.E.M _t | - | 0.05 | 0.04 | 0.02 | 0.01 | 0.05 | 0.02 | 0.04 | 0.02 | 0.02 |
| C.D.5 % | - | NS | NS | 0.05 | 0.03 | 0.13 | 0.06 | 0.10 | 0.04 | 0.05 |

G1 = V20B; G2 = Madhu B; G3 = IR 54752B; G4 = Improved Sona B; G5 = Pushpa B;
 G6 = Mangala B; G7 = Intan mutant B; G8 = Pragathi B; L1 = Bangalore; L2 = Mandya
 L3 = Shimoga; L4 = Mudigere, T1 = Treated; T2 = Untreated. NS = Not significant

Table 18 . Seedling length (cm) as influenced by interaction of genotype and location during storage

| Genotypes | Month after storage | | | | | | | | | |
|-------------------------------|---------------------|------|------|------|------|------|------|------|------|------|
| | 1 | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 17 | 19 |
| Location 1 (Bangalore) | | | | | | | | | | |
| G1 | 27.9 | 27.6 | 27.4 | 27.3 | 27.2 | 27.1 | 26.9 | 26.7 | 26.4 | 26.1 |
| G2 | 24.7 | 24.3 | 24.2 | 24.1 | 24.0 | 23.9 | 23.8 | 23.5 | 23.2 | 22.9 |
| G3 | 24.3 | 24.1 | 24.1 | 23.9 | 23.9 | 23.7 | 23.5 | 23.1 | 22.5 | 22.1 |
| G4 | 21.2 | 21.6 | 21.5 | 21.4 | 21.2 | 21.1 | 20.8 | 20.5 | 20.1 | 19.6 |
| G5 | 27.0 | 27.1 | 27.0 | 26.9 | 26.8 | 26.6 | 26.5 | 26.2 | 25.9 | 25.5 |
| G6 | 25.6 | 25.2 | 25.1 | 25.0 | 24.9 | 24.8 | 24.6 | 24.3 | 24.0 | 23.6 |
| G7 | 19.6 | 19.6 | 19.2 | 19.8 | 19.3 | 19.1 | 18.8 | 18.5 | 18.0 | 17.6 |
| G8 | 28.4 | 27.1 | 27.0 | 26.9 | 26.8 | 26.7 | 26.5 | 26.3 | 26.0 | 25.6 |
| Mean | 24.9 | 24.6 | 24.5 | 24.4 | 24.3 | 24.1 | 23.9 | 23.6 | 23.3 | 22.9 |
| Location 2 (Mandya) | | | | | | | | | | |
| G1 | 29.3 | 29.2 | 29.1 | 29.0 | 28.9 | 28.6 | 28.6 | 28.4 | 28.1 | 27.8 |
| G2 | 26.6 | 26.4 | 26.4 | 26.3 | 26.3 | 26.1 | 26.0 | 25.8 | 25.5 | 25.0 |
| G3 | 25.7 | 25.5 | 25.4 | 25.3 | 25.1 | 24.9 | 24.7 | 24.3 | 23.9 | 23.4 |
| G4 | 21.5 | 20.9 | 20.8 | 20.7 | 20.6 | 20.4 | 20.2 | 19.9 | 19.5 | 19.1 |
| G5 | 26.7 | 27.3 | 27.2 | 27.1 | 27.0 | 26.9 | 26.7 | 26.5 | 26.0 | 25.8 |
| G6 | 26.1 | 26.3 | 26.2 | 26.1 | 26.0 | 25.9 | 25.7 | 25.5 | 25.0 | 24.9 |
| G7 | 25.5 | 19.9 | 19.8 | 19.8 | 19.6 | 19.4 | 19.2 | 18.8 | 18.4 | 18.0 |
| G8 | 28.0 | 27.0 | 26.9 | 26.8 | 26.7 | 26.6 | 26.4 | 26.1 | 25.9 | 25.5 |
| Mean | 25.5 | 25.3 | 25.2 | 25.2 | 25.0 | 24.8 | 24.7 | 24.4 | 24.1 | 23.7 |
| Location 3 (Shimoga) | | | | | | | | | | |
| G1 | 26.8 | 26.2 | 26.1 | 26.0 | 25.9 | 25.7 | 25.4 | 24.9 | 24.4 | 24.0 |
| G2 | 22.5 | 23.7 | 23.7 | 23.6 | 23.5 | 23.4 | 23.2 | 22.7 | 22.2 | 21.9 |
| G3 | 23.9 | 23.4 | 23.4 | 23.3 | 23.1 | 22.9 | 22.6 | 21.9 | 21.1 | 20.7 |
| G4 | 23.1 | 23.1 | 23.0 | 22.9 | 22.8 | 22.6 | 22.3 | 21.7 | 20.9 | 20.5 |
| G5 | 25.5 | 24.1 | 24.1 | 24.0 | 23.9 | 23.8 | 23.6 | 23.2 | 22.7 | 22.4 |
| G6 | 22.8 | 22.6 | 22.6 | 22.5 | 22.4 | 22.2 | 22.0 | 21.6 | 21.1 | 20.7 |
| G7 | 20.6 | 20.1 | 20.0 | 19.9 | 19.7 | 19.5 | 19.2 | 18.6 | 17.8 | 17.4 |
| G8 | 26.0 | 25.3 | 25.2 | 25.1 | 25.0 | 24.9 | 24.7 | 24.3 | 23.8 | 23.4 |
| Mean | 23.9 | 23.6 | 23.5 | 23.4 | 23.3 | 23.1 | 22.9 | 22.4 | 21.8 | 21.4 |
| Location 4 (Mudigere) | | | | | | | | | | |
| G1 | 25.4 | 25.1 | 25.0 | 24.9 | 24.8 | 24.6 | 24.3 | 23.7 | 23.0 | 22.6 |
| G2 | 20.1 | 22.1 | 22.0 | 21.9 | 21.9 | 21.8 | 21.4 | 21.0 | 20.3 | 19.9 |
| G3 | 22.1 | 22.0 | 21.9 | 21.8 | 21.6 | 21.4 | 21.1 | 20.3 | 19.4 | 18.9 |
| G4 | 19.9 | 19.8 | 19.7 | 19.6 | 19.4 | 19.2 | 18.9 | 18.2 | 17.3 | 16.8 |
| G5 | 21.3 | 21.4 | 21.3 | 21.2 | 21.1 | 21.0 | 20.7 | 20.2 | 19.6 | 19.2 |
| G6 | 22.0 | 21.9 | 21.8 | 21.7 | 21.6 | 21.4 | 21.1 | 20.7 | 20.1 | 19.7 |
| G7 | 20.3 | 20.4 | 20.3 | 20.1 | 20.0 | 19.8 | 19.4 | 18.7 | 17.9 | 17.5 |
| G8 | 23.1 | 22.9 | 22.8 | 22.8 | 22.7 | 22.5 | 22.2 | 21.8 | 21.2 | 20.8 |
| Mean | 21.8 | 21.9 | 21.8 | 21.7 | 21.6 | 21.4 | 21.2 | 20.6 | 19.8 | 19.4 |
| S.E.m± | 0.32 | 0.19 | 0.14 | 0.07 | 0.05 | 0.19 | 0.10 | 0.15 | 0.06 | 0.08 |
| C.D.5% | 0.90 | 0.52 | 0.40 | 0.20 | 0.12 | 0.52 | 0.26 | 0.41 | 0.18 | 0.22 |

G1 = V20B; G2 = Madhu B; G3 = IR 54752B; G4 = Improved Sona B; G5 = Pushpa B;
G6 = Mangala B; G7 = Intan mutant B; G8 = Pragathi B;

differences were significant only during end of the storage period. Treated seeds of all the genotypes produced from all the location have registered the higher seedling length than untreated seeds.

4.2.4 Vigour index

The data on vigour index as influenced by genotype, location and their interaction during storage are presented in Tables 19, 20 and 21. A drastic decline in vigour index of seedlings (2263 to 1806) observed with progressive increase in storage period.

Genotypes differed significantly in maintaining vigour during storage period. The vigour index was found to decline as follows in G1: 2598 to 2126; G2: 2221 to 1929; G3: 2232 to 1664; G4: 1985 to 1505; G5: 2442 to 1984; G6: 2302 to 1880; G7: 1876 to 1377 and G8 2450 to 1986 at the end of 19 months after storage. Among the genotypes G1 recorded the highest and the lowest by G7 throughout the storage period (Table 19). The vigour index differed significantly among the locations throughout the storage period. The seeds produced from Mandya maintained the highest vigour index from initial, 2468 to 2062 at the end of the storage period (Table 19). This was followed in order by seeds produced at Bangalore (2366 to 1969) and Shimoga (2221 to 1710). The lowest vigour was observed by the seeds produced at Mudigere throughout the storage period (1998 to 1485).

Table 19 . Vigour index as influenced by genotype, location and seed treatment during storage

| Treatments | Month after storage | | | | | | | | | |
|-----------------------|---------------------|------|-------|------|-------|-------|-------|-------|-------|-------|
| | 1 | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 17 | 19 |
| Genotypes | | | | | | | | | | |
| G1 | 2598 | 2594 | 2553 | 2552 | 2523 | 2480 | 2424 | 2331 | 2233 | 2126 |
| G2 | 2221 | 2286 | 2267 | 2247 | 2225 | 2188 | 2143 | 2074 | 1991 | 1929 |
| G3 | 2232 | 2214 | 2189 | 2163 | 2132 | 2075 | 2018 | 1913 | 1789 | 1664 |
| G4 | 1985 | 1963 | 1939 | 1918 | 1890 | 1848 | 1797 | 1712 | 1602 | 1505 |
| G5 | 2442 | 2390 | 2402 | 2351 | 2322 | 2281 | 2234 | 2161 | 2082 | 1984 |
| G6 | 2302 | 2297 | 2277 | 2258 | 2227 | 2190 | 2137 | 2066 | 1977 | 1880 |
| G7 | 1876 | 1864 | 1834 | 1813 | 1791 | 1740 | 1682 | 1586 | 1483 | 1377 |
| G8 | 2450 | 2398 | 2377 | 2359 | 2331 | 2292 | 2241 | 2172 | 2084 | 1986 |
| Mean | 2263 | 2250 | 2230 | 2208 | 2180 | 2136 | 2084 | 2001 | 1906 | 1806 |
| S.E.M _t | 24.80 | 0.95 | 13.07 | 3.58 | 6.65 | 4.48 | 4.17 | 4.30 | 5.80 | 11.80 |
| C.D.5 % | 68.80 | 2.64 | 36.00 | 9.93 | 18.40 | 12.40 | 11.54 | 11.90 | 16.0 | 32.70 |
| Locations | | | | | | | | | | |
| L1 | 2366 | 2355 | 2325 | 2313 | 2288 | 2250 | 2200 | 2144 | 2060 | 1969 |
| L2 | 2468 | 2457 | 2438 | 2420 | 2392 | 2351 | 2300 | 2243 | 2176 | 2062 |
| L3 | 2221 | 2184 | 2161 | 2139 | 2111 | 2063 | 2013 | 1895 | 1788 | 1710 |
| L4 | 1998 | 2006 | 1996 | 1958 | 1930 | 1883 | 1825 | 1724 | 1599 | 1485 |
| Mean | 2263 | 2250 | 2230 | 2208 | 2180 | 2136 | 2084 | 2001 | 1906 | 1806 |
| S.E.M _t | 17.6 | 0.68 | 9.20 | 2.53 | 4.70 | 3.17 | 2.95 | 3.00 | 4.10 | 8.34 |
| C.D.5 % | 48.6 | 1.87 | 25.4 | 7.00 | 13.04 | 8.80 | 8.15 | 8.45 | 11.40 | 23.10 |
| Seed treatment | | | | | | | | | | |
| T1 | - | 2257 | 2238 | 2230 | 2209 | 2178 | 2147 | 2082 | 2010 | 1936 |
| T2 | - | 2244 | 2220 | 2186 | 2151 | 2094 | 2022 | 1921 | 1802 | 1675 |
| Mean | - | 2250 | 2230 | 2208 | 2180 | 2136 | 2084 | 2001 | 1906 | 1806 |
| S.E.M _t | - | 0.48 | 6.50 | 1.80 | 3.30 | 2.24 | 2.10 | 2.16 | 2.90 | 5.90 |
| C.D.5 % | - | 1.32 | NS | 5.00 | 9.20 | 6.20 | 5.80 | 6.00 | 8.00 | 16.34 |

G1 = V20B; G2 = Madhu B; G3 = IR 54752B; G4 = Improved Sona B; G5 = Pushpa B; G6 = Mangala B; G7 = Intan mutant B; G8 = Pragathi B; L1 = Bangalore; L2 = Mandya; L3 = Shimoga; L4 = Mudigere, T1 = Treated; T2 = Untreated. NS = Not significant

Table 20. Vigour index as influenced by interaction of genotype and location during storage

| Genotypes | Month after storage | | | | | | | | | |
|-------------------------------|---------------------|------|------|------|------|------|------|------|------|------|
| | 1 | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 17 | 19 |
| Location 1 (Bangalore) | | | | | | | | | | |
| G1 | 2723 | 2704 | 2608 | 2665 | 2638 | 2599 | 2553 | 2497 | 2410 | 2312 |
| G2 | 2384 | 2334 | 2315 | 2295 | 2271 | 2238 | 2205 | 2157 | 2100 | 2030 |
| G3 | 2274 | 2258 | 2235 | 2209 | 2186 | 2143 | 2079 | 2007 | 1907 | 1786 |
| G4 | 2013 | 2009 | 1991 | 1971 | 1946 | 1911 | 1858 | 1803 | 1708 | 1620 |
| G5 | 2621 | 2646 | 2624 | 2604 | 2580 | 2543 | 2498 | 2443 | 2373 | 2298 |
| G6 | 2469 | 2444 | 2423 | 2400 | 2374 | 2332 | 2277 | 2226 | 2148 | 2067 |
| G7 | 1858 | 1841 | 1816 | 1797 | 1766 | 1728 | 1677 | 1615 | 1523 | 1414 |
| G8 | 2704 | 2606 | 2586 | 2570 | 2545 | 2506 | 2454 | 2404 | 2309 | 2229 |
| Mean | 2380 | 2355 | 2325 | 2314 | 2288 | 2250 | 2200 | 2144 | 2059 | 1969 |
| Location 2 (Mandya) | | | | | | | | | | |
| G1 | 2884 | 2880 | 2855 | 2838 | 2810 | 2769 | 2710 | 2653 | 2588 | 2493 |
| G2 | 2588 | 2575 | 2554 | 2532 | 2513 | 2472 | 2427 | 2381 | 2325 | 2221 |
| G3 | 2436 | 2404 | 2382 | 2359 | 2327 | 2278 | 2216 | 2142 | 2043 | 1918 |
| G4 | 2061 | 1987 | 1964 | 1945 | 1920 | 1882 | 1833 | 1781 | 1721 | 1610 |
| G5 | 2620 | 2686 | 2662 | 2647 | 2614 | 2566 | 2524 | 2471 | 2405 | 2306 |
| G6 | 2568 | 2600 | 2582 | 2568 | 2538 | 2501 | 2445 | 2396 | 2328 | 2182 |
| G7 | 1972 | 1917 | 1896 | 1880 | 1851 | 1809 | 1755 | 1689 | 1615 | 1495 |
| G8 | 2757 | 2610 | 2610 | 2592 | 2561 | 2528 | 2489 | 2438 | 2383 | 2267 |
| Mean | 2486 | 2457 | 2438 | 2420 | 2392 | 2350 | 2300 | 2244 | 2176 | 2062 |
| Location 3 (Shimoga) | | | | | | | | | | |
| G1 | 2570 | 2452 | 2433 | 2414 | 2384 | 2342 | 2285 | 2151 | 2046 | 1942 |
| G2 | 2110 | 2205 | 2187 | 2169 | 2143 | 2106 | 2059 | 1965 | 1859 | 1902 |
| G3 | 2238 | 2180 | 2156 | 2129 | 2096 | 2015 | 1981 | 1832 | 1694 | 1579 |
| G4 | 2080 | 2071 | 2038 | 2015 | 1984 | 1935 | 1887 | 1758 | 1640 | 1541 |
| G5 | 2322 | 2262 | 2244 | 2221 | 2190 | 2155 | 2105 | 2002 | 1918 | 1825 |
| G6 | 2169 | 2152 | 2130 | 2109 | 2068 | 2044 | 1996 | 1896 | 1806 | 1735 |
| G7 | 1926 | 1838 | 1802 | 1778 | 1782 | 1707 | 1645 | 1510 | 1390 | 1300 |
| G8 | 2435 | 2311 | 2298 | 2278 | 2247 | 2203 | 2147 | 2050 | 1955 | 1855 |
| Mean | 2231 | 2183 | 2161 | 2139 | 2111 | 2063 | 2013 | 1895 | 1786 | 1710 |
| Location 4 (Mudigere) | | | | | | | | | | |
| G1 | 2327 | 2338 | 2317 | 2292 | 2261 | 2209 | 2146 | 2025 | 1889 | 1756 |
| G2 | 1868 | 2031 | 2011 | 1995 | 1974 | 1935 | 1881 | 1793 | 1680 | 1565 |
| G3 | 2031 | 2012 | 1986 | 1956 | 1922 | 1866 | 1795 | 1669 | 1512 | 1374 |
| G4 | 1831 | 1786 | 1763 | 1741 | 1710 | 1665 | 1609 | 1505 | 1362 | 1250 |
| G5 | 1979 | 1966 | 2079 | 1934 | 1906 | 1859 | 1810 | 1730 | 1631 | 1505 |
| G6 | 2017 | 1991 | 1975 | 1956 | 1929 | 1881 | 1831 | 1747 | 1625 | 1535 |
| G7 | 1870 | 1860 | 1825 | 1797 | 1766 | 1716 | 1651 | 1532 | 1402 | 1298 |
| G8 | 2117 | 2066 | 2014 | 1996 | 1970 | 1931 | 1874 | 1795 | 1691 | 1593 |
| Mean | 2005 | 2006 | 1996 | 1958 | 1930 | 1883 | 1825 | 1724 | 1599 | 1484 |
| S.E.m+ | 49.6 | 1.91 | 26.0 | 7.2 | 13.3 | 9.0 | 8.3 | 8.6 | 11.6 | 23.6 |
| C.D.5% | 137.6 | 5.30 | 72.0 | 19.8 | 36.8 | 24.8 | 23.1 | 23.9 | 32.1 | 65.4 |

G1 = V20B; G2 = Madhu B; G3 = IR 54752b; G4 = Improved Sona B; G5 = Pushpa B; G6 = Mangala B; G7 = Intan mutant B; G8 = Pragathi B;

Table 21 . Vigour index as influenced by interaction of genotype and seed treatment during storage

| Genotypes | Month after storage | | | | | | | |
|------------------------|---------------------|------|------|------|------|------|------|------|
| | 13 | | 15 | | 17 | | 19 | |
| | T1 | T2 | T1 | T2 | T1 | T2 | T1 | T2 |
| G1: V20 B | 2486 | 2361 | 2418 | 2245 | 2349 | 2118 | 2270 | 1982 |
| G2: Madhu B | 2196 | 2090 | 2146 | 2002 | 2085 | 1897 | 2081 | 1778 |
| G3: IR 54752 B | 2081 | 1955 | 1998 | 1827 | 1900 | 1678 | 1786 | 1532 |
| G4: Improved Sona B | 1863 | 1730 | 1798 | 1626 | 1714 | 1501 | 1622 | 1388 |
| G5: Pushpa B | 2289 | 2189 | 2228 | 2095 | 2163 | 2000 | 2090 | 1878 |
| G6: Mangala B | 2199 | 2075 | 2148 | 1985 | 2082 | 1870 | 2032 | 1728 |
| G7: Intan Mutant B | 1755 | 1609 | 1675 | 1497 | 1594 | 1371 | 1502 | 1251 |
| G8: Pragathi B | 2305 | 2177 | 2250 | 2094 | 2190 | 1979 | 2110 | 1862 |
| Mean | 2147 | 2022 | 2083 | 1921 | 2010 | 1802 | 1938 | 1675 |
| S.E.m _t | 5.9 | | 6.1 | | 8.2 | | 16.7 | |
| C.D. 5% | 16.3 | | 16.9 | | 22.7 | | 46.2 | |

T1 = Treated; T2 = Untreated

NOTE: Up to 13 months of storage interaction was not significant

The treated seeds recorded significantly higher vigour index (2257 to 1938) than untreated seeds (2244 to 1675) throughout the storage period (Table 19).

The data on interaction effects (Table 20) between genotype and location indicated significant differences over storage periods. The genotypes G1, G8, G5 and G2 maintained higher seedling vigour as compared to G7, G3 and G4 in all chosen locations until the end of the storage period. The treated and untreated seeds from Mandya have recorded vigour index (Table 21) higher than those produced at Bangalore, Shimoga and Mudigere. The interactions between genotypes and seed treatment (Table 21) indicated significant differences at the later part of the storage i.e., 13th month onwards. The interactions between G x L x T were not significant in all the months of storage period.

4.2.5 Electrical conductivity of seed leachate (EC)

The data on EC as influenced by genotype, location, seed treatment and their interaction effects during storage are presented in Tables 22 to 25 and Fig. 9 and 10. Irrespective of genotype, location and seed treatment, a consistent increase in EC was observed with progressive increase (153.8 to 217.1 μ mhos/cm) in storage period.

The genotypes differed significantly in EC during storage period (Table 22). G1 recorded the lowest EC initially (146.0 μ mhos/cm) and at the end of storage (202.7

Table 22. Electrical conductivity of seed leachate (μ mhos/cm) as influenced by genotype, location and seed treatment during storage

| Treatments | Month after storage | | | | | | | | | |
|-----------------------|---------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 1 | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 17 | 19 |
| Genotypes | | | | | | | | | | |
| G1 | 146.0 | 150.6 | 153.0 | 156.6 | 161.2 | 166.4 | 171.2 | 178.2 | 187.2 | 202.7 |
| G2 | 152.0 | 153.1 | 156.5 | 160.4 | 165.1 | 169.2 | 173.6 | 181.0 | 191.4 | 209.2 |
| G3 | 157.0 | 163.7 | 167.6 | 173.2 | 177.9 | 182.1 | 188.1 | 198.1 | 211.3 | 228.2 |
| G4 | 154.0 | 156.6 | 159.9 | 163.8 | 169.1 | 175.1 | 180.8 | 192.5 | 205.7 | 228.2 |
| G5 | 148.0 | 148.0 | 151.1 | 156.6 | 161.1 | 165.5 | 171.1 | 181.0 | 193.0 | 213.5 |
| G6 | 147.0 | 148.0 | 150.9 | 154.0 | 158.0 | 163.4 | 169.1 | 178.1 | 191.8 | 212.6 |
| G7 | 159.0 | 163.1 | 167.0 | 172.2 | 178.3 | 182.9 | 188.9 | 200.2 | 214.0 | 233.6 |
| G8 | 165.0 | 166.3 | 168.1 | 170.7 | 173.6 | 177.5 | 181.0 | 185.5 | 193.6 | 208.9 |
| Mean | 153.8 | 156.2 | 159.3 | 163.4 | 168.1 | 172.8 | 178.0 | 187.3 | 190.5 | 217.1 |
| S.E.M ⁺ | 0.54 | 0.37 | 0.29 | 0.35 | 0.35 | 0.36 | 0.36 | 0.35 | 0.36 | 0.36 |
| C.D.5 % | 1.50 | 1.02 | 0.82 | 0.98 | 0.97 | 1.01 | 1.01 | 0.98 | 0.99 | 0.99 |
| Locations | | | | | | | | | | |
| L1 | 152.0 | 153.7 | 156.0 | 159.5 | 163.2 | 168.5 | 172.7 | 178.6 | 187.8 | 202.5 |
| L2 | 141.0 | 143.4 | 146.1 | 150.1 | 154.4 | 158.6 | 164.4 | 172.0 | 182.4 | 199.1 |
| L3 | 158.0 | 161.1 | 164.5 | 169.2 | 173.3 | 177.8 | 183.4 | 193.1 | 205.8 | 225.0 |
| L4 | 164.0 | 166.5 | 170.4 | 174.9 | 181.3 | 186.2 | 191.4 | 203.6 | 218.0 | 241.9 |
| Mean | 153.8 | 156.2 | 159.3 | 163.4 | 168.1 | 172.8 | 178.0 | 187.3 | 198.5 | 217.1 |
| S.E.M ⁺ | 0.38 | 0.26 | 0.21 | 0.25 | 0.25 | 0.26 | 0.26 | 0.25 | 0.25 | 0.25 |
| C.D.5 % | 1.10 | 0.72 | 0.58 | 0.69 | 0.69 | 0.71 | 0.71 | 0.69 | 0.71 | 0.70 |
| Seed treatment | | | | | | | | | | |
| T1 | - | 155.2 | 157.1 | 159.9 | 162.9 | 166.3 | 170.5 | 177.5 | 185.2 | 199.8 |
| T2 | - | 157.2 | 161.4 | 166.9 | 173.2 | 179.2 | 185.5 | 197.2 | 211.8 | 234.4 |
| Mean | - | 156.2 | 159.3 | 163.4 | 168.1 | 172.8 | 178.0 | 187.3 | 198.5 | 217.1 |
| S.E.M ⁺ | - | 0.18 | 0.15 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 | 0.18 |
| C.D.5 % | - | 0.51 | 0.41 | 0.49 | 0.49 | 0.51 | 0.51 | 0.49 | 0.50 | 0.49 |

G1 = V20B; G2 = Madhu B; G3 = IR 54752B; G4 = Improved Sona B; G5 = Pushpa B;
 G6 = Mangala B; G7 = Inten mutant B; G8 = Pragathi B; L1 = Bangalore; L2 = Mandya
 L3 = Shimoga; L4 = Mudigere, T1 = Treated; T2 = Untreated. NS = Not significant

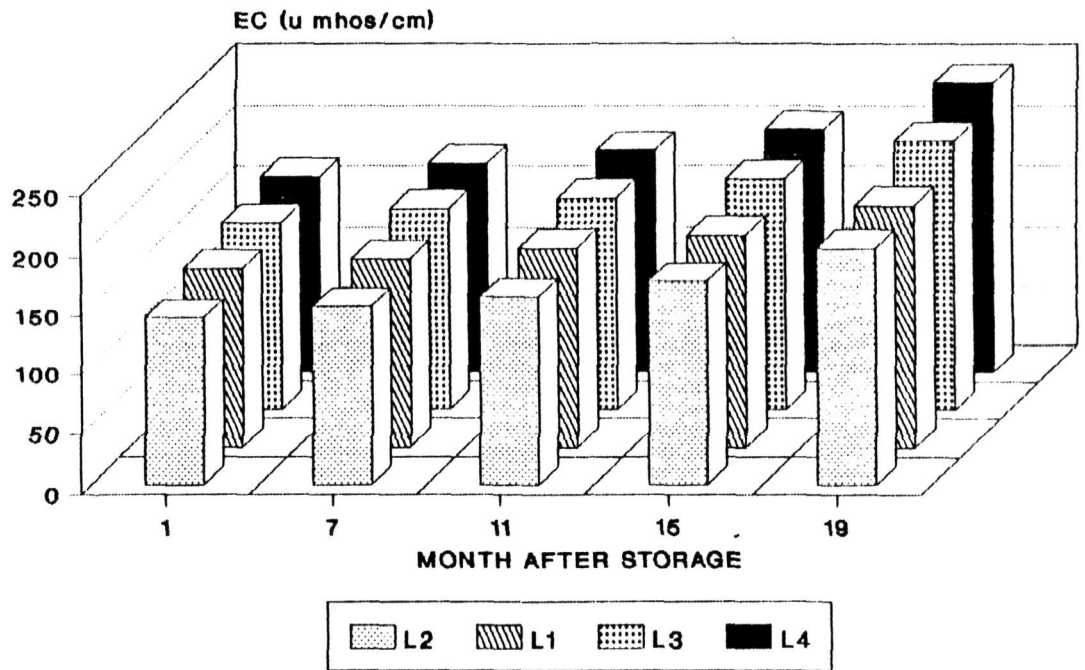


FIG 9.EFFECT OF LOCATION ON EC(u mhos/cm OF SEED LEACHATE DURING STORAGE

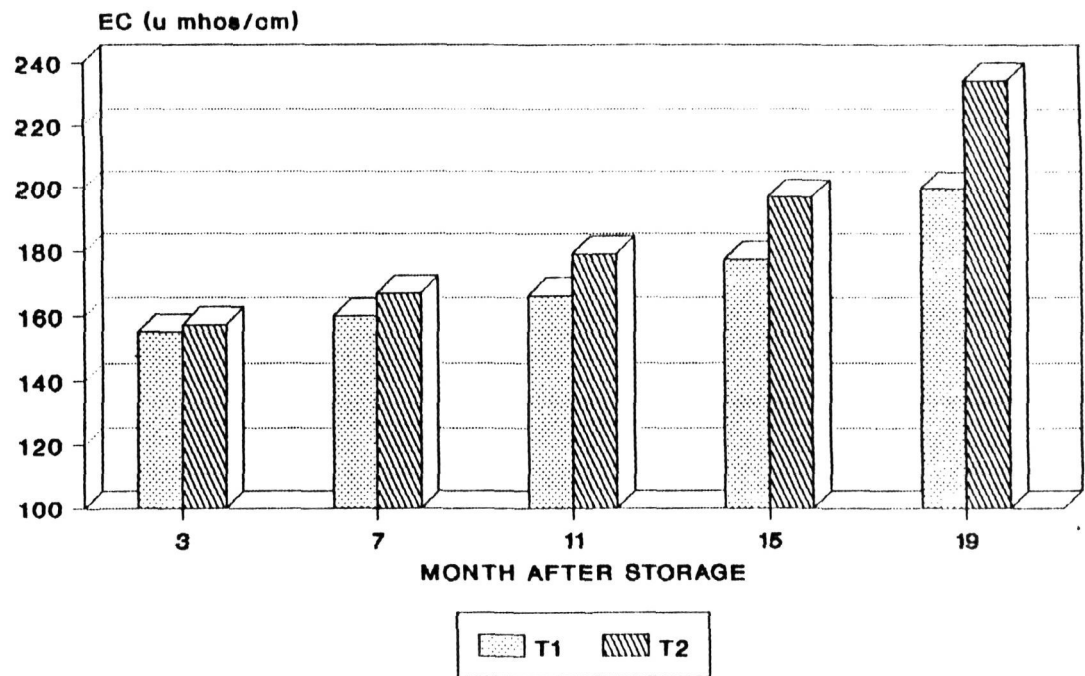


FIG 10.EC OF SEED LEACHATE AS INFLUENCED BY SEED TREATMENT DURING STORAGE.

Table 23. Electrical conductivity (μ mhos/cm) of seed leachate as influenced by interaction of genotype and location during storage

| Genotypes | Month after storage | | | | | | | | | |
|-------------------------------|---------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 1 | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 17 | 19 |
| Location 1 (Bangalore) | | | | | | | | | | |
| G1 | 143.0 | 146.5 | 148.5 | 152.5 | 155.5 | 161.0 | 165.5 | 171.5 | 178.5 | 188.0 |
| G2 | 150.0 | 151.5 | 154.5 | 159.5 | 162.5 | 167.5 | 170.5 | 176.5 | 185.5 | 198.0 |
| G3 | 151.0 | 156.5 | 160.0 | 165.5 | 169.5 | 174.0 | 180.0 | 188.0 | 199.0 | 210.5 |
| G4 | 151.0 | 152.0 | 153.0 | 156.0 | 159.5 | 167.0 | 169.8 | 177.5 | 188.5 | 208.5 |
| G5 | 151.0 | 151.0 | 152.5 | 154.5 | 157.5 | 163.0 | 166.5 | 174.5 | 183.5 | 200.5 |
| G6 | 147.0 | 149.0 | 152.0 | 156.0 | 160.0 | 165.0 | 169.0 | 170.5 | 180.5 | 198.5 |
| G7 | 156.0 | 161.5 | 165.0 | 167.5 | 174.7 | 179.0 | 184.5 | 191.0 | 201.0 | 218.5 |
| G8 | 160.0 | 161.5 | 163.0 | 164.5 | 166.5 | 171.5 | 175.5 | 179.0 | 186.0 | 197.5 |
| Mean | 152.0 | 153.7 | 156.0 | 159.5 | 163.2 | 168.5 | 172.7 | 178.6 | 187.8 | 202.5 |
| Location 2 (Mandya) | | | | | | | | | | |
| G1 | 129.0 | 134.0 | 135.5 | 138.5 | 144.5 | 150.0 | 155.0 | 161.5 | 170.0 | 184.0 |
| G2 | 135.0 | 138.0 | 140.5 | 143.6 | 148.5 | 153.0 | 157.5 | 162.5 | 173.5 | 190.0 |
| G3 | 144.0 | 149.2 | 153.5 | 159.0 | 166.0 | 170.0 | 176.5 | 184.5 | 195.0 | 203.0 |
| G4 | 143.0 | 145.0 | 146.5 | 149.5 | 153.5 | 158.0 | 166.0 | 117.0 | 188.0 | 209.5 |
| G5 | 140.0 | 138.0 | 141.5 | 147.0 | 150.5 | 153.5 | 159.0 | 166.5 | 178.0 | 197.0 |
| G6 | 130.0 | 131.5 | 135.0 | 137.5 | 139.5 | 145.0 | 152.0 | 161.0 | 173.0 | 199.0 |
| G7 | 150.0 | 152.0 | 166.5 | 162.5 | 167.0 | 170.5 | 177.5 | 186.5 | 199.5 | 216.0 |
| G8 | 156.0 | 159.5 | 160.0 | 163.5 | 165.5 | 168.0 | 172.0 | 176.5 | 182.5 | 194.5 |
| Mean | 141.0 | 143.4 | 146.1 | 150.1 | 154.4 | 158.6 | 164.4 | 172.0 | 182.4 | 199.1 |
| Location 3 (Shimoga) | | | | | | | | | | |
| G1 | 150.0 | 154.0 | 156.0 | 159.5 | 164.0 | 169.0 | 175.0 | 183.0 | 192.5 | 210.0 |
| G2 | 156.0 | 157.5 | 159.5 | 162.5 | 168.0 | 170.5 | 176.5 | 187.0 | 197.0 | 215.5 |
| G3 | 164.0 | 173.0 | 178.0 | 183.5 | 184.5 | 189.0 | 195.0 | 205.0 | 220.5 | 239.5 |
| G4 | 161.0 | 164.2 | 170.0 | 175.5 | 179.8 | 185.0 | 192.5 | 205.0 | 220.0 | 239.0 |
| G5 | 151.0 | 149.5 | 153.0 | 161.5 | 166.5 | 170.0 | 176.0 | 185.0 | 197.0 | 223.5 |
| G6 | 150.0 | 150.0 | 152.0 | 155.5 | 159.5 | 167.0 | 173.0 | 183.0 | 198.0 | 220.0 |
| G7 | 164.0 | 170.0 | 173.5 | 178.5 | 184.0 | 189.5 | 194.5 | 208.0 | 224.0 | 242.0 |
| G8 | 170.0 | 171.0 | 174.0 | 177.5 | 180.0 | 182.0 | 185.0 | 189.0 | 197.5 | 210.5 |
| Mean | 158.0 | 161.1 | 164.5 | 169.2 | 173.3 | 177.8 | 183.4 | 193.1 | 205.8 | 225.0 |
| Location 4 (Mudigere) | | | | | | | | | | |
| G1 | 163.0 | 168.0 | 172.0 | 176.0 | 181.0 | 185.5 | 189.5 | 197.0 | 208.0 | 229.0 |
| G2 | 165.0 | 165.5 | 171.5 | 176.0 | 181.5 | 186.0 | 190.0 | 198.0 | 209.5 | 233.5 |
| G3 | 169.0 | 176.0 | 179.0 | 185.0 | 191.5 | 195.5 | 201.0 | 215.0 | 231.0 | 260.0 |
| G4 | 163.0 | 165.0 | 170.0 | 174.0 | 183.8 | 190.0 | 195.0 | 210.0 | 226.5 | 256.0 |
| G5 | 151.0 | 153.5 | 157.5 | 163.5 | 170.0 | 175.5 | 183.0 | 198.0 | 213.5 | 233.0 |
| G6 | 160.0 | 161.5 | 164.5 | 167.0 | 173.0 | 176.5 | 182.5 | 198.0 | 215.5 | 233.0 |
| G7 | 167.0 | 169.0 | 173.0 | 180.5 | 187.5 | 192.5 | 199.0 | 215.1 | 231.5 | 258.0 |
| G8 | 173.0 | 173.5 | 175.5 | 177.5 | 182.5 | 188.0 | 191.5 | 197.5 | 208.5 | 233.0 |
| Mean | 164.0 | 166.5 | 170.4 | 174.9 | 181.3 | 186.2 | 191.4 | 203.6 | 218.0 | 242.0 |
| S.E.m _t | 1.10 | 0.74 | 0.60 | 0.71 | 0.70 | 0.73 | 0.73 | 0.71 | 0.72 | 0.71 |
| C.D. _{5%} | 3.00 | 2.04 | 1.65 | 1.96 | 1.94 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |

G1 = V20B; G2 = Madhu B; G3 = IR 54752B; G4 = Improved Sona b; G5 = Pushpa B;
G6 = Mangala B; G7 = Intan mutant B; G8 = Pragathi B;

μ mhos/cm) but recorded significantly higher EC than G5 (during 3rd and 5th month) and G6 during 3 to 13 months. The highest EC was registered by G7 throughout the storage (159.0 to 233.6 μ mhos/cm) except during first five months. EC differed significantly among the locations throughout the storage period (Tabale 22). The seeds produced at Mandya recorded the lowest EC throughout the storage (141.0 to 199.1 μ mhos/cm) followed by those produced at Bangalore and Shimoga. The highest EC was registered by the seeds of Mudigere (164.0 to 241.9 μ mhos/cm). On the whole, seed treatment, EC increased in seeds of all the genotypes of all locations as the storage period increased.

Treated seed recorded significantly lower EC (155.2 to 199.8 μ mhos/cm) than the untreated seeds (157.2 to 234.4 μ mhos/cm) during storage period.

Significant differences were noticed in EC for interaction between genotype and location in all the months of storage (Table 23). Seeds produced at Mandya Viz., G1, G8 and G2 leached the minimum quantity of leachates as compared to G7, G3 and G4. While the seeds of the same genotypes produced at Mudigere gave higher leachates (EC) as compared to Shimoga, Bangalore and Mandya. The treated seeds of genotypes, G1, G6, G8 and G5 maintained the viability by recording lower EC than untreated seeds till the end of storage period (Table 24). Treated seeds from all the

Table 24. Electrical conductivity of seed leachate ($\mu\text{mhos/cm}$) as influenced by interaction of (1) genotype and seed treatment (2) location and seed treatment during storage

| | | Month after storage | | | | | | | | | | | | | | | | | |
|------------------|-------|---------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|----|
| | | 3 | | 5 | | 7 | | 9 | | 11 | | 13 | | 15 | | 17 | | 19 | |
| | | T1 | T2 | T1 | T2 | T1 | T2 | T1 | T2 | T1 | T2 | T1 | T2 | T1 | T2 | T1 | T2 | T1 | T2 |
| Genotypes | | | | | | | | | | | | | | | | | | | |
| G1 | 149.5 | 152.0 | 151.0 | 155.0 | 153.0 | 160.0 | 157.0 | 165.5 | 160.7 | 172.0 | 164.5 | 178.0 | 170.2 | 186.2 | 177.2 | 197.2 | 189.0 | 216.5 | |
| G2 | 152.5 | 153.0 | 154.0 | 159.0 | 156.0 | 164.8 | 159.0 | 171.2 | 162.2 | 176.2 | 165.5 | 181.8 | 171.8 | 190.2 | 179.8 | 203.0 | 194.8 | 223.8 | |
| G3 | 163.0 | 164.0 | 166.0 | 169.0 | 170.0 | 176.8 | 171.5 | 174.2 | 174.8 | 189.5 | 179.2 | 197.0 | 185.5 | 210.8 | 195.5 | 227.2 | 209.8 | 246.8 | |
| G4 | 155.0 | 158.0 | 157.0 | 162.0 | 161.0 | 166.8 | 163.9 | 174.4 | 168.2 | 182.0 | 173.0 | 188.7 | 180.5 | 204.5 | 188.5 | 222.8 | 205.0 | 251.5 | |
| G5 | 147.0 | 149.0 | 149.0 | 153.0 | 153.0 | 160.0 | 156.0 | 166.2 | 159.2 | 171.8 | 163.8 | 178.5 | 171.5 | 190.5 | 181.0 | 205.0 | 198.0 | 229.0 | |
| G6 | 146.5 | 149.0 | 148.0 | 153.0 | 151.0 | 157.0 | 153.0 | 163.0 | 156.5 | 170.2 | 161.2 | 177.0 | 166.2 | 190.0 | 177.2 | 206.2 | 192.0 | 233.2 | |
| G7 | 163.0 | 163.0 | 166.0 | 168.0 | 169.0 | 175.2 | 174.0 | 182.0 | 177.0 | 188.8 | 181.2 | 196.5 | 188.0 | 212.2 | 197.8 | 230.2 | 214.0 | 253.2 | |
| G8 | 165.0 | 168.0 | 165.0 | 171.0 | 166.0 | 175.0 | 168.7 | 178.5 | 172.0 | 183.0 | 175.5 | 186.5 | 178.5 | 192.5 | 184.5 | 202.8 | 196.2 | 221.5 | |
| Mean | 155.0 | 157.0 | 157.0 | 161.0 | 160.0 | 167.0 | 162.9 | 173.2 | 166.3 | 179.2 | 170.5 | 185.5 | 177.5 | 197.0 | 185.2 | 211.8 | 199.8 | 234.8 | |
| S.E.m | 0.52 | | 0.42 | | 0.50 | | 0.50 | | 0.52 | | 0.52 | | 0.50 | | 0.51 | | 0.50 | | |
| C.D. 5% | 1.44 | | 1.15 | | 1.39 | | 1.37 | | 1.43 | | 1.43 | | 1.39 | | 1.41 | | 1.40 | | |
| Locations | | | | | | | | | | | | | | | | | | | |
| L1 | 152.1 | 155.2 | 153.8 | 158.4 | 156.1 | 162.9 | 158.8 | 167.7 | 162.2 | 174.8 | 165.4 | 180.0 | 169.8 | 187.4 | 176.9 | 198.8 | 189.1 | 215.9 | |
| L2 | 142.5 | 144.3 | 144.0 | 148.2 | 147.0 | 153.3 | 149.8 | 158.8 | 152.8 | 164.4 | 157.4 | 171.5 | 163.0 | 181.0 | 171.4 | 193.5 | 186.0 | 212.2 | |
| L3 | 160.5 | 161.7 | 162.6 | 166.4 | 165.4 | 173.1 | 167.2 | 179.4 | 170.5 | 185.1 | 175.2 | 191.6 | 182.0 | 204.2 | 190.8 | 220.8 | 205.0 | 245.0 | |
| L4 | 165.5 | 167.5 | 168.0 | 172.8 | 171.2 | 178.6 | 175.8 | 186.9 | 179.9 | 192.5 | 184.0 | 198.9 | 191.4 | 215.9 | 201.9 | 234.1 | 219.2 | 264.6 | |
| Mean | 155.0 | 157.0 | 157.0 | 161.0 | 159.9 | 170.0 | 162.9 | 173.2 | 166.3 | 179.2 | 170.5 | 185.5 | 177.5 | 197.1 | 185.2 | 211.8 | 199.8 | 234.4 | |
| S.E.m | 0.37 | | 0.29 | | 0.35 | | 0.35 | | 0.37 | | 0.36 | | 0.35 | | 0.36 | | 0.36 | | |
| C.D. 5% | 1.02 | | NS | | NS | | 0.97 | | 1.00 | | 1.00 | | 0.98 | | 1.00 | | 1.00 | | |

G1 = V20B; G2 = Machu B; G3 = IR 54752 B; G4 = Improved Sona B; G5 = Pushpa B; G6 = Mangala B; G7 = Intan Mitan B; G8 = Pragathi B; L1 = Bangalore; L2 = Mandya; L3 = Shivnoga; L4 = Mudigere; T1 = Treated; T2 = Untreated; NS = Not significant

Table 25. Electrical conductivity (μ mhos/cm) of seed leachate as influenced by interaction effect of genotype, location and seed treatment during storage

| Treatement | Month after storage | | | | | | | | |
|------------|---------------------|-----|-----|-----|-----|-----|-----|-----|-----|
| | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 17 | 19 |
| G1 L1T1 | 145 | 147 | 150 | 153 | 157 | 159 | 164 | 169 | 176 |
| L1T2 | 148 | 150 | 155 | 158 | 165 | 172 | 179 | 188 | 200 |
| L2T1 | 133 | 133 | 135 | 140 | 144 | 148 | 154 | 160 | 172 |
| L2T2 | 135 | 138 | 142 | 149 | 156 | 162 | 169 | 180 | 196 |
| L3T1 | 153 | 154 | 156 | 159 | 163 | 168 | 174 | 182 | 196 |
| L3T2 | 155 | 158 | 163 | 169 | 175 | 182 | 192 | 203 | 224 |
| L4T1 | 167 | 169 | 172 | 176 | 179 | 183 | 189 | 198 | 212 |
| L4T2 | 169 | 175 | 180 | 186 | 192 | 196 | 205 | 218 | 246 |
| G2 L1T1 | 150 | 152 | 156 | 157 | 161 | 163 | 168 | 175 | 186 |
| L1T2 | 153 | 157 | 163 | 168 | 174 | 178 | 185 | 196 | 210 |
| L2T1 | 138 | 139 | 142 | 145 | 148 | 151 | 155 | 165 | 178 |
| L2T2 | 138 | 142 | 145 | 152 | 158 | 164 | 170 | 184 | 202 |
| L3T1 | 158 | 157 | 157 | 160 | 162 | 167 | 176 | 184 | 199 |
| L3T2 | 157 | 162 | 168 | 176 | 179 | 186 | 198 | 210 | 232 |
| L4T1 | 164 | 167 | 169 | 174 | 178 | 181 | 188 | 197 | 216 |
| L4T2 | 167 | 176 | 183 | 189 | 194 | 199 | 208 | 222 | 251 |
| G3 L1T1 | 155 | 157 | 161 | 165 | 168 | 172 | 178 | 189 | 199 |
| L1T2 | 158 | 163 | 170 | 174 | 180 | 188 | 198 | 202 | 222 |
| L2T1 | 150 | 152 | 156 | 160 | 163 | 168 | 174 | 182 | 201 |
| L2T2 | 148 | 155 | 162 | 172 | 177 | 185 | 195 | 208 | 205 |
| L3T1 | 172 | 176 | 180 | 175 | 179 | 184 | 190 | 199 | 209 |
| L3T2 | 174 | 180 | 187 | 184 | 199 | 206 | 220 | 242 | 270 |
| L4T1 | 175 | 178 | 182 | 186 | 189 | 193 | 200 | 212 | 230 |
| L4T2 | 177 | 180 | 188 | 197 | 202 | 209 | 230 | 249 | 290 |
| G4 L1T1 | 148 | 149 | 153 | 155 | 159 | 162 | 169 | 178 | 192 |
| L1T2 | 156 | 157 | 159 | 164 | 175 | 177 | 186 | 189 | 225 |
| L2T1 | 143 | 144 | 146 | 148 | 152 | 158 | 166 | 175 | 189 |
| L2T2 | 147 | 149 | 153 | 159 | 165 | 174 | 188 | 201 | 230 |
| L3T1 | 165 | 168 | 172 | 174 | 178 | 184 | 192 | 201 | 213 |
| L3T2 | 163 | 172 | 179 | 185 | 192 | 201 | 218 | 239 | 265 |
| L4T1 | 164 | 168 | 172 | 178 | 184 | 188 | 195 | 201 | 226 |
| L4T2 | 166 | 172 | 176 | 189 | 196 | 202 | 226 | 252 | 286 |

Table continued

Continued Table 25

| Treatement | Month after storage | | | | | | | | |
|------------|---------------------|------|------|------|------|------|------|------|------|
| | 3 | 5 | 7 | 9 | 11 | 13 | 15 | 17 | 19 |
| G5 L1T1 | 150 | 150 | 151 | 153 | 156 | 159 | 166 | 171 | 186 |
| L1T2 | 152 | 155 | 158 | 162 | 170 | 174 | 183 | 186 | 215 |
| L2T1 | 136 | 139 | 144 | 146 | 148 | 152 | 158 | 168 | 184 |
| L2T2 | 140 | 144 | 150 | 155 | 159 | 166 | 175 | 188 | 210 |
| L3T1 | 150 | 153 | 158 | 161 | 164 | 168 | 176 | 186 | 206 |
| L3T2 | 149 | 153 | 165 | 172 | 176 | 184 | 194 | 208 | 241 |
| L4T1 | 153 | 156 | 160 | 164 | 169 | 176 | 186 | 199 | 216 |
| L4T2 | 154 | 159 | 167 | 176 | 182 | 190 | 210 | 228 | 250 |
| G6 L1T1 | 148 | 150 | 152 | 154 | 157 | 160 | 156 | 163 | 179 |
| L1T2 | 150 | 154 | 160 | 166 | 173 | 178 | 185 | 198 | 218 |
| L2T1 | 130 | 133 | 134 | 135 | 138 | 144 | 150 | 161 | 176 |
| L2T2 | 133 | 137 | 141 | 144 | 152 | 160 | 172 | 185 | 222 |
| L3T1 | 148 | 149 | 152 | 154 | 158 | 164 | 172 | 184 | 202 |
| L3T2 | 152 | 155 | 159 | 165 | 176 | 182 | 194 | 212 | 238 |
| L4T1 | 160 | 162 | 165 | 169 | 173 | 177 | 187 | 201 | 211 |
| L4T2 | 163 | 167 | 169 | 177 | 180 | 188 | 209 | 230 | 255 |
| G7 L1T1 | 163 | 165 | 166 | 172 | 175 | 179 | 184 | 192 | 208 |
| L1T2 | 160 | 165 | 169 | 177 | 183 | 190 | 198 | 210 | 229 |
| L2T1 | 151 | 155 | 159 | 163 | 165 | 170 | 177 | 187 | 204 |
| L2T2 | 153 | 158 | 166 | 171 | 176 | 185 | 196 | 212 | 228 |
| L3T1 | 169 | 172 | 175 | 179 | 183 | 187 | 193 | 202 | 216 |
| L3T2 | 171 | 175 | 182 | 189 | 196 | 202 | 223 | 246 | 268 |
| L4T1 | 169 | 171 | 177 | 182 | 185 | 189 | 198 | 210 | 228 |
| L4T2 | 169 | 175 | 184 | 193 | 200 | 209 | 232 | 253 | 288 |
| G8 L1T1 | 158 | 160 | 160 | 161 | 165 | 169 | 173 | 178 | 187 |
| L1T2 | 165 | 166 | 169 | 172 | 178 | 182 | 185 | 194 | 208 |
| L2T1 | 159 | 157 | 160 | 162 | 164 | 168 | 170 | 175 | 184 |
| L2T2 | 160 | 163 | 167 | 169 | 172 | 176 | 183 | 190 | 205 |
| L3T1 | 170 | 172 | 173 | 175 | 177 | 180 | 183 | 188 | 199 |
| L3T2 | 172 | 175 | 182 | 185 | 188 | 190 | 195 | 207 | 202 |
| L4T1 | 172 | 173 | 173 | 177 | 182 | 185 | 188 | 197 | 215 |
| L4T2 | 175 | 178 | 182 | 188 | 194 | 198 | 207 | 220 | 251 |
| S.Em+ | 1.00 | 0.80 | 1.00 | 1.00 | 1.03 | 1.03 | 1.00 | 1.02 | 1.01 |
| C.D. 5 % | 2.90 | 2.30 | 2.80 | 2.70 | 2.90 | 2.90 | 2.80 | 2.80 | 2.80 |

G1 = V20B; G2 = Madhu B; G3 = IR 54752 B; G4 = Improved Sona B;
G5 = Pushpa B; G6 = Mangala B; G7 = Intan Mutan B; G8 = Pragathi B;
L1 = Bangalore; L2 = Mandya; L3 = Shimoga; L4 = Mudigere
T1 = Treated; T2 = Untreated

locations especially Mandya recorded lower EC throughout the storage period as against higher EC of other locations (Table 24). The interactions between G x L x T were found to be significant till the end of storage period (Table 25).

4.2.6 Moisture content (MC)

The data on moisture content as influenced by genotype location, seed treatment and their interaction effects during 3rd, 7th, 11th, 15th and 19th month of storage are presented in Tables 26 to 29 and Fig. 11 and 12. In general MC fluctuated between 9.75 and 11.91 per cent from beginning to the end of storage period.

The MC differed significantly from 3rd month onwards until the end of storage. The MC was found to fluctuate in all the genotypes during storage period (Table 26). It was the maximum in G2 (9.98%) followed by G4 (9.92%) during 3rd month. At the end of the storage G4 (12.20%) followed by G3 (12.17%) recorded the maximum MC.

The MC differed significantly among the locations. The seeds produced at Mandya recorded significantly lower MC (9.71 to 11.83%) than those of Bangalore and Shimoga. Maximum MC was noticed in the seeds produced at Mudigere (9.82 to 11.97%) from beginning to the end of storage period (Table 26). The treated seeds registered significantly lower MC (9.68 to 11.51%) as compared to untreated seeds (9.82 to 12.31%) from initial to the end of storage period (Table 26).

Table 26. Seed moisture content (%) as influenced by genogypso, location and seed treatment during storage

| | Month after storage | | | | |
|----------------------------|---------------------|-------|-------|-------|-------|
| | 3 | 7 | 11 | 15 | 19 |
| Genotype | | | | | |
| G1 | 9.68 | 11.40 | 11.28 | 10.44 | 11.69 |
| G2 | 9.98 | 11.42 | 11.21 | 10.44 | 11.78 |
| G3 | 9.48 | 11.91 | 11.52 | 10.78 | 12.17 |
| G4 | 9.92 | 11.92 | 11.57 | 10.75 | 12.20 |
| G5 | 9.61 | 11.48 | 11.38 | 10.52 | 11.79 |
| G6 | 9.76 | 11.57 | 11.29 | 10.52 | 11.81 |
| G7 | 9.77 | 11.86 | 11.53 | 10.81 | 12.13 |
| G8 | 9.78 | 11.53 | 11.36 | 10.46 | 11.70 |
| Mean | 9.75 | 11.63 | 11.39 | 10.59 | 11.91 |
| S.Em ⁺ | 0.02 | 0.002 | 0.001 | 0.01 | 0.02 |
| C.D. $\frac{5}{\sqrt{}}$ % | 0.04 | 0.004 | 0.002 | 0.03 | 0.04 |
| Location | | | | | |
| L1 | 9.73 | 11.79 | 11.36 | 10.53 | 11.90 |
| L2 | 9.71 | 11.57 | 11.32 | 10.50 | 11.83 |
| L3 | 9.73 | 11.66 | 11.43 | 10.61 | 11.94 |
| L4 | 9.82 | 11.72 | 11.46 | 10.71 | 11.97 |
| Mean | 9.75 | 11.63 | 11.39 | 10.59 | 11.91 |
| S.Em ⁺ | 0.01 | 0.001 | 0.001 | 0.008 | 0.01 |
| C.D. $\frac{5}{\sqrt{}}$ % | 0.03 | 0.003 | 0.002 | 0.02 | 0.03 |
| Seed Treatment | | | | | |
| T1 | 9.68 | 11.46 | 11.07 | 10.09 | 11.51 |
| T2 | 9.82 | 11.81 | 11.72 | 11.09 | 12.31 |
| Mean | 9.75 | 11.63 | 11.39 | 10.59 | 11.97 |
| S.Em ⁺ | 0.008 | 0.001 | 0.001 | 0.005 | 0.007 |
| C.D. $\frac{5}{\sqrt{}}$ % | 0.02 | 0.002 | 0.002 | 0.015 | 0.002 |

G1 = V20B; G2 = Madhu B; G3 = IR 54752 B; G4 = Improved Sona B;
 G5 = Pushpa B; G6 = Mangala B; G7 = Inten Mutant B; G8 = Pragathi B;
 L1 = Bangalore; L2 = Mandya; L3 = Shimoga; L4 = Mudigere;
 T1 = Treated; T2 = Untreated

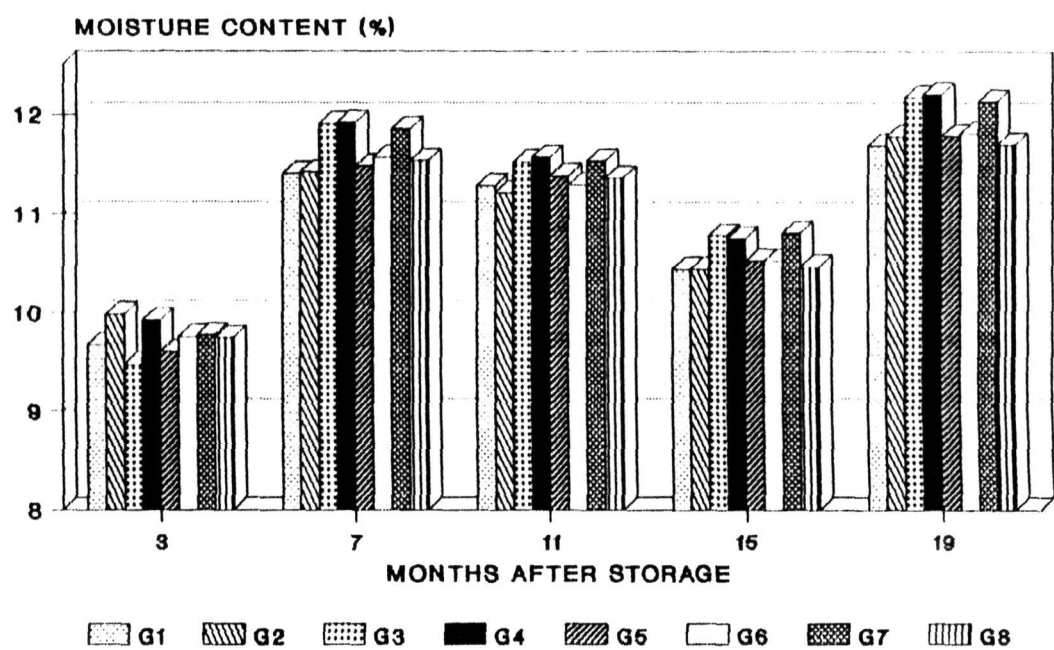


FIG 11. GENOTYPIC VARIATION FOR SEED MOISTURE CONTENT DURING STORAGE.

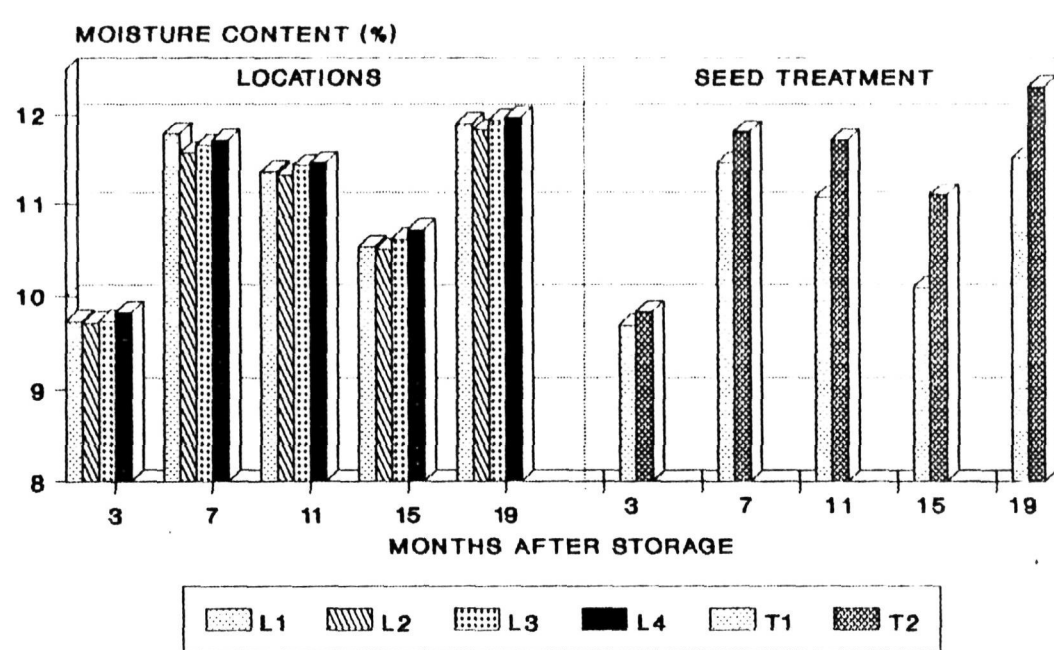


FIG 12. VARIATION IN SEED MOISTURE CONTENT DUE TO LOCATION AND SEED TREATMENT DURING STORAGE.

Table 27. Seed moisture content (%) as influenced by interaction between genotype and location

| Treatment | Month after storage | | | | |
|-------------------------------|---------------------|-------|-------|-------|-------|
| | 3 | 7 | 11 | 15 | 19 |
| Location 1 (Bangalore) | | | | | |
| G1 | 9.65 | 11.37 | 11.24 | 11.40 | 11.69 |
| G2 | 9.96 | 11.40 | 11.14 | 10.37 | 11.76 |
| G3 | 9.38 | 11.91 | 11.45 | 10.70 | 12.15 |
| G4 | 9.91 | 11.89 | 11.57 | 10.70 | 12.17 |
| G5 | 9.56 | 11.42 | 11.35 | 10.48 | 11.76 |
| G6 | 9.78 | 11.53 | 11.30 | 10.47 | 11.87 |
| G7 | 9.70 | 11.83 | 11.49 | 10.73 | 12.09 |
| G8 | 9.92 | 11.42 | 11.33 | 10.40 | 11.70 |
| Location 2 (Mandya) | | | | | |
| G1 | 9.66 | 11.31 | 11.20 | 10.31 | 11.56 |
| G2 | 9.94 | 11.39 | 11.13 | 10.34 | 11.71 |
| G3 | 9.43 | 11.81 | 11.45 | 10.92 | 12.12 |
| G4 | 9.85 | 11.82 | 11.51 | 10.66 | 12.19 |
| G5 | 9.61 | 11.46 | 11.33 | 10.43 | 11.75 |
| G6 | 9.61 | 11.54 | 11.21 | 10.49 | 11.57 |
| G7 | 9.73 | 11.81 | 11.48 | 10.75 | 12.10 |
| G8 | 9.89 | 11.42 | 11.26 | 10.33 | 11.64 |
| Location 3 (Shimoga) | | | | | |
| G1 | 9.72 | 11.43 | 11.33 | 10.49 | 10.75 |
| G2 | 10.01 | 11.43 | 11.25 | 10.47 | 11.81 |
| G3 | 9.54 | 11.96 | 11.54 | 10.81 | 12.20 |
| G4 | 9.94 | 11.97 | 11.61 | 10.77 | 12.22 |
| G5 | 9.64 | 11.50 | 11.43 | 10.55 | 11.80 |
| G6 | 9.82 | 11.62 | 11.34 | 10.50 | 11.89 |
| G7 | 9.80 | 11.89 | 11.58 | 10.83 | 12.18 |
| G8 | 9.41 | 11.50 | 11.41 | 10.46 | 11.73 |
| Location 4 (Mudigere) | | | | | |
| G1 | 9.72 | 11.52 | 11.36 | 10.57 | 11.78 |
| G2 | 10.00 | 11.46 | 11.33 | 10.59 | 11.86 |
| G3 | 9.57 | 11.97 | 11.64 | 10.91 | 12.23 |
| G4 | 10.00 | 12.00 | 11.62 | 10.85 | 10.23 |
| G5 | 9.64 | 11.53 | 11.40 | 10.62 | 11.85 |
| G6 | 9.84 | 11.59 | 11.32 | 10.61 | 11.91 |
| G7 | 9.88 | 11.90 | 11.57 | 10.92 | 12.18 |
| G8 | 9.92 | 11.80 | 11.44 | 10.62 | 11.74 |
| Mean | 9.75 | 11.63 | 11.39 | 10.59 | 11.91 |
| S.Em+ | 0.03 | 0.003 | 0.002 | 0.02 | 0.03 |
| C.D. 5 % | 0.09 | 0.009 | 0.004 | 0.06 | 0.08 |

G1 = V20B; G2 = Madhu B; G3 = IR 54752 B; G4 = Improved Sona B;
 G5 = Pushpa B; G6 = Mangala B; G7 = Intan Mutant B; G8 = Pragathi B

Table 28 . Seed moisture content (%) as influenced by interaction of (1) genotype and seed treatment (2) location and seed treatment during storage

| | Month after storage | | | | | | | | | |
|------------------|---------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| | 3 | | 7 | | 11 | | 15 | | 19 | |
| | T1 | T2 | T1 | T2 | T1 | T2 | T1 | T2 | T1 | T2 |
| Genotype | | | | | | | | | | |
| G1 | 9.64 | 9.73 | 11.13 | 11.68 | 10.95 | 11.61 | 9.92 | 10.94 | 11.21 | 12.18 |
| G2 | 9.91 | 10.04 | 11.23 | 11.60 | 10.88 | 11.54 | 9.99 | 10.89 | 11.29 | 12.27 |
| G3 | 9.42 | 9.54 | 11.86 | 11.96 | 11.20 | 11.84 | 10.25 | 11.32 | 11.90 | 12.45 |
| G4 | 9.87 | 9.98 | 11.80 | 12.03 | 11.31 | 11.84 | 10.25 | 11.25 | 11.87 | 12.53 |
| G5 | 9.55 | 9.68 | 11.26 | 11.69 | 11.01 | 11.74 | 10.03 | 11.02 | 11.33 | 12.25 |
| G6 | 9.68 | 9.84 | 11.33 | 11.80 | 10.95 | 11.63 | 10.02 | 11.01 | 11.38 | 12.24 |
| G7 | 9.74 | 9.81 | 11.76 | 11.95 | 11.22 | 11.84 | 10.33 | 11.28 | 11.82 | 12.45 |
| G8 | 9.63 | 9.94 | 11.28 | 11.79 | 11.03 | 11.68 | 9.92 | 11.00 | 11.30 | 12.10 |
| Mean | 9.68 | 9.82 | 11.46 | 11.81 | 11.07 | 11.72 | 10.09 | 11.09 | 11.51 | 12.31 |
| S.E.m+ | 0.02 | | 0.002 | | 0.001 | | 0.015 | | 0.02 | |
| C.D. 5 % | 0.06 | | 0.006 | | 0.003 | | 0.04 | | 0.06 | |
| Locations | | | | | | | | | | |
| L1 | 9.70 | 9.76 | 11.44 | 11.74 | 11.04 | 11.68 | 10.06 | 11.00 | 11.50 | 12.29 |
| L2 | 9.65 | 9.78 | 11.40 | 11.74 | 10.99 | 11.65 | 10.03 | 10.98 | 11.45 | 12.21 |
| L3 | 9.62 | 9.85 | 11.47 | 11.85 | 11.11 | 11.76 | 10.11 | 11.10 | 11.53 | 12.35 |
| L4 | 9.75 | 9.89 | 11.51 | 11.92 | 11.14 | 11.78 | 10.16 | 11.27 | 11.56 | 12.36 |
| Mean | | | | | | | | | | |
| S.E.m+ | 0.015 | | 0.002 | | 0.001 | | 0.01 | | 0.015 | |
| C.D. 5 % | 0.04 | | 0.004 | | 0.002 | | 0.030 | | 0.04 | |

G1 = V20B; G2 = Madhu B; G3 = IR 54752 B; G4 = Improved Sona B;
 G5 = Pushpa B; G6 = Mangala B; G7 = Intan Mutant B; G8 = Pragathi B;
 L1 = Bangalore; L2 = Mandya; L3 = Shimoga; L4 = Mudigere;
 T1 = Treated; T2 = Untreated

Table 29. Seed moisture content (%) as influenced by interaction effect of genotype, location and seed treatment during storage

| Treatment | Month after storage | | | | | Treatment | Month after storage | | | | |
|-----------|---------------------|-------|-------|-------|-------|-----------|---------------------|-------|-------|-------|-------|
| | 3 | 7 | 11 | 15 | 19 | | 3 | 7 | 11 | 15 | 19 |
| G1 L1T1 | 9.60 | 11.10 | 10.91 | 9.97 | 11.20 | G5 L1T1 | 9.52 | 11.23 | 11.00 | 10.00 | 11.30 |
| L1T2 | 9.70 | 11.65 | 11.57 | 10.84 | 12.18 | L1T2 | 9.61 | 11.62 | 11.71 | 10.96 | 12.23 |
| L2T1 | 9.61 | 11.01 | 11.86 | 9.81 | 11.10 | L2T1 | 9.50 | 11.25 | 10.92 | 9.98 | 11.28 |
| L2T2 | 9.72 | 11.61 | 11.54 | 10.82 | 12.03 | L2T2 | 9.72 | 11.68 | 11.75 | 10.89 | 12.23 |
| L3T1 | 9.68 | 11.16 | 10.98 | 9.99 | 11.26 | L3T1 | 9.60 | 11.28 | 11.08 | 10.04 | 11.36 |
| L3T2 | 9.76 | 11.70 | 11.69 | 10.99 | 12.24 | L3T2 | 9.69 | 11.73 | 11.78 | 11.07 | 12.24 |
| L4T1 | 9.70 | 11.28 | 11.08 | 10.03 | 11.29 | L4T1 | 9.58 | 11.30 | 11.06 | 10.09 | 11.39 |
| L4T2 | 9.73 | 11.76 | 11.65 | 11.11 | 12.28 | L4T2 | 9.71 | 11.76 | 11.75 | 11.16 | 12.32 |
| G2 L1T1 | 9.92 | 11.22 | 10.81 | 9.95 | 11.28 | G6 L1T1 | 9.76 | 11.33 | 10.96 | 10.00 | 11.44 |
| L1T2 | 10.02 | 11.58 | 11.48 | 10.79 | 12.24 | L1T2 | 9.82 | 11.73 | 11.65 | 10.94 | 12.31 |
| L2T1 | 9.90 | 11.26 | 10.83 | 9.93 | 11.22 | L2T1 | 9.42 | 11.30 | 10.86 | 10.06 | 11.26 |
| L2T2 | 9.98 | 11.52 | 11.43 | 10.76 | 12.20 | L2T2 | 9.80 | 11.78 | 11.57 | 10.93 | 11.88 |
| L3T1 | 9.92 | 11.24 | 10.90 | 10.03 | 11.32 | L3T1 | 9.77 | 11.36 | 11.00 | 10.00 | 11.40 |
| L3T2 | 10.11 | 11.63 | 11.61 | 10.91 | 12.30 | L3T2 | 9.88 | 11.88 | 11.68 | 11.00 | 12.38 |
| L4T1 | 9.93 | 11.23 | 11.00 | 10.06 | 11.35 | L4T1 | 9.79 | 11.34 | 11.00 | 10.03 | 11.42 |
| L4T2 | 10.08 | 11.69 | 11.67 | 11.12 | 12.37 | L4T2 | 9.90 | 11.84 | 11.64 | 11.19 | 12.40 |
| G3 L1T1 | 9.35 | 11.86 | 11.16 | 10.18 | 11.90 | G7 L1T1 | 9.72 | 11.78 | 11.21 | 10.26 | 11.76 |
| L1T2 | 9.42 | 11.96 | 11.75 | 11.22 | 12.40 | L1T2 | 9.69 | 11.88 | 11.78 | 11.21 | 12.43 |
| L2T1 | 9.40 | 11.74 | 11.18 | 10.21 | 11.88 | L2T1 | 9.70 | 11.71 | 11.16 | 10.28 | 11.82 |
| L2T2 | 9.46 | 11.89 | 11.73 | 11.23 | 12.36 | L2T2 | 9.76 | 11.91 | 11.80 | 11.22 | 12.38 |
| L3T1 | 9.48 | 11.91 | 11.21 | 10.26 | 11.93 | L3T1 | 9.76 | 11.76 | 11.25 | 10.38 | 11.84 |
| L3T2 | 9.60 | 12.01 | 11.87 | 11.36 | 12.48 | L3T2 | 9.84 | 12.03 | 11.91 | 11.29 | 12.52 |
| L4T1 | 9.47 | 11.96 | 11.26 | 10.36 | 11.90 | L4T1 | 9.78 | 11.82 | 11.28 | 10.41 | 11.86 |
| L4T2 | 9.68 | 11.98 | 12.03 | 11.46 | 12.56 | L4T2 | 9.98 | 11.99 | 11.87 | 11.43 | 12.50 |
| G4 L1T1 | 9.89 | 11.78 | 11.28 | 10.23 | 11.84 | G8 L1T1 | 9.89 | 11.28 | 11.00 | 9.88 | 11.30 |
| L1T2 | 9.94 | 12.00 | 11.86 | 11.18 | 12.50 | L1T2 | 9.95 | 11.56 | 11.66 | 10.92 | 12.10 |
| L2T1 | 9.82 | 11.71 | 11.23 | 10.17 | 11.87 | L2T1 | 9.85 | 11.26 | 10.91 | 9.85 | 11.20 |
| L2T2 | 9.88 | 11.93 | 11.79 | 11.16 | 12.52 | L2T2 | 9.94 | 11.60 | 11.61 | 10.82 | 12.08 |
| L3T1 | 9.89 | 11.83 | 11.38 | 10.27 | 11.88 | L3T1 | 9.86 | 11.29 | 11.09 | 9.95 | 11.32 |
| L3T2 | 9.99 | 12.11 | 11.85 | 11.27 | 12.57 | L3T2 | 9.96 | 11.71 | 11.73 | 11.97 | 12.14 |
| L4T1 | 9.88 | 11.91 | 11.36 | 10.32 | 11.91 | L4T1 | 9.93 | 11.31 | 11.14 | 10.00 | 11.38 |
| L4T2 | 10.12 | 12.09 | 11.88 | 11.39 | 12.55 | L4T2 | 9.92 | 12.29 | 11.75 | 11.30 | 12.11 |
| Mean | | | | | | 9.75 | 11.64 | 11.39 | 10.59 | 11.91 | |
| S.E.m± | | | | | | 0.043 | 0.005 | 0.005 | 0.03 | 0.04 | |
| C.D. 5 % | | | | | | 0.12 | 0.02 | 0.02 | 0.08 | NS | |

G1 = V20B; G2 = Madhu B; G3 = IR 54752 B; G4 = Improved Sona B; G5 = Pushpa b;
G6 = Mangala B; G7 = Intan Mutan B; G8 = Pragathi B; L1 = Bangalore; L2 = Mandya;
L3 = Shimoga; L4 = Mudigere; T1 = Treated; T2 = Untreated

Table 30. Storage fungi observed during the 15th month of storage period in seeds eight rice genotypes produced at four locations

| Genotype | Locations | Storage fungi | | | | | | | | | | | |
|-----------------|-----------|---------------|----|---|----|---|----|---|----|---|----|---|----|
| | | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | |
| | | T | UT | T | UT | T | UT | T | UT | T | UT | T | UT |
| V 20 B | L1 | - | - | + | - | - | + | - | + | - | + | + | + |
| | L2 | - | - | - | + | - | + | - | + | - | - | + | + |
| | L3 | - | + | - | + | + | + | - | + | - | + | - | + |
| | L4 | + | + | + | + | - | + | - | + | - | + | - | + |
| Madhu B | L1 | - | - | - | + | - | - | - | - | - | + | - | + |
| | L2 | - | - | - | - | - | + | - | + | - | + | - | - |
| | L3 | + | + | + | + | - | - | - | + | - | - | - | - |
| | L4 | - | + | - | + | - | + | - | + | - | + | - | + |
| IR 54752 B | L1 | + | + | - | - | - | + | - | - | - | + | - | + |
| | L2 | + | + | - | + | - | - | - | + | - | + | - | + |
| | L3 | + | + | - | + | - | + | + | + | - | + | - | + |
| | L4 | + | + | + | + | + | + | - | + | - | + | - | + |
| Improved Sona B | L1 | - | + | - | + | - | + | + | + | - | + | - | + |
| | L2 | + | + | - | + | - | + | - | + | - | + | - | - |
| | L3 | + | + | - | + | + | + | - | + | + | - | + | + |
| | L4 | + | + | + | + | - | + | - | - | + | + | - | + |
| Pushpa B | L1 | + | + | - | + | + | - | - | + | - | + | - | - |
| | L2 | - | + | - | - | - | + | - | - | - | + | - | + |
| | L3 | + | - | - | + | - | + | - | + | + | - | - | + |
| | L4 | - | + | - | - | + | + | - | + | - | + | - | - |
| Mangala B | L1 | - | + | - | - | + | - | - | + | - | + | - | - |
| | L2 | - | - | - | + | - | + | - | + | - | + | + | - |
| | L3 | - | + | + | - | + | - | - | + | - | - | + | + |
| | L4 | + | + | - | - | + | + | - | + | - | + | + | - |
| Intan mutant B | L1 | - | + | - | + | - | + | - | - | + | - | - | + |
| | L2 | - | - | + | - | - | + | - | + | - | + | - | - |
| | L3 | + | + | + | + | - | + | + | + | + | + | + | + |
| | L4 | - | + | - | + | + | - | + | + | + | + | + | + |
| Pragathi B | L1 | - | + | - | - | + | - | + | - | - | - | + | - |
| | L2 | - | + | - | + | - | - | - | + | - | - | - | + |
| | L3 | + | + | + | - | + | - | + | - | - | - | + | + |
| | L4 | - | + | + | + | - | + | - | + | + | - | + | - |

1= Rhizopus spp.; 2= Aspergillus flavous; 3= Aspergillus fumigatus
 4= Aspergillus niger; 5= Fusarium; 6= Penicillium spp.
 L1 = Bangalore; L2 = Mandya; L3 = Shimoga; L4 = Mudigere
 T = Treated; UT = Untreated

Interaction between the genotype and location was found significant with respect to moisture content of seed (Table 27). Genotypes G7, G3 and G4 recorded the higher MC. The seeds produced at Mandya registered low MC (Table 28). Treated seeds recorded significantly lower MC as compared to untreated seeds in all the locations and over the storage period (Table 28). Significant interactions among genotypes, location and seed treatment were also obtained (Table 29).

4.2.7 Storage fungi

The data on the incidence of storage fungi recorded on the both treated and untreated seeds produced in the four locations at 15th of storage period are presented in Table 30. In general the incidence of Rhizopus Spp., A. fumigatus and A. niger was more as compared to Fusarium Spp. and Penicillium Spp. The seeds of the genotypes viz., IR 54752 B, Improved Sona and Intan mutant harboured more storage fungi than others. The seeds produced at Mudigere and Shimoga recorded relatively more storage fungi than Mandya and Bangalore. The treated seeds exhibited low incidence of storage fungi.

EXPERIMENT -3

4.3 Hybrid Seed Production Through Main and Ratoon Crops

The results of the experiment to produce five F_1 hybrids through main and ratoon crop of parents involving two CMS lines and five restorers in combinations are presented

in Tables 31 to 33 and Fig. 13. The hybrids are, H1: IR 54752A/ARC 11353R, H2: IR 54752A/IR 54R, H3: IR 54752A/IR 46R, H4: Intan mutant A/IR 27315R and H5: Intan mutant A/IR 15324R.

4.3.1 Regeneration per cent

Regeneration percentage in the parents ranged between 93.7 and 83.3 (Table 31). Cytosterile lines showed regeneration higher than restorers. Among the parental lines studied, IR 54752 A put up the highest regeneration (93.7%) followed by Intan mutant A (91.7%) and ARC 11353 R (88.0%). The lowest regeneration was recorded in IR 54 R and IR 27315 R (83.3%).

4.3.2 Ratooning ability

Parental lines varied significantly for this trait (Table 31). Intan mutant A recorded high ratoonability (1.03) followed in order by IR 54752 A (0.97), IR 15324 R (0.97) and IR 54 R (0.86). The lowest ratooning ability was shown by IR 46 R (0.82).

4.3.2 Virus affected plants

Ratoon crop of Intan mutant a showed more susceptibility to virus (2.8%) than IR 27315 R (2.2%) and IR 15324 R (2.1%). The parental lines IR 54752 A, ARC 11353 R and IR 54 R recorded low percentage of virus affected plants (Table 31).

4.3.4 Plant height

The data on plant height recorded on both the parents in main and ratoon crops are presented in Table 32.

Table 31. Regeneration percentage, ratooning ability and virus affected plants during seed production through ratooning of parents

| Parents | Regeneration (%) | Ratooning ability | Virus affected plants (%) |
|----------------|------------------|-------------------|---------------------------|
| IR 54752 A | 93.7 | 0.97 | 0.7 |
| Intan mutant A | 91.7 | 1.03 | 2.8 |
| ARC 11353 R | 88.0 | 0.84 | 0.7 |
| IR 54 R | 85.3 | 0.86 | 0.7 |
| IR 46 R | 85.3 | 0.82 | 1.6 |
| IR 27315 R | 83.3 | 0.83 | 2.2 |
| IR 15324 R | 85.0 | 0.97 | 2.1 |

Between two female parents, IR 54752 A recorded more plant height (93.7 cm) than Intan mutant A (88.4 cm) in the main crop. Similar trend was also observed in the ratoon crop but lower values were registered than the main crop.

In the main crop, male parents varied significantly for plant height. ARC 11353 R recorded the maximum height (98.0 cm) followed by IR 15324 R (96.2 cm). The lowest height was observed in IR27315R (86.8 cm). In the ratoon crop, male parents also differed significantly for plant height. ARC 11353R registered the maximum plant height (79.6 cm) and was on par with IR 15324R (78.2 cm). The lowest height was recorded by IR54R (69.4 cm).

In general greater plant height was recorded in male (92.4 and 75.0 cm) as compared to female (75.0 and 73.8 cm) in both the main and ratoon crops. A drastic reduction in plant height was noticed in ratoon crops.

4.3.5 Productive tillers per plant

The results on number of productive tillers in respect of female and male parents as observed in the main and ratoon crops are presented in Table 32. The two Female parents differed significantly for tiller numbers in main crop, IR 54752A producing more number (13.8) than Intan mutant A (12.5). In ratoon crop, female parents IR 54752A did differ significantly (13.4) from Intan mutant A (12.9)

Number of productive tillers per plant in male parents of main crop differed significantly. IR 54R recorded the maximum productive tillers (16.2) closely followed by ARC 11353R (16.0). The minimum productive tillers were registered by IR 15324R (14.6). The male parents of hybrids H1, H2, H3 and H4 were on par in productive tillers per plant. In the ratoon crop, the male parents differed significantly among themselves with respect to productive tillers. IR 15324R recorded the maximum (14.2) followed by IR 54R (13.9). the minimum productive tillers were observed in IR 46R (12.8).

In general productive tillers were low in number in female prents as compared to male in both the main and ratoon crops.

4.3.6 Panicle length

The data on panicle length of female and male parents in the main and ratoon crops are presented in Table 32. In the main, mean panicle length of female parents was more and less in the ratoon crop as compared to male parents. Between two female parents, IR 54752A registered lengthier panicles (26.0 and 20.7 cm) than Intan mutant A (22.2 and 19.7 cm) in the both main and ratoon crops respectively.

In main crop, the male parents differed significantly for panicle length. IR 15324R recorded more (23.5 cm) panicle length than the others but was on par with ARC 11353 R (23.3

Table 32 : Plant height, yield components and days to 50 per cent flowering of female and male parents during hybrid seed production through main and ratoon crops

| Hybrids | Parents | Plant height (cm) | | Productive tillers/plant | | Panicle length (cm) | | Panicle exertion (%) | | Days to 50 % flowering | |
|----------------------------------|--------------------|-------------------|--------|--------------------------|--------|---------------------|--------|----------------------|--------|------------------------|---------|
| | | Main Ratoon | Ratoon | Main Ratoon | Ratoon | Main Ratoon | Ratoon | Main Ratoon | Ratoon | Main Ratoon | Ratoon* |
| H1 : | F - IR 54752 A | 93.7 | 74.0 | 13.8 | 13.4 | 26.0 | 20.7 | 80.6 | 71.4 | 114.0 | 83.0 |
| | M - ARC 11353 R | 98.0 | 79.6 | 16.0 | 13.4 | 23.3 | 22.9 | 91.3 | 85.8 | 116.0 | 84.0 |
| H2 : | F - IR 54752 A | 93.7 | 74.0 | 13.8 | 13.4 | 26.0 | 20.7 | 80.6 | 71.4 | 113.0 | 84.0 |
| | M - IR 54 R | 92.0 | 69.4 | 16.2 | 13.9 | 22.6 | 21.8 | 38.6 | 82.6 | 116.0 | 83.0 |
| H3 : | F - IR 54752 A | 93.7 | 74.0 | 13.8 | 13.4 | 26.0 | 20.7 | 80.6 | 71.4 | 113.0 | 84.0 |
| | M - IR 46 R | 88.8 | 74.8 | 15.6 | 12.8 | 22.9 | 22.1 | 80.3 | 76.6 | 117.0 | 85.0 |
| H4 : | F - Intan mutant A | 88.4 | 73.4 | 12.5 | 12.9 | 22.2 | 19.7 | 73.3 | 69.1 | 100.0 | 75.0 |
| | M - IR 27315 R | 86.8 | 73.1 | 15.5 | 12.9 | 23.0 | 21.1 | 83.5 | 75.5 | 107.0 | 75.5 |
| H5 : | F - Intan mutant A | 88.4 | 73.4 | 12.5 | 12.9 | 22.2 | 19.7 | 73.3 | 69.1 | 102.0 | 76.0 |
| | M - IR 15324 R | 96.2 | 78.2 | 14.6 | 14.2 | 23.5 | 21.9 | 18.6 | 84.2 | 108.0 | 77.0 |
| Mean | F | 91.5 | 73.8 | 13.3 | 13.2 | 24.5 | 20.3 | 77.7 | 70.5 | | |
| | M | 92.4 | 75.0 | 15.6 | 13.4 | 23.1 | 22.0 | 86.7 | 80.9 | | |
| For comparison of Female parents | | | | | | | | | | | |
| S.Em + | | 0.80 | 0.59 | 0.32 | 0.35 | 0.26 | 0.36 | 0.61 | 0.82 | 0.42 | 0.57 |
| C.D. 5 % | | 2.40 | 1.78 | 0.96 | 1.06 | 0.79 | 1.07 | 1.95 | 2.46 | 1.27 | 1.72 |
| For comparison of Male parents | | | | | | | | | | | |
| S.Em+ | | 0.51 | 0.53 | 0.29 | 0.13 | 0.24 | 0.18 | 0.25 | 0.59 | 0.49 | 0.49 |
| C.D. 5 % | | 1.54 | 1.60 | 0.87 | 0.40 | 0.71 | 0.55 | 0.76 | 1.76 | 1.48 | 1.47 |

* = From date of harvest

F = Female; M = Male;

cm) and IR 27315 R (23.0 cm). In the ratoon crop, panicle length also differed significantly among the male parents. ARC 11353R registered the maximum length (22.9 cm) followed by IR 46R (22.1 cm). Male parents of H2 and H5 were on par.

4.3.7 Panicle exsertion

The observation on per cent panicle exsertion of female and male parents in both main and ratoon crops are presented in Table 32. IR 54752A recorded significantly higher exsertion (80.6%) than Intan mutant A (73.3 %) in the main crop. Similar trend was noticed in the ratoon crop but the exsertion per cent was low.

In the main crop, per cent panicle exsertion differed significantly among the male parents. ARC 11353R registered the highest exsertion (91.3%) followed by IR 15324 R (89.6%). IR 46R recorded the lowest exsertion (80.3%). In the ratoon crop, per cent panicle exsertion differed significantly among the male parents. ARC 11353R recorded the maximum exsertion (85.8%) and was on par with IR 15324R. IR 46R (76.6%) and IR 27315 R (75.5%) were on par with each other due to panicle exsertion.

In general, panicle exsertion was poor in female parents of both main (77.7%) and ratoon (70.5%) crops as compared to male parents 86.7 and 80.9 per cent respectively.

4.3.8 Days to 50 per cent flowering

Data pertaining to days 50 per cent flowering are presented in Table 32.

During main crop, IR 54752 A female parent took 113-114 days and Intan mutant A, 100-102 days to 50 per cent flowering. ARC 11353R took 116 days for 50 per cent flowering and it was 2 days later to IR 54752A. Another restorer IR 54R also took 116 days being three days delay in flowering as compared to its female parent (IR 54752A). IR 46R took three days more than IR 54752A. Other two male parents IR 27315R and IR 1532R took 107 and 108 days respectively for 50 per cent flowering, thus there was seven and six days delay in 50 per cent flowering as compared to female parent Intan mutant A.

4.3.9 Seed set percentage

The data on seed set percentage on female and male parents in the main and ratoon crops are presented in Table 33 and Fig. 13..

In the main crop, seed set percentage differed significantly among the female parents. The highest seed set was observed on IR 54752A (10.43%) with ARC 11353 R followed by IR 54752A with IR 54R (8.60%). The lowest seed set was noticed in Intan mutant (2.60%) with IR 15324 R.

In the ratoon crop, seed set percentage differed significantly between female parents. The highest seed set (7.0 %) was noticed on IR 54752A with ARC 11353R followed by Intan mutant A with IR 15324 R (6.7%). The lowest seed set (4.8%) was recorded on Intan mutant A with IR 27315 R.

Male parents differed significantly due to seed set percentage in main crop, IR 15324R recorded the maximum seed set (91.4%) which was on par with (90.8%) and IR 46 R (89.2%). The lower seed set was recorded on IR 274315R (80.1%). In ratoon crop, male parents differed significantly due to seed set percentage. The maximum seed set (81.0%) was recorded on ARC 11353R, followed in order by IR 46R (77.0%) and IR 27315R (68.2%).

4.3.10 Seed yield per plant

The data on seed yield per plant of both female and male parents in main and ratoon crops are given in Table 33. F_1 hybrid seed yield on female parents differed significantly in the main crop. IR 54752A with ARC 11353 R recorded the highest yield (4.90 g) followed by the same parent with IR 54R (3.40 g). The lowest F_1 seed yield was registered by Intan mutant A with IR 15324 R (0.96g).

In the ratoon crop hybrid seed yield on female parents also differed significantly. IR 54752A with ARC 11353R recorded the highest (2.58 g) seed yield followed by same

parent with IR 46R (1.54 g). The lowest seed yield was noticed in IR 54752A with IR 54 R (1.17g), which was on par with Intan mutant A / IR 27315 R (1.21 g).

Significant differences were observed among the male parents of various hybrids for seed yield per plant. In the main crop, ARC 11353R registered the highest yield (36.4 g) followed by IR 15324R (33.6 g) and IR 46R (28.9 g). The lowest yield was recorded in IR 54R (26.7 g). In the ratoon crop, IR 15324 R significantly differed from other restorers recording the highest per plant yield (26.8 g) followed by ARC 11353R (24.3 g) and IR 54 R (19.8 g). IR 46 registered the lowest yield (16.6 g). In general F_1 hybrid seed yield and restorer yield per plant harvested from the main crop were more than those of ratoon crops.

4.3.11 Seed yield per hectare

The data on seed yield per hectare basis on both the female and male parents in the main and ratoon crops are presented in the Table 33 and Fig. 13.

Seed yield differed significantly on hectare basis. In the main crop, IR 54752A with ARC 11353R recorded the highest seed yield (1.49 t/ha) followed by IR 54752A with IR 54R (1.06 t/ha) and IR 54752A / IR 46 R (0.62 t/ha). Intan mutant A with IR 15324R registered the lowest seed yield (0.34 t/ha).

Table 33: Seed set and seed yield of female and male parents during hybrid seed production through main and ratoon crops

| Hybrids | Parents | Seed set (%) | | Seed yield / plant (g) | | Seed yield/* hectare (t) | |
|----------------------------------|--------------------|--------------|--------|------------------------|--------|--------------------------|--------|
| | | Main | Ratoon | Main | Ratoon | Main | Ratoon |
| H1 : | F - IR 54752 A | 10.43 | 7.00 | 4.90 | 2.58 | 1.49 | 0.88 |
| | M - ARC 11353 R | 90.80 | 81.00 | 36.40 | 24.30 | 4.20 | 2.80 |
| H2 : | F - IR 54752 A | 8.60 | 5.60 | 3.40 | 1.17 | 1.06 | 0.39 |
| | M - IR 54 R | 83.60 | 75.60 | 26.70 | 19.80 | 3.00 | 2.50 |
| H3 : | F - IR 54752 A | 4.80 | 5.29 | 1.90 | 1.54 | 0.62 | 0.51 |
| | M - IR 46 R | 89.20 | 77.00 | 28.90 | 18.60 | 3.60 | 2.00 |
| H4 : | F - Intan mutant A | 3.12 | 4.80 | 1.11 | 1.21 | 0.39 | 0.42 |
| | M - IR 27315 R | 80.10 | 68.20 | 27.00 | 16.60 | 3.20 | 1.90 |
| H5 : | F - Intan mutant A | 2.60 | 6.70 | 0.96 | 1.38 | 0.34 | 0.41 |
| | M - IR 15324 R | 91.40 | 78.00 | 33.60 | 26.80 | 4.00 | 3.00 |
| Mean | F | 5.91 | 5.88 | 2.45 | 1.58 | 0.78 | 0.52 |
| | M | 87.00 | 75.90 | 30.50 | 21.20 | 3.60 | 2.40 |
| For comparison of Female parents | | | | | | | |
| S.E.m + | | 0.19 | 0.10 | 0.21 | 0.05 | 0.30 | 0.02 |
| C.D. 5 % | | 0.58 | 0.29 | 0.63 | 0.14 | 0.09 | 0.05 |
| For comparison of Male parents | | | | | | | |
| S.E.m+ | | 1.26 | 0.34 | 1.14 | 0.76 | 0.05 | 0.06 |
| C.D. 5 % | | 3.80 | 1.00 | 3.44 | 2.30 | 0.15 | 0.19 |

F = Female; M = Male;

* = Based on plot yield

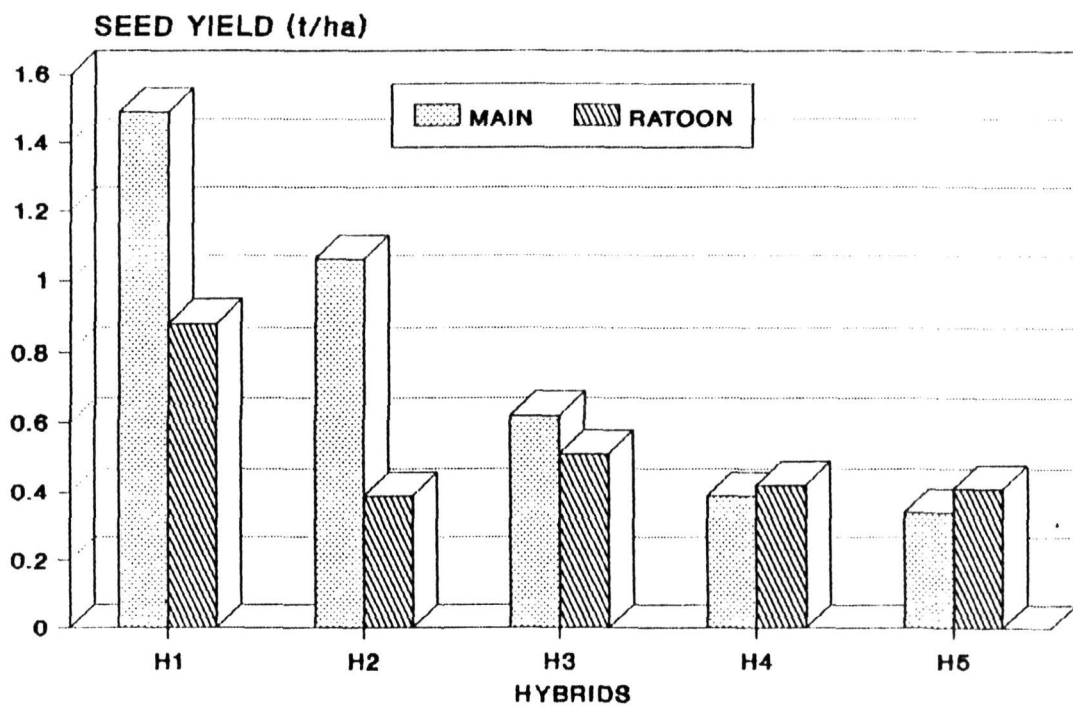
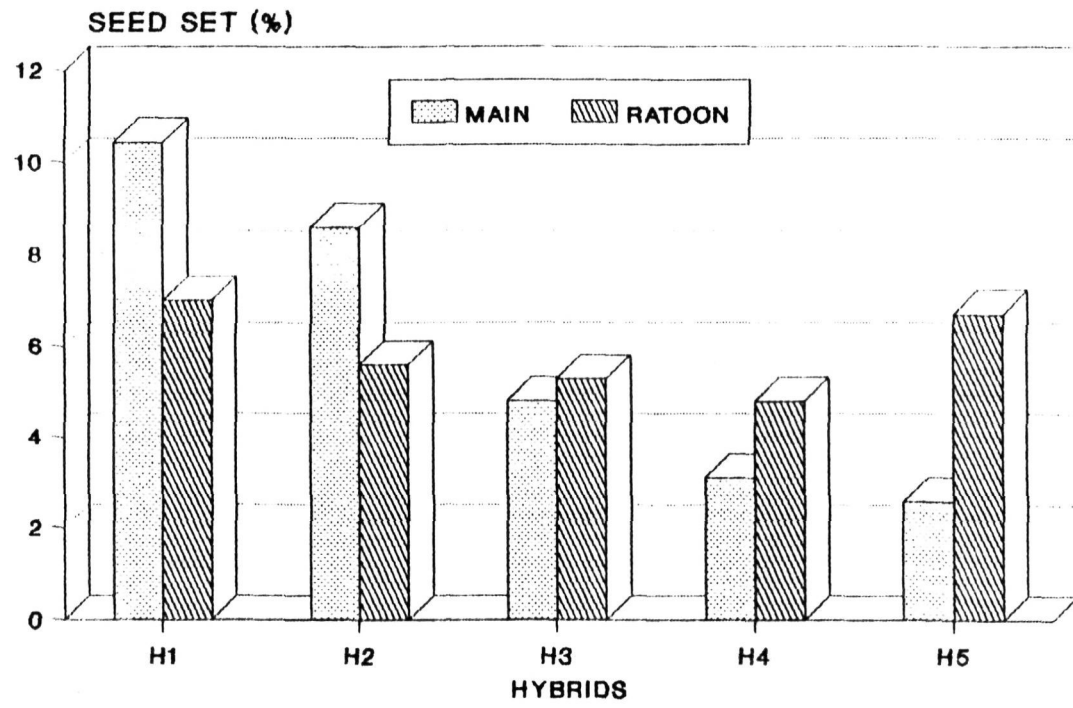


FIG 13. SEED SET AND SEED YIELD OF HYBRIDS DURING SEED PRODUCTION THROUGH MAIN AND RATOON CROPS.

In the ratoon crop also IR54752A with ARC 11353 R out yielded (0.88 t/ha) other parent combinations i.e., IR 54752A with IR 46R (0.51 t/ha). IR 54752A with IR 54 R registered the lowest F₁ hybrid seed yield (0.39 t/ha) however, it was on par with seed yield produced by IR 54752A / IR 46R, Intan mutant A / IR 27315 R and Intan mutant A / IR 15324 R. In general, ratoon hybrid seed yields were lower than main crop.

Seed yield differed significantly among male parents in both main and ratoon crops. In main crop ARC 11353 R recorded the highest seed yield (4.2 t/ha) which was on par with IR 15324R (4.0 t/ha). IR 54R registered the lowest yield (3.0 t/ha).

In the ratoon crop IR 15324R registered the highest yield (3.0 t/ha) followed by ARC 11353 R (2.8 t/ha). The lowest yield was observed in IR 27315 k (1.9 t/ha). Here also ratoon yields were lower than main crop yield.

EXPERIMENT -4

4.4 Seed Quality of F₁ Hybrids Harvested from Main and Ratoon Crops

The results of the experiment conducted during 1990 DS involving seeds of five hybrids produced from i) main crop and ii) ratoon crop are presented in Tables 34 to 37 and Fig.14 and 15.

4.4.1 Test weight of seed

The observations pertaining to the test weight are presented in table 34. Significant differences were

observed among different hybrid seeds both in the main and ratoon crops in respect of test weight. Among the hybrids of main crop, IR 54752A/ARC 11353 R recorded the maximum test weight (25.19 g) followed by IR 54752A/IR 54R (24.66 g). The minimum test weight was recorded by IR 54752A / IR 46R (23.68 g).

Among the hybrid seeds harvested from ratoon crop, the maximum test weight was recorded by IR 54752A/ ARC 11353 R (24.85 g) followed by Intan mutant A/IR 27315R (23.73g). The lowest test weight was observed in Intan mutant A /IR 15324 R (22.74 g). In total, the seeds produced from main crop (24.36 g) significantly differed from ratoon seeds (23.63 g) recording higher mean values for test weight. The interactions were found to be significant.

4.4.2 Thousand seed volume

The data on 1000-seed volume of hybrid seeds produced through main and ratoon crops are presented in Table 34. Statistical analysis revealed significant differences among the hybrids. Among the seeds of hybrids produced from the main crop, IR 54752A/IR 54R (23.80 cc) recorded the maximum volume, followed by IR 54752A/ARC 11353R (23.00 cc) and the minimum was recorded IR 54752A/IR 46R (20.2 cc).

In the ratoon crop seeds, IR 54752A/ IR 54R (22.91 cc) recorded the maximum volume followed by IR 54752A/ARC 11353R (22.66 cc). The lowest values were recorded by IR

Table 34. Test weight, 1000-seed volume and seed density of hybrid seeds produced through transplanted and ratoon crops of parental lines

| Parents | Test weight (g) | | 1000-seed volume (cc) | | Seed density (g/cc) | | |
|---------------------------|--------------------|-------|-----------------------|--------------------|---------------------|--------------------|---------|
| | Female | Male | Main | Ratoon | Main | Ratoon | Mean |
| IR 54752A/ARC 11353 R | 25.19 | 24.85 | 25.02 | 22.66 | 22.83 | 1.10 | 1.10 |
| IR 54752A/IR 54 R | 24.66 | 23.43 | 24.05 | 22.91 | 23.00 | 1.07 | 1.02 |
| IR 54752A/IR 46 R | 23.68 | 23.42 | 23.55 | 20.43 | 20.32 | 1.17 | 1.14 |
| Intan mutant A/IR 27315 R | 24.08 | 23.73 | 23.90 | 21.28 | 21.28 | 1.13 | 1.12 |
| Intan mutant A/IR 15324 R | 24.18 | 22.74 | 23.46 | 21.68 | 22.32 | 1.05 | 1.06 |
| Mean | 24.36 | 23.63 | 22.10 | 21.79 | | 1.10 | 1.09 |
| | S.E.m _t | | C.D. 5% | S.E.m _t | C.D. 5% | S.E.m _t | C.D. 5% |
| Hybrid | 0.05 | | 0.14 | 0.04 | 0.10 | 0.009 | 0.026 |
| Method of propagation | 0.03 | | 0.09 | 0.02 | 0.06 | 0.006 | 0.016 |
| Interaction | 0.07 | | 0.19 | 0.05 | 0.14 | 0.013 | 0.037 |

54752A/IR 46R (20.43 cc). Irrespective of hybrids, the seeds from the main crop registered significantly higher 1000-seed volume (22.1 cc) than did the ratoon seeds (21.79cc). The interaction effects were found to be significant.

4.4.3 Seed density

The data on seed density are presented in Table 34. Hybrids differed significantly for density of seeds both in main and ratoon crops. Among the hybrid seeds produced from the main crop, IR 54752A/IR 46R recorded the maximum (1.17 g/c) followed by Intan mutant A/IR 27315R (1.13 g/cc). The minimum value was registered by Intan mutant A/IR 15324R (1.05 g/cc).

Among the ratoon crop seeds, IR 54752A/IR 46R recorded the maximum density (1.14 g/cc) followed by Intan mutant A/IR 27315R (1.12 g/cc). The minimum value was shown by IR 54752A/IR 54R (1.02 g/cc). Seed density did not differ significantly between the seeds of main and ratoon crops. The interaction effects were also not significant.

4.4.4 Speed of germination

The observations regarding speed of germination are presented in Table 35. Hybrid seeds differed significantly among themselves both in the main and ratoon crop.

Among the hybrids in the main crop, the seeds of IR 54752A / ARC 11353R recorded the highest (36.6) value for

speed of germination followed by Intan mutant A/IR 27315R (33.2). The lowest value was registered by Intan mutant A/IR 15324R (29.6).

Among the ratoon hybrid seeds, the maximum speed of germination was recorded by IR 54752A/ARC 11353R (34.4) followed by Intan mutant A/IR 15324R (26.4). The minimum value was registered by IR 54752A/IR 46R (18.6). Significantly higher speed of germination values were recorded in the main crop seeds (32.6) as compared to ratoon crop seeds (24.1) irrespective of hybrids studied. Interaction effects were significant.

4.4.5 Germination

The data on per cent germination are presented in Table 35. There were significant differences among the hybrid seeds due to per cent germination. In the main crop, hybrid seeds harvested from IR 54752A/ARC 11353R recorded the maximum germination (98.0%) followed by IR 54752A/IR 54R (97.6%). The lowest germination was recorded by Intan mutant A/IR 27315R (89.8%).

Among the ratooned hybrids, seeds of IR 54752A/IR 54R recorded the maximum (96.0%) germination followed by IR 54752A/ARC 11353R (95.8%). The minimum germination was noticed in the seeds of Intan mutant A/IR 27315R (86.1%). Irrespective of hybrids, seeds from main crop recorded higher

germinability (94.8%) than ratoon crop (92.4%). Interactions were found significant .

4.4.6 Field emergence

The results regarding per cent field emergence are presented in Table 35 and Fig. 14. The statistical analysis revealed significant differences for this character among the hybrid seeds irrespective of method of propagation. Among the various hybrid seeds in the main crop IR 54752A/ARC 11353R registered the maximum field emergence (88.5%) which was on par with IR 54752A/IR 54R (88.3%). The minimum values were recorded by Intan mutant A/IR 27315R (80.1 %).

Among the hybrid seeds harvested from the ratoon crop the maximum field emergence was recorded by IR 54752A/ARC 11353R (85.8%), closely followed by IR 54752A/IR 54R (83.8%). The minimum was exhibited by Intar mutant A / IR 27315 R (76.30%). There was significant difference between the main and ratoon crop seed for field emergence per cent. Seedling planted main crop seeds registered significantly higher values (84.6%) than did ratoon seeds (81.51%). Interactions were not significant.

4.4.7 Root length of seedling

The data on root length of seedling are furnished in Table 36. There were significant differences among the hybrid seeds, irrespective of method of their production.

Table 35. Speed of germination, germination and field emergence of hybrid seeds produced through main and ratoon crops of parent lines

| Parents | Speed of germination | | | Germination (%) | | | Field emergence (%) | | |
|---------------------------|----------------------|------|-------------------|-------------------|-------------------|-------------------|---------------------|-------------------|---------|
| | Female | Male | Mean | Main | Ratoon | Mean | Main | Ratoon | Mean |
| IR 54752A/ARC 11353 R | | | 35.5 | 98.0 | 95.8 | 96.9 | 88.5 | 85.8 | 87.2 |
| IR 54752A/IR 54 R | | | 26.2 | 97.6 | 96.0 | 96.8 | 88.3 | 83.8 | 86.1 |
| IR 54752A/IR 46 R | | | 24.2 | 94.5 | 95.1 | 94.8 | 82.2 | 81.0 | 81.6 |
| Intan mutant A/IR 27315 R | | | 27.1 | 89.8 | 86.1 | 87.9 | 80.1 | 76.3 | 78.2 |
| Intan mutant A/IR 15324 R | | | 28.0 | 94.3 | 89.0 | 91.6 | 84.1 | 80.6 | 82.4 |
| Mean | | | 32.6 | 94.8 | 92.4 | 94.6 | 84.6 | 81.5 | |
| | | | S.Em _± | S.Em _± | S.Em _± | S.Em _± | S.Em _± | S.Em _± | C.D. 5% |
| Hybrid | | | 0.69 | 0.49 | 0.49 | 1.35 | 0.59 | 0.59 | 1.64 |
| Method of propagation | | | 0.44 | 0.31 | 0.31 | 0.86 | 0.37 | 0.37 | 1.04 |
| Interaction | | | 0.98 | 0.69 | 0.69 | 1.92 | 0.84 | 0.84 | NS |

NS = Not-significant

Among the hybrid seeds produced from main crop, IR 54752A/ARC 11353R recorded the maximum root length (16.3 cm) closely followed by IR 54752A/IR 46R (16.2 cm); the minimum root length was registered by the hybrid seeds of Intan mutant A/IR 15324R (13.6 cm).

Among the hybrid seeds harvested from ratoon crop, the maximum root length was recorded by IR 54752A/ARC 11353R (16.2 cm) followed by Intan mutant A/IR 27315R (12.9 cm). The minimum value for root length was recorded by IR 54752A/IR 54R (11.1 cm). Irrespective of hybrids, main crop seeds registered higher root length (15.2 cm) than ratoon seeds (13.1 cm). Interactions were significant.

4.4.8 Shoot length of seedling

The observations pertaining to shoot length are summarised in Table 36. Significant differences were recorded among the hybrid seeds, irrespective of propagation method. Among the hybrid seeds of main crop, IR 54752A/ARC 11353R registered the maximum shoot length (13.3 cm) closely followed by IR 54752 A / IR 54 R (11.8 cm) and Intan mutant A/IR 27315R (11.8 cm) and the lowest shoot length was recorded by IR 54752A/IR 46R (10.3 cm).

Among the hybrid seeds obtained from ratoon crop, IR 54752A/ARC 11353R recorded the maximum (13.2 cm) followed by IR 54752A/IR 54R (12.1 cm). The minimum shoot length (10.4 cm) was put up by IR 54752A/IR 46R. Irrespective of

hybrids, the main crop seeds produced significantly higher shoot length (11.6 cm) than did the ratoon seeds (11.4 cm). Interaction effects were significant.

4.4.9 Vigour index

The data on vigour index of seedlings are presented in Table 36. Vigour index differed significantly among the hybrids both in the main and ratoon crop seeds. Among the hybrids of main crop seeds, IR 54752A/ARC 11353R recorded the maximum (2887) vigour index followed by IR 54752A/IR 54R (2681) and the minimum was registered by Intan mutant A/IR 15324R (2289).

Vigour index was maximum in IR 54752A/ARC 11353R (2816) closely followed by IR 54752A/IR 54R (2220) and the minimum was registered by Intan mutant A/IR 27315R (2054) in the seeds harvested by ratoon crop. Irrespective of hybrids, seeds produced from main crop recorded higher vigour index (2543) than ratooned crop seeds (2266). Interactions were significant.

4.4.10 Seedling dry weight

The results on seedling dry weight are presented in Table 37 and Fig. 15. Significant differences were noticed among the hybrids both in the main and ratoon crops, in respect of seedling dry weight. Among the hybrids of

main crop seeds, seedling dry weight was maximum in IR 54752A/ARC 11353R (166.3 mg) closely followed by Intan mutant A/IR 27315R (157.4 mg) and minimum dry weight was recorded by Intan mutant A/IR 15324R (149.2mg).

Among the hybrids of ratoon crop seeds, the maximum seedling dry weight was observed in IR 54752A/ARC 11353R (156.5 mg) followed by Intan mutant A/IR 27315R (134.4 mg) and the minimum values were registered by Intan mutant A/IR 15324R (121.6 mg). Irrespective of hybrids, main crop seed produced higher seedling dry weight (156.10 mg) than ratoon crop seed (134.10 mg). Interactions were significant.

4.4.11 Electrical conductivity (EC) of seed leachate

Significant differences were noticed among different hybrid seeds in both seedling planted crop and ratoon crop in respect of EC (Table 37). Among the hybrids of main crop seeds, the lowest EC was recorded from seeds of IR 54752A/ARC 11353R (157 u mhos/cm) followed by IR 54752A/IR 54R (163 u mhos/cm) and the maximum EC was shown by Intan mutant A/IR 27315R (190 u mhos/cm).

Among the seeds of various hybrids harvested from ratooned crop, the lowest EC was registered by two viz., IR 54752A/ARC 11353R (173 u mhos/cm) and IR 54752A/IR 46R (173 u mhos/cm). The highest EC was noticed in Intan mutant A/IR 27315R (192 u mhos/cm). Irrespective of hybrids, seeds

Table 36. Root length, shoot length and vigour index of hybrid seeds produced through main and ratoon crops of parental lines

| Parents | Root length (cm) | | | Shoot length (cm) | | | Vigour index | | | | |
|---------------------------|------------------|------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| | Female | Male | Mean | Main | Ratoon | Mean | Main | Ratoon | Mean | | |
| IR 54752A/ARC 11353 R | | | 16.2 | 16.3 | 16.2 | 13.2 | 13.3 | 13.2 | 2887 | 2816 | 2851 |
| IR 54752A/IR 54 R | | | 13.3 | 15.6 | 11.1 | 12.1 | 11.8 | 11.9 | 2681 | 2220 | 2450 |
| IR 54752A/IR 46 R | | | 14.3 | 16.2 | 12.4 | 10.4 | 10.3 | 10.3 | 2510 | 2160 | 2335 |
| Intan mutant A/IR 27315 R | | | 13.7 | 14.4 | 12.9 | 10.9 | 11.8 | 11.4 | 2348 | 2054 | 2201 |
| Intan mutant A/IR 15324 R | | | 13.2 | 13.6 | 12.7 | 10.7 | 11.0 | 10.8 | 2289 | 2082 | 2185 |
| Mean | | | 13.1 | 15.2 | 13.1 | 11.4 | 11.6 | 11.4 | 2543 | 2266 | |
| | | | S.E.m ₊ | S.E.m ₊ | S.E.m ₊ | S.E.m ₊ | S.E.m ₊ | S.E.m ₊ | S.E.m ₊ | S.E.m ₊ | S.E.m ₊ |
| | | | C.D. 5% | C.D. 5% | C.D. 5% | C.D. 5% | C.D. 5% | C.D. 5% | C.D. 5% | C.D. 5% | C.D. 5% |
| Hybrid | | | 0.07 | 0.07 | 0.20 | 0.06 | 0.06 | 0.16 | 21.1 | 13.4 | 58.6 |
| Method of propagation | | | 0.04 | 0.04 | 0.13 | 0.03 | 0.03 | 0.08 | 13.4 | 29.9 | 37.0 |
| Interaction | | | 0.10 | 0.10 | 0.28 | 0.08 | 0.08 | 0.22 | 29.9 | 82.8 | 82.8 |

Table 37. Seedling dry weight and electrical conductivity of seed leachate of hybrid seeds produced through main and ratoon crops of parental lines

| Parents | | Seedling dry weight (mg/10 seedlings) | | | Electrical conductivity (μ mhos /cm) | | |
|---------------------------|------|------------------------------------------|--------|---------|----------------------------------------------|--------|---------|
| Female | Male | Main | Ratoon | Mean | Main | Ratoon | Mean |
| IR 54752A/ARC 11353 R | | 166.3 | 156.5 | 161.4 | 157.0 | 173.0 | 165.0 |
| IR 54752A/IR 54 R | | 152.7 | 128.2 | 140.4 | 163.0 | 186.0 | 174.0 |
| IR 54752A/IR 46 R | | 154.8 | 129.7 | 142.2 | 171.0 | 173.0 | 172.0 |
| Intan mutant A/IR 27315 R | | 157.4 | 134.4 | 145.9 | 190.0 | 192.0 | 191.0 |
| Intan mutant A/IR 15324 R | | 149.2 | 121.6 | 135.4 | 187.0 | 189.0 | 188.0 |
| Mean | | 156.1 | 134.1 | | 173.0 | 182.0 | |
| | | S.E.m _± | | C.D. 5% | S.E.m _± | | C.D. 5% |
| Hybrid | | 0.63 | | 1.75 | 1.03 | | 2.84 |
| Method of propagation | | 0.40 | | 1.11 | 0.65 | | 1.80 |
| Interaction | | 0.90 | | 2.48 | 1.45 | | 4.00 |

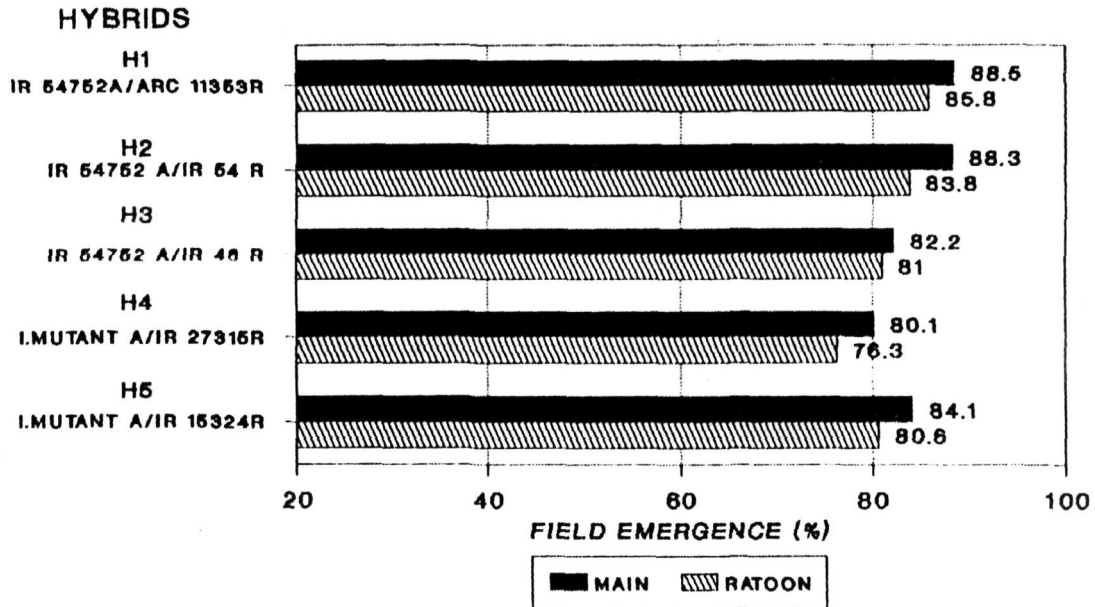


FIG 14. DIFFERENCES IN FIELD EMERGENCE (%) OF SEEDS HARVESTED FROM MAIN AND RATOON CROPS

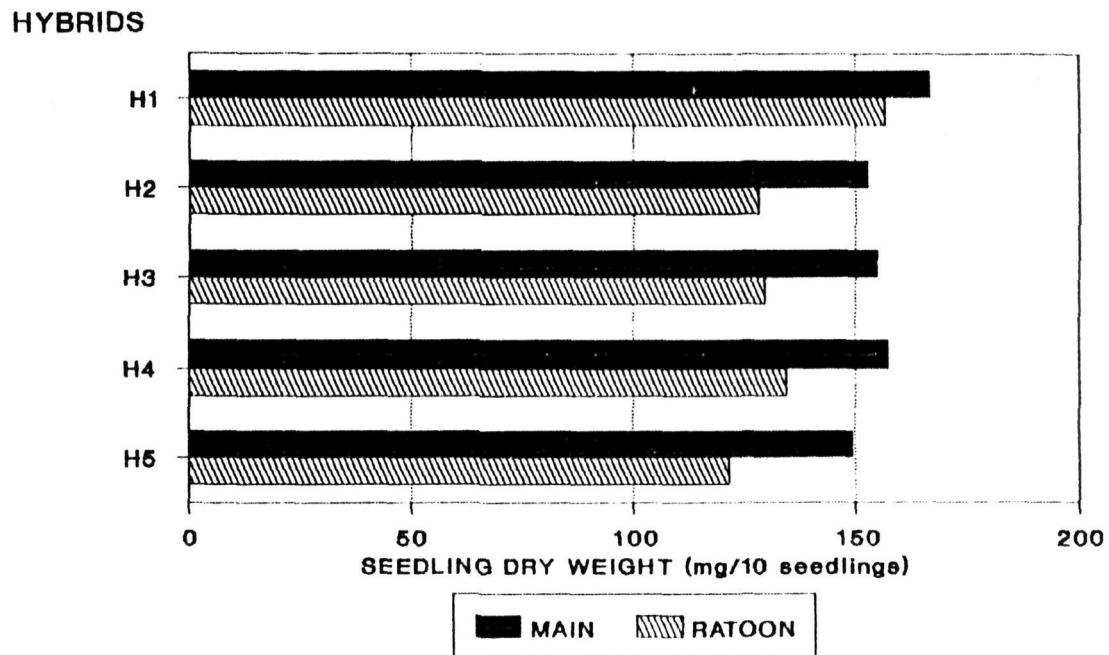


FIG 15. SEEDLING DRY WEIGHT OF SEEDS HARVESTED FROM MAIN AND RATOON CROPS

harvested from main crop recorded the less EC (173 μ mhos/cm) than ratoon crop seed (182 μ mhos/cm).

EXPERIMENT -5

4.5 Evaluation of Male Sterile, Maintainers, Restorer Lines, Hybrids and Varieties for Tiller Propagation

The results pertaining to evaluation of nine promising male sterile lines, their maintainers, seven restorers, eight F_1 hybrids and three varieties for their feasibility to vegetative propagation through tiller separation are presented in Tables 38 to 41 and Figs. 16 to 19.

4.5.1 Number of tillers per mother plant

Male sterile lines differed significantly for number of tillers recovered from mother plant. An average number of tillers recovered was 7.20 (Table 38 and Fig. 16). Pragathi A recorded the highest number of tillers (8.40) but was on par with IR 54752A (8.00) and ES 18A (8.00). Mangala A registered the lowest number of tillers (6.00).

Maintainer lines too differed significantly in recovery of tillers per mother plant. The mean number of tillers obtained was 7.33 (Table 38 and Fig. 16). Madhu B recorded the highest number of tillers (9.30) followed by Pragathi B (8.20) which was on par with Pushpa B (8.00). Mangala B registered the lowest number of tillers (5.80).

Restorer lines also differed significantly for tillers recovered per mother plant. The mean number of tillers

obtained was 7.80 (Table 39 and Fig. 17). ARC 11353 R recorded the highest number of tillers (10.0) being on par with IR 46R (9.5). The lowest number of tillers (6.0) was registered in IR 29723R and IR 20R.

All the hybrids except V 20A/IR 36R and Intan mutant A /ARC 11353R differed significantly from check varieties (Table 39 and Fig. 17). IR 54752A/ARC 11353R recorded the highest (10.5) number of tillers being on par with IR 54752/IR 27315 (10.4) and IR 54752/IR 46R (10.2). The lowest number of tillers (9.0) was recovered by V 20A /IR 36R. In general, hybrids and varieties recorded more number of tillers than A, B and K lines.

4.5.2 Field establishment

The mean field establishment per cent was 85.3. The range being from 79.7 to 96.3 per cent (Table 38 and Fig. 18). Male sterile lines differed significantly in establishment percentage. IR 54752A recorded the highest field establishment (96.3%) followed in order by Intan mutant A (88.0%), ES 18A (87.3 %) and Pushpa A (85.3%). Intanmutant A and ES 18A, Pragathi A and Madhu WA, V 20A and Mangala A were on par with each other. V 20 A recorded the lowest per cent of (79.7%) field establishment.

The data pertaining to field establishment of tillers in maintainer lines are presented in Table 38 and Fig. 18. The field establishment per cent differed significantly

Table 38. Number of tillers recovered per mother plant and their field establishment through tiller planting (CMS lines and maintainers)

| Parents | Tillers recovered per mother plant | Field establishment (%) | |
|-----------------|------------------------------------|-------------------------|--------|
| V 20 A | 7.10 | 79.7 | (63.2) |
| Improved Sona A | 6.80 | 82.3 | (65.2) |
| Mangala A | 6.00 | 80.3 | (63.7) |
| Pragathi A | 8.40 | 84.3 | (66.8) |
| IR 54752 A | 8.00 | 96.3 | (79.2) |
| Pushpa A | 7.00 | 85.3 | (67.5) |
| ES 18 A | 8.00 | 87.3 | (69.1) |
| Madhu WA | 7.00 | 84.0 | (66.4) |
| Intan mutant A | 6.40 | 88.0 | (69.8) |
| Mean | 7.20 | 85.3 | (66.9) |
| S.E.m+ | 0.28 | | 1.00 |
| C.D. 5 % | 0.83 | | 3.00 |
| V 20 B | 7.20 | 81.0 | (64.2) |
| Improved Sona B | 7.00 | 78.0 | (62.0) |
| Mangala B | 5.80 | 81.7 | (64.7) |
| Pragathi B | 8.20 | 80.7 | (63.9) |
| IR 54752 B | 7.20 | 90.3 | (71.3) |
| Pushpa B | 8.00 | 81.0 | (64.2) |
| ES 18 B | 6.30 | 81.3 | (64.4) |
| Madhu B | 9.30 | 82.3 | (65.2) |
| Intan Mutant B | 7.00 | 80.3 | (63.7) |
| Mean | 7.33 | 81.8 | (64.9) |
| S.E.m+ | 0.10 | 0.71 | |
| C.D. 5 % | 0.31 | 2.10 | |

Data in parenthesis are arcsin root transferred values.

Table 39. Number of tillers recovered per mother plant and their field establishment through tiller planting (restorers, hybrids and varieties)

| Genotypes | Tillers recovered per mother plant | Field establishment (%) | |
|----------------------------|---------------------------------------|----------------------------|--------|
| Restorers | | | |
| IR 29723 R | 6.00 | 86.7 | (68.6) |
| IR 54 R | 8.00 | 89.4 | (71.0) |
| IR 46 R | 9.50 | 91.0 | (72.6) |
| ARC 11353 R | 10.00 | 96.7 | (79.6) |
| IR 20 R | 6.00 | 81.1 | (64.3) |
| IR 36 R | 7.20 | 85.4 | (67.6) |
| IR 15324 R | 8.00 | 89.4 | (71.0) |
| Mean | 7.80 | 88.5 | (70.7) |
| S.E.m± | 0.30 | 0.66 | |
| C.D.5 % | 0.92 | 2.00 | |
| Hybrids | | | |
| Intan Mutant A/ARC 11353 R | 9.20 | 89.2 | (70.9) |
| Madhu WA / IR 46 R | 9.80 | 90.2 | (71.8) |
| IR 54752 A / IR 46 R | 10.20 | 83.5 | (66.1) |
| V 20 A / IR 36 R | 9.00 | 87.9 | (69.6) |
| Madhu WA / IR 15324 R | 9.60 | 81.2 | (64.3) |
| IR 54752A / IR 27315 R | 10.40 | 83.0 | (65.7) |
| IR 54752A / ARC 11353 R | 10.50 | 92.1 | (73.8) |
| IR 54752 A / IR 54 R | 9.80 | 85.1 | (67.3) |
| Varieties | | | |
| Jaya | 8.90 | 90.4 | (72.0) |
| CTH 1 (Mukthi) | 8.00 | 91.1 | (72.7) |
| Rasi | 8.00 | 83.2 | (65.8) |
| Mean | 9.47 | 87.0 | 69.1 |
| S.E.m± | 0.21 | 0.65 | |
| C.D.5 % | 0.62 | 1.91 | |

Data in parenthesis are arcsin root transferred values.

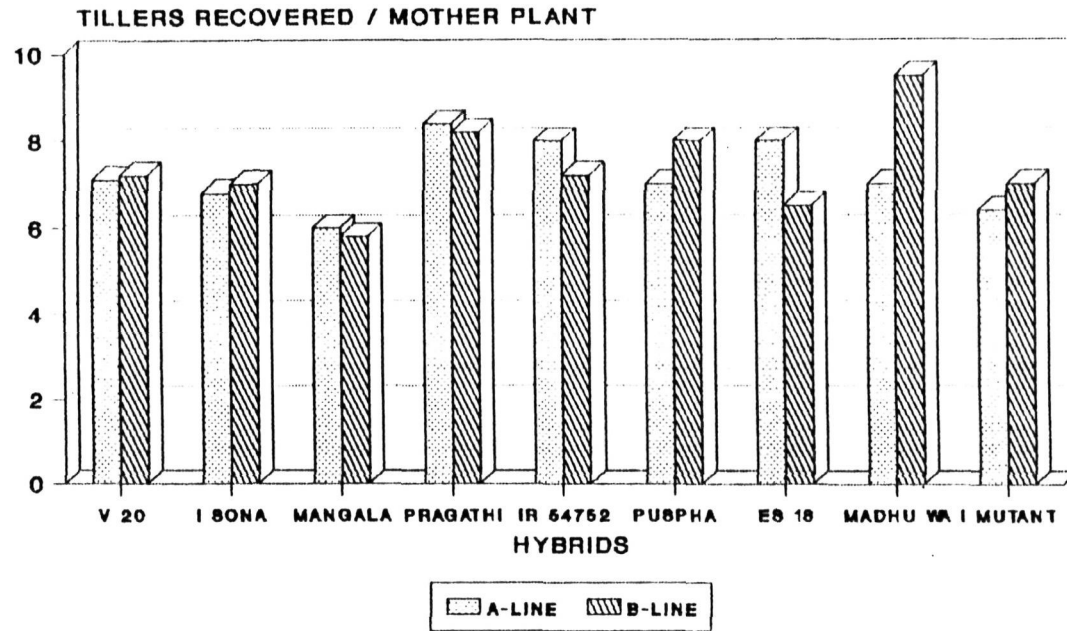


FIG 16. TILLERS RECOVERED FROM SINGLE MOTHER PLANT DURING TILLER SEPARATION IN A AND B LINES

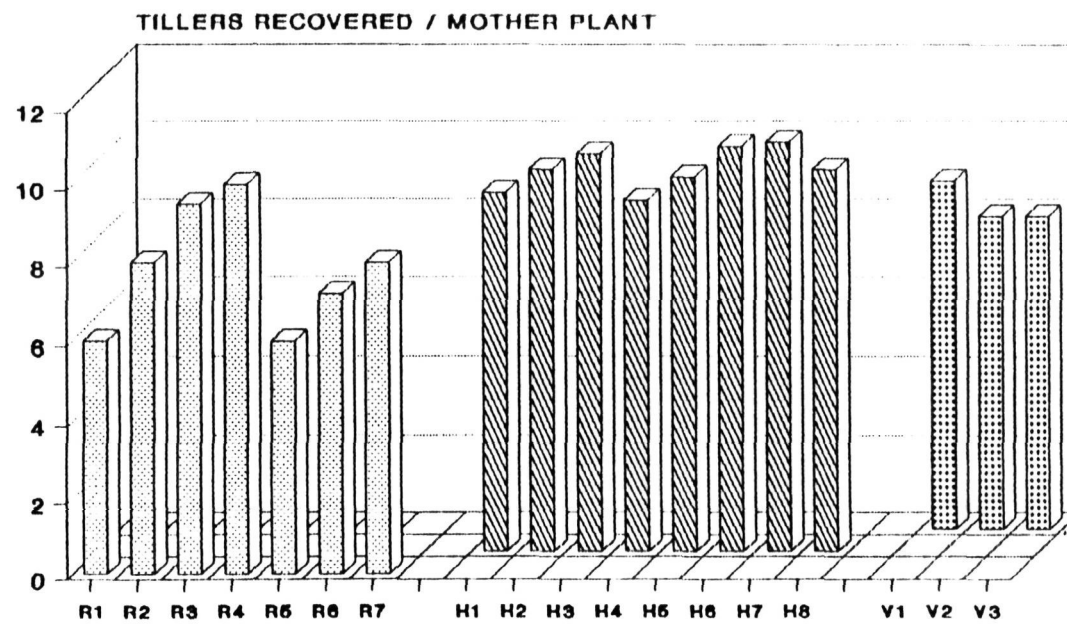


FIG 17. TILLERS RECOVERED FROM SINGLE MOTHER PLANT DURING TILLER SEPARATION IN RESTORERS, HYBRIDS AND VARIETIES

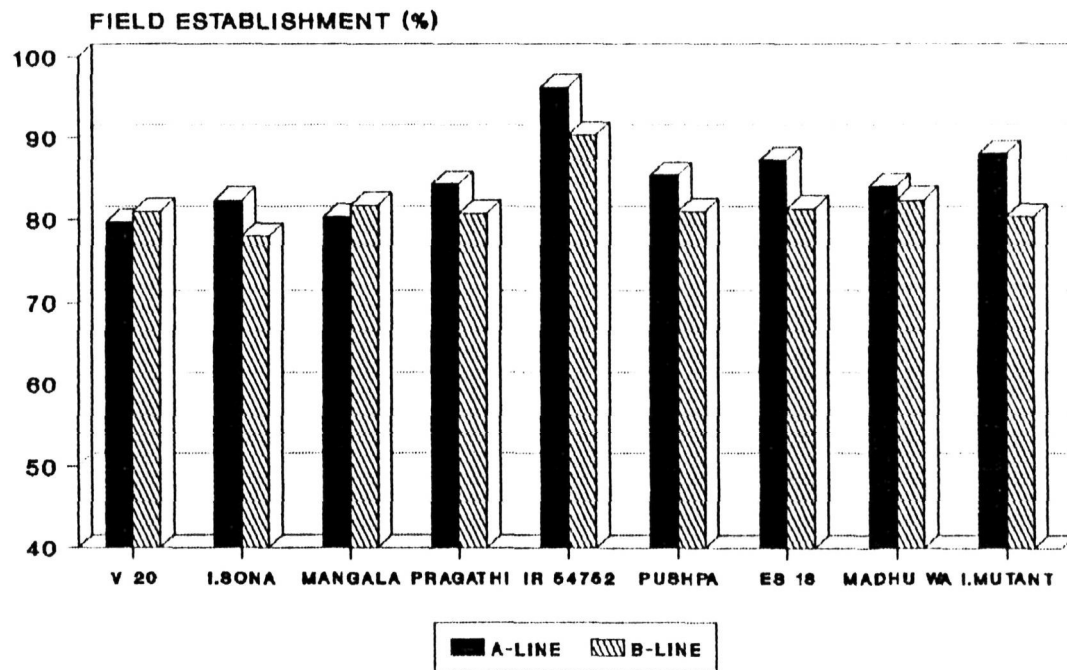


FIG 18. FIELD ESTABLISHMENT (%) IN TILLER PROPAGATED CROP OF A & B LINES

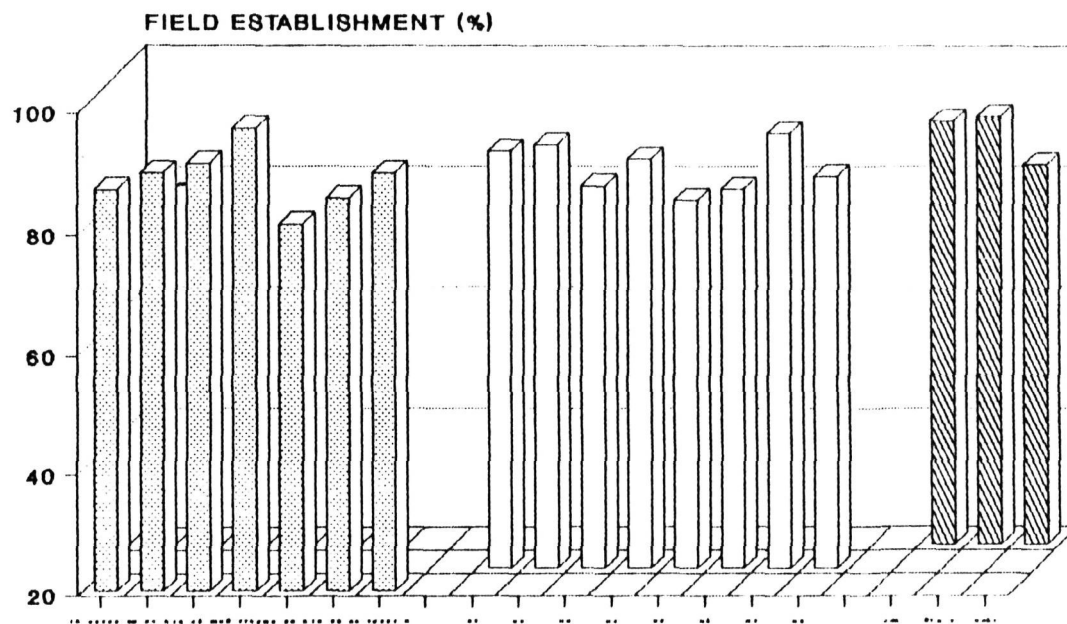


FIG 19. FIELD ESTABLISHMENT (%) IN TILLER PROPAGATED CROP OF RESTORERS, HYBRIDS AND VARIETIES

among the 'B' lines and ranged from 78.0 to 90.3 per cent with mean value of 81.8 per cent. The highest field establishment was recorded in IR 54752B (90.3%) and differed from Madhu B (82.3%), Mangala B (81.7%) and ES 18B (81.3%). Madhu, Mangala, ES 18, Pushpa and V 20 were on par. Improved sona showed very low field establishment.

Restorers also differed significantly in field establishment of tillers (Table 39 and Fig. 19). Percentage ranged from 96.7 to 81.1 with mean value of 88.5 per cent. ARC 11353R registered significantly the highest percentage of field establishment (96.7%) followed in order by IR 46R (91.0%), IR 54R (89.4%). The restorers IR 46, IR 54, IR 15324, IR 29723R and IR 36R were on par. IR 20R recorded the lowest percentage of field establishment (81.1%).

Hybrids and varieties also differed significantly in field establishment of tiller crop (Table 39 and Fig. 19). The establishment ranged from 92.10 to 81.2 per cent. The highest percentage was observed in IR 54752A/ARC 11353R followed in order by CTH 1 (91.1%), Madhu WA /IR 46 R (90.2%) and Jaya (90.4%). The lowest field establishment was observed in Madhu WA /IR 15324R (81.2%). Intan mutant A/ARC 11353R and Madhu WA/IR 46R, Madhu WA /IR 15324R and IR 54752/IR 27315 R, Jaya and CTH 1 were on par.

4.5.3 Growth and yield of male sterile lines

4.5.3.1 Plant height

Male sterile lines differed significantly in plant height in all the methods of propagation (Table 40). IR 54752A recorded the maximum plant height (87.3 cm) followed in order by Madhu WA (83.9 cm) and Intan mutant A (82.5 cm), which were on par. lowest height was registered by V 20A (63.1) cm).

Tiller propagated crop recorded more plant height (75.7 cm) than seedling planted crop (75.6 cm). Interaction effects at same or different levels did not show any significant differences.

4.5.3.2 Productive tillers per plant

Productive tiller number differed significantly among the male sterile lines (Table 40). Both IR 54752A and Intan mutant A recorded the maximum number of productive tillers (14.3) followed by Mangala A (13.9) and Pushpa A (13.7). The lowest number of tillers was recorded by improved sona (11.9) which was on par with ES 18A (12.2), Pragathi A (12.6) and V 20A (12.7). Productive tillers did not differ significantly due to method of propagation and their interactions.

4.5.3.3 Panicle length

Significant variations were noticed due to panicle length among the male sterile lines (Table 40) it ranged from 18.2 to 25.3 cm. Pushpa A recorded the maximum panicle

length (25.3 cm) followed in order by IR 54752A (23.9 cm) and Pragathi A (23.2 cm). ES 18A recorded the minimum panicle length of 18.2 cm.

Significant differences were not noticed due to method of propagation and their interactions. However, vegetatively propagated crop of V 20A, IR 54752A, ES 18A and Intan mutant A recorded numerically more values for panicle length than their respective seedling planted crop.

4.5.3.4 Total spikelets per panicle

Male sterile lines differed significantly for number of spikelets per panicle, irrespective of method of propagation (Table 40). Spikelet number ranged from 84.5 to 135.5. Pushpa A recorded significantly the highest number of spikelets (135.5) was being on par with IR 54752 A (134.5). The lowest number of spikelets was registered by ES 18A (84.5).

Spikelet number did not differ significantly due to the method of propagation and their interaction with genotype.

Table 40 . Plant height and yield components of male sterile lines as influenced by tiller separation and planting

| Genotype | Plant height (cm) | | | Productive tillers/pl. | | | Panicle length (cm) | | | Total spikelets /panicle | | |
|---------------------------------|-------------------------|--------------|------|-------------------------|-------------|------|-------------------------|--------------|------|--------------------------|--------------|-------|
| | Main crop | Tiller crop | Mean | Main crop | Tiller crop | Mean | Main crop | Tiller crop | Mean | Main crop | Tiller crop | Mean |
| V 20 A | 62.0 | 64.2 | 63.1 | 12.4 | 13.0 | 12.7 | 19.0 | 19.3 | 19.2 | 88.0 | 92.0 | 90.0 |
| Improved Sona A | 68.3 | 65.0 | 66.6 | 12.0 | 11.8 | 11.9 | 22.1 | 22.0 | 22.1 | 115.0 | 108.0 | 111.0 |
| Mangala A | 77.5 | 78.0 | 77.8 | 13.8 | 14.0 | 13.9 | 20.8 | 20.6 | 20.7 | 96.0 | 90.0 | 93.0 |
| Pragathi A | 77.3 | 74.0 | 75.6 | 12.8 | 12.5 | 12.6 | 23.5 | 23.0 | 23.2 | 116.0 | 123.0 | 119.0 |
| IR 54752 A | 86.3 | 88.2 | 87.3 | 14.0 | 14.6 | 14.3 | 23.8 | 24.0 | 23.9 | 132.0 | 137.0 | 134.5 |
| Pustpa A | 78.6 | 77.4 | 78.0 | 13.6 | 13.8 | 13.7 | 25.4 | 25.2 | 25.3 | 138.0 | 133.0 | 135.5 |
| ES 18 A | 65.4 | 67.2 | 66.3 | 11.6 | 12.8 | 12.2 | 18.1 | 18.3 | 18.2 | 82.0 | 87.0 | 84.5 |
| Madhu WA | 83.4 | 84.5 | 83.9 | 13.1 | 12.8 | 12.9 | 21.2 | 21.0 | 21.1 | 116.0 | 110.0 | 113.0 |
| Intan Mutant A | 82.0 | 83.0 | 82.5 | 14.0 | 14.6 | 14.3 | 21.9 | 22.1 | 22.0 | 116.0 | 109.0 | 112.5 |
| Mean | 75.6 | 75.7 | | 13.0 | 13.3 | | 21.8 | 21.7 | | 111.0 | 110.0 | |
| Comparing means of Genotype (G) | S.E.m [±] 0.99 | C.D.5 % 2.97 | | S.E.m [±] 0.29 | C.D.5% 0.87 | | S.E.m [±] 0.18 | C.D.5 % 0.55 | | S.E.m [±] 2.18 | C.D.5 % 6.50 | |
| Method of propagation (T) | 0.61 | NS | | 0.13 | NS | | 0.08 | NS | | 1.36 | NS | |
| G at same level of T | 1.82 | NS | | 0.40 | NS | | 0.23 | NS | | 4.10 | NS | |
| G at same/different level of T | 1.63 | NS | | 0.41 | NS | | 0.24 | NS | | 3.60 | NS | |

NS = Not significant

4.5.4 Growth and yield of maintainers under tiller planting

4.5.4.1 Plant height

Plant height differed significantly among the maintainer lines (Table 41) in all methods of propagation. IR 54752B registered the highest plant height (87.5 cm). The lowest plant height was registered by V 20B (63.3 cm). This character did not vary significantly due to method of propagation and their interactions.

4.5.4.2 Productive tillers per plant

Productive tillers per plant differed significantly among the maintainer lines, irrespective of method of propagation (Table 41). IR 54752B recorded the maximum number of productive tillers (14.2) followed in order by Intan mutant B (13.8) and Madhu B (13.1). Improved sona registered the lowest number of tillers (9.9).

Productive tillers did not differ significantly between two methods of propagation and their interaction with genotype.

4.5.4.3 Panicle length

Panicle length (Table 41) differed significantly among the maintainer lines. Pushpa B recorded the maximum panicle length (25.0 cm) followed in order by IR 54752B (24.3 cm) and Pragathi B (23.2 cm). The minimum panicle length was observed in ES 18B (18.2 cm).

Panicle length did not differ significantly due to method of propagation and their interaction.

4.5.4.4 Spikelet number per panicle

Spikelets per panicle differed significantly among the maintainer lines (Table 41). Pushpa B recorded the maximum number of spikelets (128.0) followed by IR 54752B (126.0). The lowest number was observed in ES 18 B (79.5).

Spikelet number did not differ significantly between two methods of propagation, though seedling planted main crop recorded numerically more spikelets (107.0). The interaction between genotype and method of propagation was not significant.

4.5.4.5 Filled spikelets per panicle

Filled spikelets differed significantly among the maintainer lines, irrespective of method of propagation (Table 41). The highest number of filled spikelets (94.5) was recorded by IR 54752B followed in order by Intan mutant B (85.0) and Pragathi (83.5). The lowest number of filled spikelets was observed in both V 20 B (63.0) and ES 18B (63.0).

The genotypes IR 54752B, Intan mutant B, ES 18 B, V 20 B and Mangala B recorded more number of filled spikelets in vegetatively propagated tiller crop than in seedling planted

Table 41. Plant height and yield components of maintainer (B) lines as influenced by tiller separation and planting

| Genotypes | Plant height (cm) | | | Productive tillers/pl. | | | Panicle length (cm) | | | Spikelets /panicle | | |
|---------------------------------|-------------------------|-------------|------|-------------------------|-------------|------|-------------------------|-------------|------|-------------------------|-------------|-------|
| | Main crop | Tiller crop | Mean | Main crop | Tiller crop | Mean | Main crop | Tiller crop | Mean | Main crop | Tiller crop | Mean |
| V 20 B | 63.0 | 63.5 | 63.3 | 11.8 | 12.0 | 11.9 | 18.6 | 18.6 | 18.6 | 86.0 | 83.0 | 84.5 |
| Improved Sona B | 71.0 | 69.0 | 70.0 | 10.0 | 9.8 | 9.9 | 22.0 | 21.8 | 21.9 | 112.0 | 104.0 | 108.0 |
| Mangala B | 80.0 | 81.8 | 80.9 | 12.0 | 12.8 | 12.4 | 20.6 | 20.8 | 20.7 | 92.0 | 95.0 | 93.5 |
| Pragathi B | 74.0 | 72.0 | 73.0 | 11.6 | 11.0 | 11.3 | 23.3 | 23.0 | 23.2 | 110.0 | 116.0 | 113.0 |
| IR 54752 B | 87.0 | 88.0 | 87.5 | 13.6 | 14.8 | 14.2 | 24.0 | 24.5 | 24.3 | 128.0 | 124.0 | 126.0 |
| Pustpa B | 80.0 | 79.0 | 79.5 | 12.8 | 11.0 | 11.9 | 25.0 | 25.0 | 25.0 | 132.0 | 124.0 | 128.0 |
| ES 18 B | 67.3 | 69.2 | 68.3 | 10.6 | 11.2 | 10.9 | 18.0 | 18.3 | 18.2 | 78.0 | 81.00 | 79.5 |
| Madhu B | 82.0 | 82.0 | 82.0 | 13.0 | 13.2 | 13.1 | 21.0 | 20.9 | 20.9 | 109.0 | 106.0 | 107.5 |
| Intan Mutant B | 81.2 | 78.3 | 79.8 | 13.5 | 14.0 | 13.8 | 21.6 | 21.8 | 21.7 | 116.0 | 110.0 | 113.0 |
| Mean | 76.2 | 75.9 | | 12.1 | 12.2 | | 21.6 | 21.6 | | 107.0 | 104.8 | |
| Comparing means of Genotype (G) | S.E.m ² 0.96 | C.D.5% 2.88 | | S.E.m ² 0.17 | C.D.5% 0.51 | | S.E.m ² 0.09 | C.D.5% 0.26 | | S.E.m ² 2.22 | C.D.5% 6.70 | |
| Method of propagation (T) | 0.70 | NS | | 0.16 | NS | | 0.05 | NS | | 1.40 | NS | |
| G at same level of T | 2.10 | NS | | 0.49 | NS | | 0.14 | NS | | 4.20 | NS | |
| G at same/different level of T | 1.75 | NS | | 0.38 | NS | | 0.13 | NS | | 3.70 | NS | |

NS = Not significant

Continued Table 41.

| Genotypes | Filled spiklets/panicle | | | Seed yield / plant (g) | | | Test weight (g) | | |
|---------------------------------|----------------------------|-----------------|------|----------------------------|----------------|------|----------------------------|-----------------|-------|
| | Main crop | Tiller crop | Mean | Main crop | Tiller crop | Mean | Main crop | Tiller crop | Mean |
| V 20 B | 60.0 | 66.0 | 63.0 | 13.6 | 15.7 | 14.6 | 24.86 | 24.88 | 24.87 |
| Improved Sona B | 82.0 | 73.0 | 77.5 | 14.5 | 12.1 | 13.3 | 21.01 | 20.93 | 20.97 |
| Mangala B | 76.0 | 77.0 | 76.5 | 16.0 | 17.5 | 16.7 | 21.89 | 21.87 | 21.88 |
| Pragathi B | 86.0 | 81.0 | 83.5 | 17.1 | 16.5 | 16.8 | 21.14 | 21.07 | 21.10 |
| IR 54752 B | 92.0 | 97.0 | 94.5 | 22.1 | 23.9 | 23.0 | 22.9 | 22.70 | 22.80 |
| Pushpa B | 83.0 | 78.0 | 80.5 | 18.2 | 15.9 | 17.1 | 19.03 | 18.98 | 19.00 |
| ES 18 B | 62.0 | 64.0 | 63.0 | 11.8 | 12.9 | 12.4 | 19.28 | 19.63 | 19.45 |
| Madhu B | 80.0 | 78.0 | 79.0 | 17.3 | 19.1 | 18.2 | 20.26 | 20.25 | 20.25 |
| Intan Mutant B | 83.0 | 87.0 | 85.0 | 20.9 | 22.0 | 21.4 | 20.83 | 20.91 | 20.87 |
| Mean | 78.2 | 77.9 | | 16.8 | 17.3 | | 21.24 | 21.25 | |
| Comparing means of Genotype (G) | S.E.m [±] 1.24 | C.D.5 % 3.70 | | S.E.m [±] 0.27 | C.D.5% 0.80 | | S.E.m [±] 0.06 | C.D.5 % 0.18 | |
| Method of propagation (T) | 0.65 | NS | | 0.07 | 0.21 | | 0.03 | NS | |
| G at same level of T | 1.96 | 5.83 | | 0.21 | 0.64 | | 0.09 | NS | |
| G at same/different level of T | 1.86 | 5.56 | | 0.30 | 0.92 | | 0.09 | NS | |

NS = Not significant

crop. But Improved sona B, Pragathi B, Pushpa B and Madhu B registered less number of filled spikelets in tiller crop.

4.5.4.6 Seed yield

Maintainer lines differed significantly due to seed yield (Table 41) per plant. IR 54752B registered the maximum yield (23.0g) followed by Intan mutant B (21.4 g). The lowest yield was in ES 18 B (12.4 g).

The tiller propagated crop registered significantly higher yield (17.3g) than seedling planted crop (16.8g). Interaction effects were significant in both the methods of propagation. The genotypes propagated through tillers viz., V 20B, Mangala B, IR 54752B, ES 18B, Madhu B and Intan mutant B showed more seed yield than seedling planted crop except in Improved sona, Pragathi B and Pushpa B.

4.5.4.7 Test weight

Test weight differed significantly among the maintainer lines (Table 41). V 20B recorded significantly the highest test weight (24.87 g) followed by IR 54752B (22.80g). The lowest test weight was observed in Pushpa B (19.00 g). Significant differences for test weight were not noticed due to method of propagation and their interaction at both the levels.

4.5.5 Growth and yield as influenced by tiller propagation in restorer lines

4.5.5.1 Plant height

Plant height varied significantly among the restorers (Table 42). ARC 11353R registered the highest plant height (88.6 cm) but was on par with IR 15324R (87.7 cm), followed by IR 29723 R (82.2 cm) and IR 54 R (80.4 cm). The minimum height was registered by IR 36 (71.4 cm).

Plant height did not differ significantly due to method of propagation. However, numerically higher values (81.4 cm) were observed in tiller crop than seedling planted crop (81.1 cm). The interactions were significant. The restorers, IR 29723R, IR 46R, ARC 11353R, IR 153234 R showed greater plant height in vegetatively in tiller crop than their respective seedling planted crop. But remaining restorer lines showed quite opposite behaviour.

4.5.5.2 Productive tillers per plant

Irrespective of method of propagation restorer lines varied significantly for number of productive tillers (Table 42). IR 46R recorded significantly more number of tillers (15.1) than ARC 11353R (14.5), IR 15324R (14.1) and IR 29723R (14.0). The comparatively low number of productive tillers was exhibited by IR 20 R (13.6). Number of productive tillers did not vary due to method of propagation. ARC 11353R showed significant differences recording more

productive tillers (15.0) in tiller crop than other restorers.

4.5.5.3 Panicle length

Restorers differed significantly in panicle length, irrespective of method of propagation (Table 42). ARC 11353R showed significantly the maximum panicle length (23.7 cm) followed by IR 15324R (23.2 cm) and IR 46R (22.5 cm). IR 36 R registered the minimum panicle length (19.8 cm).

Significant differences were not noticed for panicle length due to method of propagation. However, tiller crop recorded numerically more lengthy panicles (22.0 cm) as that of seedling planted crop (21.9 cm). The restorers IR 29723R, IR 46, ARC 11353R, IR 15324R recorded longer panicles in vegetatively tiller crop than in seedling planted crop but it was quite opposite in IR 54, IR 20 and IR 36R.

4.5.5.4 Spikelets per panicle

Number of spikelets differed significantly among the restorers, irrespective of method of propagation (Table 42), ranging from 106.0 to 140.0. ARC 11353R recorded a highest number of spikelets (134.0) but was on par with IR 15324 R and IR 20 R (131.0). The lowest number of spikelets (106.0) was recorded in IR 54 R. There was no significant difference between seedling and tiller propagated crop for number of spikelets.

4.5.5.5 Filled spikelets per panicle

Irrespective of method of propagation restorers differed significantly for filled spikelets per panicle (Table 42). ARC 11353 R recorded the highest number of filled spikelets (107.0) followed in order by IR 15324R (100.0) and IR 46R (89.5). The three restorers IR 29723R, IR 20R and IR 36R were on par. IR 54R registered the lowest number of filled spikelets (77.5).

Differences were not significant for filled spikelets due to method of propagation. But vegetatively propagated ARC 11353R recorded significantly more filled spikelets than the seedling planted crop.

4.5.5.6 Seed yield per plant

The restorer lines differed significantly due to seed yield (Table 42). ARC 11353R registered the highest yield (25.3g) but was on par with IR 46R (24.6g). IR 29723R (23.2g) and IR 15324R (22.9 g) followed the top yielder in order. IR 54 R recorded the lowest yield (18.2g).

Seed yield did not vary significantly due to method of propagation. However, tiller crop recorded numerically more seed yield (22.3 g) than seedling planted crop (21.8g). Restorer lines at same or different level of propagation method varied significantly. Vegetatively propagated restorers IR 46 R and IR 15324R registered significantly more seed yield whereas IR 20 and IR 36 R recorded lower yield than their respective main crop.

Table 42. Plant height, yield components and seed yield of restorer lines as influenced by tiller separation and planting

| Genotype | Plant height (cm) | | | Productive tillers/pl. | | | Panicle length (cm) | | | Spikelets /panicle | | |
|---------------------------------|-------------------------|-------------|------|-------------------------|-------------|------|-------------------------|-------------|------|-------------------------|-------------|-------|
| | Main crop | Tiller crop | Mean | Main crop | Tiller crop | Mean | Main crop | Tiller crop | Mean | Main crop | Tiller crop | Mean |
| IR 29723 R | 81.3 | 83.2 | 82.2 | 13.8 | 14.1 | 13.9 | 22.3 | 22.5 | 22.4 | 115.0 | 112.0 | 113.0 |
| IR 54 R | 80.5 | 80.3 | 80.4 | 13.5 | 14.0 | 13.8 | 21.8 | 21.7 | 21.7 | 101.0 | 111.0 | 106.0 |
| IR 46 R | 78.9 | 80.2 | 79.6 | 14.9 | 15.2 | 15.1 | 22.4 | 22.6 | 22.5 | 118.0 | 123.0 | 120.5 |
| ARC 11353 R | 87.3 | 90.0 | 88.6 | 14.0 | 15.0 | 14.5 | 23.6 | 23.9 | 23.7 | 138.0 | 142.0 | 140.0 |
| IR 20 R | 80.5 | 76.8 | 78.6 | 14.1 | 13.0 | 13.6 | 20.3 | 20.1 | 20.2 | 136.0 | 126.0 | 131.0 |
| IR 36 R | 73.2 | 69.6 | 71.4 | 13.2 | 12.6 | 12.9 | 19.9 | 19.7 | 19.8 | 112.0 | 102.0 | 107.0 |
| IR 15324 R | 86.0 | 89.4 | 87.7 | 13.8 | 14.4 | 14.1 | 23.1 | 23.3 | 23.2 | 133.0 | 136.0 | 134.0 |
| Mean | 81.1 | 81.4 | | 13.9 | 14.0 | | 21.9 | 22.0 | | 122.0 | 121.7 | |
| Comparing means of Genotype (G) | S.E.m ⁺ 0.41 | C.D.5% 1.27 | | S.E.m ⁺ 0.17 | C.D.5% 0.54 | | S.E.m ⁺ 0.12 | C.D.5% 0.38 | | S.E.m ⁺ 3.02 | C.D.5% 9.30 | |
| Method of propagation (T) | 0.38 | NS | | 0.09 | NS | | 0.06 | NS | | 1.67 | NS | |
| G at same level of T | 1.00 | 3.00 | | 0.24 | 0.74 | | 0.15 | NS | | 4.42 | NS | |
| G at same/different level of T | 0.82 | 2.50 | | 0.25 | 0.75 | | 0.16 | NS | | 4.35 | NS | |

NS = Not significant

Continued Table 42

| Genotype | Filled spikelets/panicle | | | Seed yield /plant (g) | | | Test weight (g) | | |
|---------------------------------|----------------------------|-----------------|-------|----------------------------|----------------|------|-----------------------------|------------------|-------|
| | Main crop | Tiller crop | Mean | Main crop | Tiller crop | Mean | Main crop | Tiller crop | Mean |
| IR 29723 R | 89.0 | 86.7 | 87.8 | 22.9 | 23.5 | 23.2 | 21.11 | 21.09 | 21.10 |
| IR 54 R | 78.0 | 77.0 | 77.5 | 18.0 | 18.5 | 18.2 | 19.02 | 19.03 | 19.02 |
| IR 46 R | 86.0 | 93.0 | 89.5 | 23.2 | 26.0 | 24.6 | 21.10 | 21.14 | 21.12 |
| ARC 11353 R | 103.0 | 111.0 | 107.0 | 24.4 | 26.3 | 25.3 | 20.82 | 20.94 | 20.88 |
| IR 20 R | 86.0 | 81.0 | 83.5 | 20.1 | 17.8 | 18.9 | 20.03 | 19.90 | 19.96 |
| IR 36 R | 87.0 | 79.0 | 83.0 | 22.3 | 19.8 | 21.0 | 19.89 | 19.80 | 19.84 |
| IR 15324 R | 98.0 | 103.0 | 100.0 | 21.8 | 24.0 | 22.9 | 20.16 | 20.18 | 20.17 |
| Mean | 89.6 | 90.1 | | 21.8 | 22.3 | | 20.30 | 20.29 | |
| Comparing means of Genotype (G) | S.E.m ⁺ 2.19 | C.D.5 % 6.75 | | S.E.m ⁺ 0.45 | C.D.5% 1.38 | | S.E.m ⁺ 0.018 | C.D.5 % 0.054 | |
| Method of propagation (T) | 0.67 | NS | | 0.26 | NS | | 0.14 | NS | |
| G at same level of T | 1.78 | 5.40 | | 0.68 | 2.10 | | 0.36 | NS | |
| G at same/different level of T | 2.52 | 7.75 | | 0.66 | 2.00 | | 0.31 | NS | |

NS = Not significant

4.5.5.7 Test weight

Restorer lines differed significantly for test weight (Table 42) IR 46R registered significantly more test weight (21.12 g) than IR 29723R (21.10g) and ARC 11353R (20.88g); and IR 54R recorded the lowest test weight (19.02g). Test weight did not vary significantly due to method of propagation and interaction.

4.5.6 Growth and grain yield of hybrids and varieties under tiller crop

4.5.6.1 Plant height

Irrespective of method of propagation, hybrids and varieties differed significantly in plant height (Table 43). The hybrid IR 54752 A/IR 27315R registered the maximum plant height (87.1 cm), followed in order by IR 54752A/ARC 11353R (86.8 cm), IR 54752A/IR 54R (84.4 cm), CTH 1 (83.5 cm) and IR 54752A/IR 46R (83.1 cm). The hybrid V20A /IR 36R recorded the minimum plant height (67.6 cm).

Plant height differed significantly between two methods of propagation. Tiller crop registered more plant height (81.5 cm) than seedling planted crop (80.3 cm). Interactions were not significant

4.5.6.2 Productive tillers per plant

Productive tillers differed significantly among the hybrids and varieties (Table 43). Hybrid IR 54752A/ARC 11353R recorded maximum number of productive tillers (15.6) and was on par with Jaya (15.3) and Intan mutant A/ARC 11353R (15.2).

Madhu WA / IR 15324R recorded the minimum number of productive tillers (12.3).

Tiller propagated crop registered significantly more number of productive tillers (14.0) than seedling planted crop (13.6). Genotypic interaction at same or different levels of method of propagation was found to be significant due to productive tillers. Vegetatively propagated genotypes viz., IR54752A/IR46R, IR54752A/IR27315R, IR54752A/ ARC 11353R, IR54752A/IR54R, Jaya and CTH 1 recorded more productive tillers than the respective seedling planted crop. But rest of the genotypes did not vary due to vegetative propagation.

4.5.6.3 Panicle length

Panicle length differed significantly among the hybrids and varieties, in both the methods of propagation (Table 43). IR54752A/ARC11353R recorded significantly the maximum panicle length (25.1cm) followed in order by IR54752A/IR46R (24.4cm), IR54752A/IR54R (23.9cm) and IR54752A/IR27315 (23.9cm). The lowest panicle length was registered by V20A/IR36R (19.9cm). Panicle length did not differ significantly due to the method of propagation.

4.5.6.4 Spikelet number per panicle

Spikelet number per panicle differed significantly among the hybrids and varieties (Table 43). Intan mutant A/ARC 11353 R recorded the highest number of spikelets (134.5) followed in order by IR 54752A / ARC11353 R (133.5),

IR54752A/IR27315R (129.5) and Madhu WA/IR15324R (126.0). Rasi registered the lowest number (97.0). Spikelet number did not differ due to method of propagation and interaction.

4.5.6.5 Filled spikelets per panicle

Irrespective of method of propagation filled spikelets differed significantly among the hybrids and varieties (Table 43). The highest number of filled spikelets (107.5) was recorded in IR 54752A/ARC 11353R followed by IR 54752 A/IR 27315 R (99.0) and Intan mutant A /ARC 11353 (94.5).

In general filled spikelets were more in hybrids than in varieties except in V 20A /IR 36R (79.5). Rasi recorded the lowest number of filled spikelets (66.0). Filled spikelets did not differ significantly due to method of propagation. Varieties and hybrids varied significantly in both the methods of propagation.

4.5.6.6 Grain yield per plant

Grain yield differed significantly among the hybrids and varieties in both methods of propagation (Table 43 and Fig. 20). IR 54752A /ARC 11353R recorded significantly high grain yield (28.7g) and was on par with Intan mutant A/ARC 11353R -26.8g; Jaya -26.4 g ; IR 54752A/IR 27315R -26.2 g; and IR 54752A /IR 46R -25.4 g. The lowest yield was registered by Rasi (17.3 g).

Mean grain yield did not differ significantly due to method of propagation. However tiller propagated crop of all

Table 43. Plant height, yield components and yield of hybrids and varieties as influenced by tillere propagation

| Genotype | Plant height (cm) | | Productive tillers/pl. | | Panicle length (cm) | | spikelets /panicle | | | | |
|---------------------------------|------------------------------------|--------------|------------------------------------|-------------|------------------------------------|--------------|------------------------------------|---------------|-------|-------|-------|
| | Main crop | Tiller crop | Main crop | Tiller crop | Main crop | Tiller crop | Main crop | Tiller crop | | | |
| Intan Mutant A / ARC 11353 R | 80.0 | 84.2 | 82.1 | 15.6 | 15.2 | 21.3 | 21.6 | 21.5 | 134.0 | 135.0 | 134.5 |
| Madhu WA / IR 46 R | 78.0 | 79.0 | 78.5 | 14.0 | 14.0 | 21.8 | 22.0 | 21.9 | 112.0 | 110.0 | 111.0 |
| IR 54752A / IR 46 | 82.0 | 84.2 | 83.1 | 15.0 | 14.5 | 24.2 | 24.6 | 24.4 | 126.0 | 120.0 | 123.0 |
| V 20 A/IR 36 R | 69.5 | 65.6 | 67.6 | 12.8 | 13.2 | 20.0 | 19.8 | 19.9 | 110.0 | 103.0 | 106.5 |
| Madhu WA / IR 15324 R | 81.0 | 80.0 | 80.5 | 12.0 | 12.3 | 20.3 | 20.2 | 20.3 | 128.0 | 124.0 | 126.0 |
| IR 54752 A /IR 27315 R | 86.2 | 88.0 | 87.1 | 14.0 | 13.6 | 23.8 | 23.9 | 23.9 | 129.0 | 130.0 | 129.5 |
| IR 54752 A / ARC 11353 R | 84.3 | 89.2 | 86.8 | 16.0 | 15.6 | 24.9 | 25.2 | 25.1 | 129.0 | 138.0 | 133.5 |
| IR 54752 A / IR 54 R | 83.4 | 85.3 | 84.3 | 12.8 | 12.4 | 23.9 | 23.9 | 23.9 | 122.0 | 120.0 | 121.0 |
| Jaya | 80.0 | 83.2 | 81.6 | 15.8 | 15.3 | 22.2 | 22.6 | 22.4 | 118.0 | 124.0 | 121.0 |
| CTH 1 | 83.0 | 84.0 | 83.5 | 13.0 | 12.6 | 22.1 | 23.0 | 22.6 | 112.0 | 119.0 | 115.0 |
| Rasi | 76.2 | 74.2 | 75.2 | 12.6 | 12.8 | 21.0 | 20.6 | 20.8 | 102.0 | 92.0 | 97.0 |
| Mean | 80.3 | 81.5 | 81.6 | 14.0 | 13.6 | 22.3 | 22.5 | 22.5 | 120.2 | 119.5 | |
| Comparing means of Genotype (G) | S.E _m ⁺ 0.84 | C.D.5 % 2.48 | S.E _m ⁺ 0.15 | C.D.5% 0.46 | S.E _m ⁺ 0.08 | C.D.5 % 0.23 | S.E _m ⁺ 4.20 | C.D.5 % 12.40 | | | |
| Method of propagation (T) | 0.37 | 1.10 | 0.07 | 0.20 | 0.05 | 0.16 | 1.20 | NS | | | |
| G at same level of T | 1.25 | NS | 0.23 | 0.68 | 0.18 | NS | 3.90 | NS | | | |
| G at same/different level of T | 1.22 | NS | 0.22 | 0.66 | 0.15 | NS | 5.00 | NS | | | |

NS = Not significant

Continued Table 43.

| Genotypes | Filled spikelets / panicle | | | | | | Grain yield / plant (g) | | | | | | Test weight (g) | | | | | | |
|------------------------------------|----------------------------|-----------------|----------------------------|----------------------------|-----------------|----------------------------|----------------------------|-----------------|----------------------------|----------------------------|-----------------|----------------------------|----------------------------|---------------|----------------------------|----------------------------|---------------|----------------------------|---------------|
| | Main crop | | Tiller crop | | Mean | | Main crop | | Tiller crop | | Mean | | Main crop | | Tiller crop | | Mean | | |
| | | | | | | | | | | | | | | | | | | | |
| Iran Mutant A / ARC 11353 R | 92.0 | 97.0 | 94.5 | 25.2 | 28.3 | 26.8 | 21.98 | 22.04 | 22.01 | 87.0 | 90.0 | 88.5 | 23.3 | 23.4 | 23.4 | 20.52 | 20.57 | 20.54 | |
| Machu WA / IR 46 R | 89.0 | 91.0 | 90.0 | 24.0 | 26.8 | 25.4 | 21.08 | 21.09 | 21.09 | 89.0 | 91.0 | 90.0 | 24.0 | 26.8 | 25.4 | 21.08 | 21.09 | 21.09 | |
| IR 54752A / IR 46 | 83.0 | 76.0 | 79.5 | 23.1 | 20.8 | 21.9 | 22.21 | 22.16 | 22.18 | 83.0 | 76.0 | 79.5 | 23.1 | 20.8 | 21.9 | 22.21 | 22.16 | 22.18 | |
| V 20 A/IR 36 R | 93.0 | 89.0 | 91.0 | 22.9 | 22.0 | 22.5 | 20.79 | 20.72 | 20.75 | 93.0 | 89.0 | 91.0 | 22.9 | 22.0 | 22.5 | 20.79 | 20.72 | 20.75 | |
| Machu WA / IR 15324 R | 97.0 | 101.0 | 99.0 | 24.7 | 27.6 | 26.2 | 22.20 | 22.26 | 22.23 | 97.0 | 101.0 | 99.0 | 24.7 | 27.6 | 26.2 | 22.20 | 22.26 | 22.23 | |
| IR 54752 A / IR 27315 R | 104.0 | 111.0 | 107.5 | 27.2 | 30.1 | 28.7 | 21.75 | 21.86 | 21.80 | 104.0 | 111.0 | 107.5 | 27.2 | 30.1 | 28.7 | 21.75 | 21.86 | 21.80 | |
| IR 54752 A / ARC 11353 R | 89.0 | 91.0 | 90.0 | 22.3 | 24.2 | 23.3 | 22.02 | 22.05 | 22.04 | 89.0 | 91.0 | 90.0 | 22.3 | 24.2 | 23.3 | 22.02 | 22.05 | 22.04 | |
| IR 54752 A / IR 54 R | 80.0 | 86.0 | 83.0 | 24.9 | 27.9 | 26.4 | 23.86 | 23.93 | 23.89 | 80.0 | 86.0 | 83.0 | 24.9 | 27.9 | 26.4 | 23.86 | 23.93 | 23.89 | |
| Jaya | 76.0 | 83.0 | 79.5 | 20.2 | 22.4 | 21.3 | 21.92 | 21.94 | 21.93 | 76.0 | 83.0 | 79.5 | 20.2 | 22.4 | 21.3 | 21.92 | 21.94 | 21.93 | |
| CIH 1 | 70.0 | 62.0 | 66.0 | 18.4 | 16.1 | 17.3 | 19.88 | 19.83 | 19.85 | 70.0 | 62.0 | 66.0 | 18.4 | 16.1 | 17.3 | 19.88 | 19.83 | 19.85 | |
| Rasi | 87.3 | 88.8 | 88.8 | 23.3 | 24.5 | 24.5 | 21.65 | 21.68 | 21.68 | 87.3 | 88.8 | 88.8 | 23.3 | 24.5 | 24.5 | 21.65 | 21.68 | 21.68 | |
| Mean | | | | | | | | | | | | | | | | | | | |
| Comparing means of Genotype (G) | S.E.m ⁺ 1.90 | C.D.5 % 5.70 | S.E.m ⁺ 0.67 | S.E.m ⁺ 1.93 | C.D.5 % 5.70 | S.E.m ⁺ 0.67 | S.E.m ⁺ 0.03 | C.D.5 % 0.10 | S.E.m ⁺ 0.01 | S.E.m ⁺ 0.03 | C.D.5 % 0.10 | S.E.m ⁺ 0.01 | S.E.m ⁺ 0.04 | C.D.5 % NS | S.E.m ⁺ 0.04 | S.E.m ⁺ 0.04 | C.D.5 % NS | S.E.m ⁺ 0.04 | C.D.5 % NS |
| Method of propagation (T) | 2.20 | 6.50 | 2.22 | 2.49 | 7.33 | 2.22 | 2.49 | 7.33 | 2.22 | 6.51 | 2.22 | 2.49 | 7.33 | 7.33 | 2.22 | 2.49 | 7.33 | 2.22 | 6.51 |
| G at same level of T | 2.50 | 7.30 | 2.50 | 2.49 | 7.33 | 2.50 | 2.49 | 7.33 | 2.50 | 7.30 | 2.50 | 2.49 | 7.33 | 7.33 | 2.50 | 2.49 | 7.33 | 2.50 | 7.30 |
| G at same/different level of T | | | | | | | | | | | | | | | | | | | |

NS = Not significant

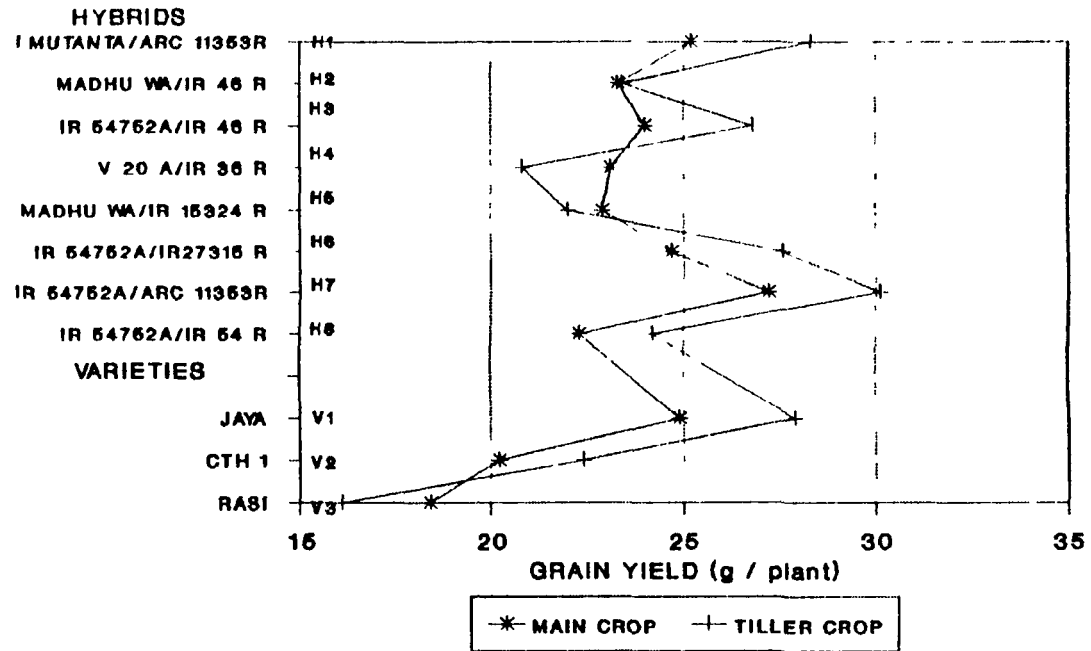


FIG 20. GRAIN YIELD (g/pl) OF HYBRIDS & VARIETIES IN MAIN & TILLER PLANTED CROPS

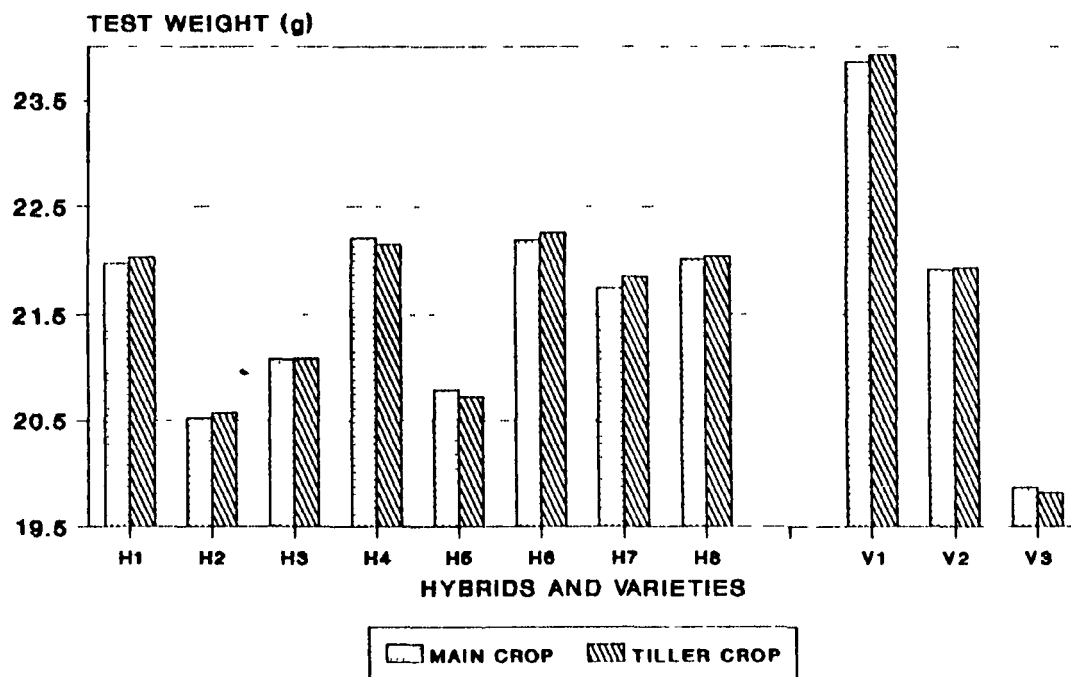


FIG 21. TEST WEIGHT (g) OF HYBRIDS AND VARIETIES IN MAIN & TILLER PLANTED CROPS

hybrids and varieties, except V 20A/IR 36R, Madhu WA /IR 15324R, and Rasi recorded numerically more yield than the respective seedling planted crop.

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4.5.6.7 Test weight

In both methods of propagation, hybrid and varieties differed significantly for test weight (Table 43 and Fig. 21). The variety Jaya recorded significantly the highest test weight (23.89 g) followed in order by IR 54752A/ IR 27315 R (22.23g), V 20A/IR 36 (22.18g) and IR 54752A/ IR 54R (22.04g). Test weight did not differ significantly due to method of propagation. However, numerically more test (21.68g) was recorded in vegetatively propagated crop than seedling planted crop (21.65g).

EXPERIMENT -6

4.6 Field Performance of Tiller Planted Crop as Influenced by Age of Tillers

The experiment consisted of two age group of tillers obtained through tiller separation at two different dates (T1 and T2) along with seedling planted - control (T0) in eight varieties. The results on the field performance of rice varieties as influenced the age of tillers and their interaction effects are presented in Tables 44 and 45 and Plates 2, 3 and 4.

4.6.1 Number of tillers recovered per mother plant

The data pertaining to number of tillers per mother plant obtained during tiller separation are given in Table 44. Significant difference was noticed between the time of tiller separation irrespective of varieties under study.



Plate 2: Tillers separated from mother plant of IR 54752A / ARC 11353 R for vegetative propagation

Plate 3: Tillers separated from mother plant of ARC 11353R for vegetative propagation



Plate 4: Field view-Tiller planted crop and seedling planted crop

Tiller aged 70 days (T2) recorded the highest number of tillers (15.8) and the lowest (9.9) was in T1 (50 days old).

Varieties differed significantly due to number of tillers obtained per mother plant. The highest number of tiller was observed in V3 (14.4) followed by V5 (14.1); V4 (14.0) and the lowest in V7 (10.1). The interaction between variety and age of tiller indicated significant difference.

4.6.2 Plant height

Significant differences were noticed for plant height due to age of tillers (Table 44). The tiller crop (T1) recorded the highest (82.7 cm) plant height closely followed by seedling planted control (82.0). T2 recorded the lowest value (72.8 cm).

Irrespective of age of tillers varieties showed significant differences for plant height. V4 registered the highest plant height (94.2 cm) followed by V5 (89.5 cm) and V6 (87.1 cm). The lowest plant height was recorded by V7 (57.8 cm). The interaction effects between varieties and tiller age were significant for this character.

4.6.3 Number of tillers per plant

The results on tillers per plant are given in Table 44. Irrespective of varieties, tiller number per plant differed significantly due to age of tiller. It was high in T1 (12.8) followed by T0 (12.6) and the lowest was in T2 (10.0).

Varieties also differed significantly with respect to tillers per plant. V3 recorded the highest (13.3) followed by V6 (12.9), and the lowest was in V2 (10.6). Interaction effect between variety and age of tillers was significant.

4.6.4 Productive tillers per plant

The data on productive tillers per plant are presented in Table 44. Productive tillers differed significantly between age of tillers in all the varieties. Tiller crop (T1) recorded the highest number of productive tillers (12.6) followed by T0 (11.9) and the least was in T2 (9.5).

Varieties differed significantly for number of productive tillers in all tiller age groups. V3 (13.1) recorded the highest value followed by V6 (12.7) and the lowest was in V8 (9.3). Interaction effects between age of tillers and varieties were significant.

4.6.5 Panicle length

Panicle length differed significantly due to tiller age in all varieties (Table 44). Maximum panicle length was recorded in T1 (22.0 cm) followed by T0 (21.9 cm) and the minimum was in T2 (19.6 cm). Varieties too differed significantly for this trait. Maximum panicle length was registered by both V4 (24.1 cm) and V5 (24.1 cm) closely followed by V6 (23.7 cm). Minimum was noticed in V7 (17.1 cm). The interaction between tiller age and varieties were significant.

Table 44. Growth and yield components of rice varieties as influenced by age of tillers

| Treatment | No. of tillers recovered from mother plant | Plant Height (cm) | No. of tillers/plant | Productive tillers/plant | Panicle length (cm) |
|----------------------------------------------------------------|--------------------------------------------|-------------------|----------------------|--------------------------|---------------------|
| Age of tiller (T) | | | | | |
| T0 | - | 82.0 | 12.6 | 11.9 | 21.9 |
| T1 | 9.9 | 82.7 | 12.8 | 12.6 | 22.0 |
| T2 | 15.8 | 72.8 | 10.0 | 9.5 | 19.6 |
| S.E.M. | 0.02 | 0.14 | 0.07 | 0.18 | 0.13 |
| C.D. 5 % | 0.13 | 0.54 | 0.27 | 0.72 | 0.51 |
| Varieties (V) | | | | | |
| V1 ARC 11353 R | 12.6 | 84.6 | 11.1 | 10.9 | 19.8 |
| V2 IR 46 R | 13.4 | 80.8 | 10.6 | 10.5 | 20.4 |
| V3 Madhu KA / IR 15324 R | 14.4 | 79.5 | 13.3 | 13.1 | 22.7 |
| V4 IR 54752 A / ARC 11353 R | 14.0 | 84.2 | 12.0 | 11.7 | 24.1 |
| V5 IR 54752 A / IR 54 R | 14.1 | 89.5 | 11.0 | 10.7 | 24.1 |
| V6 IR 54752 A / IR 27315 R | 13.2 | 87.1 | 12.9 | 12.7 | 23.7 |
| V7 V 20 B | 10.1 | 57.8 | 11.8 | 11.3 | 17.1 |
| V8 ES 18 B | 11.3 | 59.9 | 11.4 | 9.3 | 17.3 |
| S.E.M. | 0.03 | 0.35 | 0.06 | 0.12 | 0.09 |
| C.D. 5 % | 0.10 | 1.00 | 0.20 | 0.34 | 0.25 |
| Interaction (T x V) | | | | | |
| T0 V1 | - | 86.4 | 11.3 | 11.2 | 20.4 |
| T0 V2 | - | 82.8 | 12.0 | 11.8 | 20.6 |
| T0 V3 | - | 82.8 | 14.5 | 14.2 | 24.0 |
| T0 V4 | - | 97.2 | 12.7 | 12.4 | 25.0 |
| T0 V5 | - | 91.1 | 11.2 | 11.0 | 24.9 |
| T0 V6 | - | 89.9 | 13.8 | 13.8 | 24.8 |
| T0 V7 | - | 61.0 | 12.4 | 12.4 | 17.5 |
| T0 V8 | - | 65.0 | 12.5 | 8.0 | 18.1 |
| T1 V1 | 9.8 | 87.8 | 11.2 | 11.2 | 20.5 |
| T1 V2 | 10.2 | 82.6 | 12.1 | 12.0 | 20.6 |
| T1 V3 | 10.7 | 87.7 | 14.8 | 14.8 | 23.9 |
| T1 V4 | 11.0 | 96.4 | 12.4 | 12.2 | 25.1 |
| T1 V5 | 11.5 | 93.0 | 11.4 | 11.2 | 25.0 |
| T1 V6 | 9.5 | 90.8 | 14.2 | 14.2 | 25.0 |
| T1 V7 | 7.8 | 62.4 | 13.6 | 12.6 | 17.7 |
| T1 V8 | 9.2 | 66.0 | 13.0 | 12.0 | 18.3 |
| T2 V1 | 15.3 | 79.6 | 10.8 | 10.4 | 18.6 |
| T2 V2 | 16.6 | 77.1 | 7.6 | 7.6 | 20.0 |
| T2 V3 | 18.1 | 72.9 | 10.8 | 10.2 | 20.3 |
| T2 V4 | 17.0 | 89.0 | 11.1 | 10.6 | 22.2 |
| T2 V5 | 16.7 | 84.3 | 10.5 | 10.0 | 22.4 |
| T2 V6 | 17.0 | 80.6 | 10.7 | 10.2 | 21.2 |
| T2 V7 | 12.3 | 50.0 | 9.4 | 9.0 | 16.1 |
| T2 V8 | 13.4 | 48.6 | 8.8 | 8.0 | 15.6 |
| For comparison of means | | | | | |
| V at same level of T | | | | | |
| S.E.M. | 0.04 | 0.60 | 0.11 | 0.21 | 0.16 |
| C.D. 5 % | 0.13 | 1.67 | 0.30 | 0.59 | 0.44 |
| T at same or different level of V | | | | | |
| S.E.M. | 0.05 | 0.58 | 0.12 | 0.27 | 0.20 |
| C.D. 5 % | 0.16 | 1.65 | 0.38 | 0.89 | 0.65 |
| T0 = No tiller separation; Seedling planted crop | | | | | |
| T1 = Tiller separation 50 days after sowing; 50 day old tiller | | | | | |
| T2 = Tiller separation 70 days after sowing; 70 day old tiller | | | | | |

4.6.6 Percentage of filled spikelet

The data on percentage of filled spikelets are presented in Table 45. Filled spikelet percentage differed significantly due to the age of tillers. The tiller planted crop, T1 (85.6%) recorded the highest percentage and seedling planted crop T0 and T2 recorded 83.9 and 66.9 per cent respectively.

Varieties differed significantly irrespective of age of tillers planted in per cent filled spikelets. The lowest filling was found in V7 (69.1%). The interaction between tiller age and varieties was significant.

4.6.7 Grain yield per plant

The data on yield per plant as influenced by tiller age and interaction effects are presented in Table 45. Significant differences were noticed between the age of tiller in respect of grain yield. Vegetatively propagated tiller crop T1 (21.3g) registered higher grain yield than T0 (20.4 g). The lowest yield was found in T2 (10.9g).

Irrespective of tiller age, varieties differed significantly. V6 recorded the highest grain yield (23.7 g) per plant followed in order by V4 (22.0 g) and V1 (19.0g). The lowest yield per plant was given by V8 (11.2 g). Interaction effects were significant in all tiller age groups and varieties.

4.6.8 Grain yield per hectare

Irrespective of varieties, yield per hectare basis differed significantly between tiller age groups (Table 45). Tiller crop T1 recorded the highest grain yield of (7.48 t/ha) as compared to seedling planted crop T0 (6.83 t/ha). Aged tiller (T2) registered the lowest yield (4.07 t/ha). Varieties also differed significantly among them with respect to grain yield. V4 recorded the highest yield (7.68 t/ha) followed by V1 (7.12 t/ha). The lowest yield was recorded in V8 (3.67 t/ha). The interaction effects between age of tillers and varieties were significant.

4.6.9 Test weight

The results on test weight as influenced by tiller age and varieties are presented in Table 45. Test weight differed significantly due to tiller age groups. Vegetatively propagated tiller crop T1 recorded the highest (20.89g) followed by T0 (20.85g) and the lowest was T2 (19.08g).

Test weight also varied significantly among the varieties. V6 registered the highest test weight (22.04 g) followed by V5 (21.51 g) and V7 (21.21g). The lowest test weight was recorded by V8 (18.39). The interaction effects between tiller age and varieties were significant.

4.6.10 Days to maturity (from planting date)

The data on days to maturity as influenced by age of tiller and varieties are presented in Table 45. Days to maturity differed significantly due to tiller age and

Table 45: Yield and maturity of rice varieties as influenced by age of tillers

| Treatments | Filled spikelet (%) | Yield/plant (g) | Yield/hectare * (t) | Test weight (g) | Days to maturity after |
|------------------------------------------|---------------------|-----------------|---------------------|-----------------|------------------------|
| Age of tiller (T) | | | | | |
| T0 | 83.9 | 20.4 | 6.83 | 20.85 | 104.0 |
| T1 | 85.6 | 21.3 | 7.48 | 20.89 | 99.8 |
| T2 | 66.7 | 10.9 | 4.07 | 19.08 | 80.5 |
| S.E.m+ | 0.16 | 0.06 | 0.02 | 0.01 | 0.24 |
| C.D. 5 % | 0.63 | 0.23 | 0.06 | 0.03 | 1.00 |
| Varieties (V) | | | | | |
| V1 ARC 11353 R | 80.8 | 19.0 | 7.12 | 19.13 | 104.1 |
| V2 IR 46 R | 76.9 | 16.0 | 6.06 | 19.63 | 103.3 |
| V3 Madhu WA / IR 15324 R | 82.9 | 18.9 | 7.05 | 19.70 | 97.0 |
| V4 IR 54752 A / ARC 11353 R | 85.3 | 22.0 | 7.68 | 20.65 | 101.0 |
| V5 IR 54752 A / IR 54 R | 76.0 | 16.7 | 6.80 | 21.51 | 95.0 |
| V6 IR 54752 A / IR 27315 R | 86.5 | 23.7 | 6.94 | 22.04 | 98.3 |
| V7 V 20 B | 69.1 | 12.4 | 3.70 | 21.21 | 64.3 |
| V8 ES 18 B | 72.2 | 11.2 | 3.67 | 18.39 | 65.7 |
| S.E.m+ | 0.50 | 0.19 | 0.03 | 0.02 | 0.40 |
| C.D. 5 % | 1.40 | 0.53 | 0.07 | 0.05 | 1.10 |
| Interaction (T x V) | | | | | |
| T0 V1 | 85.2 | 19.8 | 7.64 | 19.23 | 115.3 |
| V2 | 80.4 | 18.8 | 6.79 | 20.00 | 117.0 |
| V3 | 86.9 | 22.6 | 7.87 | 20.54 | 111.0 |
| V4 | 88.8 | 25.1 | 8.05 | 21.66 | 116.0 |
| V5 | 81.2 | 20.4 | 7.72 | 22.72 | 108.0 |
| V6 | 90.2 | 27.0 | 7.87 | 22.63 | 115.0 |
| V7 | 78.4 | 15.2 | 4.32 | 21.46 | 74.0 |
| V8 | 80.0 | 14.2 | 4.40 | 18.84 | 76.0 |
| T1 V1 | 88.6 | 20.6 | 8.18 | 19.2 | 104.0 |
| V2 | 82.1 | 20.4 | 7.67 | 20.03 | 101.0 |
| V3 | 90.4 | 24.0 | 8.64 | 20.56 | 94.0 |
| V4 | 91.2 | 26.1 | 9.12 | 21.59 | 99.0 |
| V5 | 80.4 | 20.9 | 8.36 | 22.71 | 92.0 |
| V6 | 89.8 | 27.1 | 8.49 | 22.62 | 97.0 |
| V7 | 80.0 | 10.3 | 4.78 | 21.52 | 62.0 |
| V8 | 82.1 | 14.6 | 4.63 | 18.89 | 61.0 |
| T2 V1 | 68.6 | 16.5 | 5.55 | 18.95 | 93.0 |
| V2 | 68.3 | 8.9 | 3.73 | 18.86 | 92.0 |
| V3 | 71.4 | 10.2 | 4.63 | 18.09 | 86.0 |
| V4 | 75.8 | 14.9 | 3.89 | 18.72 | 88.0 |
| V5 | 66.6 | 8.9 | 4.31 | 19.10 | 85.0 |
| V6 | 79.6 | 17.1 | 4.47 | 20.88 | 83.0 |
| V7 | 48.9 | 5.6 | 2.01 | 20.64 | 57.0 |
| V8 | 54.4 | 4.9 | 1.99 | 17.43 | 60.0 |
| For comparison of means | | | | | |
| V at same level of T | | | | | |
| S.E.m+ | 0.87 | 0.33 | 0.04 | 0.03 | 0.68 |
| C.D. 5 % | 2.40 | 0.91 | 0.12 | 0.07 | 1.88 |
| I at same or different level of V | | | | | |
| S.E.m+ | 0.83 | 0.31 | 0.04 | 0.03 | 0.68 |
| C.D. 5 % | 2.32 | 0.88 | 0.13 | 0.07 | 2.00 |

* = Determined from plot yield

T0 = Seedling planted crop; No tiller separation

T1 = 50 day old tiller; Tiller separation 50 days after sowing

T2 = 70 day old tiller; Tiller separation 70 days after sowing

varieties. Seedling planted crop took the maximum number of days (104.0 days) followed by T1 (99.8 days) and T2 (80.5 days).

Among the varieties, V1 registered the maximum number of days (104.1 days) followed by V2 (103.3) and V4 (101.0 days). V7 and V8 attained maturity at 64.3 and 65.7 days after planting, respectively. Significant differences were noticed due to interaction effects between tiller age and varieties.

EXPERIMENT -7

4.7 Seed Quality as Influenced by Type of Tiller

The results relating to seed quality as influenced by type of tiller in IR 46R (G1) and ARC 11353R (G2) genotypes are presented in Table 46.

4.7.1 Test weight

Irrespective of type of tiller, ARC 11353R (G2) registered significantly higher test weight (21.54g). In both the genotypes test weight decreased from T1 to T10. First tiller recorded the highest test weight (20.93 g). followed by in order T2 (20.90g) and T3 (20.88g). Interaction between genotype and tiller type was significant for test weight (Table 46).

4.7.2 Initial germination

Genotypes differed significantly in initial germination percentage (Table 46 and Fig. 22) irrespective of tillers. Seeds of early developed four tillers recorded the highest

germination being on par with each other. Germination was low in late tillers (T5 to T10) than in early tillers (T1 to T4). Interaction between genotype and tiller was significant.

4.7.3 Initial vigour index

Vigour index of the IR 46R (2725) was on par with that of ARC 11353R (2803) as shown in Table 46. In all genotypes under study, seeds from early formed tillers recorded higher vigour index than late tillers (T5 to T10). The tillers T1 to T4 were all on par. Interaction between genotype and tiller was found to be non-significant for vigour index. However, seeds of ARC 11353R of all the tillers exhibited higher vigour index than IR 46R.

4.7.4 Germination after ageing

ARC 11353R registered higher germination (55.4%) than IR 46 R (35.3%) as shown in Table 45. Seeds from early tillers differed from late tillers for their response to ageing. Early formed tillers (T1 to T4) showed higher germination than the rest. Interaction was significant.

4.7.5 Vigour index after ageing

Even after ageing, ARC 11353 recorded higher vigour index (1623) as against IR 46R (1200) as shown in Table 46. Vigour index of seeds from early tillers was significantly more than those from late tillers. Ninth and tenth tillers registered very low vigour index. Interaction was found to be significant.

Table 46 . Seed quality as influenced by different tillers in rice

| Tiller | Test weight (g) | | | Initial germination (%) | | | Initial vigour index | | | Germination after ageing (%) | | | Vigour index after ageing | | |
|--------|-----------------|-------|-------|-------------------------|----------------|----------------|----------------------|-------|------|------------------------------|----------------|----------------|---------------------------|------|------|
| | G1 | G2 | Mean | G1 | G2 | Mean | G1 | G2 | Mean | G1 | G2 | Mean | G1 | G2 | Mean |
| T1 | 20.21 | 21.66 | 20.93 | 81.3 (97.6) | 86.7 (99.6) | 84.0 (98.5) | 3080 | 3142 | 3111 | 44.8 (49.6) | 51.5 (61.3) | 48.2 (55.4) | 1656 | 1910 | 1783 |
| T2 | 20.18 | 21.63 | 20.90 | 80.1 (97.0) | 87.4 (99.7) | 83.8 (98.3) | 3012 | 3082 | 3046 | 43.4 (47.3) | 51.7 (61.6) | 47.6 (54.4) | 1600 | 1892 | 1746 |
| T3 | 20.13 | 21.64 | 20.88 | 79.8 (96.7) | 86.4 (99.6) | 83.1 (98.1) | 2959 | 3012 | 2985 | 42.5 (45.7) | 50.8 (60.0) | 46.6 (52.8) | 1521 | 1835 | 1678 |
| T4 | 20.12 | 21.63 | 20.87 | 75.9 (93.9) | 85.3 (99.3) | 80.6 (96.6) | 2900 | 2948 | 2924 | 41.7 (44.3) | 50.4 (59.3) | 46.0 (51.8) | 1402 | 1794 | 1598 |
| T5 | 20.09 | 21.60 | 20.84 | 72.0 (90.3) | 83.2 (98.6) | 77.6 (94.4) | 2808 | 2878 | 2843 | 39.1 (39.7) | 50.0 (58.7) | 44.5 (49.2) | 1250 | 1740 | 1495 |
| T6 | 20.02 | 21.58 | 20.80 | 71.1 (89.6) | 80.6 (97.3) | 75.8 (93.4) | 2742 | 2792 | 2767 | 37.0 (36.2) | 48.6 (56.3) | 42.8 (46.2) | 1149 | 1681 | 1415 |
| T7 | 20.03 | 21.53 | 20.78 | 68.4 (86.4) | 81.1 (97.6) | 74.7 (92.0) | 2620 | 2682 | 2651 | 33.8 (31.0) | 46.9 (53.4) | 40.4 (42.2) | 1008 | 1526 | 1267 |
| T8 | 19.95 | 21.50 | 20.72 | 66.1 (83.6) | 76.1 (94.3) | 71.1 (88.9) | 2488 | 2600 | 2544 | 31.1 (26.6) | 45.2 (50.3) | 38.1 (51.7) | 898 | 1362 | 1130 |
| T9 | 19.91 | 21.43 | 20.67 | 61.1 (76.6) | 72.0 (90.3) | 66.5 (83.4) | 2358 | 2496 | 2427 | 26.8 (20.3) | 43.8 (48.0) | 35.3 (34.2) | 790 | 1300 | 1045 |
| T10 | 19.86 | 21.25 | 20.55 | 56.4 (70.3) | 68.5 (86.6) | 62.4 (78.4) | 2280 | 2402 | 2341 | 20.3 (12.0) | 42.1 (45.0) | 31.2 (28.5) | 728 | 1156 | 962 |
| Mean | 20.05 | 21.54 | | 71.3 (88.2) | 80.8 (96.3) | | 2725 | 2803 | | 56.0 (35.3) | 48.1 (55.4) | | 1200 | 1623 | |
| S. Err | | | | | | | | | | | | | | | |
| G | 0.005 | 0.013 | | 0.36 | 0.99 | | 40.3 | 111.6 | | 8.6 | 24.0 | | 2.8 | 7.7 | |
| T | 0.011 | 0.030 | | 0.80 | 2.21 | | 90.0 | 249.5 | | 19.3 | 53.4 | | 6.2 | 17.2 | |
| GxT | 0.015 | 0.042 | | 1.13 | 3.12 | | 127.3 | 353.0 | | 27.3 | 75.6 | | 8.8 | 24.3 | |

T = Tiller ; G1 = IR 46; G2 = ARC 11353 R;
 Figures in parantheses are original values

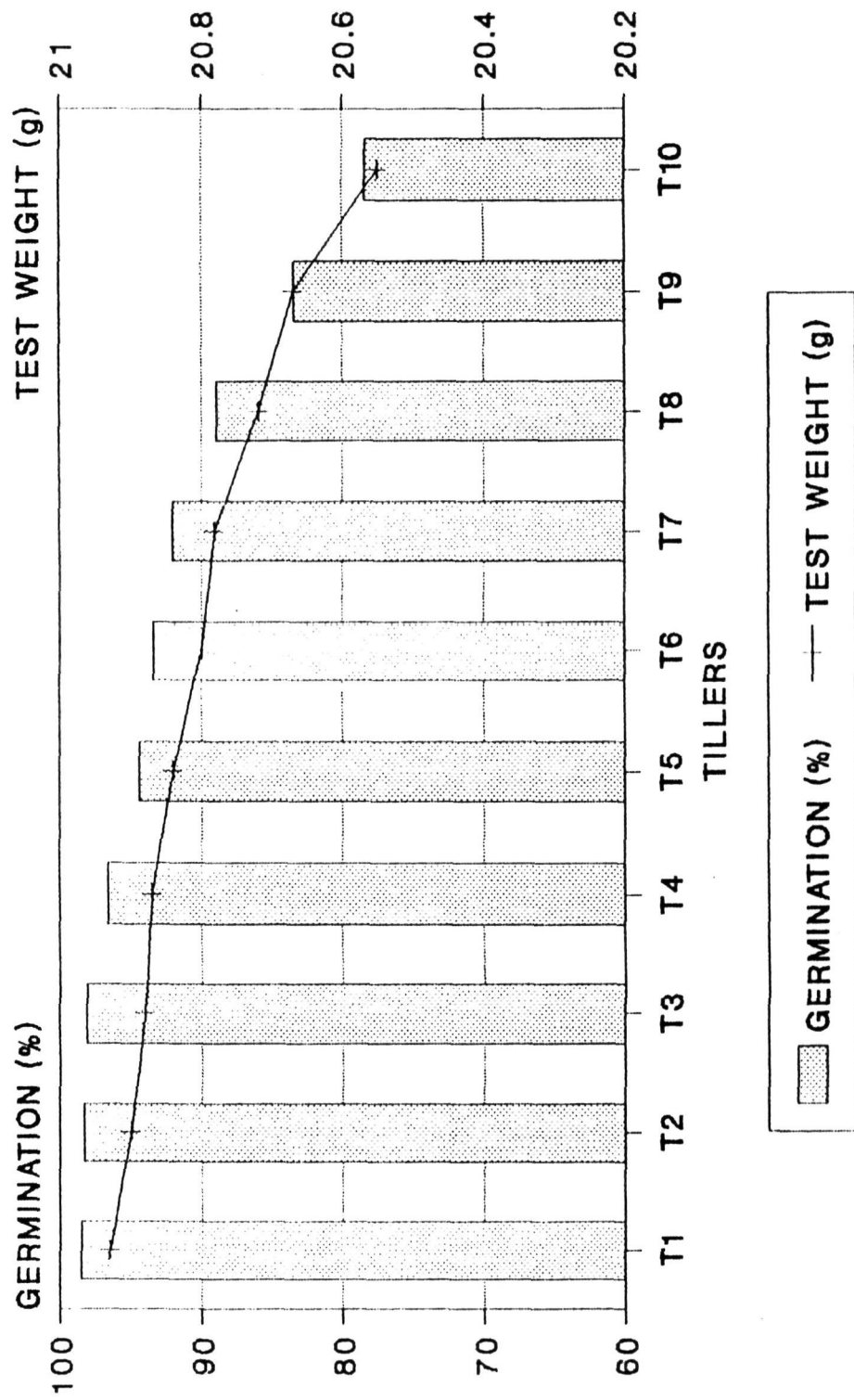


FIG 22. INITIAL SEED GERMINATION AND TEST WEIGHT AS INFLUENCED BY DIFFERENT TILLER TYPES

EXPERIMENT -8

4.8 Seed Production Through Stubble Cropped Parents and Field Performance of Stubble Planted Hybrids

The results of the experiment conducted during 1990 DS involved stubbles of four 'A' lines (V 20A, IR 54752A, ES 18A and Intan mutant A), their maintainers for seed production and performance of 5 hybrids and 3 varieties for grain production are presented in Tables 47 and 48 respectively (Fig. 23 and Plate 5,6 and 7).

4.8.1 Regenerating capacity of tillers

The data pertaining to number of regenerated tillers per single plant of A and B lines are presented in Table 47 and Plate 5 and 6. Statistical analysis revealed significant differences for this parameter between V 20A/B and Intan mutant A/B. But others were on par. A all A lines recorded higher number of regenerated tillers than the maintainers. The number of regenerating tillers obtained per mother plant ranged between 13.4 and 15.7 for 'A' lines and 10.2 and 12.7 for B lines respectively.

The results on number of regenerating tillers obtained per plant in hybrids and varieties are presented in Table 48. Genotypes differed significantly for this character. Among the hybrids, Madhu WA/IR 46 recorded maximum number of tillers (15.0) and among varieties, ARC 11353 recorded the highest (11.5). The lowest number was recorded by the hybrid V20A/IR36 R (8.3). Except G1 and G2, all genotypes were on par.

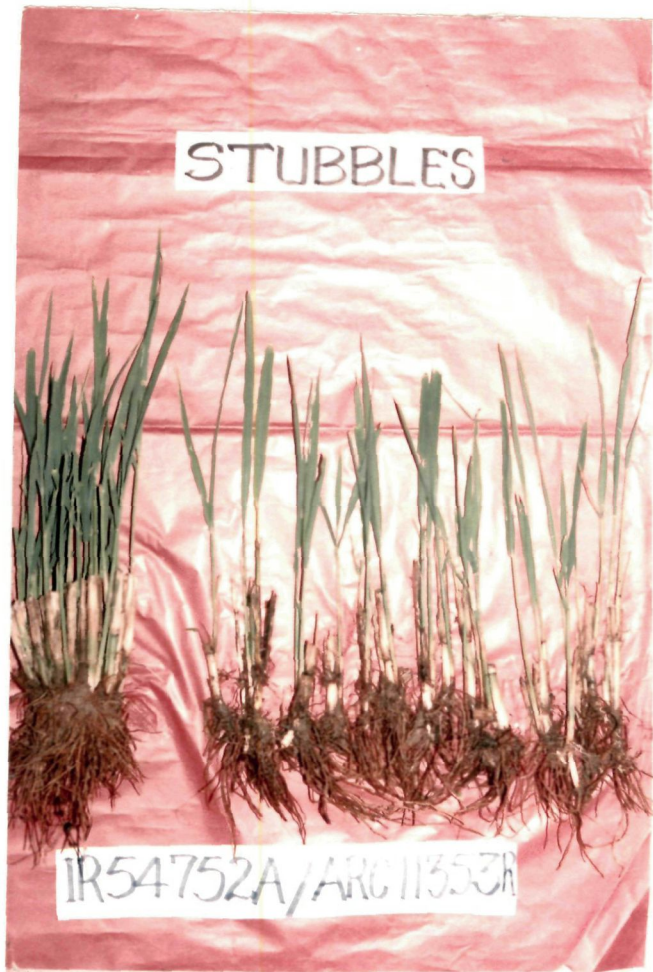


Plate 5: Regenerated stubbles (slips) recovered from a hill for stubble planting in IR 54752A/ARC 11353R



Plate 6: Regenerated stubbles (slips) of Madhu WA / IR 46 R prepared for planting



Plate 7: Stand of stubble (slips) planted hybrid rice crop of IR 54752A / ARC 11353 R

4.8.2 Field establishment of stubbles.

The results on per cent field establishment stubbles in A and B lines are presented in Table 47 and Fig. 23. V20A and IR54752A differed significantly whereas ES18A and Intan mutant A were on par from B lines. The field establishment of stubbles ranged between 57.1 and 72.4 for 'A' lines and 49.5 and 74.3 per cent for 'B' lines.

The data on per cent field establishment of stubbles per plot in hybrids and varieties are presented in Table 48. Significant differences were observed among the genotypes. The high establishment was recorded in the hybrid Madhu WA/IR 46 (86.7%); IR54752 A/ARC 11353 R (83.8) and varieties ARC 11353 R (84.8) The establishment was very poor in Rasi variety (63.8%).

4.8.3 Plant height

The observations pertaining to plant height of A and B stubble crops were furnished in Table 47. There are significant difference between and among A and B lines. The plant height of stubble crop ranged from 48.2 to 70.0 cm in A lines and 59.3 to 81.3 cm in B lines.

Significant differences were noticed among the hybrids and varieties due to plant height (Table 48). The highest plant height was seen in hybrid IR 54752A/ ARC 11353R (93.2 cm) followed by Madhu WA/IR 46 R (90.0cm) and ARC 11353 R (86.0 cm). The lowest height was recorded in hybrid V 20A/IR 36R (75.6 cm).

4.8.4 Number of tillers per plant

The data on number of tillers per plant in A and B lines are presented in Table 47. Significant differences were noticed between and among parental lines. Among A lines, V20 A produced the maximum tillers (26.4) and V20 B did so (22.6) among B lines. The lowest number of tillers was in IR 54752B (17.8).

The results on number of tillers per plant in hybrids and varieties are given in Table 48. The entries Madhu WA/IR 15324R (23.6), Madhu WA /IR 46R (23.0) and IR 54752A/ARC 11353R (22.4) differed significantly from IR 20 (16.5) and V20A/IR 36 (18.0). The variety IR 20 registered the minimum tillers per plant (16.5).

4.8.5 Number of productive tillers per plant

The results pertaining to number of productive tillers per plant in A and B lines are presented in Table 47. Significant differences were observed between A and B lines except for V 20A and B. Among 'A' lines, Intan mutant A recorded the highest value (23.0) and IR 54752A the lowest (19.0). Among the 'B' lines V 20B recorded the highest number of productive tiller (21.0) and lowest was in IR 54752B (16.6).

Significant differences were noticed among the hybrids and varieties in respect of productive tillers per plant (Table 48). The hybrid Madhu WA/IR 15324R recorded the highest productive tillers (21.6) closely followed by IR 54752A /ARC 11353R (21.4), Madhu WA /IR 4bR (19.2) and Rasi variety (19.0).

4.8.6 Seed yield

The observations pertaining to seed yield of 'A' and 'B' lines are presented in Table 47 and Fig. 23. Significant differences were observed among parental lines for seed yield. On per plant basis, the maximum seed yield (5.8g) was recovered in IR 54752A and the minimum in V 20 A (4.2 g). Among 'B' lines, IR 54752B recorded the maximum yield (6.9 g) and the minimum was in ES 18 B (4.8 g).

On per hectare basis, Intan mutant A produced the highest yield (1.00t) which was on par with IR54752 A (0.95t), and ES 18 A recorded the lowest seed yield of 0.62 t/ha. Among 'B' lines, IR 54752B recorded the maximum mean yield (2.56 t) closely followed by Intan mutant B (2.03t) and the minimum was recorded in V 20 B (1.21t).

Table 47 . Number of regenerating tillers, their field establishment and seed yield of parents in stubble crop

| Parents | No. of regenerating tillers/ mother plant | Field establishment of stubbles (%) | Plant height (cm) | Tillers / plant | Productive tillers /plant | Seed yield per | |
|--------------------|-------------------------------------------|-------------------------------------|-------------------|-----------------|---------------------------|----------------|---------------|
| | | | | | | Plant (g) | Hectare * (t) |
| V 20 A | 15.7 | 68.6 | 48.2 | 26.4 | 20.2 | 4.2 | 0.76 |
| V 20 B | 10.2 | 49.5 | 59.3 | 22.6 | 21.0 | 4.9 | 1.21 |
| IR 54752 A | 13.4 | 66.7 | 70.0 | 19.5 | 19.0 | 5.8 | 0.95 |
| IR 54752 B | 11.6 | 74.3 | 81.3 | 17.8 | 16.6 | 6.9 | 2.56 |
| ES 18 A | 14.3 | 57.1 | 60.6 | 22.4 | 21.2 | 4.4 | 0.62 |
| ES 18 B | 12.7 | 56.2 | 65.2 | 19.1 | 18.0 | 4.8 | 1.35 |
| Intan mutant A | 14.3 | 72.4 | 62.5 | 24.8 | 23.0 | 5.5 | 1.00 |
| Intan mutant B | 10.3 | 66.7 | 75.5 | 18.8 | 17.0 | 6.1 | 2.03 |
| Mean | 12.8 | 63.9 | 64.6 | 21.4 | 19.5 | 5.3 | 1.31 |
| S.E.m ⁺ | 1.00 | 2.48 | 0.71 | 0.94 | 0.78 | 0.52 | 0.04 |
| C.D.5 % | 3.02 | 7.54 | 2.17 | 2.84 | 2.36 | 1.56 | 0.11 |

* = Computed based on plot yield

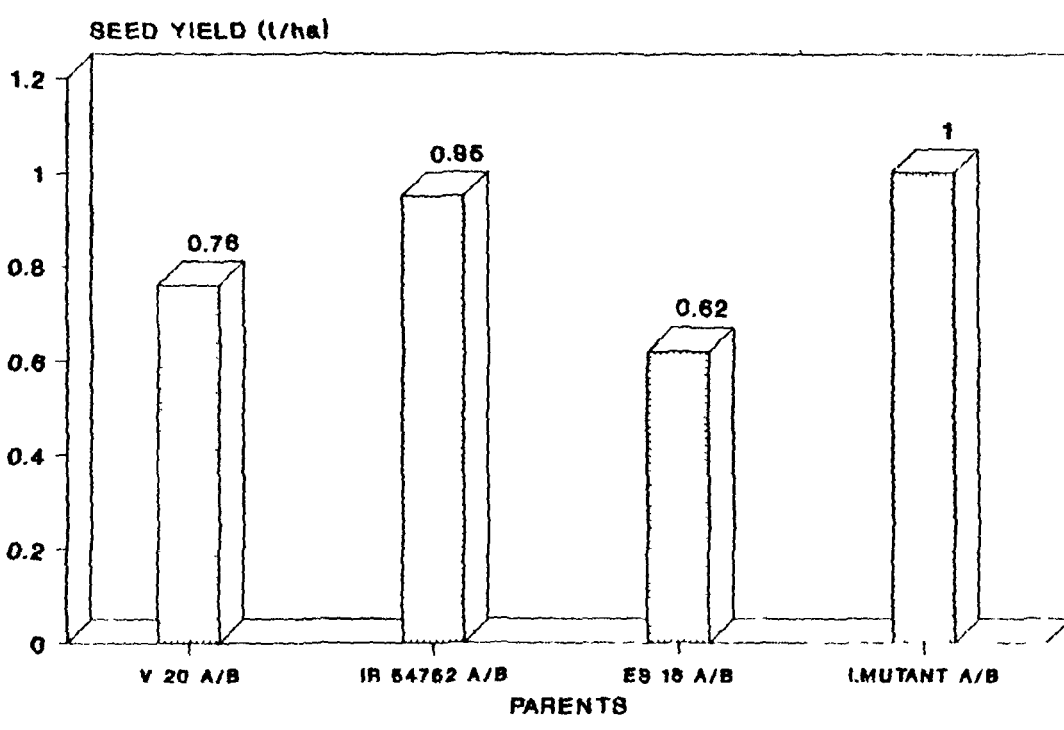
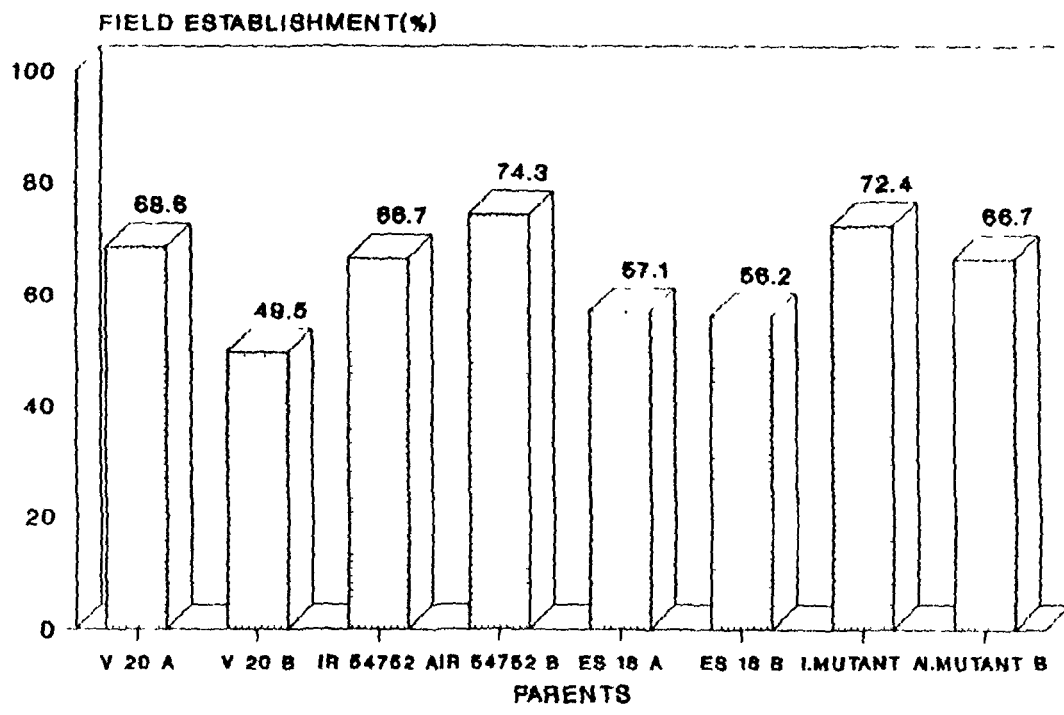


FIG 23. FIELD ESTABLISHMENT AND SEED YIELD IN SEED PRODUCTION (A/B) THROUGH STUBBLE PLANTING

Table 48. Number of regenerating tillers, their field establishment, growth and grain yield in stubble crops of hybrids and varieties

| Hybrid/ variety | No. of regenerating tillers/ mother plant | Field establishment of stubbles (%) | Plant height (cm) | Tillers / plant | Productive tillers /plant | Grain yield per | |
|---------------------------|----------------------------------------------------|----------------------------------------------|-------------------------|--------------------|---------------------------------|-----------------|------------------|
| | | | | | | Plant (g) | Hectare # (t) |
| G1 Madhu WA / IR 46 R | 15.0 | 86.7 | 90.0 | 23.0 | 19.2 | 11.4 | 4.94 |
| G2 V 20 A / IR 36 R | 8.3 | 79.0 | 75.6 | 18.0 | 16.6 | 9.1 | 3.60 |
| G3 Madhu WA/IR 15324 R | 10.1 | 77.0 | 81.1 | 23.6 | 21.6 | 10.2 | 3.93 |
| G4 IR 54752 A/ARC 11353 R | 11.2 | 83.8 | 93.2 | 22.4 | 21.4 | 15.0 | 6.28 |
| G5 Rasi | 9.7 | 63.8 | 80.2 | 22.0 | 19.0 | 8.4 | 2.68 |
| G6 IR 20 | 10.4 | 83.8 | 84.2 | 16.5 | 15.5 | 6.6 | 2.80 |
| G7 ARC 11353 R | 11.5 | 84.8 | 86.0 | 19.2 | 18.2 | 9.0 | 3.85 |
| Mean | 10.9 | 79.8 | 84.3 | 20.7 | 18.8 | 9.96 | 4.01 |
| S.E.m+ | 0.69 | 1.51 | 0.43 | 0.64 | 0.88 | 0.52 | 0.11 |
| C.D.5 % | 2.13 | 4.66 | 1.34 | 1.96 | 2.70 | 1.61 | 0.33 |

* = Computed based on plot yield

4.8.7 Grain yield

The data on grain yield per plant are presented in Table 48. Significant differences were observed among entries. The hybrid IR 54752A/ARC 11353R recorded the maximum yield (15.0g) which differed significantly from Madhu WA/IR 46R (11.4g), Madhu WA/IR 15324R (10.2g), V 20 A/IR36R (9.1g), ARC 11353R (9.0g), Rasi (8.4g) and IR 20 (6.6g). The other genotypes were on par.

On hectare basis, grain yield differed significantly among the genotypes studied. The hybrid IR 54752A/ARC 11353R recorded the highest grain yield (6.28 t) followed by Madhu WA /IR 46 R (4.94 t) and Madhu WA /IR 15324R (3.93 t). The lowest grain yield was noticed in Rasi (2.68 t).

EXPERIMENT -9

4.9 Performance of Stubble Crop as Influenced by Time of Mother Crop Harvest

The results of the experiment involving a poor ratooner, good ratooner and a hybrid variety to assess stubble crop performance as influenced by time of harvesting of main crop are presented in Tables 49 and 50 and Fig. 24.

4.9.1 Per cent regeneration

Per cent regenerated hills in ratoon crop differed significantly (Table 49 and Fig. 24) due to time of harvesting of main crop. Harvesting main crop at physiological maturity (H1) recorded the highest number of regenerated hills (84.1 %) per plot which was on par with H2:

harvesting one week after physiological maturity (80.1%). Harvesting main crop two weeks after physiological maturity recorded the lowest number of regenerated hills (72.8%). Regenerated hills differed significantly in varieties too. IR 54752A/ARC 11353R recorded the maximum regenerated hills (91.0%) which was on par with ARC 11353R (90.9 %) Pushpa showed the minimum (55.1%). The interaction between harvesting time of mother crop and varieties at all levels was not significant.

4.9.2 Regenerated tillers per plant

Significant differences were not noticed among the harvesting time of mother crop for number of regenerated tillers (Table 49). Regenerated tillers per plant ranged from 10.1 (H3) to 10.6 (H1).

Significant differences were also observed among the varieties for regenerated tillers per plant. V1 recorded the maximum (12.4) which differed significantly from V2 (11.2) and V3 (7.7).

4.9.3 Field establishment of stubbles

Field establishment percentage of stubbles differed significantly with respect to time of harvesting of mother crop (Table 49). H1 recorded the highest (95.4%) followed by H2 (91.0%) and the lowest in H3 (84.4%).

Significant differences were observed among the varieties due to field establishment of stubbles. V3 registered the highest (97.6%) followed by V1 (88.8%) and V2 (84.6%). The interaction effects between harvesting time of main crop and varieties at different levels were significant.

4.9.4 Plant height

Significant differences were not noticed in plant height due to harvesting time (Table 49), but only varieties differed significantly in plant height of stubble crop. V3 (86.1 cm) was on par with V1 (84.5 cm). V2 recorded the lowest (65.3 cm). The interaction was not significant at the same or different levels of varieties and harvesting time.

4.9.5 Total tillers per plant

The number of total tillers per plant in stubble crop differed significantly due to harvesting time of mother crop (Table 49). H2 recorded the highest number of tillers (15.7) which was on par with H1 (15.6); significantly differing from H3 (15.3). Varieties also differed significantly for total tillers per plant. V3 registered the highest (16.9) followed by V1 (16.0). V2 recorded the lowest (13.8) number of tillers. The interaction effects between the harvesting time of main crop and the varieties were significant.

4.9.6 Productive tillers per plant

Productive tillers per plant of stubble crop differed significantly due to harvesting time of mother crop (Table 49). H1 (12.3) registered the highest number followed by H2 (12.1) and H3 (11.9). Varieties also differed significantly in respect this character. V3 recorded the maximum number of productive tillers (13.1) closely followed by V1(12.1) and V2 (11.1). The interaction between harvesting time of mother crop and the varieties was not significant.

4.9.7 Panicle length

The data on panicle length are presented in Table 49. Significant differences were noticed with respect to this character due to harvesting time of main crop. H1 (20.2 cm) recorded the highest values closely followed by H2 (20.0 cm) and H3 (19.9 cm). Varieties also differed significantly for panicle length. V3 (22.1 cm) registered the highest followed by V1 (19.7 cm) and V2 (18.3cm). Interaction effects were also significant.

4.9.8 Spikelets per panicle

Spikelet number per panicle of stubble crop differed significantly due to harvesting time of main crop (Table 50). H1 recorded the highest number (112.1) closely followed by H2 (110.3); but H1 differed significantly from H3 (108.0). Significant differences were observed among the varieties too for spikelet number. V3 (130.0) recorded the highest number followed by V1 (116.0) and V2 (84.5). In general in

Table 49 . Regenerated hills per plot, regenerated tiller per plant and their field establishment, growth and yield components of stubble planted crop as influenced by harvesting time of main crop

| Treatment | Regenerated | | Field establi- ment (%) | Plant height (cm) | Total tillers/ plant | Productive tillers / plant | Panicle length (cm) |
|---------------------------------------|----------------|-------------------|-------------------------------|-------------------------|----------------------------|----------------------------------|---------------------------|
| | Hills/ plot | tillers/ plant | | | | | |
| Harvesting time (H) | | | | | | | |
| H1 | 84.1 | 10.6 | 95.4 | 78.6 | 15.6 | 12.3 | 20.2 |
| H2 | 80.1 | 10.5 | 91.0 | 78.8 | 15.7 | 12.1 | 20.0 |
| H3 | 72.8 | 10.1 | 84.4 | 78.5 | 15.3 | 11.9 | 19.9 |
| S.E.m + | 1.76 | 0.13 | 0.57 | 0.57 | 0.05 | 0.04 | 0.03 |
| C.D. $\bar{5}$ | 4.95 | NS | 2.22 | NS | 0.18 | 0.14 | 0.11 |
| Varieties (V) | | | | | | | |
| V1 | 90.9 | 12.4 | 88.8 | 84.5 | 16.0 | 12.1 | 19.7 |
| | | | | (86.1) | (17.2) | (12.6) | (19.9) |
| V2 | 55.1 | 7.7 | 84.6 | 65.3 | 13.8 | 11.1 | 18.3 |
| | | | | (67.2) | (15.1) | (13.1) | (18.7) |
| V3 | 91.0 | 11.2 | 97.6 | 86.1 | 16.9 | 13.1 | 22.1 |
| | | | | (86.2) | (18.6) | (14.7) | (22.1) |
| S.E.m + | 1.53 | 0.07 | 0.45 | 0.72 | 0.07 | 0.05 | 0.03 |
| C.D. $\bar{5}$ % | 4.74 | 0.22 | 1.38 | 2.21 | 0.21 | 0.14 | 0.10 |
| Interaction (H x V) | | | | | | | |
| H1V1 | 96.6 | 12.6 | 95.4 | 84.5 | 16.1 | 12.2 | 19.8 |
| H1V2 | 60.4 | 8.0 | 92.6 | 65.2 | 14.0 | 11.3 | 18.6 |
| H1V3 | 95.4 | 11.2 | 98.3 | 86.2 | 16.8 | 13.3 | 22.2 |
| H2V1 | 91.4 | 12.5 | 90.3 | 84.3 | 16.0 | 12.1 | 19.7 |
| H2V2 | 56.9 | 7.8 | 85.7 | 65.8 | 14.1 | 11.1 | 18.3 |
| H2V3 | 91.9 | 11.3 | 97.1 | 86.2 | 17.1 | 13.1 | 22.1 |
| H3V1 | 84.8 | 12.0 | 80.3 | 84.7 | 15.9 | 11.8 | 19.6 |
| H3V2 | 47.9 | 7.2 | 75.3 | 64.9 | 13.2 | 11.0 | 18.1 |
| H3V3 | 85.6 | 11.0 | 97.3 | 85.9 | 16.8 | 12.9 | 22.0 |
| V at same level of H | | | | | | | |
| S.E.m + | 2.66 | 0.12 | 0.78 | 1.24 | 0.12 | 0.08 | 0.05 |
| C.D. $\bar{5}$ % | NS | NS | 2.40 | NS | 0.36 | NS | 0.17 |
| H at same/different level of V | | | | | | | |
| S.E.m + | 2.80 | 0.16 | 0.85 | 1.16 | 0.11 | 0.08 | 0.05 |
| C.D. $\bar{5}$ % | NS | NS | 2.90 | NS | 0.34 | NS | 0.17 |

H1 = Harvesting at physiological maturity V1 = ARC 11353 R (good ratooner)
H2 = Harvesting at one week after physiological maturity V2 = Pushpa (poor ratooner)
H3 = Harvesting at two week after physiological maturity V3 = IR 54752 A/ARC 11353 R (Hybrid)
NS = Not significant; Figures in parantheses are results of respective seedling planted varieties

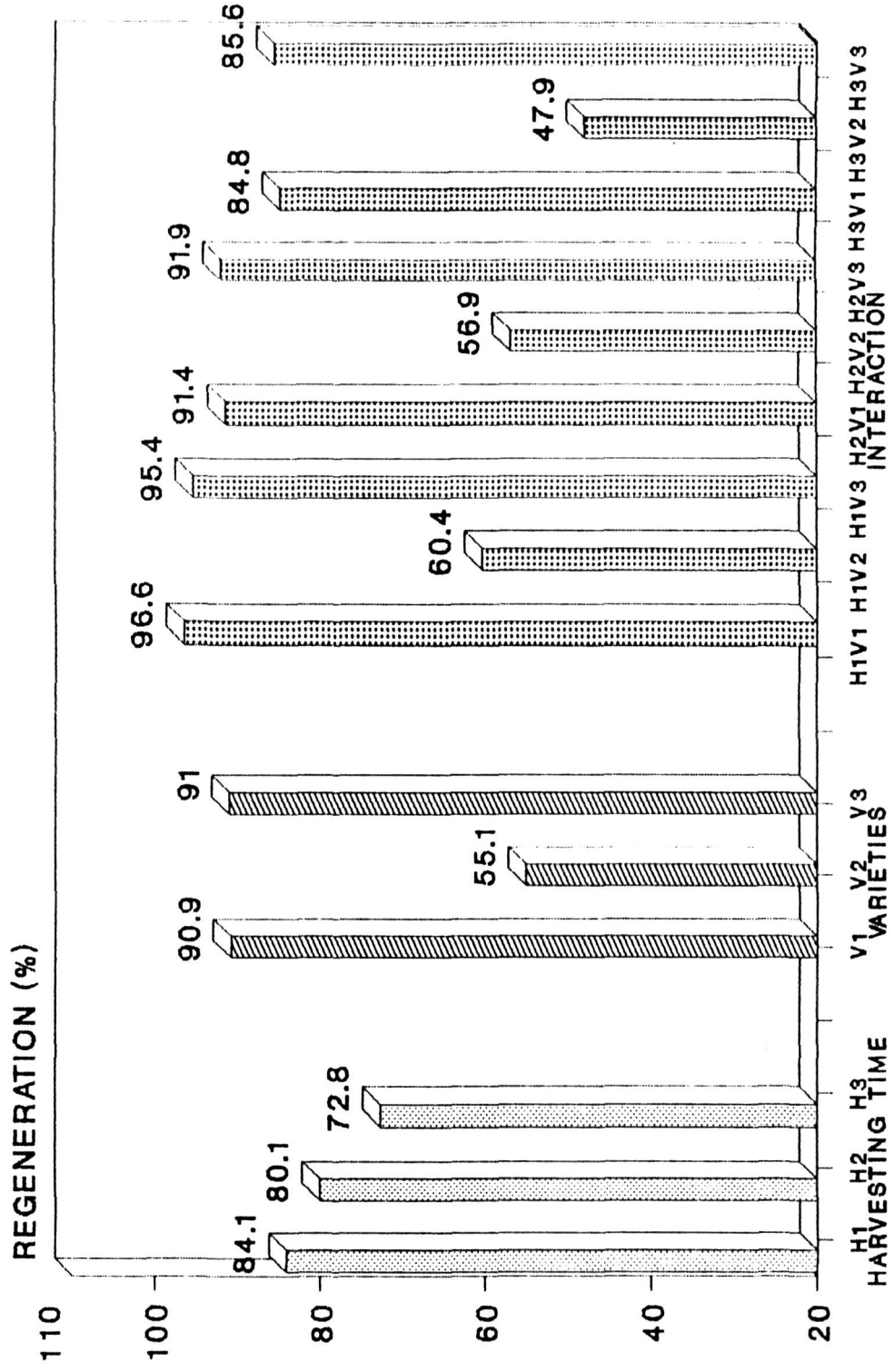


FIG 24. REGENERATED HILLS (%) IN RATOON CROPS AS INFLUENCED BY HARVESTING TIME OF MAIN CROP

all the varieties, main crop recorded more number of spikelets than respective stubble crop. Interaction effects between harvesting time and varieties due to total spikelets per panicle differed significantly.

4.9.9 Filled spikelets per panicle

The data on filled spikelets per panicle are furnished in Table 50. Significant differences were observed between harvesting time of main crop for filled spikelets. Harvesting at physiological maturity (H1) registered the highest filled spikelets (103.1) which was on par with H2 (100.8) and differed significantly from H3 (97.8).

Significant differences were noticed among the varieties for filled spikelets. V3 (119.0) showed the highest number and differed significantly from V1 (106.0) and V2 (76.8).

4.9.10 Per cent filled spikelets

Percentage filled spikelets differed significantly due to harvesting time of main crop (Table 50). H1 registered the highest (91.9%) which was on par with H2 (91.4%) and significantly differing from H3 (90.3%). Negligible differences were observed among the varieties for per cent filled spikelet in stubble crop. In general it was higher in the main crop of V1 and V2 but not in V3. Interactions were significant among the varieties and harvesting time for per cent filled spikelets in stubble crop.

4.9.11 Grain yield per plant

Grain yield of stubble crop did not vary significantly due to time harvesting of main crop (Table 50). However, harvest at physiological maturity registered the highest grain yield (21.6g) followed in numerical order by H2 (21.2g) and H3 (20.4g).

Varieties differed significantly for grain yield per plant. V3 recorded the highest grain yield (24.6g) per plant followed by V1 (22.1g) and lowest by V2 (16.5g). Main crop grain yield was more in V1 and V2, but low in V3. The interactions between time of harvesting and varieties was not significant.

4.9.12 Grain yield per hectare

The data on grain yield per hectare are presented in Table 50. Significant differences were noticed due to harvesting time of main crop on grain yield of stubble crop. H1 recorded the highest yield (6.96 t/ha), significantly differing from H2 (6.69 t/ha) and H3 (6.19 t/ha). Varieties too differed for grain yield. V3 registered the highest yield (8.68 t/ha) closely followed by V1 (7.72 t/ha) and the lowest by V2 (3.44 t/ha). In general grain yield was high in main crop of V1 and V2 and less in V3 as compared to the respective stubble crops. Interaction effect between harvesting time and variety as reflected in grain yield was significant.

Table 50. Yield and yield attributes of stubble crop as influenced by time of harvesting of main crop

| Treatment | Spikelets/ panicle | Filled spikelets | | Grain yield per | | Test weight (g) |
|---------------------------------------|-----------------------|------------------|----------|-----------------|----------------|-----------------------|
| | | per panicle | per cent | Plant (g) | Hectare (t) | |
| Harvesting time (H) | | | | | | |
| H1 | 112.1 | 103.1 | 91.9 | 21.6 | 6.96 | 20.05 |
| H2 | 110.3 | 100.8 | 91.4 | 21.2 | 6.69 | 19.86 |
| H3 | 108.0 | 97.8 | 90.3 | 20.4 | 6.19 | 19.68 |
| S.E.m + | 0.60 | 0.90 | 0.40 | 0.44 | 0.02 | 0.01 |
| C.D. $\bar{5}$ % | 2.35 | 3.40 | 1.58 | NS | 0.08 | 0.04 |
| Varieties (V) | | | | | | |
| V1 | 116.0 | 106.0 | 91.4 | 22.1 | 7.72 | 19.14 |
| | (123.0) | (116.0) | (95.3) | (24.80) | (9.10) | (19.16) |
| V2 | 84.5 | 76.8 | 90.8 | 16.5 | 3.44 | 18.22 |
| | (92.0) | (88.0) | (96.0) | (19.80) | (4.51) | (18.28) |
| V3 | 130.0 | 119.0 | 91.5 | 24.6 | 8.68 | 22.22 |
| | (135.0) | (99.0) | (73.2) | (21.0) | (6.10) | (22.36) |
| S.E.m+ | 0.76 | 0.71 | 0.54 | 0.46 | 0.014 | 0.007 |
| C.D. $\bar{5}$ % | 2.34 | 2.20 | NS | 1.42 | 0.043 | 0.02 |
| Interaction (H x V) | | | | | | |
| H1V1 | 120.0 | 110.0 | 91.7 | 22.1 | 8.31 | 19.17 |
| H1V2 | 87.3 | 80.3 | 92.0 | 17.3 | 3.77 | 18.45 |
| H1V3 | 129.1 | 119.1 | 92.2 | 25.4 | 8.80 | 22.53 |
| H2V1 | 116.0 | 102.0 | 87.9 | 22.2 | 7.86 | 19.12 |
| H2V2 | 84.4 | 79.3 | 93.8 | 16.9 | 3.48 | 18.12 |
| H2V3 | 130.5 | 121.1 | 92.7 | 24.6 | 8.74 | 22.32 |
| H3V1 | 112.0 | 106.0 | 94.6 | 21.9 | 7.00 | 19.13 |
| H3V2 | 81.6 | 70.7 | 86.6 | 15.4 | 3.08 | 18.08 |
| H3V3 | 130.4 | 116.8 | 89.6 | 23.8 | 8.51 | 21.82 |
| V at same level of H | | | | | | |
| S.E.m+ | 1.32 | 1.23 | 0.95 | 0.80 | 0.02 | 0.012 |
| C.D. $\bar{5}$ % | 4.06 | 3.80 | 2.92 | NS | 0.08 | 0.04 |
| H at same/different level of V | | | | | | |
| S.E.m+ | 1.23 | 1.33 | 0.87 | 0.79 | 0.03 | 0.014 |
| C.D. $\bar{5}$ % | 4.04 | 4.57 | 2.84 | NS | 0.10 | 0.05 |

H1 = Harvesting at physiological maturity

H2 = Harvesting at one week after physiological maturity

H3 = Harvesting at two week after physiological maturity

V1 = ARC 11353 R (good ratooner)

V2 = Pushpa (poor ratooner)

V3 = IR 54752 A/ARC 11353 R (Hybrid)

NS = Not significant; Figures in parantheses are results of respective seedling planted varieties

4.9.13 Test weight

Test weight of stubble crop differed significantly due to harvesting time of main crop (Table 50). Harvest at physiological maturity - H1 registered the highest test weight (20.05g) followed by H2 (19.86g) and H3 (19.68). Varieties also differed significantly for test weight. V3 (22.22g) recorded the highest weight followed by V1 (19.14g) and V2 (18.22g). Interaction effects between harvesting time and variety were significant for test weight.

EXPERIMENT -10

4.10 Performance of Stubble Planted Crop after Root Dipping

The results of the experiment (1990 WS) involving stubble crop of F₁ hybrid, IR 54752A/IR46R as influenced by root dipping of stubbles in chemicals are presented in Table 51.

4.10.1 Field establishment

Field establishment percentage varied significantly among the treatments (Table 51 and Fig. 25). Stubbles dipped in Rogar + DAP (T5) registered the highest field establishment (94.2%) followed by Rogar + Emissan (94.0%). The treatment T5 differed significantly from other treatments viz., T3: 92.60%; T2: 93.2%; T1: 91.8% and the lowest in control: 87.0%. Seedling planted check recorded 95.0 per cent of field establishment being on par with T5.

4.10.2 Plant height

Significant differences were observed in plant height due to treatment over the control (Table 51). The stubbles in T5 recorded the highest plant height (72.1cm) followed by T4 and T1 (71.3 cm). The lowest height was noticed in the T7 (70.3 cm). However, seedling planted hybrid (T8) recorded greater height (73.4 cm) than the stubble planted crop. The treatments T1 to T7 were on par .

4.10.3 Productive tillers per plant

Significant differences were noticed among the treatments in productive tillers (Table 51). The maximum number (15.2) was observed in T5 (root dipping in Rogar + DAP) followed by Emissan + Rogar (15.0) and the minimum was observed in the control (13.7). The treatments T1, T2, T3, T4, T5 and T6 were all on par. The seedling planted hybrid recorded numerically more productive tillers (15.8) was on par with T5.

4.10.4 Panicle length

Panicle length differed significantly among the treatments (Table 51). The maximum panicle length was recorded in the treatment including Rogar + DAP (19.2 cm) closely followed by Emissan + Rogar (19.1 cm) and the minimum was in the control (18.1 cm). Seedling planted hybrid recorded panicle length of 19.3 cm which was on par with T5. The treatments T1 and T3, T4 and T5 and T8 were on par.

4.10.5 Per cent filled spikelets

The data on per cent filled spikelets are presented in Table 51. Significant differences were noticed among the treatments. The maximum per cent filled spikelets (93.7%) was noticed in the treatment involving Rogar + DAP followed by Emissan + Rogar (92.5%) and Emissan + Rogar + DAP (92.4%). The lowest filled spikelet percentage was recorded in the control (82.0%). Seedling planted hybrid registered 85.2 per cent. The treatments. T1, T2, T3, T4, T5 and T6 were all on par.

4.10.6 Grain yield

The grain yield of stubble planted hybrid IR 54752A/IR 46R based on 5 plants and on hectare basis are given in Table 51 and Fig. 25. Significant differences were noticed among the various treatments for grain yield.

Based on five plants observation, the treatment involving Rogar + DAP recorded the highest grain yield (75.5 g) closely followed by Emissan + Rogar (72.5 g) and Emissan + Rogar + DAP (71.0 g). The lowest yield was registered by the control (57.5g). Seedling planted hybrid recorded 67.8 g yield per 5 plants.

On hectare basis, the treatment involving Rogar + DAP recorded the maximum grain yield (7.50 t) closely followed by Emissan + Rogar (7.12 t) and Emissan + Rogar + DAP (7.00 t). The lowest yield was registered in control (5.75 t).

Table 51 . Plant height, yield attributes and grain yield of IR 54752 A/IR 46 R hybrid in stubble crop as influenced by root dipping

| Treatment | Field establishment (%) | Plant height (cm) | Productive tillers / plant | Panicle length (cm) | Filled spikelets (%) | Grain yield per 5 plants Hectare # (g) | Grain yield per Hectare # (t) |
|----------------------------|-------------------------|-------------------|----------------------------|---------------------|----------------------|----------------------------------------|-------------------------------|
| Emissan | 91.80 | 71.3 | 14.2 | 18.3 | 91.1 | 66.5 | 6.50 |
| Rogar | 93.20 | 70.7 | 14.5 | 18.6 | 91.8 | 68.5 | 6.87 |
| Diammonium phosphate (DAP) | 92.60 | 70.8 | 14.1 | 18.3 | 91.3 | 69.0 | 6.75 |
| Emissan + Rogar | 94.00 | 71.5 | 15.0 | 19.1 | 92.5 | 72.5 | 7.12 |
| Rogar + DAP | 94.20 | 72.1 | 15.2 | 19.2 | 93.7 | 75.5 | 7.50 |
| Emissan + Rogar + DAP | 93.80 | 70.9 | 14.9 | 18.9 | 92.4 | 71.0 | 7.00 |
| Control | 87.00 | 70.3 | 13.7 | 18.1 | 82.0 | 57.5 | 5.75 |
| Seedling planted check | 94.00 | 73.4 | 15.8 | 19.3 | 85.2 | 67.8 | 6.80 |
| Mean | 92.60 | 71.4 | 14.7 | 18.7 | 90.0 | 68.5 | 6.78 |
| S.E.m+ | - | 0.45 | 0.35 | 0.06 | 0.69 | 2.85 | 0.07 |
| C.D.5 % | - | 1.36 | 1.10 | 0.17 | 2.10 | 8.62 | 0.20 |

* = Determined from plot yield

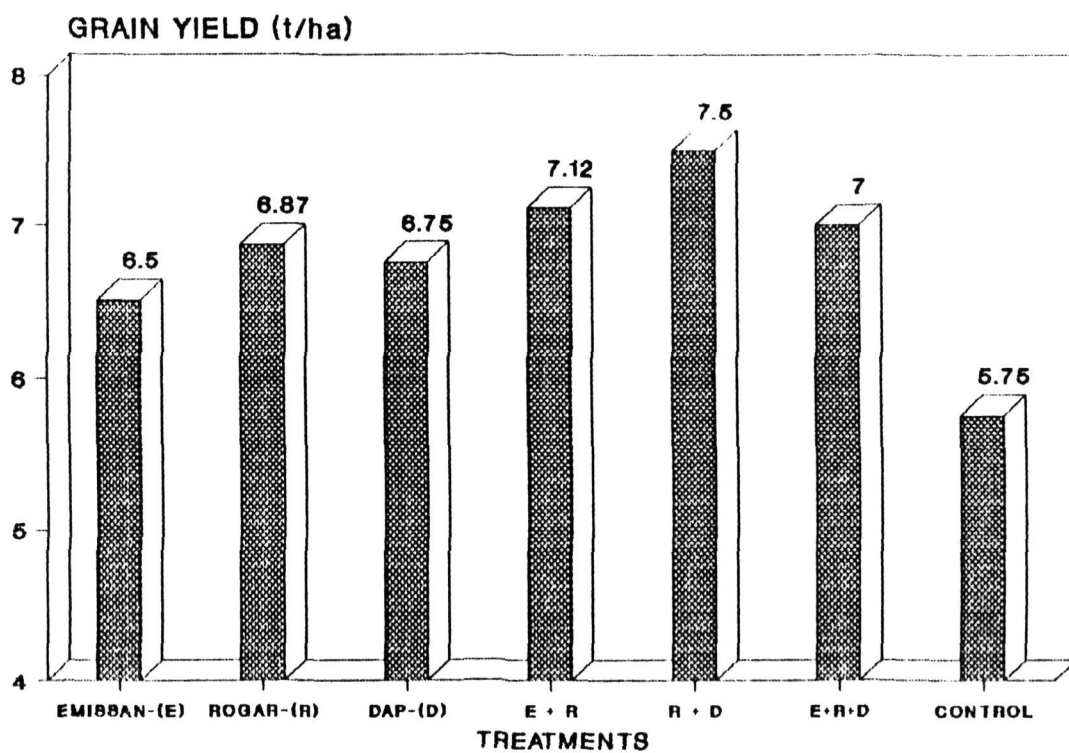
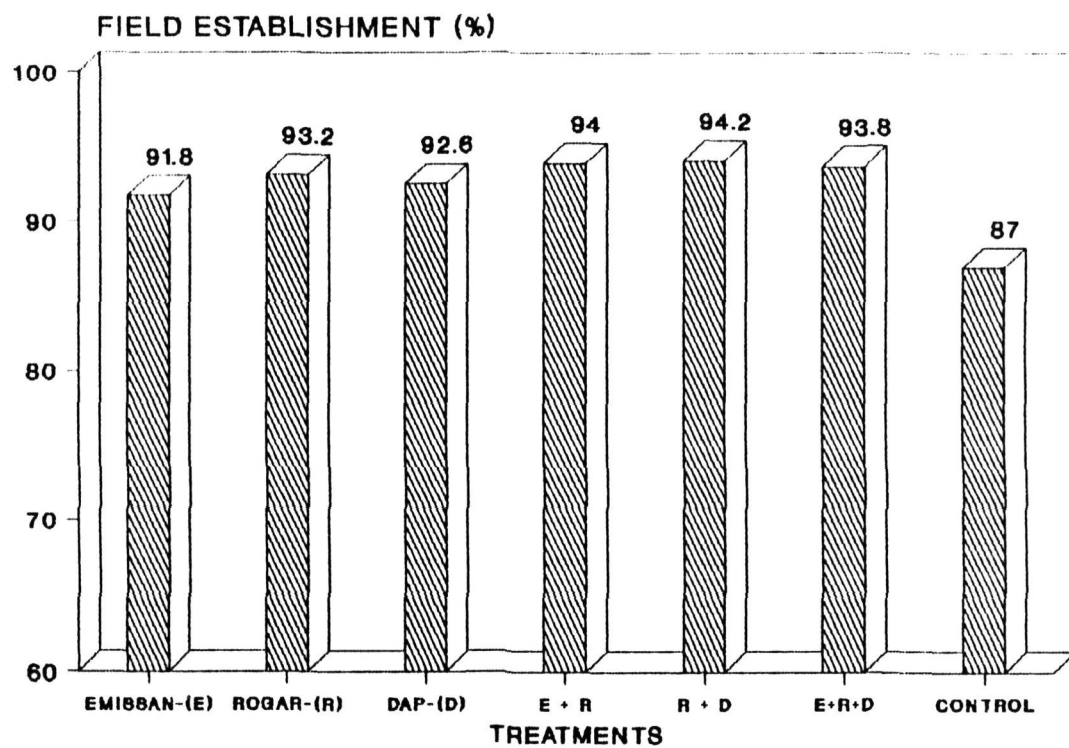


FIG 25. EFFECT OF ROOT DIP ON FIELD ESTABLISHMENT (%) AND GRAIN YIELD OF STUBBLE CROP (IR 54752 A/ IR 46 R)

Seedling planted hybrid recorded 6.80 tonnes grain yield per hectare.

EXPERIMENT -11

4.11 Optimum Planting Ratio for Parental and Hybrid Seed Production

4.11.1 Planting ratio in IR 62829 A/B seed production

The results pertaining to the effect of planting ratio on seed set and seed yield in parental seed production are presented in Table 52 and plate 8.

4.11.1.1 Number of productive tillers

Results indicated significant differences among the planting ratios in number of productive (seed bearing) tillers per plant (Table 52). The treatment 2B:4A (T5) recorded the maximum productive tillers (14.8) closely followed by 2:6 (14.8). The minimum tillers (11.8) were registered in 2:10 which was on par with 2:8 (12.3).

4.11.1.2 Panicle length

Differences were not significant for panicle length (Table 44). Panicle length ranged from 19.5 to 19.3 cm irrespective of planting ratios.

4.11.1.3 Spikelets per panicle

Total number of spikelets per panicle (Table 52) which ranged from 152.0 to 139.0 did not vary significantly among the planting ratios.

4.11.1.3a Days to 50 per cent flowering

IR 62829A took 103 days and IR 62829B took 99 days for 50 per cent flowering.

4.11.1.4 Filled spikelets per panicle

Filled spikelets per panicle differed significantly among the planting ratios (Table 52). The filled spikelets were high in the ratio of 1:2, 2:4 and 2:6 (23.0, 22.0 and 20.0 respectively). The minimum filled spikelets were observed in 2:10 ratio (13.0).

4.11.1.5 Seed set per cent

Seed set percentage differed significantly among the ratios (Table 52). The highest seed set was observed in 2:4 (16.9%) which was on par with 1:2 (16.8%), 2:6 (14.3%) and 1:3 (14.1%). The lowest seed set was observed in 2:10 (9.7%) followed by 1:5 (9.8%).

4.11.1.7 Seed yield

The data pertaining to seed yield per plant and hectare basis are furnished in Table 52. Significant differences were noticed among the ratios for seed yield per plant. The maximum yield was recorded in 1:2 (5.6 g/plant) ratio followed by 2:4 (5.2 g/plant) and 2:6 (5.0 g/plant) which was on par with 2:8 (4.7g/plant). The minimum seed yield per plant was observed in 2:10 (2.9 g/plant) and in 1:5 (3.0 g/plant).

Per hectare yield also showed significant differences among the ratios studied (Table 52) but it was different from the above trend. The ratio 2:6 recorded the highest seed

Table 52. Seed set and seed yield as influenced by planting ratio in seed production of IR 62829 A/B

| Planting ratio | Productive tillers per plant | Panicle length (cm) | Total spikelets/Plant | Filled spikelets/panicle | Seed set (%) | Seed yield per | |
|----------------|------------------------------|---------------------|-----------------------|--------------------------|--------------|----------------|--------------|
| | | | | | | Plant (g) | Hectare* (t) |
| T1 - 1:2 | 14.2 | 19.4 | 146.3 | 23.0 | 16.8 | 5.60 | 1.37 |
| T2 - 1:3 | 14.2 | 19.3 | 140.0 | 18.0 | 14.1 | 4.90 | 1.50 |
| T3 - 1:4 | 13.1 | 19.4 | 146.0 | 16.0 | 12.2 | 4.20 | 1.43 |
| T4 - 1:5 | 12.3 | 19.3 | 152.0 | 13.0 | 9.8 | 3.00 | 1.02 |
| T5 - 2:4 | 14.8 | 19.5 | 139.0 | 22.0 | 16.9 | 5.20 | 1.40 |
| T6 - 2:6 | 14.8 | 19.4 | 147.0 | 20.0 | 14.3 | 5.00 | 1.57 |
| T7 - 2:8 | 12.3 | 19.3 | 144.0 | 17.0 | 12.7 | 4.70 | 1.07 |
| T8 - 2:10 | 11.8 | 19.3 | 149.0 | 13.0 | 9.7 | 2.90 | 0.96 |
| Mean | 13.4 | 19.4 | 145.5 | 17.7 | 13.3 | 4.44 | 1.30 |
| S.E.m± | 0.29 | 0.09 | 4.81 | 1.24 | 1.23 | 0.27 | 0.04 |
| C.D. 5% | 0.89 | NS | NS | 3.83 | 3.81 | 0.83 | 0.12 |

* = Determined from plot yield Days 50 per cent flowering: A - 103 days
 NS = Not significant B - 99 days



Plate 8: The optimum planting ratio (2:6) for IR 62829A/B seed production



Plate 9: Field view - Evaluation of planting ratios during seed production of IR 62829A/IR 9761-19-1R

yield (1.57 t/ha) which on par with 1:3 (1.50 t/ha). The lowest seed yield was given by 2:10 ratio (0.96 t/ha).

4.11.2 Planting ratio in IR 62829 A/IR 9761-19-1R hybrid seed production

The results pertaining to hybrid seed yield and yield attributing characters on IR 62829 A/ IR 9761-19-1R as influenced by planting ratio (A/R) are presented in Table 53, Fig. 26 and Plate 9)

4.11.2.1 Number of productive tillers per plant

Significant differences were not noticed among the planting ratios for productive tillers per plant. The tillers ranged from 12.9 to 13.3 (Table 53)

4.11.2.2 Spikelets per panicle

Significant differences were not observed due to total spikelets per panicle and ranged from 130 to 140 (Table 53).

4.11.2.3 Filled spikelets per panicle

Filled spikelets per panicle differed significantly among the ratios. All the 3 ratios (1:2, 2:4 and 2:6) recorded 8.0 filled spikelets per panicle and were on par with 1:3 (7.0), 1:4 (6.0). Minimum number of filled spikelets were noticed in 2:10 (3.0) ratio (Table 53).

4.11.2.3a Days to 50 per cent flowering

The restorer took 95 days and female parent took 105 days to flower 50 per cent.

4.11.2.4 Seed set per cent

There were significant difference among the planting ratios (Table 53 and Fig. 26) in seed set percentage. The highest seed set was observed in 1:2 (5.8%) closely followed

Table 53. Seed set and seed yield as influenced by planting ratio in hybrid seed production of IR 62829 A / IR 9761-19-1 R

| Planting ratio | Productive tillers per plant | Spikelets/panicle | Filled spikelets/panicle | Seed set (%) | Hybrid seed yield per | | Yield increase or decrease over 2:1 (%) |
|----------------|------------------------------|-------------------|--------------------------|--------------|-----------------------|---------------|-----------------------------------------|
| | | | | | Plant (g) | Hectare * (t) | |
| T1 - 1:2 | 13.2 | 138.0 | 8.0 | 5.80 | 2.28 | 0.61 | 0.00 |
| T2 - 1:3 | 13.1 | 130.0 | 7.0 | 5.70 | 2.26 | 0.76 | +24.70 |
| T3 - 1:4 | 13.0 | 135.0 | 6.0 | 4.50 | 1.70 | 0.57 | - 5.90 |
| T4 - 1:5 | 13.0 | 138.0 | 5.0 | 3.40 | 1.41 | 0.45 | -25.80 |
| T5 - 2:4 | 13.2 | 140.0 | 8.0 | 5.60 | 2.30 | 0.63 | + 3.40 |
| T6 - 2:6 | 13.3 | 132.0 | 8.0 | 5.70 | 2.26 | 0.80 | +31.80 |
| T7 - 2:8 | 13.0 | 136.0 | 5.0 | 3.60 | 1.65 | 0.56 | - 8.24 |
| T8 - 2:10 | 12.9 | 138.0 | 3.0 | 2.70 | 1.16 | 0.43 | -29.50 |

Mean 13.10 136.0 6.4 4.60 1.87 0.60
 S.E.m⁺ 0.15 3.45 0.85 0.20 0.04 0.03
 C.D. 5 % NS NS 2.62 0.60 0.12 0.09

* = Determined from plot yield Days to 50 per cent flowering:
 NS = Not significant

IR 62829A - 105 days
 IR 9761R - 96 days

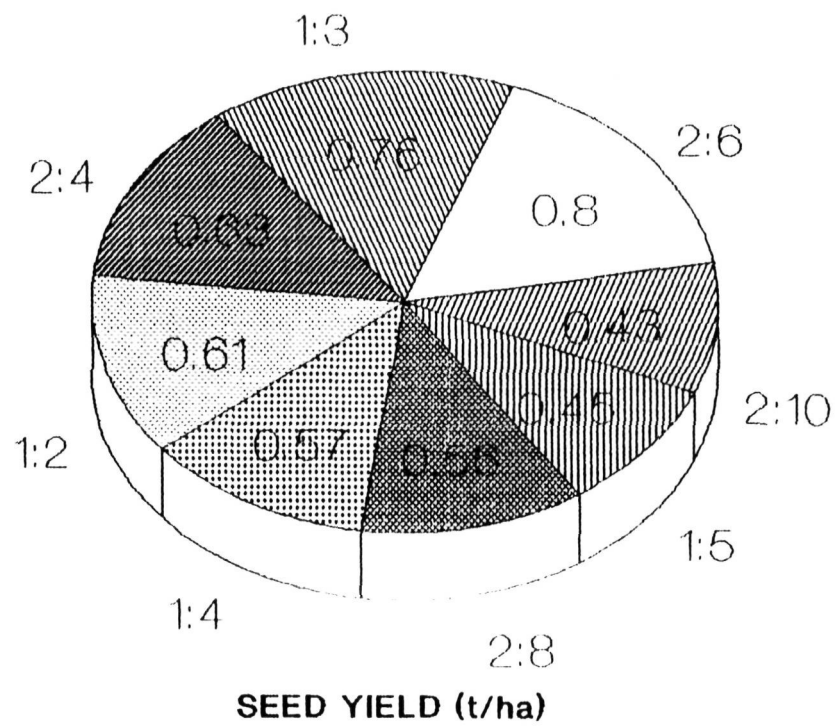
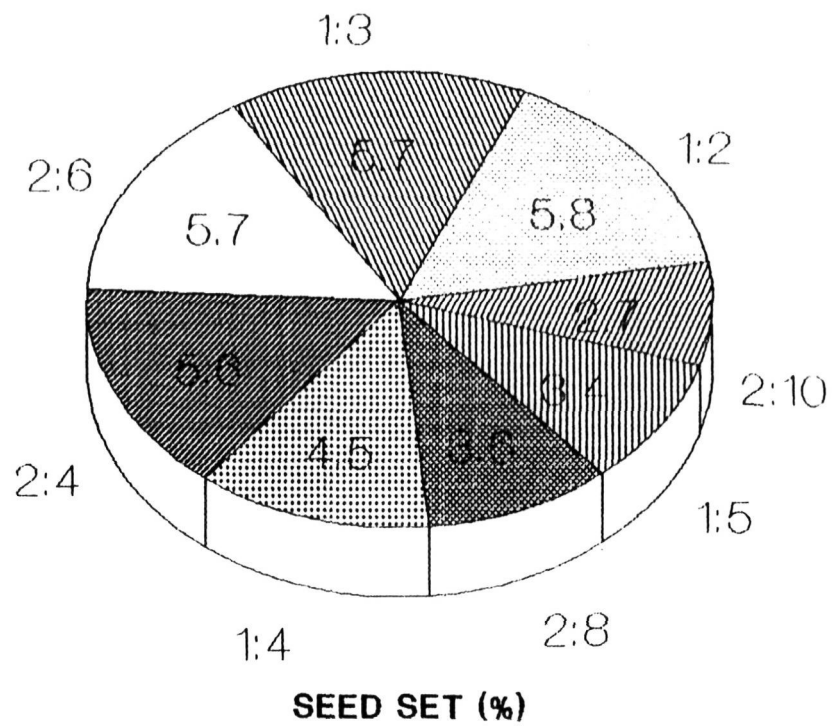


FIG 26. SEED SET AND SEED YIELD AS INFLUENCED BY PLANTING RATIO IN IR 62829A/IR 9761 R HYBRID SEED PRODUCTION

by 2:6 (5.7%), 1:3 (5.7%) and 2:4 (5.6%). The minimum seed set was observed in 2:10 (2.7 %).

4.11.2.5 Hybrid seed yield

The observations on hybrid seed yield per plant and hectare basis are given in Table 53 and Fig. 26. Hybrid seed yield per plant differed significantly among the planting ratios studied. The maximum seed yield per plant was recorded in 2:4 (2.30 g) which was on par with 1:2 (2.28 g), 1:3 (2.26 g) and 2:6 (2.26g). The minimum yield was registered in 2:10 ratio (1.16 g). Per hectare hybrid seed yield also differed significantly. The ratio 2:6 recorded the maximum seed yield (0.80 t) which was on par with 1:3 (0.76 t). The lowest yield was observed in 2:10 (0.43 t) followed by 1:5 (0.45 t).

EXPERIMENT -12

4.12 Synchronization of Flowering of parents in seed production of Hybrids

4.12.1 Synchronization in IR 62829A/B seed Production

The results of the experiment involving IR 62829A and IR 62829 B are presented in Table 54.

4.12.1.1 Days to 50 per cent flowering

The female parent IR 62829A took 107 days and its maintainer took 103 days for 50 per cent flowering. Better synchrony was achieved in sowing B four days after female sowing (T2). Continuous pollens could be supplied by giving one more staggering on 8th day after female sowing as in T8.

4.12.1.2 Productive tillers per plant

Productive tillers per plant differed significantly among the treatments (Table 54). Sowing of male 4 and 8 days later to female (T8) recorded the highest productive tillers (14.8) per plant which was on par with T6 (14.2), T7 (14.1), T5 (14.0) and T4 registered the lowest tillers (11.0) followed by T1 (11.9).

4.12.1.3 Filled spikelets per panicle

Significant differences were observed for filled spikelets per panicle of female parent (Table 54). The treatment T8 recorded the highest number of filled spikelets (26.0) followed by T6 (18.0) and T2(16.0).

4.12.1.4 Seed set percentage

The data on per cent seed set indicated significant differences among the same female parent sets of different treatments (Table 54). The highest seed set was recorded in T8 (18.71%) followed by T6 (12.68%). The lowest seed set was registered in T1 (4.38%).

4.12.1.5 Seed yield

Significant differences were observed in seed yield per plant of female line due to various staggered sowing of male parent (Table 54). The highest seed yield per plant was recorded in T8 (6.83 g) followed by T6 (4.80 g) and T2 (4.31g). The lowest yield was registered by T4 (1.41 g).

Table 54. Seed yield contributing factors and yield as influenced by synchronization of flowering in parent seed production of IR 62829 A/B

| Male staggering DAFS | Productive tillers/ plant | Filled spikelets / panicle | Seed set /panicle | Seed yield per | | Flowering Behaviour (%) | | |
|----------------------------|---------------------------------|----------------------------------|-------------------------|----------------|-----------------|-------------------------------|----|----|
| | | | | Plant (%) | Hectare* (t) | A | B1 | B2 |
| 2 | 11.9 | 6.0 | 4.38 | 1.61 | 0.38 | 50 | 78 | - |
| 4 | 14.0 | 16.0 | 11.15 | 4.31 | 0.88 | 50 | 49 | - |
| 6 | 13.6 | 7.0 | 4.78 | 1.97 | 0.45 | 50 | 31 | - |
| 8 | 11.0 | 6.0 | 4.38 | 1.41 | 0.29 | 50 | 09 | - |
| 2, 8 | 14.0 | 11.0 | 7.55 | 3.02 | 0.71 | 50 | 80 | 8 |
| 4, 6 | 14.2 | 18.0 | 12.68 | 4.80 | 1.07 | 50 | 48 | 34 |
| 6, 8 | 14.1 | 15.0 | 9.97 | 4.03 | 0.94 | 50 | 33 | 10 |
| 4, 8 | 14.8 | 26.0 | 18.71 | 6.83 | 1.49 | 50 | 49 | 10 |
| Mean | 13.45 | 13.1 | 9.20 | 3.49 | 0.78 | | | |
| S.E.M. | 0.34 | 1.71 | 1.36 | 0.28 | 0.024 | | | |
| C D 5 % | 1.04 | 5.20 | 4.10 | 0.86 | 0.07 | | | |

DAFS = Days after female sowing

NS = Not significant

B1 and B2 = Staggered first and second rows in a set

The seed yield of female parent per hectare basis followed the same trend as above (Table 55). Treatment T8 recorded the highest seed yield (1.49 t/ha) followed by T6 (1.07 t/ha). The lowest yield was observed in T4 (0.29 t/ha) followed by T1 (0.38 t/ha).

4.12.2 Synchronisation in IR 62829 A/ IR 9761-19-1R hybrid seed production

Data on seed yield as influenced by synchronization of female: IR 62829A and male: IR 9761-19-1R are presented in Table 55.

4.12.2.1 Days to 50 per cent flowering

The female parent IR 62829A took 108 days whereas male took 99 days for 50 per cent flowering (Table 55). There was a perfect synchrony of flowering between male and female when male was sown nine days later to female. Sowing male parent 9 and 13 days after sowing female resulted in better synchrony and continuous supply of pollen.

4.12.2.2 Productive tillers per plant

Significant differences were obtained for number of productive (seed bearing) tillers per plant due to synchrony of male parent with female (Table 55). Sowing male parent 9 and 13 days later to female (T8) recorded the maximum productive tillers (14.6) followed by T7 (sowing male, 9 and 11 days later to female) i.e., 14.0 tillers. Treatment T4 recorded the minimum tillers (9.8) followed by T1 (10.9).

4.12.2.3 Filled spikelets per panicle

Significant differences were recorded for filled spikelets on female parent due to different staggered sowing of male (Table 55). Sowing male parent 9 and 13 days after female sowing registered the highest number of filled spikelets (21.0) followed by T6 (18.0) and T4 recorded the lowest (5.3) filled spikelets.

4.12.2.4 Seed set percentage

Significant differences were noticed for seed set percentage due to various staggered sowing of male parent (Table 55 and Fig. 27). Sowing male 9 and 13 days after sowing of female recorded the highest seed set (13.72%) but was on par with the treatment of sowing of male 9 and 11 days later to female (12.33%). The lowest seed set (2.56%) was recorded on female by single sowing of male parent 13 days after female.

4.12.2.5 Hybrid seed yield

The highest seed yield per plant was recorded (Table 55 and Fig 27) in T7 (6.42g) followed by T6 (5.29g). T4 recorded the lowest seed yield (0.74g) per plant.

Seed yield per hectare computed based on plot yield followed the same trend. T7 recorded the highest seed yield (1.86 t/ha) followed by T6 (1.61 t/ha). The lowest hybrid seed yield was observed in T4 (0.22 t/ha).

Table 55. Hybrid seed yield and yield attributes as influenced by synchronization of flowering in IR 62829 A/ IR 9761-19-1 R seed production

| Male staggering DAFS | Productive tillers/ plant | Filled spikelets /panicle | Seed set (%) | Seed yield per | | Flowering behaviour (%) | | |
|-------------------------|---------------------------------|---------------------------------|--------------------|----------------|------------------|-------------------------------|----|----|
| | | | | Plant (g) | Hectare * (t) | A | R1 | R2 |
| 7 | 10.9 | 7.0 | 4.72 | 1.60 | 0.43 | 50 | 71 | - |
| 9 | 12.9 | 12.0 | 7.45 | 3.08 | 0.86 | 50 | 52 | - |
| 11 | 11.0 | 8.0 | 5.26 | 1.84 | 0.59 | 50 | 39 | - |
| 13 | 9.8 | 5.3 | 2.56 | 0.74 | 0.22 | 50 | 29 | - |
| 7, 9 | 12.6 | 13.0 | 8.72 | 3.42 | 0.98 | 50 | 70 | 51 |
| 9, 11 | 14.0 | 18.0 | 12.33 | 5.29 | 1.61 | 50 | 52 | 41 |
| 9, 13 | 14.6 | 21.0 | 13.72 | 6.42 | 1.86 | 50 | 50 | 29 |
| 11, 13 | 12.3 | 14.0 | 8.80 | 3.61 | 1.01 | 50 | 41 | 28 |
| Mean | 12.26 | 12.29 | 7.94 | 3.25 | 0.95 | | | |
| S.E.M. | 0.41 | 0.76 | 0.52 | 0.08 | 0.05 | | | |
| C D 5 % | 1.24 | 2.31 | 1.57 | 0.24 | 0.16 | | | |

DAFS = Days after female sowing

R1 and R2 = Staggered first and second rows in a set

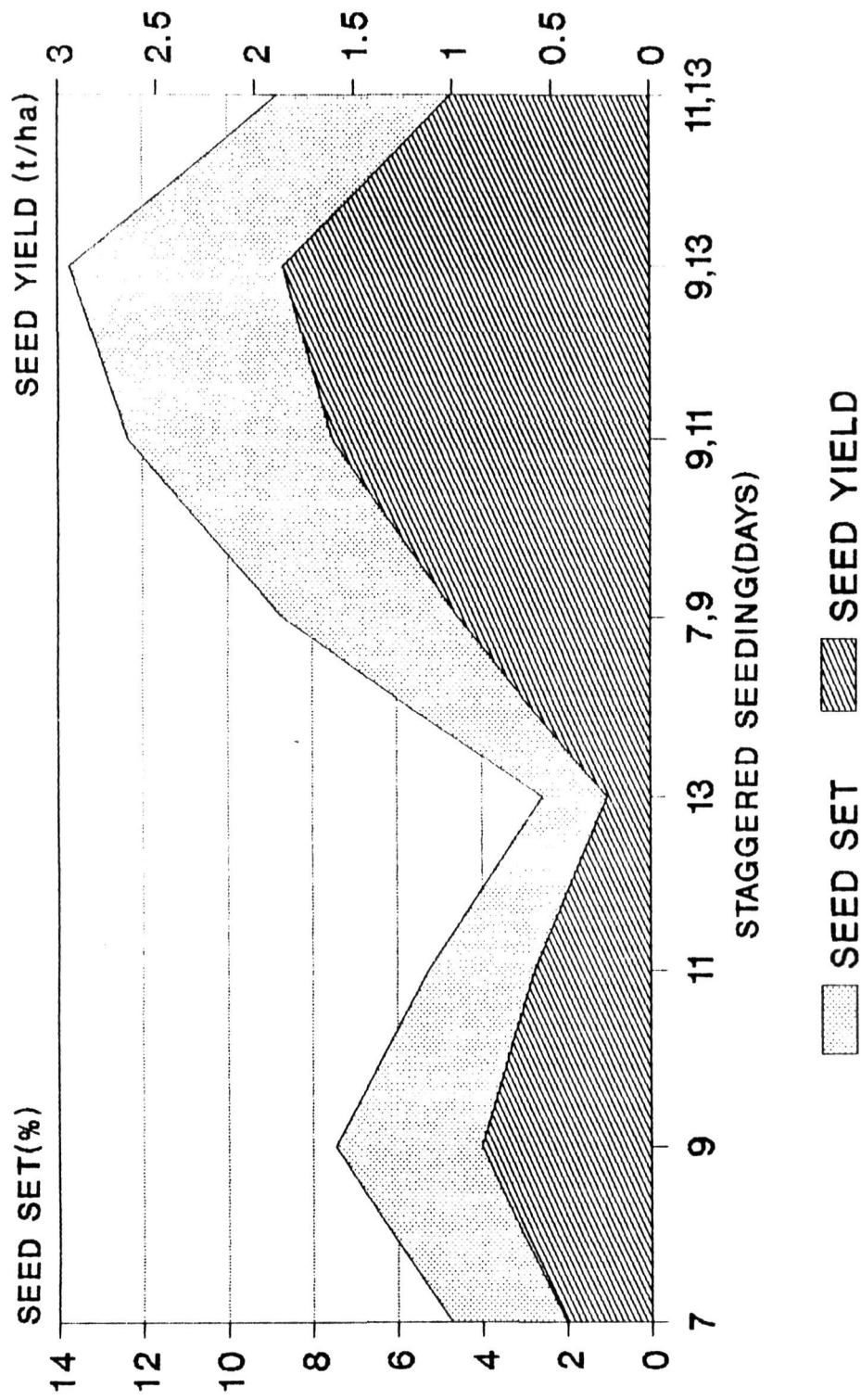


FIG 27. SEED SET AND SEED YIELD AS INFLUENCED BY SYNCHRONIZATION OF FLOWERING IN HYBRID SEED PRODUCTION(IR 62829A/IR 9761R)

EXPERIMENT -13

4.13 Effect of Foliar Spray on Seed Set and Seed Yield

The results pertaining to the growth, out crossing and seed yield on CMS (IR 54752 A / B) line as influenced by foliar chemical spray are presented in Tables 56 and 57 and Fig. 28.

Behaviour of IR 54752 A

4.13.1 Plant height

There were significant differences among the different treatments for plant height (Table 56). The treatment with GA_3 (60ppm) recorded the maximum plant height (94.7cm) closely followed by urea spray, 1.5 percent (92.0cm) and urea, 2.0 per cent (91.8cm). The plant height was minimum (89.6cm) in Boric acid (0.5%) treatment.

4.13.2 Number of productive tillers

Statistical analysis revealed significant differences in tillers due to treatments (Table 56). The maximum number of productive tillers (10.8) were recorded by GA_3 spray (60ppm) and Boric acid (1.0 %) followed by boric acid 0.5 per cent (10.6). The minimum productive tillers (9.0) were recorded by spraying 1.5 per cent KNO_3 followed by 1.0 per cent. The treatments T2, T7 and T8 were on par with each other differed significantly from T6, T5, T4 and T3 which on par with each other.

4.13.3 Panicle exertion

Per cent panicle exertion differed significantly due to various foliar sprays (Table 56). Spraying of GA_3 recorded the maximum exertion (72.1%) followed by urea 2.0 per cent (68.9 %). The treatments T4, T5, T6, T7 and T8 were on par.

4.13.4 Panicle length

The panicle length differed significantly due to sprays (Table 56). The maximum panicle length of 25.6 cm was recorded in treatment with Boric acid (1.0% closely followed by GA_3 , 60 ppm (25.5 cm). The treatment T5, T6 and T7 were on par.

4.13.5 Filled spikelets per plant

Filled spikelets per plant differed significantly due to treatments (Table 56). Spraying of 60 ppm GA_3 recorded the maximum number of filled spikelets (69.0) followed by Boric acid 1.0 per cent (62.0). The lowest values was registered by the control.

4.13.6 Per cent seed set

The results on seed set percentage are presented in Table 56 and Fig. 28. Statistical analysis revealed significant differences for this character due to treatments. The highest seed set (6.95%) was in the treatment with GA_3 , closely followed by Boric acid 1.0 per cent spray (6.78%). the control recorded the lowest (4.64 %) seed set and differed significantly from the rest.

Table 56 . Growth and yield components of IR 54752 A as influenced by foliar chemical spray in seed production of IR 54752 A / B

| Treatments | Plant height (cm) | Productive tiller / plant | Panicle exertion (%) | Panicle length (cm) | Filled spikelets / plant | Seed set (%) |
|-------------------------------|-------------------|---------------------------|----------------------|---------------------|--------------------------|--------------|
| T1 - Control | 90.8 | 10.4 | 64.5 | 24.1 | 39.0 | 4.64 |
| T2 - GA (60 ppm) 3 | 94.7 | 10.8 | 72.1 | 25.5 | 69.0 | 6.95 |
| T3 - Urea (1.5 %) | 92.0 | 9.4 | 67.1 | 25.3 | 50.2 | 6.29 |
| T4 - Urea (2.0 %) | 91.8 | 9.2 | 68.9 | 25.5 | 59.4 | 6.21 |
| T5 - KNO ₃ (1.0 %) | 89.9 | 9.2 | 67.9 | 25.4 | 49.2 | 6.14 |
| T6 - KNO ₃ (1.5 %) | 90.3 | 9.0 | 68.5 | 25.4 | 57.0 | 6.73 |
| T7 - Boric Acid (0.5 %) | 89.6 | 10.6 | 68.7 | 25.4 | 53.0 | 6.01 |
| T8 - Boric Acid (1.0 %) | 90.7 | 10.8 | 68.6 | 25.6 | 62.0 | 6.78 |
| Mean | 91.2 | 9.9 | 68.3 | 25.3 | 54.8 | 6.22 |
| S.E.m± | 0.45 | 0.09 | 0.49 | 0.03 | 0.30 | 0.04 |
| C.D.5 % | 1.64 | 0.27 | 1.48 | 0.09 | 0.90 | 0.12 |

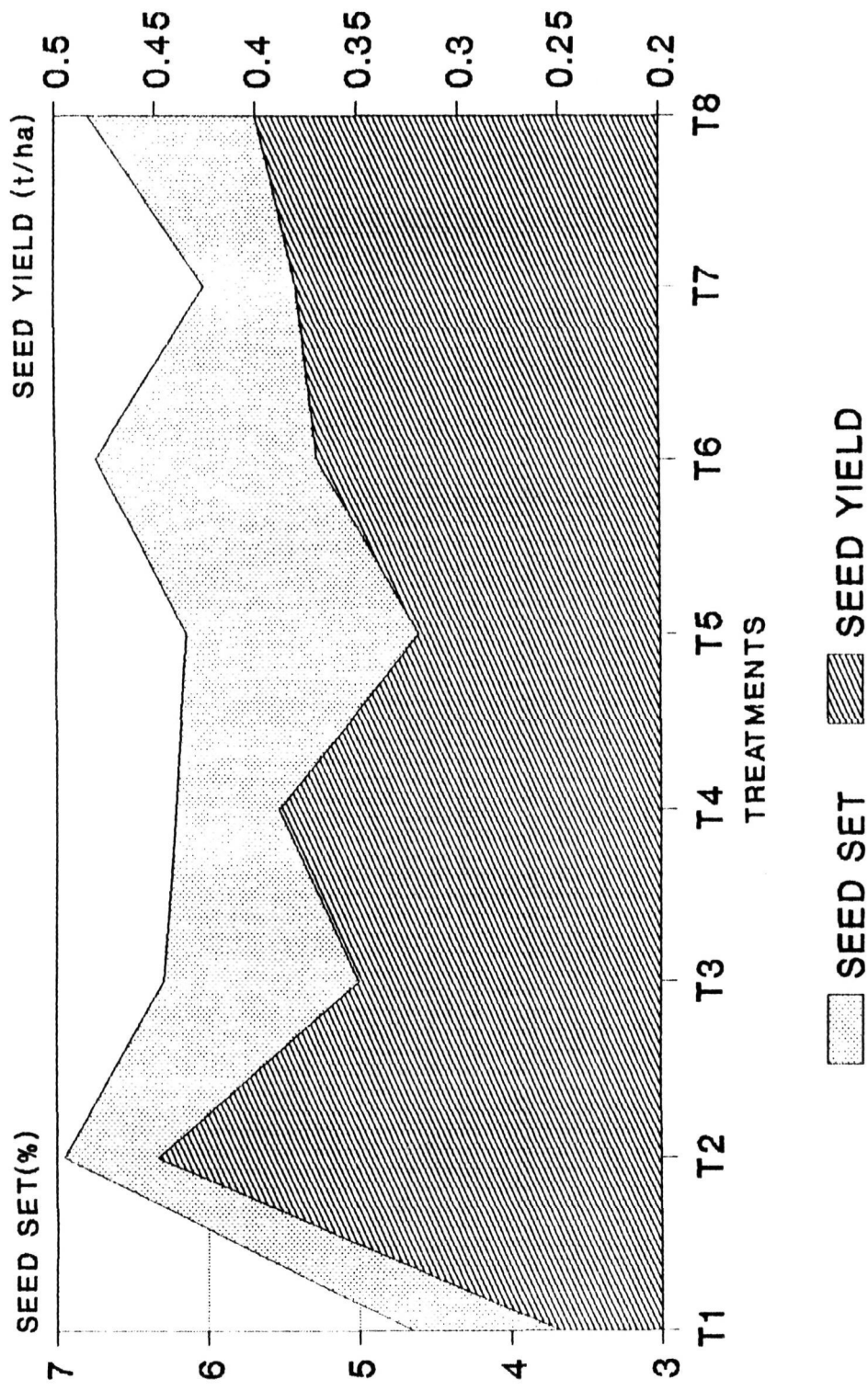


FIG 28. EFFECT OF FOLIAR SPRAY ON SEED SET AND SEED YIELD IN SEED PRODUCTION OF IR 54752 A / B

Table 57. Seed yield and test weight of IR 54752 A as influenced by foliar chemical spray in seed production of IR 54752 A / B

| Treatment | Seed yield per Hectare* | | Seed yield increase / decrease over | | Test weight (g) |
|-------------------------------|-------------------------|--------------------------|-------------------------------------|---------|-----------------|
| | Plant (g) | Hectare ³ (%) | GA ³ (%) | Control | |
| T1 - Control | 0.80 | 0.25 | -41.90 | 0.00 | 21.42 |
| T2 - GA (60 ppm) ³ | 1.49 | 0.45 | 0.00 | + 72.20 | 21.68 |
| T3 - Urea (1.5 %) | 1.08 | 0.35 | -22.60 | + 33.30 | 21.48 |
| T4 - Urea (2.0 %) | 1.25 | 0.39 | -12.90 | + 50.00 | 21.63 |
| T5 - KNO ₃ (1.0 %) | 1.06 | 0.32 | -29.00 | + 22.20 | 21.58 |
| T6 - KNO ₃ (1.5 %) | 1.24 | 0.37 | -16.10 | + 44.40 | 21.54 |
| T7 - Boric Acid (0.5 %) | 1.14 | 0.38 | -16.10 | + 44.40 | 21.49 |
| T8 - Boric Acid (1.0 %) | 1.32 | 0.40 | - 9.70 | + 55.60 | 21.66 |
| Mean | 1.17 | 0.36 | | | 21.56 |
| S.E.m + | 0.02 | 0.01 | | | 0.02 |
| C.D.5% | 0.06 | 0.03 | | | 0.06 |

* = Determined from plot yield

4.13.7 Seed yield

Significant differences were noticed in seed yield due to treatments (Table 57 and Fig. 28). The maximum seed yield per plant (1.49 g) was recorded in the treatment of GA₃ followed in order by Boric acid (1.32 g), urea 2 per cent (1.25g), KNO₃ 1.5 per cent (1.24 g), Boric acid 0.5 per cent (1.14 g), urea 1.5 per cent (1.08g) and KNO 1.0 per cent (1.06g). The lowest seed yield was recorded by the control (0.80 g).

Seed yield per hectare computed, based on plot yield also followed the same trend. The highest seed yield per hectare was recorded by GA (0.45t), closely followed by Boric acid 1.0 per cent (0.40t). The lowest seed yield was noticed in the control (0.25t). The treatments T6 and T7, T4 and T7, T3 and T7, T2 and T8 were on par with each other.

4.13.8 Test weight

The data on test weight of IR 54752 A seed are presented in Table 57. The maximum test weight was recorded by GA₃ (21.68g) closely followed by Boric acid 1.0 per cent (21.66g). The minimum value was registered by the control (21.42g). The treatments T2, T4 and T8, T5 and T6, T6 and T7 were on par.

EXPERIMENT -14

4.14 Seed Quality of IR 54752 A as Influenced by Foliar spray

The results of seed quality attributes of IR 54752 A as influenced by foliar chemical spray during production of CMS line are presented in Tables 58.

4.14.1 Seed germination

Results indicated negligible differences due to treatment in seed germination (Table 58). All the treatments recorded high seed germination as compared to control (95.5%). The maximum germination (98.8%) was in treatment GA_3 (60 ppm) followed by Boric acid 0.5 per cent (98.3%) and KNO_3 1.0 per cent (98.3%).

4.14.2 Field emergence

The observations pertaining to per cent field emergence are furnished in Table 58. The treatments differed significantly for this character. The maximum field emergence was recorded by GA (97.3%) followed in order by KNO_3 1.0 per cent (96.4%) and KNO_3 1.5 per cent (96.4%). The minimum was registered by the control (93.3%).

4.14.3 Shoot length

Shoot length varied with treatments significantly (Table 58). Maximum shoot length (15.3cm) was recorded in the treatment of GA_3 and Boric acid (0.5%) closely followed by KNO_3 1.0 per cent (15.3 cm) which were on par with each other. The lowest shoot length (12.9 cm) was registered by control.

4.14.4 Root length

All the treatments differed significantly over the control for root length (Table 58). The maximum root length was observed in the GA_3 (14.2 cm), closely followed by KNO_3 1.0 per cent (14.2cm). The minimum root length was noticed

in the control (13.8 cm). The treatments T2 and T4, T4 and T5, T5 and T7, T7 and T8 and T4 and T8 were on par.

4.14.5 Vigour index

The observations pertaining to vigour index are presented in Table 58. All the treatments recorded significantly higher vigour index over control (2554). The maximum vigour index was registered by the treatment boric acid 1.0 per cent (2878) which was on par with KNO_3 1.0 per cent (2873) and GA_3 60 ppm (2868). The treatments T7 and T8, T5 and T6, T2 and T3 and T2 and T5 were on par.

4.14.6 Seedling dry weight

There were significant differences among the treatments for seedling dry weight (Table 58). The maximum seedling dry weight was registered by the treatment KNO_3 1.0 per cent (122.7 mg) and was on par with GA_3 (122.5 mg). The minimum value was recorded by the control (118.0 mg) followed by urea 1.5 per cent (119.2 mg). The treatments T5 and T6, T5 and T7, T6 and T7 and T6 and T8 were on par.

4.14.7 Ageing response

Seeds obtained from GA_3 recorded lower germinability (83.0) as compared to Boric acid 0.5 per cent (89.0%). Higher concentration of KNO_3 , urea and Boric acid also registered lower germinability and were on par (Table 58).

Table 58. Seed quality attributes of IR 54752 A seeds as influenced by foliar spray during production of IR 54752 A / B

| Treatment | Germination (%) | Field emergence (%) | Seedling | | | Vigour index | Germination after ageing (%) |
|-------------------------------|-----------------|---------------------|------------------------------|-------------------|------------------|--------------|------------------------------|
| | | | dry weight (mg/10 seedlings) | Shoot length (cm) | Root length (cm) | | |
| T1 - Control | 95.5 | 93.3 | 118.0 | 12.9 | 13.8 | 2554 | 81.0 |
| T2 - GA (60 ppm) ³ | 98.8 | 97.3 | 122.5 | 15.3 | 14.2 | 2869 | 83.0 |
| T3 - Urea (1.5%) | 96.4 | 93.3 | 119.2 | 14.8 | 13.9 | 2764 | 84.0 |
| T4 - Urea (2.0%) | 96.8 | 94.3 | 121.5 | 15.2 | 14.2 | 2827 | 82.0 |
| T5 - KNO ₃ (1.0%) | 98.3 | 96.4 | 122.7 | 15.2 | 14.2 | 2873 | 86.0 |
| T6 - KNO ₃ (1.5%) | 97.8 | 96.4 | 122.0 | 14.6 | 13.9 | 2799 | 82.0 |
| T7 - Boric Acid (0.5%) | 98.3 | 96.2 | 121.8 | 15.3 | 14.2 | 2878 | 89.0 |
| T8 - Boric Acid (1.0%) | 97.4 | 95.4 | 122.0 | 15.1 | 14.2 | 2868 | 83.0 |
| Mean | 97.4 | 95.3 | 121.0 | 14.8 | 14.1 | 2804 | |
| S.E.m + | 1.38 | 1.02 | 0.39 | 0.06 | 0.05 | | 7.80 |
| C.D.5% | NS | 3.08 | 1.18 | 0.17 | 0.15 | | 23.60 |

NS = Not significant

DISCUSSION

V. DISCUSSION

The successful development of hybrid maize in the 1930s provided an impetus for breeders of other crops including self pollinating cereals such as rice, wheat and often cross pollinated crops like sorghum, to exploit the phenomenon of "hybrid vigour".

Jones (1926) was the first in USA to report heterosis in rice. Periodically, suggestions of developing F_1 rice hybrids to exploit heterosis commercially have been made by rice scientists in India (Richharia, 1962; Mahadevappa, 1973), China (Yuan, 1966), U.S. (Carnahan et al., 1972) and IRRI (Athwal and Virmani, 1972). But China happened to be the first country to exploit heterosis in developing hybrid rice.

China's commercial hybrids yield about 20 per cent more than the best conventional varieties. This has encouraged the rice scientists all over the world to explore the potentials of hybrid rice, especially under irrigated conditions. Initial results have indicated prospects of increasing rice yields through hybrids by about one tonne per hectare.

Chinese hybrids and CMS lines were unsuccessful when tested in other Asian countries because they were not adapted to tropical conditions and susceptible to major pests and diseases. Led by IRRI, work on production of suitable male sterile lines and F_1 combinations of A/R lines was

reinitiated in India, Indonesia, Republic of Korea, Thailand and Japan. Preliminary trials showed 20 per cent yield advantage due to heterosis. However, the natural outcrossing rate in rice cultivars is low and hybrid seed production, using male sterility has been posing difficulties limiting immediate commercialisation of hybrids.

In 1973, when seed production of promising hybrids started in China, F_1 seed yields were less than 0.1 t/ha. Now, techniques for hybrid seed production have been improved and standardised, consequently seed yields have increased substantially. In 1982, 0.15 m.ha area earlier devoted to hybrid seed production was reduced to 0.12 m.ha, as hybrid seed yield on average increased to 1.5 t/ha.

The most important factor determining outcrossing rate on CMS lines are synchronisation of flowering and planting ratio between male and female parents. It is not uncommon in China to get 2.0 to 2.5 tonnes of hybrid seed per hectare. The highest hybrid seed yield in China was 6.1 t/ha for hybrid Wei You 64 in Xu-Pu country, China during 1985 summer (Yuan et al., 1985). Extensive use of GA3 increases outcrossing and seed yield but it is costly outside China. So there is a need to investigate a substitute chemical for the same to make hybrid rice commercially viable.

Considering the existence of exploitable level of heterosis in rice and the inherent problems associated with seed production, research has been initiated in the University of Agricultural Sciences, Bangalore to study the feasibility of vegetative propagation to aid towards economising seed production. Besides cost factor and saving on fresh seed requirement, there are many other advantages with this technique. Different methods of vegetative propagation possible for adoption are i) ratooning ii) tiller separation and planting and iii) stubble planting. Ratooning is not only remunerative in commercial cultivation but can be also practised during seed production whenever there is non-synchrony of flowering between parental lines during the main crop season. Tiller separation and stubble planting also seem to be promising means under certain situations, since it is possible to cover six to ten times the area by adapting these methods because each tiller becomes planting unit.

Apart from genotypes, the environment under which seed production is taken up has a profound influence not only on outcrossing rate but also on seed viability and storability. Hence, selection of the best provenance for seed production should become an integral part of seed programme. The present investigation aims at finding out the influence of

- i. genotype, provenance and season on initial seed quality,
- ii. storability of genotypes as influenced by provenance and seed treatment,
- iii. comparison of seed production of hybrids through the main crop and ratoon crops for their seed yield and quality,
- iv. feasibility of vegetative propagation with special reference to tiller separation and stubble planting,
- v. seed set and seed yield as influenced by planting ratio, synchronization of flowering between parents and
- vi. seed set, yield and quality as influenced by foliar spray during parental seed production.

The experiments conducted with these objectives yielded encouraging results. The highlights of the results are discussed in this chapter.

5.1 Seed Quality as Influenced by Genotype, Provenance and Season

Seed quality is a complex phenomenon comprehending genetical, physical, physiological and biochemical aspects of seed behaviour. Seed viability, vigour and longevity are predominantly determined by the genotype (Kurdikeri, 1991), production location (Vanagmudi and Karvaratharju, 1985), mother plant nutrition (Nandisha and Mahadevappa, 1984) weather during seed development and maturity (Odiemah, 1988) and season (Venkata Reddy et al., 1990).

Results of the present study have revealed significant variation in seed quality due to genotype, production location, season and their interaction effects. The results obtained on these aspects are discussed herein.

5.1.1 Genotypes and seed quality

As presented under results genotypes differed significantly due to seed characters viz., test weight, seed volume and seed density causing for differences in seed quality parameters such as germination, speed of germination, field emergence, seedling length, vigour index, electrical conductivity of seed leachate and accelerated ageing test response.

The test weight differed significantly among the genotypes. V 20B recorded significantly more test weight (25.92g) followed by IR 54752B (24.28g) and the lowest by Pushpa (19.04g). Variation in the test weight is a genetic character which depends on seed size. Such variations are also reported by Umamaheshwar (1983). Mahanteshappa (1989) and Yogeasha (1991) in rice. Other seed characters like seed volume and density followed almost the same trend. Superiority of V 20B genotype in respect of these characters can be attributed to its big seed size, test weight and better seed filling. Earlier reports of Shivappa (1988) and Deshpande (1988) strongly support the present finding.

Irrespective of production location and season, genotypes differed significantly for seed quality parameters. V 20B recorded the highest germination (96.01%) closely followed by Pushpa (95.7%) and Mangala (95.5%). Superiority of these genotypes was attributed to their genetic potential,

seed weight and density (Maranville and Clegg, 1977). On the contrary, seeds of Mangala and Pushpa which have comparatively lower test weight, showed better germination, but IR 54752B (93.3%) with higher seed weight registered marginal decrease in germination.

Seedling length of the genotypes under the study differed significantly and ranged from 20.2 cm (Intan mutant) 27.3 (V 20). The vigour index was maximum in V 20B (2626) closely followed by Pragathi B (2501), Mangala (2409) and was the lowest in Intan mutant (1906). The superiority noticed in vigour index can attributed to high germination and increased seedling length besides being characteristic of the genotypes. Speed of germination too followed the same trend V 20B recorded the highest value (31.6), followed by Pushpa (30.3); but it was minimum in Improved sona (29.0). Difference in germination speed appeared to be due to inherent capacity of genotypes to germinate faster and grow rapidly resulting in vigorous seedling. It is also reported to be dependent on reserve food material and its efficient utilization during germination (Styer et al., 1980). The present results are consistent with those of Linhares (1980) and Mathur et al. (1982) who observed higher germinability and vigour in heavy seeds. The present results also support by findings of Cicero and Orsi (1978) who noticed higher vigour in heavy seeds than in lighter, as recorded in the four rice cultivars. Field emergence of the genotypes was

also in tune with vigour index of V 20 B, being superior to the rest. This superiority was attributed to high seedling vigour. But the emergence values were lower than germination values which could be due to environmental stresses, as germination test was conducted under favourable laboratory conditions.

The electrical conductivity is widely used as a vigour test to measure seed quality in most of the crops and EC values are inversely related to seed quality. In the present study, seeds of V 20B were recorded the lowest EC (146 μ mhos/cm) and Pragathi B (165 μ mhos/cm) and Intan mutant (159 μ mhos/cm) recorded high EC. The differences in EC could be ascribed to variation in integrity of membrane permeability. More electrolytes leaked by Pragathi could be due to its larger endosperm with more internal concentrations of sugar and free amino acids which might have leached out in relatively greater proportion than in other genotypes rather than entirely due to loss of membrane integrity (Abdul-Baki and Anderson, 1970). It was purely by a passive diffusion process and not caused by changes in membrane permeability (Abdul-Baki and Anderson (1972). This illustration is valid for Pragathi and it is also reflected in accelerated ageing test proving its better quality by maintaining higher germinability (83.7%) even after ageing. Similarly higher germination was observed in the seeds of Pragathi B, Mangala B and V 20B after ageing test. On the contrary, the seeds

of genotypes IR 54752B, Intan mutant B and Improved Sona B proved their lower seed quality by registering poor germination after ageing test. The inferior quality is a consequence of seed deterioration i.e., summation of all physical, physiological and biochemical changes occurring in the seed which ultimately lead to its death (Delouche, 1973). Such deterioration is variable among seed kinds, varieties, seed lots of same variety and among individuals. This statement of Delouche (1973) also clearly supports the variation in germinability after AA among the genotypes studied. Such varietal differences were also observed by Murugesan et al. (1989), Krishnasamy and Seshu (1990). Lower seed quality of IR 54752B, Intan mutant B and improved sona genotypes could be attributed to more discolouration and fungi incidence.

5.1.2 Effect of provenance on seed quality

In the present study, the seed quality is found to differ greatly due to locations. The significant differences noticed due to locations for test weight are worth discussing here. Irrespective of genotypes, seed produced at Mandya recorded higher test weight (22.9 g) closely followed by that produced at Bangalore (22.7g), Shimoga (22,.0g) and Mudigere (21.1g). Higher test weight of Mandya seeds can be attributed to favourable conditions provided to mother crop during its growth, seed development and maturity. The

present results are in agreement with those of Yogeasha (1991) who also observed higher test weight in seeds of Mandya and Bangalore conditions and lower seed weight in Mudigere seeds. The present findings also support the reports of Dighe and Patil (1986) who observed effect of environment on seed size, resulting in small seeds under less favourable conditions. Such variations among the locations for test weight are also reported by Tripathi and Laxman Singh (1979), DRR (1990) and Kurdikeri (1991).

Similarly, the seed volume and density too followed the same trend as that of test weight. Seeds produced at Mandya followed those produced at Bangalore and Shimoga recording higher values, Mudigere seed recorded low values for the above seed characteristics. The present results are strongly supported by DRR (1990), wherein different grade size rice varieties were distinctly different at different locations (Hyderabad, Maruteru, Chinsurah and Mandya). Inferior quality of seeds produced at Mudigere can be attributed to rain damage at seed development and maturity (Hegde *et al.*, 1983). The variation among the genotypes in that location might be due to varietal differences in responding to rain damage.

Germination was higher in seeds produced at Mandya (97.0%) followed by that produced at Bangalore (95.8%) and Shimoga (93.7%). Higher germinability of seeds produced at Mandya and Bangalore could be due to the highly favourable,

disease free environmental conditions under which seeds developed and matured.

The locations Mandya and Bangalore are classified as dry zones receiving more solar radiation than Shimoga and Mudigere. Mudigere situated at hilly region receives the lowest solar radiation in addition to having lower temperature than other locations. Shimoga comes under transitional zone receiving lower radiation than Bangalore and Mandya due to cloudy weather. Hence, it may be concluded that higher intensity of solar radiation, heat sum and sunshine hours at Mandya and Bangalore could be the causes for better growth and yield (Yogeesha, 1991) resulting in better quality seed. Such variations for germinability of seeds produced at different locations are also reported by Burris (1977) in maize, Berezkin and Guida (1980) in wheat, Maeda and Sawazaki (1982) as well as Vanagmudi and Karivaratharaju (1985) in Sorghum and Thiagarajan (1990) in rice. On the contrary, Umamaheshwar (1983) in rice and Morgapuram (1989) in maize reported negligible variation among the locations for seed germination.

With regard to seedling length, significant differences were noticed due to locations. Seed produced at Mandya recorded the maximum seedling length (25.5 cm as compared to those produced at Bangalore (24.8 cm) and the minimum at Mudigere (21.8 cm). The differences in seedling length were due to the favourable environment during crop growth, seed

development and maturation at Mandya, Bangalore and less favourable environment at Mudigere. The present results are in agreement with the results of Burris (1977) but in contrast to the statement made by Umamaheshwar (1983) and Vangamudi and Karivaratharaju (1985) also failed to observe significant variation in root shoot growth across the locations.

Similarly, vigour index of seedlings also followed the same trend as seedling length. This is expected since vigour index is the multiplication of seedling length and germination per cent. Seeds of genotypes produced at Mandya recorded the highest vigour index (2479) closely followed by Bangalore (2395), Shimoga (2240) and the lowest in Mudigere (2007) which might be attributed to seed discolouration due to fungi. The maximum seedling vigour index recorded by the seeds of Mandya and Bangalore could be associated to higher seedling length, germination, test weight and seed density (Copeland, 1988). Such variations in seedling vigour over locations were also reported by Maeda and Sawazaki (1982) and Vanagmudi and Karivaratharaju (1985). On the contrary, Kurdikeri (1991) failed to notice significant variation for vigour index among locations.

Superiority of seedling vigour index of seeds produced at Mandya reflected in higher speed of germination and field emergence. This differences in the above two parameters over

locations could be mainly due to condition of good health and natural robustness in the seeds which, upon planting, permit germination to proceed rapidly under a wide range of field conditions which is otherwise defined as seedling vigour. The present results are in agreement with those of Kurdikeri (1991) who also observed variation in field emergence across the locations.

Superiority of seed quality was again reflected in significantly lower EC values of seeds produced at Mandya and Bangalore than those produced at Shimoga and Mudigere. This suggested the poor membrane integrity of seeds produced at the latter locations which could be ascribed to unfavourable environment that prevailed during seed development and maturation due to precipitation (Promilakumari et al., 1992) and high humidity (Sessouma, 1987).

Results on accelerated ageing test indicated significant difference due to locations. Mandya followed by Bangalore produced seeds proved their superiority for seed quality over the rest of the locations by maintaining higher germinability. Poor seed quality of seeds produced from Shimoga might be due to higher incidence of discolouration which was clear indication of fungal attack.

5.1.3 Effect of season on seed quality

Climatic factors which have a profound influence on crop productivity and seed quality are the most difficult to

be manipulated. Seed yield and quality are the overall result of crop growth, seed development and maturation. Any favourable or unfavourable condition occurring when the plant is at certain growth stage may be modified or compensated for during the subsequent process depending upon the environmental conditions. The environmental conditions under which a seed crop matures definitely influences the viability and vigour. Therefore it is important to study the prevailing seasonal factors on seed quality.

With regard to seed characters, small differences were noticed for test weight. Seed produced during dry season registered significantly higher density (1.38g/cc) than wet season seeds (1.34g/cc), irrespective of genotype and production location. The present findings on some of the seed characters are in agreement with the results of Padmajarao (1988) who found high density grains more from summer crop than from Kharif crop. On the contrary, Palanisamy et al. (1986) recorded higher test weight from Kharif sown crop in Bhendi. Yogeasha (1991) did not notice significant difference between dry and wet season for test weight in rice.

Some seed quality attributes differed significantly due to production seasons. In total, seed produced in dry season exhibited superior quality over that produced during wet season crop. Seeds from dry season not only recorded

significantly higher germination (94.9%) but also registered higher speed of germination (30.3) higher seedling length (24.1 cm) and lower EC (153u mhos/cm) than wet season seeds. Better quality of seeds produced during dry season was due to favourable climatic conditions the crop could experience throughout its growth, seed development and maturation. Narasingarao (1987) also reported the superiority of rice seeds of summer crop than those of Kharif season. He stated that the total solar radiation, sunshine hours and difference between maximum and minimum temperatures were greater in summer than in Kharif. Kamalan Joseph et al.(1988), in their rice experiment also recorded the influence of specific weather elements such as average temperature, rainfall, sunshine hours, wind velocity at various growth stages on crop growth, yield and quality in rice. Similar results pertaining to superiority of dry season seed for germination were also reported by Fernandes et al. (1980), in rice and Rajarao (1981) in bajra. But Sessouma (1987) explained the poor viability of wet season seeds due to higher humidity at maturity .

Interaction effect

In general, the seeds of genotypes G1 and G3 produced at Mandya and Bangalore during dry season showed higher test weight, but it was not so with regard to seed volume. Seeds of G1 and G3 from wet season produced at Mandya and Bangalore recorded higher values with respect to seed

density. All most all genotypes produced at Shimoga and Mudigere during both the seasons recorded inferior seed quality as compared to that produced at Mandya and Bangalore. Though the interaction between L x G was not significant, numerically higher values were recorded by G6L1, G1L1, G1L2, G1L3 and G6L1. In interaction between genotype and season, G1S2 registered higher seed density followed by G6S2, G1S1 and G3S2. Thus, seed characters do have specific influence when a genotype interacts with a particular environment. Similarly the interaction between genotype and location was significant with respect to germination. G1L2 recorded the highest followed by G1L1. Interaction between genotype and season was significant. G1S1, G2S2, G4S2 and G8S2 recorded higher germinability than the rest. In interaction between location and season, seeds produced from both the seasons at Bangalore and Mandya showed equal germination but in case of Shimoga and Mudigere locations, dry season crop recorded superiority over wet season. This clearly indicates specific influence of production environment and season on seed quality.

In interaction between genotype and location for seedling length, G1, G8 and G5 recorded higher seedling length and G4 and G7 lower seedling length in all the locations but they showed varied performance. The genotypes G1, G8 and G5 produced longer seedlings in both the seasons indicating the superiority of their genetic potential at

different environments. Vigour index of the above genotypes was maximum in Mandya and Bangalore locations and minimum in Mudigere. This superiority can be attributed to more germinability and seedling length of seeds produced at favourable weather conditions of dry season.

With regard to speed of germination, the genotypes G1, G8, G5 and G2 have shown better performance in all the four locations and two seasons proving the superiority of strong genetic potential. The seedling vigour has caused for higher field emergence in G1, G5, G2 and G8 genotypes in all environments. Such differences in seed quality under varied environments are also reported by Funk et al. (1962), Banumurthy and Gupta (1981), Kant et al. (1983) and Dharmalingam (pers. Comm.). The differences in seed quality due to seasonal variation are also reported by Saini et al. (1980) and Fernandes et al. (1980).

Leaching of metabolites is one of the important characteristics for assessing the quality (Ching, 1972; Pollock and Roos, 1972). The genotypes G1, G5, G2 have also shown the intact permeability when produced under different environments. Low quantity of exudates leached out and measured by electrical conductivity (Bradnok and Mathews, 1970) was shown to be associated with the vigour and viability. There is inverse relationship between seed quality and EC values.

More quantity of electrolytes leached from the genotypes G3, G4 and G7 produced in all the four locations thereby indicating poor seed quality (Abdul-Baki and Anderson, 1972) and low metabolic activity of these seeds. The electrolyte leached from these genotypes was more particularly in seeds of Mudigere and Shimoga. This could be ascribed to unfavourable environment during seed development and maturity influencing the membrane integrity.

Recently, due to frequent use of 'Accelerated Ageing' technique (Delouche and Baskin, 1973) which simulates the storage conditions in the tropical and subtropical regions, more and more investigations turned their attention towards the mechanism of the ageing process in seeds. In the present study, the genotypes produced at four environments and two seasons significantly varied for their response towards ageing test proving their superiority or inferiority. The results of ageing test revealed the superiority of seeds of G8, G1, G5, G6 and G2 and inferiority of those of G7, G3 and G4 genotypes from all the four environments indicating resistance or susceptibility to adverse environment. Though G8 leached more EC, it showed better germinability and seedling vigour after AA test indicating that higher EC is not entirely due to lack of membrane integrity but also due to genotypic difference. . Further it is argued that the number of seeds for estimation of EC based on weight will be more in small seeds than in big seeds and as such the surface area will be more. Higher EC of G8 seeds might be due to more

number of seeds together with increased surface area (Mullat, 1979), rather than loss of membrane integrity. In general, the genotypes G1, G8, G5, G2 and G6 produced during dry season at Mandya and Bangalore followed by Shimoga recorded better quality as compared to Mudigere which was inferior.

5.2 Seed Storability as Influenced by Genotype, Provenance and Seed Treatment

The results pertaining to germination, field emergence, seedling length, vigour index, electrical conductivity of seed leachate recorded during storage are discussed here under.

5.2.1 Behaviour of genotypes during storage

In the present study, seed germination was found to differ significantly among the genotypes throughout the storage period. There was a gradual decrease in germination with the time of storage in all the genotypes irrespective of production location and seed treatment. The genotypes Pushpa B (95.7-84.7%), Madhu (95.2-84.2%) V20B (96.0-84.1%), Mangala B (95.5-84.1%) and Pragathi B (94.6-82.9%) maintained the minimum certification standards for germination even after 19 months of storage, while the rest of the genotypes (IR54752B, improved sona B and intanmutant B) could maintain the standards upto 17 months. This variation in deterioration among the genotypes is obviously due to the genetic control to resist deterioration during storage and initial seed quality. Such differences in storability among the rice genotypes were also reported by Biswas (1973);

Agrawal (1977), Gomez et al. (1986), Juliano et al. (1990) and Subhakar (1992).

The seedling length was found to differ significantly among the rice genotypes. The reduction in seedling length was less in the seeds of genotypes V20B (27.0-25.1cm), Pragathi B (25.3-23.8cm), Pushpa B (25.5-23/2cm), Mangala B (24.0-22.2) and Madhu B (23.4-22.4cm) as compared to IR54752 B, Improved sona B and Intanmutant B. The present findings are in agreement with that Deshpande et al. (1991), Kurdikeri (1991) and Ramegowda (1992). Another aspect of closely related to seed deterioration is vigour. Abdul-Baki and Anderson (1973) assessed vigour by multiplying germination per cent and seedling length, which they termed as vigour index. Assessment of vigour index is also relevant since germination alone may be an incomplete assessment, since the seedling length is a measure of synthesis, mobilization and quality. The vigour index generally decreased significantly in all the tested genotypes with the increase in storage period (2263 - 1806) but interestingly, the extent of reduction varied with the genotype. Eventhough V 20 B (2126) and Pragathi B (1986) maintained higher vigour index at the end of storage period, their rate of deterioration was fast as compared to Madhu and Managala. The above two genotypes due to their high initial vigour could maintain better vigour against the rest of the genotypes under storage study. Storability of any genotype depends on their initial seed quality (Gomez et al. 1986) and prestorage history (Delouche,

1990). The genotypes IR 54752 B, Intan mutant B and Improved sona B recorded the minimum vigour index as their initial vigour was low and rate of deterioration was fast due to susceptibility to storage fungi and insects.

In the present study the genotypes maintaining better seedling vigour also recorded higher field emergence. The seeds of genotypes V 20 B, Pragathi B, Mangala B and Madhu B performed better by exhibiting higher field emergence. It clearly indicates the extent of deterioration and susceptibility of genotypes to infestation and infection. Several storage experiments on rice seeds with different cultivars and under different storage conditions also revealed that the reduction in germination and seedling vigour was certain. However the rate and extent of reduction varied with the cultivar, storage conditions and other factors like seed moisture and the status of the seed at the time of storage (Dharamlingam, 1978; Agrawal, 1979; Ghose et al., 1981 Tomar and Singh, 1986). They also observed that the decline in germination was coupled with increased number of abnormal seedlings and are not capable of surviving to maturity. Further the surviving seedlings may show poorly developed roots and /or shoots with necrotic root meristems.

The loss of viability and vigour during storage is attributed to hygroscopic nature of the seeds. During ambient storage conditions, seed moisture content fluctuates with concomitant changes in atmospheric relative humidity and temperature (Loole, 1950 and Saibabu et al., 1983). In the

present study also significant fluctuations in seed moisture content (9.75-11.91%) were noticed in all the months of storage. This variation in seed moisture depends on hygroscopic nature of particular genotype, temperature and relative humidity of storage. The genotypes which have maintained better viability and vigour did not show much fluctuation in seed moisture content as compared to IR 54752B, Improved Sona B and Intan mutant B, which have recorded significantly high seed moisture content, similar fluctuations in seed moisture content and loss in viability and vigour due to varied relative humidity and temperature under ambient or artificial storage conditions have been reported by Jalote and Vaish (1976), Nagarajan and Karivaratharaju (1976), Khanna and Yadav (1979), Tomar and Singh (1986) and Kurdikeri (1991).

As deterioration progresses during storage, cellular membranes lose their selective permeability, permitting the cytoplasmic metabolites leach into the intercellular spaces. Membrane degradation occurs due to both hydrolysis of phospholipids by phospholipase and phospholipid autooxidation; therefore, in the strict sense, it might be considered as a result of ageing rather than a cause (Copeland, 1988). Berjak and Villiers (1972) opined the membrane damage in general, as the symptom of mitochondrial damage first to appear and therefore, it may be considered as most critical one to play a major role in seed deterioration. It is widely accepted that loss of membrane permeability is one of the

causes for loss in viability presumably, a loss in membrane permeability under unfavourable conditions of storage leading to increased leaching out of seed constituents and thus loss in viability (Ching and Schoolcraft 1968 and Sen, 1977). The leachate exudates as measured by electrical conductivity (Bradnok and Mathews, 1970) was shown to be associated with the loss of vigour and viability. Increased leachate was related to low metabolic activity of seed (Abdul-Baki and Anderson, 1972). In the present investigation, irrespective of genotypes, there was a general increase in EC from 153.8 to 217.1 μ mhos/cm at the end of storage. The genotype V 20B (146.0-202.7 μ mhos/cm), although recorded lower EC, it has leached more than pragathi (165.0 to 208. μ mhos/cm). The other genotypes which have leaked out lower quantity of exudates were Madhu B (152.0 - 209.2 μ mhos/cm), Mangala B (147.0-212 μ mhos/cm) and Pushpa B (148.0-213.5 μ mhos/cm). EC values are inversely proportional to quality. Thus, the seed viability and vigour of the above genotypes were superior throughout the storage period, hence, the statement holds true. The genotypes IR 54752 B, Improved sona B and Intan mutant B have recorded higher EC values which has clearly reflected in poor viability and vigour during storage. The above results are in agreement with the findings of Abdul-Baki and Anderson (1972) and Ghose et al. (1981).

5.2.2 Effect of provenance on seed quality during storage

It has been stated that the advantages of producing seed in areas especially suited to seed production are increased yield and quality, since the weather conditions such as temperature, relative humidity, photoperiod, wind velocity, soil type may vary from location to location resulting in differential seed quality. Therefore, the selection of the best provenance for seed production becomes an integral part of production programmes. The present investigation aims to find out the effect of production location on storability of eight rice genotypes.

All the seeds produced at Mandya followed by Bangalore maintained significantly very high germination, seedling length, vigour index and lower electrical conductivity. These quality parameters induced vigorous field emergence throughout the storage period. The superiority of these two locations for producing quality seeds of was attributed to highly favourable climatic conditions during crop growth, seed development and maturation. High viability, vigour, storability of seeds produced here were due to their better seed characters like test weight, seed volume and density. Such differences in seed characters due to different environments were also noticed by Austin (1972), Kant et al.(1983). Superiority of production location for quality seeds of various crops have been also reported by Hurreis (1977), Kristan and Skala (1980), Banumurthy and Gupta

(1981), Maeda and Sawazaki (1982), Kant et al. (1983), Vanagmudi and Karivaratharaju (1985), Kovav (1988) and Thiagarajan (1990).

The seeds produced at Shimoga and Mudigere were of low quality and hence, could not maintain vigour and viability and leached more exudates, especially at the later period of storage. Loss of vigour and viability from the above locations was not only attributed to adverse climatic factors during seed development and maturation but also to more hygroscopic nature of these seeds which have carried storage pests and pathogens during storage. The present findings are also in agreement with the findings of Prakash and Kuraw (1983) and Subhakar (1992). Loss of vigour and viability and membrane degradation during seed ageing were attributed to increased leachate which was related to low metabolic activity of seed (Abdul-Baki and Anderson, 1972) decreased activity of alpha amylase, dehydrogenase and polyphenol oxidase enzymes and ATPase (Paul et al., 1970), increased activity of lipase and oxidase enzyme (Dhaliwal et al., 1991), free radical damage (Pammenter et al., 1974) and chromosome aberrations (Rao et al., 1987).

5.2.3 Effect of seed treatment on seed quality during storage

Rice is subjected to the depredation of various fungal pathogens (Neergard, 1977; Sharma et al., 1990) and storage pests (Sukprakarn, 1985; Uttam et al., 1985; Sauphanor,

1988). The loss of viability, vigour and weight have been reported by Prakash and Kuraw (1983), Girish et al. (1975), Pawar et al. (1985), and Sharma et al. (1990). Importance of seed treatment against pathogens has also been well documented by Asokan et al. (1980), Anahosur and Hegde (1980), Sathyanarayan Rao and Ranganathaiah (1988).

Irrespective of genotypes and location, there was a gradual drop in germination even in treated seeds and, also a sharp decline in untreated seeds during the storage period. Thiram treated seeds maintained very good germinability (94.3 - 85.8 %) retaining the seed certification standards (80.%)

even after 19 months of storage as against untreated seeds (94.0 - 78.2%). Treated seeds significantly differed from the control throughout storage period. The gap between these two in maintaining viability was narrow initially and widened later (Deshpande, 1988). This shows the superiority of seed dressing fungicide-Thiram, in protecting the seeds from hazards of storage fungi and maintaining the viability against seed deterioration. Such decline in viability due to storage fungi was also reported by Neelakanta (1982) and harmful effects of storage pests were also noted by Uttam et al. (1985), Nigam et al. (1987), Subhakar (1992). The beneficial effect of fungicide treatment was also observed by Sivaprakasam et al. (1976) in Sorghum, Vyas and Neme (1975) and Asokan et al. (1980).

Reduction in seedling length, another face of seed deterioration was more pronounced in untreated seed lot than in treated seeds throughout the storage period. Treated seeds maintained its seedling vigour by producing lengthier seedlings in all the months of storage than untreated seeds. This was in confirmity with the findings of Pawar et al. (1985) and Gora et al. (1987). Seedling vigour index of treated seeds (2257-1938) was significantly higher than untreated ones (2244-1675) in all the months of storage and even at the end. This could be attributed to lengthy seedlings and increased germination in treated seeds.

Treated seeds recorded significantly low moisture content (9.68 - 11.51%) than the untreated lot (9.82-12.31%) throughout the storage period. Higher moisture content of untreated seeds may be the result of interactions between hygroscopic nature of seed and fungal activity, which inturn lead to development of heat and moisture.

Higher viability and vigour of treated seeds reflected in higher field emergence (89.2 -77.1%) than untreated (88.8-72.5%) seeds. Similar findings have been reported by Kulik (1977) and Deshpande (1988), Electrical conductivity of seed leachate of treated seeds was lower (155.2-199.8 u mhos/cm) than untreated seeds (157.2-234.4 u mhos/cm) during 19 months of storage period. Increase leakage of exudates during seed deterioration might be due to reduced metabolic activity of

untreated seeds (Agrawal, 1979) which was preceded by low enzymic activity (Kalpana Sur and Basu, 1986) decreased ATP production (Nagashima and Ota, 1986), accumulation of free radicals (Tappel, 1973) and toxic substances like coumarin and ferulic acid and lead to loss of germinability and vigour (Agrawal and Kharlukhi, 1985).

Interaction effects

The interaction effects between genotypes and location were significant throughout the storage period. All the genotypes produced at Mandya and Bangalore could maintain viability and vigour more than certification standards compared to Shimoga and Mudigere, suggesting the superiority of Mandya and Bangalore over other locations. Further seeds of these two locations also registered greater seedling length, lower seed moisture, lower electrical conductivity and high field emergence in all the months of storage. The genotypes V 20, Madhu, Pushpa, Mangala and Pragathi produced at Shimoga also maintained germination more than 80 per cent, but seeds of all the genotypes produced at Mudigere failed to prolong the viability beyond 15 months of storage, suggesting non-suitability of this environment for seed production. The genotypes Improved sona, IR 54752B and Intan mutant lost their viability (80.0 %) before 17 months. This loss in viability resulted from increased leachate, sharp reduction in seedling length concomitant fluctuation in seed moisture content and fungi activity.

Seeds produced in all the locations when treated with fungicide could maintain germinability and vigour better than untreated seeds. Among the treated seeds, the ones produced at Mandya and Bangalore were superior to other locations in retention of viability. The genotypes V 20, Madhu, Pragathi, Mangala and Pushpa when treated, could maintain higher vigour and viability indicating the importance of seed treatment and genetic potential to resist the deterioration. Increased leachate, sharp reduction in seedling length, concomitant fluctuation in seed moisture content of untreated seeds resulted in loss of vigour and viability during storage. This could be ascribed to harmful effects of insect and fungal activity on untreated seeds during storage.

5.3 Hybrid Seed Production Through Main and Ratoon Crops

5.3.1 Hybrid seed production through main crop

Rice being a strictly self pollinated crop, natural outcrossing rate is very poor. Nevertheless, outcrossing in this crop is influenced by agromorphological characters of parent lines. Further it is also influenced by floral characters of both the parents like angle of glume opening (Shankaramurthy, 1991) duration of glume opening (Parmar et al., 1979), anther size, anther exertion and pollen shedding (HRT, 1981), stigma size and exertion (Virmani et al., 1980b), Flowering time and stigma receptivity (Virmani and Tan, 1982). Even planting direction and ratio (Shanbhogue

and Mahadevappa, 1991) influence the seed setting and seed yield. Further, these traits are controlled by weather and seasonal variations (Mallaiah, 1985).

In the present study, the rice parental lines of some hybrid combinations showed significant difference for plant height. Similar genotypic differences were also reported by Ramachandra (1989). Greater plant height of restorers (male) noticed in this study is advantage in hybrid seed production as it facilitates better pollen dispersal.

Present results of taller male parents causing for high seed set also supported by Rutger and Carnhan (1981). They opined that the tall paternal plant type is desirable for wind blown pollen dispersal on semidwarf female parents. According to Virmani and Edwards (1983) Chinese researchers also use the restorer lines that are 10-20 cm taller than CMS lines.

Due to better synchronization of flowering between female and male parents of IR 54752 A/ ARC 11353R comparatively higher seed (10.43%) set was observed on female which lead to higher number of filled spikelets. Higher seed set was also attributed to better panicle exertion of female parent (Virmani et al., 1980a). Cumulative effect of all these yield attributes resulted in better F₁ hybrid yield of IR 54752A/ARC 11353R (4.90 g/plant and 1.49 t/ha). The

hybrid H2 (IR 54752A/IR 54R) took second place with regards to seed yield.

Further in hybrid seed production of IR 54752A/IR 46R, male took four more days to flower as compared to female. So this improper synchrony resulted in lower seed set on female and lower seed yield.

Between the two CMS lines selected for study, IR 54752A recorded higher seed set which is due to its better floral characters and agronomic traits (Ramachandra, 1989). Higher F_1 seed yield in H1 is also attributed to better agronomic performance of the restorer line ARC 11353R which is taller, besides, having good floral characters with high pollen load.

Intan mutant A in combination with either IR 27315R or IR 15324R failed to record better performance due to poor synchrony between parents (Ramachandra, 1989). Such differences in performance among the various female parents with restorers were also noticed by Djeacoumar (1988). Dharmarajan (1990) and Shanbhogue and Mahadevappa (1991).

5.3.2 Hybrid seed production through ratooning of parents

Poor seed set on female parent is a major constraint in commercialising rice hybrids. Despite adopting supplementary pollination techniques, the extent of seed set on outcrossing on sterile lines did not reach desired level. Considering the existence of exploitable level of heterosis in rice and

the inherent problems associated with seed production, research has been initiated to study the feasibility of vegetative propagation to aid in economising seed production. It is revealed that besides cost factor and saving on fresh seed requirement, the other advantages of vegetative propagation are : i) reduction in total duration, and ii) minimization of cost of production. Further, by effective roguing in the main crop season, the problem of rogues and pollen shedders in hybrid seed production can be totally eliminated in ratoon production.

To find out the possibility of hybrid seed production through ratooning of parents, all the two females and restorers from main crop were cut (harvested) depending on differences in days to 50 per cent flowering, to achieve synchrony between parents in ratoon crops. In the present study ratoon growth of all the parents was lower than that of main crop. Stunted growth and low productive tiller number in ratoon crop were conspicuous (Shanbhogue, 1988). Further it was also reported that despite inherent ratoonability, the growth, yield and maturity of ratoon crop depends on growth duration of respective main crop (Plucknett *et al.*, 1978 and Mahadevappa, 1979), cutting height (Bahar and Dedatta, 1977), state of maturity at which main crop was cut (Haque, 1975), nodes from which ratoon tiller originated, C:N ratio in the stubble (Iso, 1954).

In the present study, it was possible to achieve synchrony in all the five hybrids in ratoon crop. However the ratoon seed yields varied among the parents. But in case of instant mutant A/IR 27315R (0.42t/ha) and instant mutant A/IR 15324R (0.41 t/ha), the F_1 ratoon yields realised were more than the respective main crop. This variation could be attributed to perfect synchrony of flowering in ratoon crop, despite impaired Panicle exertion in the parents (Shanbhogue, 1988).

Restorers also varied for their growth and yield performance. Similar varietal differences for yield was also noticed by Palchamy and Soundrapandian (1988) and Arumugachamy et al. (1991). Similar attempts to produce hybrids or multiplication of parents were also made by Chauhan (1988) and Shanbhogue (1988) and Mahadevappa et al. (1989).

5.3.2 Quality of seeds harvested from main and ratoon crops

With the understanding of importance of quality seed, the demand for quality seed is increasing enormously in all the crops. Recently, rice ratoon cropping has been successfully utilized in the hilly regions of Karnataka. Here the ratoon crop comes to harvest in summer season which is desirable for quality seed production. Also with the advent of hybrids in rice, there is considerable scope to utilize ratoons for parental and F_1 seed production. Whether or not

ratooning ability can be utilized for the maintenance of parents and multiplication of seed is determined by the quality of the seed it produces. Very meagre research has been carried out on the aspect of evaluating the seed quality of ratoon rice and comparing it with its main crop seeds. Hence, research on this potentially important subject was taken up. The very low cost of cultivation of the ratoon crop coupled with saving in the time required for production has lead to the use of ratoon crop seeds in research fields, though not on commercial scale as yet.

With this background, the results of the laboratory studies conducted to evaluate the seed quality of both the main and ratoon crops of F_1 hybrid seeds of five experimental hybrids are discussed hereunder.

Test weight of all the F_1 hybrids from main crop was more than the respective ratoon crop. Such reports are also stated by Rao and Damodaran (1972) in Sorghum and Webb et al. (1975) in rice which revealed that the seeds of ratoon crop were less uniform, smaller and lighter than the seeds of main crop. However, the reason for the contrasting variation in the test weight seems to be the differential varital response to ratooning. Other reasons which may be either physiological or biochemical are yet to be investigated.

Significantly higher mean 1000-seed volume was recorded from the main crop seeds (22.10 cc) than their respective ratoon crop (21.79cc). All the hybrids differed in their seed volume. Again the genotypic differences coupled with the dependance of seed volume on its test weight are attributed to these differences. Vasudev (1989) also observed high test weight of main crop seeds against respective ratoon seeds. He further reported that these variations might have caused for observed differences in seed volume. Hybrid seeds produced from main and ratoon crop varied significantly within and between the methods of propagation along with interactions for seed density. Except Intan mutant A/IR 15324R, all the hybrid seeds produced from main crop recorded higher density than their ratoon seeds. Since the seed density is a derivative of both the test weight and volume, the observed variations in seed density are attributed to the variations in these parameters (Vasudev, 1989).

Further the results of standard germination test and speed of germination indicated not only the differences among the hybrids but also the superiority of main crop seeds. This could be ascribed to variation in seed weight and density and are in accordance with the findings of Tseng and Lin (1962) who noticed delayed germination of rice from light seeds. Vasudev (1989) also observed poor performance of ratoon seeds and reported that the variations were due to

high protein content of ratoon seeds, which is negatively correlated with viability (Khairwal and Tomer, 1981). However, The physiological and biochemical means for such losses in the viability of the ratoon crop seeds are to be probed into.

In general, the seeds produced from seedling planted maincrop recorded significantly longer roots (15.2 cm) and shoots (11.6 cm). With regard to root length, the hybrids IR 54752A/ARC 11353R (16.2 cm) followed by IR 54752A/IR 46K (14.2 cm) produced longer roots and Intan mutant A/IR 15324R (13.2 cm) shorter roots, irrespective of the method of propagation. The hybrid IR 54752A/ARC 11353R and IR 54752A/IR 54R also showed longer shoot length. Present findings are also inconformity with those of Vasudev (1989) who observed differences in root and shoot length among the genotypes.

Seeds of the main crop registered significantly longer root-shoots as compared to ratoon seeds. Findings of Vasudev (1989) strongly support the present results with respect to superiority of main crop seeds. Amaral and Dos (1979), Cicero et al. (1978) and Vasudev (1989) also observed very high root-shoot lengths from heavier rice seeds.

Significantly high vigour indices were observed in the main crop seeds than in respective ratoon crop seeds. The differences observed in germination per cent and root

shoot lengths have caused highly significant variations between the main and ratoon crop seeds in all the hybrids. This result is strongly supported by Nagaraj (1984), who noticed higher vigour index in the main crop seeds as compared to the ratoon crop seeds.

Seedling dry weight of main crop seeds also followed the same trend as that of vigour index (Nagaraj, 1984). A significant positive association was recorded between test weight and seedling dry weight (Takeda, 1972). Higher vigour indices of main crop seeds were also reflected in higher field emergence. Superiority of main crop seeds for better field emergence was also observed by Vasudev (1989).

Seeds harvested from seedling planted main crop exhibited lower EC values than ratoon seeds. The hybrid seeds also varied between them for EC values in both the main and ratoon crops. These results revealed the superiority of membrane integrity of main crop seeds and varietal differences for membrane permeability. These results are in agreement with the work of Vasudev (1989). However, why such differences exist among the varieties between main and ratoon crop seeds are still to be understood through biochemical and physiological investigations.

5.4 Vegetative Propagation through Tiller and Stubble Planting

5.4.1 Evaluation of some male sterile lines, maintainer, restorer lines, hybrids and varieties for vegetative propagation through tiller separation

The results obtained from the experiment involving promising male sterile lines and respective maintainers, restorers, F₁ hybrids and varieties planted as seedling¹ planted main crop and vegetatively propagated tiller crop are discussed herein.

The rice plant undergoes two distinct phases of growth and development before it completes its life cycle. The first is the vegetative phase and the second is the reproductive phase. Normally, a tiller bud is borne in the axil of each leaf which may or may not develop into a full tiller presumably depending on the environmental conditions prevailing at the time of its formation. Profused tillering during the early phase of vegetative growth with perennating habit offers a great scope for tiller separation and planting them to exploit the vigour. Richharia (1960) and Richharia et al. (1964) have indicated the scope for extending this technique under normal cultural and environmental conditions. They also suggested that vegetative propagation would probably acts as a trigger mechanism in activating the dormant buds thereby increasing the scope of vegetative multiplication of individual tillers.

Recovery of number of tillers (Planting material) varied significantly among sterile lines, maintainers, restorers, hybrids and varieties. Hybrids and varieties produced more number of fresh tillers than other parental lines which may be attributed to genotypic effect. Among the male sterile lines, Pragathi A, IR 54752A and ES 18A; among maintainer lines, Madhu B, Pragathi B and Pushpa B recorded more number of tillers. IR 46R, IR 54R and IR 15324R among the restorers; IR 54752A/ARC 11353R, IR 54752A/IR 27315 R and IR 54752A/IR 46R among the hybrids and Jaya among the varieties recorded more tillers as planting material. Such genotypic variation for recovery of tillers was also observed by Richharia et al. (1964), Sateesha Babu (1986) and Sharma et al. (1987).

In general maintainer lines exhibited lower percentage of field establishment as compared to male sterile lines. Restorers, hybrids and varieties established better than sterile lines. There was considerable genotypic variation among different parent lines, hybrids and varieties for field establishment.

With regard to growth, plant height differed significantly among the genotypes under study. Plant height did not differ significantly due to method of propagation except in case of hybrids and varieties. The present results are in conformity with Richharia et al. (1964) who observed increase in plant height of some vegetatively propagated

genotypes. Contrary to this they also observed indifferent response of some genotypes to this technique of propagation. Genotypic variation in respect of plant height is also reported by Sateesha Babu (1984), and Sharma et al. (1987).

Number of productive tillers differed significantly among the genotypes studied. Similar genotypic variation for productive tillers was also noticed by Richharia et al. (1964). Productive tillers did not differ significantly due to method of propagation except in case of hybrids and varieties. Present results are partially in accordance with Richharia et al. (1964) who observed comparatively low number of effective tillers in vegetatively propagated tiller crop. Interaction effect revealed that some of the genotypes did not respond positively towards vegetative propagation for this character (Sateesha Babu, 1986; Sharma et al. 1987).

There were a considerable genotypic differences for panicle length. Except hybrids and varieties, parental lines (A, B and R) did not differ significantly for mean panicle length due to method of propagation. Vegetatively propagated hybrids and varieties recorded significantly more panicle length than seedling planted crop. Similar results were also explained by Richharia et al. (1964). Interaction between genotype and method of propagation revealed that only some of the genotypes could respond to tiller separation and planting (Richharia et al., 1964). This could be ascribed to both genetic and environmental interaction.

Restorers, hybrids and varieties recorded more number of spikelets and filled spikelets as compared to other parental lines (Vidyachandra, Pers Com.). All the genotypes also varied significantly among themselves for total and filled spikelets. Mean number of spikelets and filled spikelets in vegetatively propagated tiller crop did not differ significantly as compared to seedling planted main crop. Some of the vegetatively propagated genotypes (IR 54752B and Intan mutant B; IR 46, ARC 11353R and IR 15324R; Intan mutant A / ARC 11353R, IR 54752A / ARC 11353R; Jaya and CTH 1) recorded more number of filled spikelets as that of their respective main crop. Similar differential response for this technique of tiller separation in many genotypes was also noticed by Richharia et al. (1964).

Significant yield differences noticed among the parental lines, hybrids and varieties may be attributed to genotypic differences. Yield did not differ significantly due to method of propagation except in case of maintainer lines. Besides significant differences, marginal increase in test weight observed in some of the vegetatively propagated tiller crop might have contributed towards marginal increase in yields of the same genotypes. The present findings with respect to test weight and yield are in accordance with Richharia et al. (1964) and Padmaja Rao (1990).

5.4.2 Field performance of tiller crop as influenced by age of tiller

To understand the potentiality of some of the genotypes for tiller propagation it is important to know about recovery of number of tillers by a single mother plant. This is more relevant when there is scarcity of parental material during seed production as well as planting hybrids for commercial cultivation.

Experimental results have revealed that delay in tiller separation can yield more number of tillers for further planting. Tiller separation at 50 days after sowing resulted in low recovery (9.9) of fresh tillers as compared to tiller separation at 70 days after sowing which recorded 15.5 tillers per mother plant.

Varieties also differed in their capacity to produce tillers. In the present study, the recovery of tillers was also influenced by duration of mother crop. Short duration varieties like ES 18 (11.26) and V 20 (10.5) produced comparatively less number of tillers. Similar variation in tiller number was also reported by Ramachandra (1989). Tillers separated from mother plant at early stage (T1) put up better growth like fresh seedling planted crop, while tillers separated at later stages (T2) exhibited stunted growth with low number of tillers.

Luxuriant growth of vegetatively propagated (T1) tiller crop recorded better yield components like more number of productive tillers, more panicle length, filled

spikelets per plant (Richharia, 1961), higher 1000-grain weight (Padmaja Rao, 1990) which resulted in higher yield (7.48/ha) as compared to seedling planted crop (6.83 t/ha). This may be attributed to better photosynthetic efficiency and propagated crop (T1), as also reported by Richharia et al. (1964). Jagannathan and Banerjee (1982) also observed the potentiality of tiller planted crop for high tillering within a very short period.

Poor performance of tillers separated at later stages (T2) could be ascribed to its stunted growth and low number of productive tillers. They could not establish properly behaving like aged seedlings with uneven flowering and maturity. Further, the planting material consisted of primary, secondary and tertiary tillers that adding to variation in flowering. It is well documented that performance of primary and secondary tillers was similar while compared to tertiary tillers (Sateesha Babu, 1986). Among the eight entries under study the hybrid IR 54752A/ARC 11353 performed better (7.68 t/ha) followed in order by ARC 11353 a restorer line (7.12 t/ha), Madhu WA /IR 15324 (7.05 t/ha). Similar varietal variation with respect to field performance in vegetatively propagated crop was also noted by Richharia et al. (1964) and Sateesha Babu (1986). Interaction effects showed that tiller separation at 50 days after sowing exhibited better field performance as that of seedling planted crop.

With regard to maturity, tiller planted crop attained maturity as early as seedling planted crop in all genotypes. Similar finding was reported by Richharia et al. (1964). The superiority of vegetative propagation through tiller crop was also reported by Jagannathan and Banerjee (1982), Sateesha Babu (1986), Padmaja Rao (1990) and NSC (1990). Only one contradictory report is by Sharma et al. (1987).

5.4.3 Quality of seeds from different tiller types

Seed to seed variation in germination and vigour are often encountered during quality evaluation. Among the various factors responsible for heterogeneity of a seed sample, its position on plant (Ovcharov et al., 1978), type of tiller (Selvaraj and Subramanian, 1989) and rachis within the panicle of rice crop (Krishnasamy and Kempuchetty, 1989) play an important role. The results obtained from evaluation of seed quality of seeds obtained from various tiller types have been discussed herein.

Test weight differed significantly among the genotypes. ARC 11353 recorded the higher seed weight than IR 46. Test weight also varied significantly among different tiller types (T1 to T10), early formed first 10 tillers registering the maximum test weight. Linear decline in test weight was noticed for the seeds developed on subsequent tillers. Superiority of seeds obtained from early formed primary and secondary tillers was also reported by Sateesha Babu (1986), Padmaja Rao (1988) and selvaraj and Subramanian (1989) for test weight.

Seeds obtained from early flowered first four tillers (T1-T4) registered higher germinability and vigour index. these results are in agreement with those of Petrov et al. (1981), Sateesha Babu (1984), Merwade et al. (1989) and Selvaraj and Subramanian (1989) who noticed increased germinability and vigour of seeds developed from either primary or secondary tillers over subsidiary tillers.

Even as per ageing test, the seeds developed on the first 4 tillers registered higher germinability and vigour and differed significantly from the seeds produced on subsequently flowered tillers (T5 to T10). This is suggestive of good storability of early formed seeds on primary or secondary tillers. Present results are in agreement with those of Selvaraj and Subramanian (1989). Seed vigour and storability are also influenced by seed position on rachis within the panicle in rice (Krishnasamy and Kempuchetty, 1989).

5.4.4 Seed production through stubble cropped parents and field performance of stubble planted hybrids

One way of minimising the cost of hybrid seed production is substitution of vegetative propagation for seed wherever possible. This would reduce dependence on seed cum time. One other advantage in vegetative propagation is that only confirmed 'true to type' plants can be allowed to grow, there by eliminating the rogues. The use of vegetative propagation either in seed production or for commercial

production of rice is primarily influenced by the genotype. Only genotypes with ability for regeneration and resistance to virus diseases and ability for production of uniform tillers can be used for adopting this practice. Of the different vegetative propagation methods, stubble planting appears to be relatively more promising, because the yields recorded by stubble plant crops are close to the main crop yields (9-11 t/ha) and always above ratoon crop yields (Mahadevappa et al., 1989). The results obtained on stubble planting of A/B lines and evaluation of field performance of stubble planted hybrids and varieties are discussed hereunder.

5.4.4.1 Parental seed production through stubble planting

In this study all the four CMS lines recorded higher number of regenerating tillers per mother plant as compared to respective 'B' lines. This can be attributed to higher amount of carbohydrates left in the stubble and roots after main crop harvest. Because, the cytosterile lines have not utilized all its resources during reproductive stage of mother plant due to poor seed set on it, unlike in their counter parts (B). Such genotypic differences for regenerating tillers were also reported by Volkova and Smetanin (1971).

Field establishment of stubbles is mainly dependent on their survival capacity and genetic vigour (Yogeesha and Mahadevappa, 1987). Intan mutant A followed by V 20A and

IR 54752A showed better field establishment as compared to ES 18A. In general cytosterile lines showed better field establishment than their counterparts. These results are in agreement with those of Yogeesh and Mahadevappa (1987) who also observed similar trend in their study with multiplication of four CMS lines through stubbles.

As regard to growth, the cytosterile lines recorded lower plant height and more number of total tillers per plant than their counterparts (Sharma et al. 1987). These differences appear to be genetic hence, is advantageous in seed production. Higher plant height of 'B' lines helps in better pollen dispersal on 'A' lines during anthesis and is an advantage during supplementary pollination too (Rutger and Carnhan, 1981; Virmani and Edwards, 1983). Further, potentiality for high tillering within a very short period in vegetatively propagated rice was also noticed by Jagannathan and Banerjee (1982).

Seed yield per plant differed significantly among the cytosterile lines, as synchronization of flowering between parental lines plays a major role (Djeacoumar, 1988; Ramachandra, 1989; Dharmarajan, 1990; Shanbhogue and Mahadevappa, 1991) and better floral traits of A line (Virmani and Tan, 1982; Ramachandra, 1989; Shankaramurthy, 1991) and anther size, exsertion and pollen shedding of male parent (HR1, 1981). Comparatively higher yield of IR 54752A (5.8g) could be ascribed to favourable floral traits of both

the parents resulted in higher seed set (not given in table) inspite of comparatively low number of productive tillers. But yield per hectare of IR 54752A was slightly lower than Intan mutant A which was due to better field establishment of Intan parents and more number of productive tillers. Lower seed yield realised on ES 18A could be attributed to uneven flowering of parents (Mahadevappa et al., 1986) lack of synchrony (Ramachandra, 1989) resulting in low seed set on A line (Azzini and Rutger, 1982) and this was also coupled with poor field establishment of A/B parents (57.1 and 56.2 % respectively). Similar attempts to produce hybrid seeds in rice through stubble planting were also made by Patil (1983) Yogeasha and Mahadevappa (1987), Shanbhogue (1988) and UAS (1989) and results of all are in agreement.

5.4.4.2 Field performance of hybrids and varieties as stubble crop

As presented under results stubble planted crops of some hybrids and varieties were evaluated for their field performance. The main objective of this experiment was to reduce the pressure on the requirement of fresh hybrid and save on the cost of F_1 hybrid seeds wherever possible (Mahadevappa et al., 1989). The stubbles of the main crop form sources for planting material for planting the next crop of rice if the genotypes or hybrids have the genetic potential to respond to this practice (NSC, 1990).

In the present study, the number of regenerating tillers obtained per mother plant ranged from 8.3 to 15.0 in F_1 hybrids and 9.7 to 11.5 in varieties. Madhu WA/ IR 46R recorded the highest regrowth (15.0) followed by IR 54752A/ARC 11353R (11.2). The genotypic differences and superiority of F_1 hybrids over varieties regenerating more number of tillers after ratooning was also reported by Mahadevappa et al. (1989). They recorded a multiplication ratio of 1:15 in some promising hybrids.

Genotypic variation in field establishment among the hybrids and varieties has been reported by Yogeesh and Mahadevappa (1987). In the present study, Madhu WA/IR 46R and IR 54752A/ARC 11353R recorded the maximum field establishment among the hybrids, while ARC 11353 (84.8%) and IR 20 (83.8%) showed the highest establishment among the varieties. Poor establishment of V 20A/IR 36R and Rasi were also noted. These differences were mainly attributed to genetic potential. It may be mentioned here that Das and Ahmed (1989) observed similar performance of rice seedling with 50 per cent damaged and undamaged roots. Hence, root damage may not be a reason for poor performance.

Hybrids put up better growth in terms of plant height, total tillers and yield as compared to varieties (Mahadevappa et al., 1989). In general stubble crop of F_1 hybrids recorded higher yield against varieties. This could be

ascribed to better field establishment, crop growth and more number of productive tillers per plant in hybrids. However, the grain yield was low as compared to main crop grain yield, which may be due to shorter panicles (Richharia, 1961) and uneven maturity (Mahadevappa et al. 1989). The panicles that matured early were damaged by birds and were subjected to shattering loss causing for significant yield reduction. Among the hybrids stubble crop of IR 54752A/ARC 11353R registered the highest grain yield (6.28 t/ha) followed by Madhu WA/ IR 46 R (4.94 t/ha), while ARC 11353R (3.85 t/ha) among varieties, indicated the genetic potential and hybrid vigour for further commercial exploitation of these lines for vegetative propagation. Similar results were also reported by NSC (1990) in the study of propagation of three experimental hybrids through stubble planting. Mahadevappa et al. (1989) and Radhakrishna (1992) also got encouraging results in vegetative propagation of hybrid rice through stubble planting.

5.4.4.3 Performance of stubble crop as influenced by harvesting time of main crop

In the present study, 3 varieties viz., ARC 11353R (good ratooner), Pushpa (poor ratooner) and IR 54752 A/ARC 11353 R (hybrid) were harvested at their physiological maturity, one week after physiological maturity, two weeks after physiological maturity and allowed to regenerate. The regenerated tillers were planted and evaluated for field

performance. The results pertaining to this experiment are discussed hereunder.

Stage of main crop harvest affects ratoonability (Haque, 1975). Among the three harvesting stages in the present study, cutting the crop at physiological maturity proved to be the best to get higher percentage of ratoonability (84.1%). Delayed harvesting registered least number of regenerated hills per plot (72.8%). This clearly indicated the importance of time of cutting the mother crop for further vegetative propagation. The present findings are in agreement with those of Parago (1963) and Grist (1965) who suggested to harvest the main crop when they are still green to get good ratoon. If harvesting is delayed, the culms of the growing ratoon tillers were damaged because they elongated within the old leaf sheaths (Szokolay, 1956). However, regenerated tillers per unit area did not vary significantly due to different cutting time (Reddy *et al.*, 1979).

Height of the stubble crop was not affected by harvesting time. But, the stubble crop obtained by cutting main crop at physiological maturity recorded significantly higher number of productive tillers, panicle length, 1000-grain weight and grain yield than late cuttings. Harvesting two weeks after maturity caused reduction in all parameter except in plant height. Rice ratooning depends on

the ability of dormant buds on the stubble of first crop that remain viable (Nair and Sahadevan, 1961). Thus, it is important to harvest at physiological maturity. Harvesting the crop at its senescence may result in poor ratoonability resulting in reduction of C:N ratio in their stubbles. The decline in growth and yield performance of crop harvested 10 to 20 days later than its maturity has also been reported by Ichii and Kuwada (1981).

Stubble planted varieties differed significantly in their growth and yield, IR 54752A/ARC 11353R performing the best, but Pushpa was inferior to all others. The hybrid and ARC 11353 R have comparable genetic potential for ratoonability, while Pushpa proving itself as a poor ratooner. The hybrid IR 54752A/ARC 11353R recorded higher number of productive tillers, longer panicles, more number of filled spikelets and higher grain yield per plant. Thus better field establishment coupled with yield attributing characters have resulted in higher grain yield. Crop of ARC 11353R also performed well comparatively. It is clear that ARC 11353 can be commercially exploited for vegetative propagation. Superiority of the hybrid IR 54752A/ARC 11353R and the variety ARC 11353 and inferiority of Pushpa as a stubble crop could be ascribed to their genetic potential and hybrid vigour. Plucknett et al. (1978) also stated that ratoonability is a inherent genetic factor affecting its

performance, further it depends on thickness of culms (Cuevas-Perez, 1980). Thick culms may store more carbohydrates than thin culms (Pushpa), and probably would be reflected in ratoon potential and yield. Similar varietal differences with respect to ratoonability and performance have been reported by Volkova and Smetanin (1971). Superiority of hybrid over pure lines as stubble crop has also been reported by Mahadevappa et al. (1989) and Radhakriahna (1992).

Interaction effects between harvesting time of main crop and variety revealed that the stubble crop obtained from harvesting the main crop at physiological maturity put up luxurious growth and recorded more yield especially in H1V3 and H1V1. This was followed by harvesting the crop one week late. Stubble crop from much delayed main crop harvest exhibited poor growth and yield. Thus the investigation has clearly indicated adverse effects of delayed harvesting of main crop.

5.4.4.4 Field performance of stubble crop as influenced by root dipping in chemicals

Poor field establishment of vegetatively propagated stubble crop needs greater attention. It depends both on genotype and agronomic practices. Root dipping in insecticides and nutrients helps the stubbles for quick and better establishment preventing early infection. An effort was made in this investigation to improve the field

performance of stubble crop of hybrid IR 54752 A / IR 46 by root dipping.

As brought out under results root dipping in Rogar + DAP showed improvement in field establishment (94.2%). Better vegetative growth in this treatment resulted in increased principal yield components viz., productive tillers and filled spikelet percentage ultimately causing enhancement in grain yield (7.50 t/ha), i.e., accounting for 1.75 t more grain yield than the control. This is attributed to the beneficial effect of Rogar + DAP. Rogar might have helped in early establishment of stubble by protecting the root zone and warding off hazards in rhizosphere. The present results confirm the findings of Balasubramaniam and Palanisamy (1983) who got better performance with carbofuran (0.2%) as a root dip chemical against root nematodes in wet land rice and Prabhakarrao *et al.* (1988) who observed the beneficial effects of Diammonium phosphate nutrient. It may be mentioned here that the above authors reported higher uptake of nitrogen, phosphorus and potash with this treatment.

Root dipping in Emissan + Rogar and Emissan + Rogar + DAP were next effective treatments. It was observed that the chemical combination was better than using the any one of them singly (T1 to T3). Similar findings with other nutrients have been reported by Zia *et al.* (1987).

5.5 Effect of Planting Ratio, Synchronization of Flowering and Foliar Spray of Chemicals on Seed Set, Seed Yield and Quality

5.5.1 Effect of planting ratio on seed set and yield

Among the eight planting ratios studied in the parental seed production of IR 62829A/B, seed set was high in 2:4, followed by 1:2, 2:6 and 1:3 than 1:4, 1:5 and 2:10. The increased seed set rate at narrow male to female ratio (Satato and Sukamandi, 1989) may be attributed to the abundant availability of pollen and relatively shorter distance the pollens have to travel thereby enhancing chances of fertilization and seed setting. Kumar and Sharma (1984) also observed lower seed setting with increased distance from CMS line. However, the results on IR 62829A are contrary to the findings of Carnahan et al. (1972) and Patil (1983) where they recorded higher seed set in 1:5 ratio. Azzini and Rutger (1982) obtained an average outcrossing percentage of 32.5 on 'Bir-Co' cytoplasmic male sterile line by planting them in alternate rows with pollinators. These results are also different from the findings of Sahai et al. (1987) where they found the best planting combination to be 1:6 ratio.

Like outcrossing rate, 'per plant seed yield' was also high in narrow planting ratios viz., 1:2 (5.6 g) followed by 2:4 (5.2g) and 2:6 (5.0 g) but it is important to note that yield per hectare did not follow the above trend. The

optimum planting ratio 2:6 recorded 1.57 t/ha followed by followed by 1:3 (1.50 t/ha) as compared to low yield of narrow ratio like 1:2 (1.37 t/ha) and wider ratio 1:5 (1.02 t/ha). The planting ratios 1:3 and 2:6 recorded higher seed yield which could be ascribed to optimum plant population of female along with moderately high seed set. In spite of their high seed set, the narrow ratios failed to register high seed yield because of less number of females per unit area. In wider ratios like 2:10 and 1:5, too low seed yield is due to poor seed set. This low seed set could be due to lack of pollen dispersal up to farther placed plants.

In the same season, in the seed production of IR 62829A/ IR9761-19-1 R, 2:6 recorded the highest seed yield (0.80 t/ha) followed by 1:3 (0.76 t/ha). These results are in agreement with the findings of Djeacoumar (1988), Ramachandra (1989) and Shanbhogue and Mahadevappa (1991) who have observed higher seed yield in 2:6 ratio. It is evident from both the parental and hybrid seed production revealed that the optimum planting ratio 2:6 or 1:3 .

5.5.2 Seed Yield as Influenced by Synchronization of Flowering of Parents

Importance of synchronization of flowering of parents in parental seed multiplication (A/B) and F_1 seed production (A/R) in rice needs no emphasis. It can be accomplished by staggered sowing of male parent where the differences in flowering between the two parents is more than

3 - 4 days. Since the standardization of synchrony is a basic need for further seed production technology, an attempt was made to determine optimum planting synchrony in seed multiplication of IR 62829A/B and F₁ seed production of IR 62829A/ IR 9761-19-1R.

The results revealed that optimum synchrony can be achieved by delayed sowing of 'B' line, 4 days after female sowing in IR 62829 A/B production. By this, we can synchronise 50 per cent flowering of both the parents. Male takes 99 days, while female takes 103 days to reach 50 per cent flowering. Earliness of maintainer in flowering as compared to their respective 'A' line was also observed by Meghachandra Singh (1986).

Besides, the perfect synchrony, there is also a need for continuous supply of pollens to obtain high seed set and yield (Liu et al., 1984). In the present study, treatment involving staggered sowing of 'B' line, i.e., 4 and 8 days after sowing of female recorded higher seed set (18.71%) and seed yield (1.49 t/ha) than the rest of the treatments. Due to better synchrony between parents in hybrid seed production, higher seed set and yield were also obtained by Virmani et al. (1980a), Azzini and Rutger (1982), Meghachandra Singh (1986) and Rangaswamy and Sreerangasamy (1988).

In the same season were made to achieve synchronization in hybrid seed production of IR 62829A/IR 9761-19-1R . The results revealed that male is earlier (96 days) to female (105 days) for days to 50 per cent flowering and hence, sowing of male, 9 days after female sowing resulted in better synchrony. Still higher seed yield (1.86 t/ha) was obtained by late sowing of male seeds, 9 and 13 days after female. Increase in yield was not only attributed to synchronization but also due to continuous supply of pollens by second set of sowing. Better outcrossing resulted in more number of filled spikelets and productive tillers per plant in this treatment.

5.5.3 Effect of foliar spray on seed set and yield

The growth regulator GA_3 , extensively used in hybrid rice seed production for better panicle exertion of CMS lines is a costly input. Hence, a search was made to findout suitable substitutes. The effectiveness of cheaper chemicals like urea, boric acid, potassium nitrate (KNO_3) in increasing outcrossing and yield in sorghum, pearl millet and rice have been well documented by the earlier researchers (Joshi, 1976; Sureshnath, 1981; Prasad et al., 1988).

In the present study the increased height of both the parents due to GA_3 was observed as compared to other chemicals and control. Similar reports have been also published by Kalina (1963), Vasundhara (1987) and Prasad et al. (1988). GA_3 also enhanced panicle exertion more

visibly, followed in order by urea and boric acid. Similar increased panicle exertion by GA_3 spray was also observed by Dharmarajan (1990).

The treatment involving spraying of GA_3 recorded maximum seed yield of 0.45 t/ha accounting for 72.2 per cent increase over the control but it was on par with 1.0 per cent boric acid (0.40 t/ha). The increased seed yield with GA_3 spraying could be due to more panicle exertion, more number of filled spikelets and higher per plant yield over other treatments. Apart from increasing panicle exertion, GA_3 is also known to influence favourably the glume characters like angle and duration of glume opening (Dharmarajan, 1990). It also helped to induce synchronized flowering between primary and secondary tillers (prasad et al., 1988). GA_3 in its effect was followed by boric acid (1.0%) spray which accounted for 55.6 per cent more yield than the control and just 9.7 per cent lower yield as compared to GA_3 treatment.

Effectiveness of GA_3 in increasing outcrossing and seed yield in hybrid rice production have been well documented by Lin and Yuan (1980), Sahai et al. (1988) and Duan and Ma (1992). On the contrary, Vasundhara (1987) reported that application of 60 ppm GA_3 was not effective.

Superiority of boric acid in increasing outcrossing and seed yield could be ascribed to increase in availability of viable pollen to the receptive stigma for a longer period

(Joshi, 1976), increased pollen tube growth (Sureshnath, 1981) and fertilizing capacity (Garg et al., 1980). Sureshnath (1981) also observed increased outcrossing due to boron spray in hybrid sorghum seed production (CSH 5). Donaire (1991) also reported the importance of boron in maintaining an acid pH during pollen germination.

Foliar spray of 2 per cent urea bagged third position followed by KNO_3 . The effectiveness of urea spray in seed production was also reported by Joshi (1976) in sorghum and Prasad et al. (1988) in rice. On the whole, boric acid (1.5%) or urea (2.0 %) sprayed at booting stage was not as effective as GA_3 . Neither urea nor boric acid increased the plant height of CMS line during this study.

5.5.4 Seed quality as influenced by foliar chemical spray

Initial germination as influenced by application of GA_3 , urea, boric acid and KNO_3 did not differ significantly. However, GA_3 recorded numerically higher germination followed by 0.5 per cent boric acid. Increased germination percentage of seeds sprayed with these chemicals may be attributed also to its growth regulator effect and also higher seed weight (Takeda, 1972) as compared to control.

Field emergence percentage followed the same trend as that of germination, but the values were lower. Though root length did not differ significantly, shoot length was

highest and similar in both GA_3 treatment and 0.5 per cent boric acid. Higher root shoot length coupled with germination increased vigour index and dry matter of seedlings in the treatments of boric acid 0.5 per cent followed by GA_3 . However, other treatments like KNO_3 and urea recorded higher values for all the seed quality attributes as compared to the control. Similar beneficial effects of growth regulator and other chemicals are also documented by suresh nath (1981).

One interesting point that emerged from Accelerated ageing test was that seed obtained from GA_3 treatment recorded lower germinability (83.0%) and was almost equal to treatment of boric acid (1.00%) followed by KNO_3 (0.5%) and KNO_3 (1.0%). Like-wise results also revealed the adverse effect of high concentration of boric acid indicating poor storability of these seeds. Similar deleterious effect of GA_3 on germination after AA test has been reported by Duan and Ma (1992).

Practical Application of Results

The following practical applications are indicated based on the results obtained in the present studies:

1. Mandya and Bangalore should be preferred locations for rice seed production since the seeds produced here possessed better seed quality as well as storability.

2. Seed production during dry season should be preferred to wet season in all locations.
3. Seeds of rice genotypes V 20 B, Madhu B, Pushpa B, Mangala B and Pragathi b are better storers and can be stored more than 19 months without loss of viability as per minimum level of seed certification standard.
4. Seed treatment with Thiram at 2 g/kg of seed can be practised for better storage.
5. There is a possibility of production of F₁ hybrids through ratooning of parents, provided both cytosterile and restorer lines have better ratoonability, and technology needs to be developed through extensive field trails..
6. Synchrony of flowering of the parents can be accomplished in the ratoon crop, cutting the main crop at appropriate time based on the main differences in days to 50 per cent flowering.
7. Potential hybrids, CMS lines, maintainers and restorers can respond better to vegetative propagation through tiller separation.

8. Tiller separation at 50th day after sowing may be followed to obtain optimum number of fresh planting material and better field performance of tiller crop.

9. Seeds obtained from early developed tillers are preferable for better seed quality.

10. In case of scarcity, parent seeds (A/B) can be multiplied through stubble planting.

11. When there is a dearth of hybrid. Seeds, stubbles from previous season (of proven hybrid) can be wisely utilized to cover more area under commercial cultivation since the multiplication ratio is more than 1:10, and stubble management needs to be standardized.

12. Harvesting the main crop at physiological maturity can yield more number of ratoon tillers for further vegetative propagation as stubble crop and improve field establishment.

13. Root dipping of stubbles in Rogar+DAP can be practised for better field establishment and performance.

14. In IR 62829 A/B seed production, staggered seeding of 'B' line, 4 and 8 days after sowing of A can be practiced for better synchronization, higher seed set and seed yield.

15. For hybrid seed production of IR62829 A/IR 9761-19-1R, staggered sowing of male parent on the 9th and 13th day after sowing 'A', can produce maximum hybrid seed yield.

16. Planting ratio of 2:6 or 1:3 (male to female) can be adopted for both the parental (IR 62829 A/B) and hybrid (IR 62829 A/IR 9761-19-1R) seed production to get better seed set and yield.

17. Foliar chemical spray of boric acid (1.0%) and urea (2.0%) during boot leaf stage and two per cent flowering can be practiced in hybrid rice seed production.

FUTURE LINE OF WORK

1. The studies on provenance are to be continued and suitable areas are to be identified for seed production of parents and hybrids.
2. Further, there is a need to continue storage studies on various A,B,R and F1 hybrids from different production environments covering longer period.
3. Effect of season and some more seed treatment with chemicals on storability of parents and F1 hybrids under ambient conditions, various combinations of relative humidity and temperature are to be studied.
4. Identification of best storage places for ambient storage is felt very much necessary.
5. Study on comparison of field performance between various parents during "Seed production through main crop" and "ratoon crop" has to be studied in both the seasons. Further, their seed quality and storability are to be further assessed.

6. Feasibility of tiller separation in various newly developed A,B,R lines and F1 hybrids needs to be tested.
7. It is necessary to study the seasonal effect on "tiller separation and planting" and evaluation of their field performance.
8. Effect of repeated tiller separation (splitting) within a season and their performance in different A,B,R lines and F1 hybrids needs a detailed study.
9. More efficient planting designs are to be tailored for hybrid seed production in rice.
10. Since GA3 is costly, other cheaper chemicals to substitute GA3, in hybrid rice seed production are to be found out. Further these seeds have to be tested for their storability.

SUMMARY

VI SUMMARY

The study included five laboratory and nine field experiments carried out during 1989-1992 at the University of Agricultural sciences, Bangalore to understand the "Effect of provenance, method of propagation and technique of seed production on seed yield and quality of hybrid rice (Oryza Sativa L.)". The salient findings of the various experiments are summarised here.

Seeds of 8 rice genotypes (maintainer lines) produced at 4 locations (Bangalore, Mandya, Shimoga and Mudigere) during two seasons (1989 WS and 1990 DS) were evaluated for their various seed characters and quality.

Genotypes differed significantly for various seed characters viz., test weight, seed volume and density. Seed quality attributes viz., germination, speed of germination, field emergence, seedling length, vigour index, electrical conductivity of seed leachate and accelerated ageing test response also varied significantly among the genotypes.

The genotypes V20B, IR54752 B, Mangala B and Pragathi B were found to be superior in various seed characters while V20B, Pushpa B, Pragathi B, Mangala B, and Madhu B were superior in various seed quality attributes studied. The rest of the genotypes, Pushpa B, Pragathi B, Mangala B, and V20B recorded better germinability even after accelerated

ageing test revealing their superiority. The rest of the genotypes IR 54752 B, Intan mutant B and Improved Sona B were inferior in one or other seed quality parameters.

Out of the 4 production locations, seeds produced at Mandya recorded the highest seed quality followed by those producing at Bangalore and Shimoga. Mudigere location was found to be inferior to all other locations.

Between the two seasons, seeds produced during dry season registered significantly higher density but on par in respect of seed volume. However, the test weight did not differ between the two seasons. Dry season seed crop recorded significantly higher germination, speed of germination and lower EC but field emergence, seedling length, vigour index and response to ageing test were found to be not significant between the two seasons.

The same genotypes produced in 4 locations were stored in cloth bag for 19 months (January 1990 to July 1991) with seed treatment (Thiram 2.0 g/kg) and without seed treatment under ambient conditions. Various seed quality parameters were tested bimonthly.

Irrespective of production location, genotypes and seed treatment, all the seed quality parameters dropped gradually and EC increased as the storage period advanced. The magnitude of reduction in seed quality was slow at earlier phase and accelerated at the later part of storage

The genotypes differed significantly for all the seed quality parameters including fluctuation of seed moisture content during the storage period. The genotypes V 20B, Pushpa B, Pragathi B, Mangala B and Madhu were proved to be better storers, maintaining more than 80 per cent viability until the end of storage period. The rest of the genotypes Intan mutant B, IR 54752B and Improved B sona were poor storers.

Seeds produced at Mandya followed by those of Bangalore and Shimoga recorded better storability while Mudigere seeds exhibited poor storability and could be stored only up to 15 months.

Treated seeds registered significantly higher germinability, vigour and lower EC and moisture content throughout the storage period.

Treated seeds of V 20, Pushpa, Pragathi, Mangala, Madhu produced at Mandya followed by Bangalore were found to be superior to those of Shimoga and Mudigere seeds.

The results of hybrid seed production experiments revealed that the CMS line IR 54752A performed relatively better than Intan mutant A exhibiting better growth, floral traits, seed set and yield. Out of the 5 restorers, ARC 11353R followed in order by IR 54R, IR 46R and IR 15324 R performed better. The maximum seed yield were obtained in

the combination of IR 54752A/ARC 11353R followed by IR 54752A/ IR 54 and IR 54752 A / IR 46K as compared to Intan mutant A/ IR 27315R and Intan mutant A/IR 15324R.

The growth of ratoon parents was less and they took less number of days for flowering. It was possible to achieve the synchrony by ratooning in all parents. But seed set and yield were more in ratoon crop of Intan mutant A/IR 27315R and Intan mutant A / IR 15324R due to better synchrony as that of its respective main crop.

With regards to seed quality, the ratoon F_1 hybrid seeds recorded relatively lower quality as that of seeds produced through seedling planted main crop. However, IR 54752A/ARC 11353R registered better seed quality compared to the other F_1 s.

To understand the effect of days to tiller separation on recovery of fresh tillers and their field performance, eight genotypes were, tiller separated at two stages. It was observed that tiller separated at earlier stage (50 DAS) performed better than seedling planted crop. The initial recovery of number of tillers for further planting was low at earlier tiller separation as compared to later stage (70 DAS). Delay in tiller separation (and planting) resulted in poor growth as well as yield.

The genotype ARC 11353 and IR 54752A/ARC 11353R, Madhu WA/ IR 15324 R, IR 54752 A/IR 27315 R and IR 54752A/IR 54R hybrids performed better. Short duration genotypes V 20 and ES 18 also responded well to this technique. Vegetatively propagated tiller crop took less number of days than that of seedling planted crop to attain maturity.

Study on quality of seeds obtained from different tillers revealed that, early developed tillers (T1-T4) could exhibit higher test weight, better germinability even after ageing test. A linear decline in seed quality was observed in "later tillers" (T4 - T10). The restorer line ARC 11353 R recorded better seed quality as compared to IR 46 R, suggesting the existence of genotypic differences.

Another innovative approach in vegetative propagation is stubble planting. Experimental results showed that it is possible to maintain the CMS lines through stubble planting in cases of inadequacy of parental seeds. IR 54752A/B and Intan mutant A/B responded better for this purpose.

In another study, commercial cultivation of F₁ hybrids through stubble planting was also found feasible. Two hybrids IR 54752 A/ ARC 11353 R and Madhu WA / IR 46R and restorer (ARC 11353 R) responded well for vegetative propagation.

The experiment carried out during 1990 WS, revealed that harvesting the mother crop at physiological maturity recorded highest regeneration. Regenerated tillers per plant did not differ significantly between harvesting time but varied significantly among three varieties. Stubbles obtained by harvesting the mother crop at physiological maturity showed maximum field establishment differing significantly from later harvests. Plant height was not affected by harvesting time. Yield components and yield differed significantly due to harvesting time. The hybrid IR 54752A/ARC 11353R recorded high yields followed in order by ARC 11353, and Pushpa was much inferior.

Stubble root dipping in Rogar (0.1%) + DAP (3%) for 25 minutes established better stubble crop and exhibited better field performance than other treatments as well as seedling planted check. Significant improvement in field establishment, growth resulted in higher grain yield in this treatment.

Among the eight planting ratios studied IR 62829 A / B seed multiplication and IR 62829A / IR 9761-19-1R F₁ hybrid seed production, 2 male to 6 female ratio was found to be the best followed by 1:3.

Though higher seed set was observed in the lower ratio (1:2), it did not register higher seed yield due to lower female population per unit area. On the contrary, despite

maximum female plants per unit area, higher planting ratios (1:4, 1:5, 2:8 and 2:10) did not record higher seed yield due to poor seed set.

Studies were also carried out to optimise the synchronization of flowering between the parents during parental seed multiplication of IR 62829A/B and F_1 hybrid seed production of IR 62829A/IR 9761-19/1R (1992-DS). It was found that sowing of IR 62829 B line 4 days later than 'A' resulted in better synchrony. To supply continuous pollen, another set of sowing of 'B', 8 days later was also necessary.

During F_1 hybrid seed production (IR 62829A/IR 9761-19-1R) sowing of male (IR 9761-19-1R) nine days later to 'A' line was found to synchronise in flowering with female parent. One more set of male sowing on 13th day was found necessary to assure continuous pollen supply.

The experiment conducted with eight treatments to find out cheaper chemicals to substitute for GA_3 in IR 54752A/B parent seed production (1990 WS) indicated that it was not possible to substitute GA_3 cent-per cent by any other chemical. However, Boric acid (1.0%) spray at booting and two per cent flowering stage to both the parents can improve seed set to get yield which is about 90.3 per cent the yield of GA_3 . Urea (2.0%) spray registered 87.1 per cent

of GA_3 yield. GA_3 not only increased the plant height but also the panicle exertion. Neither boric acid nor urea could increase the plant height.

A line seeds produced with chemical spray recorded significantly higher seed quality than the control. Though germination did not differ significantly due to chemicals, GA_3 , KNO_3 (1.0%) improved field emergence, root shoot, growth and boric acid improved the vigour index. The adverse effect of GA_3 spray during seed production also evident from AA test.

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*Original not seen

APPENDICES

APPENDIX 1

Actual weather data during the crop growth period recorded at the Meteorological Observatory, MRS, Hebbal, Bangalore.

| Month/Year | Rainfall (mm) | Temperature (°C) | | Relative humidity (%) | | Sunshine hours per day |
|-------------|------------------|------------------|---------|-----------------------|----|------------------------|
| | | Maximum | Minimum | | | |
| 1989 | | | | | | |
| July | 182.2 | 28.0 | 19.9 | 96 | 71 | 5.5 |
| August | 47.6 | 28.3 | 19.4 | 96 | 66 | 5.9 |
| September | 215.0 | 28.7 | 19.5 | 95 | 63 | 6.7 |
| October | 253.6 | 28.9 | 18.6 | 95 | 55 | 6.0 |
| November | 90.0 | 27.1 | 16.0 | 94 | 51 | 8.2 |
| December | 0.0 | 26.5 | 16.1 | 96 | 54 | 8.1 |
| 1990 | | | | | | |
| January | 8.2 | 27.6 | 12.4 | 93 | 35 | 8.9 |
| February | 0.0 | 30.7 | 15.0 | 90 | 38 | 10.2 |
| March | 2.6 | 32.7 | 20.1 | 82 | 36 | 9.6 |
| April | 8.8 | 34.9 | 22.3 | 82 | 34 | 9.4 |
| May | 67.6 | 31.7 | 21.3 | 92 | 54 | 7.4 |
| June | 29.7 | 30.2 | 20.1 | 93 | 57 | 6.1 |
| July | 17.7 | 29.1 | 19.5 | 95 | 59 | 4.9 |
| August | 69.4 | 27.7 | 19.7 | 95 | 68 | 4.2 |
| September | 72.7 | 31.3 | 19.9 | 90 | 56 | 6.9 |
| October | 53.7 | 28.7 | 19.5 | 92 | 62 | 6.0 |
| November | 16.4 | 27.1 | 17.4 | 94 | 57 | 6.4 |
| December | 5.0 | 26.7 | 15.6 | 95 | 51 | 8.3 |
| 1991 | | | | | | |
| January | 0.0 | 28.9 | 15.7 | 95 | 42 | 9.3 |
| February | 6.0 | 30.7 | 15.5 | 89 | 34 | 10.2 |
| March | 0.0 | 33.3 | 19.9 | 79 | 29 | 10.0 |
| April | 6.0 | 32.6 | 21.4 | 84 | 35 | 9.0 |
| May | 9.0 | 34.1 | 21.8 | 83 | 42 | 9.2 |
| June | 9.0 | 29.2 | 21.0 | 91 | 67 | 4.7 |
| July | 47.7 | 28.1 | 19.8 | 90 | 64 | 3.8 |
| 1992 | | | | | | |
| January | 0.0 | 26.4 | 12.1 | 92 | 38 | 8.4 |
| February | 0.0 | 30.3 | 16.4 | 91 | 43 | 8.9 |
| March | 0.0 | 33.2 | 14.1 | 80 | 25 | 10.0 |
| April | 2.8 | 34.0 | 19.9 | 81 | 32 | 10.4 |
| May | 142.9 | 33.2 | 21.1 | 85 | 45 | 8.1 |
| June | 154.8 | 29.6 | 20.3 | 91 | 61 | 5.8 |
| July | 118.7 | 28.3 | 19.2 | 91 | 63 | 4.7 |

APPENDIX II

Geographical distribution, annual rainfall & soil type of different experimental sites

| Site | Zone | Soil type | Altitude (m) | Latitude | Longitude | Annual rainfall (mm) |
|---------------------|---------------|---------------------------------|--------------|-----------------|-----------|----------------------|
| Hebbal | Eastern dry | Sandy clay loam slightly acidic | 899 | 13°N | 77°-57E | 830.0 |
| Mandya | Southern dry | Sandy clay loam | 764 | 12.5°N 30" E | 76°49' | 763.0 |
| Honnavile (Shimoga) | Transi-tional | Sandy clay loam to clay loam | 600 | 13°53' 30"N | 75°40' | 800.0 |
| Mudigere | Hilly | Sandy clay loam | 800 - 900 | 13°17'N | 76°21E | 2461.0 |

APPENDIX III

Mean monthly meteorological data of different locations (Hebbal, Mandya, Honnavile and Mudigere) during the crop growth period.

| Month / Year | Temperature (°C) | | Relative humidity (%) | Rainfall (mm) | Sunshine (hours) |
|------------------|------------------|---------|-----------------------|---------------|------------------|
| | Maximum | Minimum | | | |
| HEBBAL | | | | | |
| June 1989 | 30.3 | 20.0 | 93.57 | 51.5 | 6.6 |
| July | 28.0 | 19.9 | 96.71 | 182.2 | 5.5 |
| August | 28.3 | 19.4 | 96.66 | 47.1 | 5.9 |
| September | 28.7 | 19.5 | 95.63 | 215.6 | 6.7 |
| October | 28.9 | 18.6 | 95.55 | 253.6 | 6.0 |
| November | 27.1 | 16.0 | 94.51 | 9.0 | 8.2 |
| December | 26.5 | 16.1 | 96.54 | 0.0 | 8.2 |
| January 1990 | 27.6 | 12.4 | 93.35 | 8.2 | 8.9 |
| February | 30.7 | 15.0 | 90.38 | 0.0 | 10.2 |
| March | 32.7 | 20.1 | 82.36 | 2.6 | 9.6 |
| April | 34.9 | 22.3 | 82.34 | 8.8 | 9.4 |
| May | 31.7 | 21.3 | 90.54 | 67.6 | 7.4 |
| June | 30.2 | 20.1 | 93.57 | 29.7 | 6.1 |
| MANDYA | | | | | |
| June 1989 | 29.5 | 19.1 | 91.00 | 31.9 | 9.7 |
| July | 28.3 | 19.5 | 88.00 | 190.9 | 7.6 |
| August | 28.1 | 20.1 | 87.00 | 29.2 | 8.0 |
| September | 29.8 | 18.9 | 88.00 | 88.8 | 7.9 |
| October | 30.0 | 19.3 | 88.00 | 176.0 | 7.9 |
| November | 29.0 | 18.0 | 85.00 | 12.4 | 9.7 |
| December | 28.1 | 15.1 | 84.00 | 1.0 | 9.1 |
| January 1990 | 28.7 | 15.4 | 83.00 | 1.8 | 10.1 |
| February | 31.2 | 14.5 | 86.00 | - | 9.9 |
| March | 32.30 | 19.1 | 84.00 | 8.6 | 10.3 |
| April | 34.3 | 21.5 | 80.00 | 3.6 | 9.5 |
| May | 31.3 | 19.8 | 87.00 | 110.8 | 8.6 |
| June | 23.0 | 19.5 | 86.00 | - | 6.1 |
| HONNAVILE | | | | | |
| June 1989 | 29.7 | 21.5 | 69.00 | 80.6 | NR |
| July | 26.0 | 22.4 | 82.00 | 231.5 | NR |
| August | 25.1 | 21.9 | 86.00 | 141.9 | NR |
| September | 27.3 | 22.0 | 76.00 | 26.6 | NR |
| October | 26.8 | 21.7 | 76.00 | 18.2 | NR |
| November | 25.7 | 21.5 | 76.00 | 40.3 | NR |
| December | 26.9 | 22.4 | 78.00 | - | NR |
| January 1990 | 33.8 | 17.1 | 60.00 | - | NR |
| February | 31.3 | 17.2 | 63.00 | - | NR |
| March | 34.0 | 18.6 | 66.00 | - | NR |
| April | 32.6 | 23.7 | 84.00 | - | NR |
| May | 35.6 | 21.2 | 88.00 | - | NR |
| MUDIGERE | | | | | |
| June 1989 | 23.9 | 18.1 | 88.00 | 339.4 | |
| July | 23.0 | 18.0 | 91.00 | 638.8 | |
| August | 23.0 | 17.7 | 90.00 | 259.0 | |
| September | 24.8 | 17.7 | 84.00 | 118.8 | |
| October | 27.4 | 17.1 | 81.00 | 308.6 | |
| November | 27.9 | 16.5 | 67.00 | 11.0 | |
| December | 27.4 | 14.6 | 69.00 | 33.0 | |
| January 1990 | 29.0 | 13.0 | 60.00 | 19.2 | |
| February | 30.2 | 13.6 | 63.00 | - | |
| March | 31.7 | 15.4 | 65.00 | - | |
| April | 33.2 | 18.3 | 67.00 | 46.0 | |
| May | 28.9 | 18.7 | 79.0 | 165.4 | |

APPENDIX IV

Mean temperature ($^{\circ}\text{C}$) and relative humidity (%) recorded at Laboratory, Seed Technology Department, University of Agricultural Sciences, GKVK, Bangalore from January 1990 to July 1991

| | 1990 | | 1991 | |
|-----------|--------------------------------|-------------------|--------------------------------|-------------------|
| | Temperature $^{\circ}\text{C}$ | Relative humidity | Temperature $^{\circ}\text{C}$ | Relative humidity |
| January | 22.5 | 36 | 24.5 | 46 |
| February | 23.8 | 35 | 26.2 | 38 |
| March | 25.3 | 34 | 29.5 | 33 |
| April | 27.8 | 36 | 28.5 | 42 |
| May | 25.7 | 48 | 25.5 | 45 |
| June | 25.8 | 54 | 24.5 | 56 |
| July | 25.3 | 55 | 23.3 | 52 |
| August | 25.0 | 62 | | |
| September | 25.9 | 54 | | |
| October | 25.0 | 54 | | |
| November | 23.8 | 56 | | |
| December | 21.3 | 49 | | |

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