"GENETIC AND PHYSIOLOGICAL ANALYSIS OF RATOONING IN RICE (*Oryza sativa* L.)"

By

AMBILI S. NAIR

THESIS

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DEPARTMENT OF PLANT BREEDING AND GENETICS
COLLEGE OF HORTICULTURE
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DECLARATION

I hereby declare that this thesis entitled **"Genetic and physiological analysis of ratooning in rice (*Oryza sativa* L.)"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara

AMBILI S. NAIR

CERTIFICATE

Certified that this thesis, entitled **"Genetic and physiological analysis of ratooning in rice (*Oryza sativa* L.) "** is a record of research work done independently by **Miss.Ambili S. Nair,** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Dr.C.A.Rosamma
Chairperson, Advisory Committee
Associate Professor
Agricultural Research Station
Mannuthy

Vellanikkara

CERTIFICATE

We, the undersigned members of the Advisory Committee of Miss. **Ambili S. Nair,** a candidate for the degree of **Master of Science in Agriculture with major in Plant Breeding and Genetics,** agree that the thesis entitled **"Genetic and physiological analysis of ratooning in rice (*Oryza sativa* L.)"** may be submitted by Miss. Ambili S. Nair, in partial fulfilment of the requirements for the degree.

Dr.C.A.Rosamma
(Chairperson, Advisory Committee)
Associate Professor
Agricultural Research Station
Mannuthy

Dr.K.Pushkaran
Professor & Head
Dept. of Plant Breeding & Genetics
College of Horticulture
Vellanikkara

Dr.K.Nandini
Assosicate Professor
Dept. of Plant Breeding & Genetics
College of Horticulture
Vellanikkara

Dr.V.K.G.Unnithan
Associate Professor
Department of Agricultural Statistics
College of Horticulture
Vellanikkara

EXTERNAL EXAMINER

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Dedicated to my beloved

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Introduction

INTRODUCTION

Rice is the staple food for more than 65 per cent of the Indian population. It is grown in an area of 42.3 million hectares under varying moisture regimes and diverse ecological situations. The current level of rice production (80.5 million tonnes) has to be raised to 95 million by the end of the ninth five year plan and further to 103 million tonnes by the end of tenth five year plan to meet the needs of increasing population. (Mathur *et al.*, 1999). Under such a situation, vital importance should be given to develop strategies which can increase the productivity of rice. Crop intensification and higher yield seem to be the prospective avenues open for scientists to bridge the increasing gap between production and demand for food since there is meagre possibility of bringing more area under rice cultivation.

In irrigated areas, some residual moisture is available in fields after the rice crop is harvested. But usually it is not enough for a second crop, even of an early maturing variety. The puddled soil conditions make it difficult to use this land for an upland crop after the rice crop. In rainfed areas, only one crop per year is generally grown. The moisture left in the field at the end of the wet season is often adequate for a second short-duration crop. However, the soil moisture may not be enough to permit high returns on investments in seedling and pesticides for another rice crop. Under such a situation, ratoon cropping of rice has been suggested as one of the means of increasing the rice production without increasing the land area (Mahadevappa, 1979). Efficient use of land and labour during their idle periods in mono-cropped areas and of the residual moisture that would otherwise be wasted after harvesting the first crop are the advantages of rice ratoon cropping system. Thus, ratoon cropping can be considered as an improved practice for getting high total production from areas with limited availability of water and time for a second crop.

Rice ratooning is practiced in several parts of the world, yet it is being practiced on a commercial scale only in the United States of America, (Chauhan *et al.*, 1985). In India it has been practiced in certain parts of Karnataka, Kerala, Assam and West Bengal.

In Kerala, there has been a reduction of area under rice from 8.74 lakh hectares in 1972-1973 to 4.2 lakh hectares in 1997-98. Now we are producing only one third of our requirement. Due to various socio-economic constraints, we are not in a position to bring more area under rice cultivation and hence to achieve the target of increased rice production, it requires raising the production per unit area. In Kerala we can suggest ratooning as an important means of intensifying the rice production. Koottumundakan cultivation, practiced in some parts of Aleppey district, can be considered as a ratoon cropping system, gives light towards the scope for the adoption of such a practice in our state. Therefore superior ratooning genotypes with other desirable attributes are to be identified. If the identified genotypes with superior performance in both the main and ratoon crops exhibit extraordinarily high combined yields, we can achieve higher productivity.

Hence, the present study on ratooning was carried out with the following objectives.

1. to assess the genetic variability among the genotypes of different eco-geographical origin
2. to determine the genetic parameters like heritability, genetic advance and genetic gain of different morphological and physiological characters both in main and ratoon crops
3. to determine genotypic and phenotypic correlations among various morphological and physiological characters in both the crops.
4. to find out the direct and indirect effects of different morphological and physiological characters on main and ratoon crop yield.
5. formulation of suitable selection models .

6. to find out main crop characters that contribute to better ratoon performance and finally to a high total yield
7. identification of genotypes suitable for ratooning.

Review of Literature

REVIEW OF LITERATURE

A brief review of the research works on genetic variability, genotypic and phenotypic coefficients of variation, heritability, genetic gain and advance, character association and path analysis in respect of some characters in rice relevant to the present study is given below. Research works in main crop and ratoon crop are reviewed separately.

2.1 Main crop

2.1.1 Genetic variability

Shankar (1981) in his study on 196 varieties for 16 characters found that the variability created for grain yield and grain number was very high. Variability in flowering duration was observed by Lal *et al.* (1983).

Singh *et al.* (1984) reported high genetic variability for the characters namely grains panicle^{-1}, days to maturity, sterility percentage, 1000 grain weight, panicle length and plant height.A wide variation in 1000 grain weight was observed by Shamsuddin (1986). Shamsuddin and Singh *et al.* (1986) reported substantial genetic variability for traits like panicle length and grains panicle^{-1}. Singh *et al.* (1986) indicated considerable variation in flowering duration, and plant height. Sardana and Sasikumar (1987) reported wide range of variation in number of grains panicle^{-1}, flowering duration 1000 grain weight, panicle length and plant height.

Chauhan *et al.* (1989) reported a high range of variation in characters namely grains panicle^{-1}, panicle length and 1000 grain weight. Chaubey and Richharia (1990) indicated considerable genetic variation for the traits panicle length, 1000 grain weight and harvest index. Significant differences were noted among eight varieties tested for characters viz. flag leaf area, yield, filled grains panicle^{-1} and panicle length. Bashar *et al.* (1991) and Satpute (1996) observed genetic variations for days to 50 per cent flowering, plant height and number of grains panicle^{-1}.

2.1.2 Phenotypic and genotypic coefficients of variation

Shamsuddin (1986) reported high estimate of genotypic coefficient of variation (GCV) for the characters number of grains panicle^{-1} and 1000 grain weight. Sardana and Sasikumar (1987) indicated moderate GCV for the characters viz. plant height, panicle length and number of grains panicle^{-1}.

Reddy *et al.* (1988) recorded moderate value for GCV with reference to the characters number of grains panicle^{-1} and high GCV for plant height. Li *et al.* (1991) reported that the genetic variation coefficient was highest for panicles plant^{-1} followed by grain density and lowest for plant height.

Sarma and Roy (1993) observed higher GCV for 100 grain weight. Chaubey and Singh (1994) obtained phenotypic coefficient of variation (PCV) greater than GCV for all the yield related traits they have studied. Sawanth and Patil (1995) reported high coefficients of variation for grains panicle^{-1} and plant height. Significant GCV was observed for plant height and total tillers hill^{-1} by Shanthakumar *et al.* (1998).

2.1.3 Heritability and expected genetic advance

Shamsuddin (1986) reported that number of grains panicle^{-1} and 1000 grain weight had high estimates of heritability and expected genetic advance. Singh *et al.* (1986) reported high heritability estimate for plant height and panicle length. High heritability in the broad sense for days to 50 per cent flowering and days to harvest was also reported by him. Moderate estimate of heritability and genetic advance for characters viz. plant height, panicle length and number of grains panicle^{-1} was indicated by Sardana and Sasikumar (1987). High heritability estimates coupled with high expected genetic advance was observed for panicle bearing tillers plant^{-1} by De and Rao (1988).

Reddy *et al.* (1988) recorded moderate value for heritability estimate and expected genetic advance with respect to the character number of grains panicle^{-1}. He also observed high estimates of heritability and genetic advance for plant height and 1000 grain weight. High heritability estimate for number of grains panicle^{-1}, plant height, 1000 grain weight, days to 50 per cent flowering and days to harvest was reported by Kihupi and Doto (1989).

High expected genetic advance as percentage of mean associated with high heritability estimates were observed for the number of grains panicle^{-1} by Pathak and Patel (1989). They also indicated high heritability coupled with high expected genetic advance for 1000 grain weight and plant height. Sardana *et al.* (1989) recorded high heritability in the broad sense coupled with low expected genetic advance for plant height, days to 50 per cent flowering, number of days to harvest and panicle length. Chaubey and Richharia (1990) found high heritability in the broad sense for 1000 grain weight. They also reported high heritability estimate for panicle length and grain yield.

Gomathinayagam *et al.* (1990) observed high heritability estimates coupled with high expected genetic advance for the trait panicle bearing tillers plant^{-1}. Li *et al.* (1991) showed high heritability for heading date followed by 1000 grain weight. High heritability estimates for plant height was reported by Anandakumar (1992) and Bai *et al.* (1992).

Lokaprakash *et al.* (1992) indicated high heritability coupled with high expected genetic advance for 1000 grain weight. He also obtained high expected genetic advance as percentage of mean associated with high heritability estimates for number of grains panicle^{-1}. Remina *et al.* (1992) reported that number of grains panicle^{-1} had high estimates of heritability and expected genetic advance. Roy and Kar (1992) showed high heritability, in the broad sense coupled with high expected genetic advance for 1000 grain weight. High heritability for harvest index was also reported by them.

Yadav (1992) showed that heritability estimates were high for plant height, harvest index, days to 50 per cent flowering and days to maturity. Chauhan *et al.* (1993) found high heritability coupled with high expected genetic advance for 1000 grain weight. High heritability in the broad sense associated with low expected genetic advance were observed for plant height, days to 50 per cent flowering and panicle length.

Katoch *et al.* (1993) observed high heritability in the broad sense coupled with low expected genetic advance for 1000 grain weight, plant height, days to 50 per cent flowering and panicle length. High heritability estimate for number of grains panicle^{-1} was observed by Patil *et al.* (1993). Sarma and Roy (1993) obtained high heritability and genetic advance for grains panicle^{-1} and grain weight. Chakraborty and Hazarika (1994) reported high heritability in the broad sense coupled with low expected genetic advance for plant height, 1000 grain weight, days to 50 per cent flowering and panicle length. High expected genetic advance as percentage of mean associated with high heritability estimates were observed for number of grains panicle^{-1} by Ramalingam *et al.* (1994) and Ganesan *et al.* (1995).

Sawanth and Patil (1995) obtained high value of heritability coupled with high genetic advance for grains panicle^{-1}, plant height and 1000 grain weight. Wali and Mahadevappa (1995) found that heritability estimates were high for plant height and maturity, but low for grain yield. Broad sense heritability for 1000 grain weight and panicle length ranged from 0.7 to 0.9 (Rao *et al.*, 1997). Shanthakumar *et al.* (1998) observed high heritability and genetic advance for plant height and total tillers hill^{-1}.

2.1.4 Correlation

Grain yield showed a significant positive correlation (in descending order of magnitude) with number of effective tillers, 1000 grain weight, number of grains panicle^{-1} and panicle length. Hence, selection for these characters is suggested for yield improvement (Dhanraj *et al.*, 1987).

Paramasivan (1987) reported significant correlation for plant height, number of productive tillers plant^{-1} and number of grains panicle^{-1}. Ismail (1988) revealed that number of full grains panicle^{-1} was the character with greatest direct influence on yield. Manuel and Palanisamy (1989) observed that grain yield was significantly and positively correlated with days to flowering, plant height, flag leaf area, panicles plant^{-1}, panicle length and grains panicle^{-1}. Reuben and Kisanga (1989) revealed that proportion of sound matured grains panicle^{-1} and panicle length were important in influencing grain yield. These components were also positively associated among themselves and with grain yield. Sampath *et al.* (1989) observed that yield was correlated significantly with 100 grain weight, panicle length and number of grains panicle^{-1}.

In a field experiment to test the relative yield performance of certain genotypes, Malik *et al.* (1990) reported that while 1000 grain weight had positive association with grain yield, the number of grains panicle^{-1} and plant height were associated negatively with ultimate grain yield. Correlation study in rice by Murthy *et al.* (1991) revealed that leaf area at early crop growth stage and harvest index showed positive association with grain yield, while leaf area at flowering showed no association with grain yield.

Bai *et al.* (1992) conducted experiment with 58 medium duration rice cultivars in wet and dry seasons of 1990, in Kerala. Grain yield plant^{-1} was positively correlated with numbers of productive tillers, plant height, panicle length and number of grains panicle^{-1} at genotypic and phenotypic levels. Flag leaf area was positively correlated with yield only at genotypic level.

In a study conducted by Mirza *et al.* (1992) plant height was positively correlated with panicle length and 1000 grain weight. Grain yield was positively correlated with 1000 grain weight and number of grains panicle^{-1}. Rosamma *et al.* (1992) reported positive correlation of yield with different characters viz. panicle length, number of grains panicle^{-1}, 1000 grain weight, plant height, number of total tillers plant^{-1} and crop duration.

Sakhare *et al.* (1992) reported plant height as the most influential component on grain yield in a correlation study between grain yield and seven yield components for 30 rice cultivars. Chau and Bhargava (1993) recorded that grain yield was positively correlated with grain number, leaf area duration during grain filling, while it was negatively correlated with LAI at flowering.

In a study of 26 indica rice genotypes of tall and semidwarf stature, Katoch *et al.* (1993) reported that grain yield had significant positive association with harvest index and grains panicle^{-1} in both the sets of genotypes at the phenotypic level. In addition, grain yield showed significant association with effective tillers plant^{-1} in tall statured plants. Sarma and Roy (1993) observed that plant height, panicle length and grains panicle^{-1} were significantly and positively correlated with grain yield.

Chakraborty and Hazarika (1994) reported that the grain yield exhibited significant and positive correlation with plant height, panicle length, panicles plant^{-1} and kernel breadth at genotypic and phenotypic levels. Grain yield plant^{-1} was positively correlated with number of ear bearing tillers and plant height. Positive correlation was also noted between panicle length and plant height (Chaubey and Singh, 1994). Marwat *et al.* (1994) found that the most important characters which influence grain yield were flag leaf area, grains panicle^{-1}, 1000 grain weight and panicle length.

Grain yield was positively and significantly correlated with panicle length, grains panicle^{-1} and 100 grain weight (Ramalingam *et al.*, 1995). Yolanda and Das (1995) observed that grain yield was significantly and positively correlated with panicle length, grains panicle^{-1}, 100 grain weight and harvest index. Grains panicle^{-1} was the main component character effecting yield directly. Chauhan (1996) noted positive and significant relationship of harvest index and biological yield with grain yield. It was suggested that increase in plant height and growth duration would tend to increase straw yield and panicle length as days to 50 per cent flowering and plant height were positively and significantly correlated with these characters.

A study of correlation among nine quantitative traits in 66 diverse genotypes in rice revealed that grain yield was positively and significantly correlated with number of fertile grains panicle^{-1} and 1000 grain weight. Days to flowering registered lower positive association with grain yield, whereas tiller number showed a somewhat negative association (Dash *et al.*, 1996).

Gopalakrishnan and Ganapathy (1996) showed that grains panicle^{-1}, panicle length and 100 grain weight were responsible for grain yield plant^{-1}. Nath and Talukdar (1997) opined that grain yield plant^{-1} was positively and significantly correlated with number of grains panicle^{-1} and 100 grain weight at genetic level.

Sarawgi *et al.* (1997) indicated that grain yield of rice had significant positive correlation with 100 grain weight, grain width and harvest index.

Verma and Mani (1997) reported that phenotypic level panicle length exhibited high positive association with number of grains panicle^{-1} and grain yield plant^{-1}. Phenotypic correlation coefficients showed that days to flowering, leaf area index, number of productive tillers, and harvest index were significantly and positively correlated with grain yield (Selvamani and Rengasamy, 1998).

Shanthakumar *et al.* (1998) observed that days to 50 per cent flowering, total tillers hill^{-1} and effective tillers hill^{-1} had positive correlation with yield. Gupta *et al.* (1999) informed that grain yield was positively associated with panicles plant^{-1}, panicle length and grains panicle^{-1}. Negative correlations were observed for panicles plant^{-1} with grains panicle^{-1} and grains panicle^{-1} with 100 grain weight. Panicle length was positively associated with grains panicle^{-1}.

2.1.5 Selection indices

Panwar *et al.* (1989) reported the lack of association of grain weight with grain number offers scope to improve both characters by selection. Path analysis for a line showed that selection for less number of sterile grains with low sterility percentage is the most single important selection criterion to improve productivity of the semi dwarf lines (Rao, 1990).

Anandakumar (1992) revealed by partitioning analysis that only plant height and tiller number have a basis for selection criterion in yield improvement of upland rice cultures. Mirza *et al.* (1992) suggested that panicle length, number of grains panicle^{-1} and number of panicles plant^{-1} should be used as selection criteria.

For increasing grain yield in rice high leaf area at early crop stages (45 and 60 days after sowing) and harvest index were suggested by Murthy *et al.* (1992).Genetic correlations among yield and yield components viz. panicle number, panicle length and plant height for southern long grain rice were estimated by Gravois and Mcnew (1993) and were used in developing selection methodologies in the breeding programmes.

A study conducted by Mishra *et al.* (1993) revealed that 100 grain weight can be successfully utilized to identify higher yielding genotypes during early generation selection in rainfed rice. Chakraborty and Hazarika (1994) reported that direct selection for the five yield components viz. plant height, panicle length, panicles plant^{-1} and kernel breadth could improve grain yield in rice.

Chaubey and Singh (1994) suggested number of ear bearing tillers as a selection criterion in rice hybridization programmes. Direct selection for number of effective tillers plant^{-1}, 1000 grain weight, grain width, grain length and grain thickness would increase harvest index. There was no common causal factor that directly influenced both grain yield and harvest index, although 100 grain weight, grain length, grain width and grain thickness could be augmented in selection criteria for the simultaneous improvement of both the traits (Sarawgi *et al.*, 1997).

Gholipoor *et al.* (1998) reported 100 grain weight as the most important component of yield for the lines under study and can be used as a selection criterion in breeding programme to improve yield. However, the role of number of grains panicle^{-1} and number of panicles plant^{-1} should be overlooked while selecting for 100 grain weight.

2.2 Ratoon crop

Gupta and Mitra (1948) tested 170 rice varieties for ratoonability and found that only 16 of them produced a good ratoon crop. They also observed clear varietal differences in the ratooning ability. Out of 170 varieties tested, only 16 gave some sort of an yield, the rest either did not produce any shoots or formed only sterile spikelets. All the stalks that were left over after the first harvest did not give out shoots. There was a wide variation in the number of ratooning stalks among the genotypes tested. The number of ratooning stalks ranged from 14 to 86 per cent of the original stalks. Only two (TN 32 and CH 10) out of a dozen early varieties showed any capacity to ratoon and gave yields amounting to 9.47 per cent and 6.73 per cent respectively, of the first crop.

It was reported that except seed viability all other characters like plant height, panicle length, spikelet size and number of productive tillers were less pronounced in the ratoon crop than in the main crop (Saran and Prasad, 1952). Reddy and Pawar (1959) reported that different varieties of paddy behaved differently in ratooning habit.

A study on ratooning by Balasubramanian *et al.* (1970) in the high yielding fertilizer responsive varieties IR-8, CO 32, ADT 27 and Jeeragasamba revealed that ratooning is a varietal character in rice. The ratoon crop was uniformly low in respect to plant height, as compared to the planted crop. The cutting height had no effect on grain yield, but exerted marked influence on the straw yield. In all the four varieties the duration of the ratoon crop was shorter than that of the planted crop.

Bahar and De Datta (1977) reported that, of six IRRI varieties and lines grown as ratoon crop, IR 28, IR 2061 and IR 632-3-1 produced the highest yields and took 73 and 57 days respectively to mature. Mahadevappa (1979) revealed that the grain yields obtained from the ratoon crop ranged from 6 to 140 per cent of the main crop yield. When per hectare yield of the main crop varied from 0.8 to 7.5 t ha^{-1}, the respective ratoon crop yields ranged from 0.1 to 8.7 t ha^{-1}. The average yields of the main crop and ratoon crop were 3.7 and 2.1 t ha^{-1}, respectively, the latter being 58 per cent of the former.

The good ratooning ability of the variety Intan at the Agricultural Research station, Madikeri, Karnataka led to its uses in a preliminary study of rice ratoon patterns in 1976. The plant crop or main wet season crop matured in 166 days. It was harvested on 30^{th} January and yielded 2.2 t ha^{-1}. In the same area a ratoon crop of the same variety was grown without additional fertilizer and with only natural seepage and residual water. It yielded 1.7 t ha^{-1} in 109 days (Reddy *et al.*, 1979).

Some cultivars with longer growth duration have better ratooning ability. Cultivars with intermediate to late maturity produce higher yields than those with early maturity. A ratoon crop of late maturing IR 42 yielded significantly more than early maturing IR 36 and medium maturing IR 38 (Sompaew, 1979).

Zandstra and Samson (1979) indicated that high ratoon yields may require selection of varieties that have crop durations longer than 170 days and ratoons of very early maturing varieties may not be promising. But of late, early maturing varieties with high ratoonability have been bred and released for commercial cultivation.

Ratooning is an important means of intensifying the production of graminaceous crops at low cost. In a preliminary investigation, ratooning of the transplanted wet season rice varieties of early to medium duration, harvested in September gave rice yields of 0.2 to 1.0 t ha^{-1} without any care and without any cultural operations after the main crop. In the ratoon crop the number of panicles per hill and number of filled spikelets per panicle and test weight of the grains were reduced. Many tillers could not exert their panicles beyond the flag leaf due to low temperature in December (Chatterjee *et al.*, 1982).

The ratooning ability of 57 hybrids and five standard varieties was evaluated in the 1983 dry season at IRRI. Fourteen hybrids and the variety IR 56 performed consistently well. The hybrid IR 19657-34-2-2-3-3A/IR 36 showed the highest regeneration and had the most tillers and panicles per m^2. Selecting parents with good ratooning ability is suggested for hybrid rice breeding programmes (Chauhan *et al.*, 1983).

Twenty rice varieties were grown at Pattambi during the 1981 Kharif season by Karunakaram *et al.* (1983). The main crop was harvested to leave 15 cm tall stubble and entries were then assessed for ratoon performance. Main crop grain yields varied from 3.2 to 4.9 t ha^{-1} while ratoon crop yields varied from 0.1 to 0.5 t ha^{-1}.

Hou (1984) in a study of ten varieties noted that there was a positive correlation at harvest between ratooning ability and the content of total non structural carbohydrates in the stem bases.

Ratooning ability of seven rice cultivars was determined in field trials carried out in calcareous silt loam in 1979. C 8585 and NC 1626 ratoons yielded 32 and 24 per cent respectively of the main crop yield of 3.5 and 4.1 t ha^{-1}. Cultivar NC 1626 yielded higher when the yields of the main and ratoon crops were combined. The ratoon crop was 25 per cent shorter than main crop. The panicle bearing shoots $hill^{-1}$ of the ratoon was positively correlated with that of the main crop. The ratoon crop had lower grain weight than the main crop and matured 70 days earlier (Singh *et al.*, 1984)

Reddy (1985) evaluated 135 varieties and six high yielding improved varieties in two separate experiments. Yields ranged from 0-2.05 t ha^{-1} for the ratoon crop. Main crop yield and ratoon crop duration showed a significant correlation with ratoon yield. Ratoon crop duration ranged from 20-80 days. The higher ratoon yield was obtained in 66 days.

Chauhan *et al.* (1986) evaluated 118 entries for ratooning ability in an unreplicated trial. Main crop flowering, maturity and height varied substantially. In ratoon crop within a variety, many hills did not produce ratoon tillers. Palchamy (1986) studied rice varieties 'Bhavani' and 'Vaigai' sown at the end of June matured in 133 and 107 days and gave paddy yields of 8 and 6.5 t ha^{-1}, respectively. Their ratoon crops matured in 70 and 76 days producing yields of 3.29 and 4.85 t ha^{-1} respectively. Sixteen rice hybrids were planted by Rao and Shivashankar (1986) and reported that hybrids had greater regeneration capacity than varieties.

Reddy *et al.* (1986) conducted two field experiments, one for testing 45 genotypes for their ratoonability and the other for assessing a set of 25 genotypes for their performance in the main and ratoon crop during the wet and dry seasons of 1980-81. Eighteen cultures showed good regrowing ability in the ratoon crop. Two cultures viz. Intan and Mingolo performed better than others when ratooned.

In a field trial, 17 inbred lines selected for irrigated cultivation from advanced trials of a breeding programme, the grain yield of the ratoon crop was 2244 to 3403 kg ha^{-1}. Ratoon crop plants of all lines were shorter than directly sown plants and their growth cycle was shorter ranging from 64 to 78 days (Santos *et al.*, 1986).

Prakash and Prakash (1987) identified main crop grain yield, number of regenerated tillers and number of panicles rationed $plant^{-1}$ as suitable criteria for selecting genotypes with good ratoon yield.

Ten out of 24 breeding lines showed ability to ratoon. Ratoon ability varied from 59.4-94.9 per cent and ratoon growth duration from 49 to 61 days being 38.47 per cent of the main crop duration. Ratoon grain yield ranged from 0.8-1.7 t ha^{-1} and was 36-71 per cent of main crop yield. Reduction in ratoon grain yield resulted primarily from smaller and fewer panicles than main crop (Singh *et al.*, 1987).

Bene (1988) showed that ratoon harvested date was negatively correlated with main crop harvest date, and positively correlated with main crop flowering date, panicle length and grains $panicle^{-1}$. The number of non flowering tillers $hill^{-1}$ was closely correlated with tiller and panicle indices of the ratoon crop.

Bollich *et al.* (1988) reported ratoon crop yield independent of crop yield. Carbohydrate reserves in the culm at maturity generally had a positive but low relationship with ratoon crop yield. In a study of 24 advanced photoperiod-insensitive summer rice genotypes rationed by cutting the stems 15 cms above the ground, only ten showed regeneration (Chauhan *et al.*, 1988). RP1664-466-693-1333 had the greatest ratooning ability with 94.9 per cent hill regeneration, and the highest ratoon grain yield (1.7t/ha). Ratoon growth duration varied from 49 to 61 days and productivity per day of the ratoon crop was comparable to that of the main crop.

Karunakaran *et al.* (1988) tested positive potential for rice ratooning in different areas of Kerala. The system of rice cultivation known locally as koottumundakan practiced in Kerala resembles ratooning. Field trials showed that the best ratoon yields (up to 1.6 t ha^{-1}) were obtained from long duration (140-160 d) cultivars.

Studies made by Mahadevappa *et al.* (1988) showed that varieties differ widely in ratooning ability, type of tillers produced, growth period duration, grain quality and yield.

Grain yield in main and ratoon crops and growth duration were assessed by Palchamy and Purushothaman (1988). Ratoon yields ranged from 0.43 t ha^{-1} (cv. Ponni) to 2.2 t ha^{-1} (cv. Bhavani) the latter being 86.6 per cent of the main crop yield. Ratoon crop duration ranged from 66 to 88 days. No significant correlation was established between ratoon crop yield and crop duration.

Singh (1988) showed that number of panicle bearing shoots $hill^{-1}$ of the ratoon crop was positively correlated with that of main crop. The reduction in number of ripened grains $panicle^{-1}$ of the ratoon crop was greater (20-26%) than panicle length reduction (8-11%). The ratoon crop matured 70 days earlier and had lower grain weight than the main crop.

Main crop stubble carbohydrate content and ratoon grain yields were measured in six genotypes by Arumugachamy *et al.* (1990) IET 7552 and Bhavani had the highest ratoon grain yields (15.1 and 14.4 g 10^{-1} plants respectively). The effect of stubble carbohydrate content on ratoon yield was not significant.

Palchamy *et al.* (1990) when assessed, Bhavani among three varieties had a significantly higher ratoon grain yield and stubble carbohydrate content than Ponni and IR 20. Herbage yield was highly correlated with ratooning ability and herbage weight per ratoon hill Kupkanchanakul *et al.* (1991).

Mathew *et al.* (1992) in a field study at Pattambi, tested 15 rice cultivars for ratooning ability. Of these eight showed potential for ratooning, producing ratoon grain yields in the range 621-1523 kg ha^{-1}. The longest duration 151 days cultivars produced the highest yields of more than 1000 kg. Arumugachamy *et al.* (1993) reported that in rice, the plant crop traits like plant height, panicle length and grain number $panicle^{-1}$ had positive and significant correlation with ratoon yields. Selection based on grain number $panicle^{-1}$ and days to 50 per cent flowering could be effective since they showed high direct and indirect effect on ratoon yields.

Turner and Jund (1993) illustrated a moderate positive correlation between ratoon yields and total non structural carbohydrates in culm and leaves in main crop. Main crop plants with elevated total non structural carbohydrates levels produced ratoon yields upto 5.3 t ha^{-1} averaging 48 and 33 per cent higher than plants with low total nonstructural carbohydrate at main crop harvest.

Nadaf *et al.* (1994) expressed ratooning ability as the ratio of ratoon tillers to main crop tillers. Information on genetic variability, heritability and genetic advance for yield and its components is derived from data on 12 characters in 102 genotypes by Wali and Mahadevappa (1995). Heritability estimates were high for plant height, maturity, regeneration percentage and number of plants regenerated, but low for grain yield and ratooning ability. High heritability coupled with high genetic advance were observed for plant height and regeneration percentage. Yoshida and Hozono (1995) reported that ratoon crop produced about 30 per cent of the gross yield of the parent crop.

Ratooning in rice enabled a second smaller crop to be taken without the necessary planting a new crop. Methods of increasing the yield of ratoon rice to give it a greater advantage were discussed by Jiang and Jiang (1996). Zheng and Zhang (1996) showed that development period is very short for ratoon rice with rapid production of panicles. In the ratoon crop panicle production took as little as

25-30 days. Yield was related to the number of tillers produced, the grain number panicle^{-1}, the proportion of effective panicles and the 1000 grain weight. Yields were lower than from the main crop.

Liang *et al.* (1997) noted that panicle number in the first and ratoon crop was considered to have the most effect on yield. Shi and Shi (1997) reported benefits of ratoon cultivation in rice and the increased use of the technique. In trials in 1992-96 yields of the main crop of rice yields were 7.60-9.46 t ha^{-1} and the ratoon crop yielded 3.1-6.2 t ha^{-1}.

Materials and Methods

MATERIALS AND METHODS

The present study was conducted in the Department of Plant Breeding and Genetics, College of Horticulture, Vellanikkara during the period 1999-2000. The field experiment was laid out at Agricultural Research Station, Mannuthy of Kerala Agricultural University during Kharif 1999-2000. The area is located at an altitude of 1.5 m above mean sea level and falls between 10°32' N latitude and 76°10' E longitude. The soil is laterite loam and geographically it falls in the warm humid tropical climatic zone.

Fifty rice genotypes comprising of local strains, high yielding varieties and elite breeding lines formed the experimental material for the study. Details of the genotypes are presented in Table 1.

Details of experiments carried out in the present investigation are given below:

3.1 Evaluation of main crop

The experiment was laid out with 50 genotypes in randomized block designing (RBD) with three replications adopting a spacing of 20x15 cm and plot size of 3.75 m^2 (Plate 1). Package of practice recommendations of Kerala Agricultural University (KAU, 1996) were adopted for raising the crop. Need based plant protection measures were adopted to control pests and diseases. The main crop was harvested at the time of physiological maturity, leaving stubble height of 30 cm. Observations on different morphological, physiological and anatomical characters as listed below were recorded.

The observations were recorded from five plants in each replication selected randomly from the middle row and the mean worked out.

Table 1. Details of the rice genotypes used in the experiment

Sl. No.	Variety	Parentage
1	CO 43	Dasal/IR 20
2	CORH 2	IR 58025A/C20R
3	ADT 36	Triveni/IR 20
4	Ponmani	Pankaj/Jaganath
5	ADT 43	IR 50/Improved White Ponni
6	White Ponni	Taichung 85/Mayang Ebos
7	ADT 38	IR 1529-680-3-2/IR 4432-52-6-4/IR 7963-30-2
8	ASD 20	IR 18348-38-3/IR 25863-61-3-2//IR58
9	IR 8	Dee-geo-woo-gen/Peta
10	IR 20	IR 262/TKM 6
11	IR 36	IR 1561//IR244/*O.nivara*///CR 94-13
12	IR 64	IR 5657-33-2-1/IR2061-465-1-5-3
13	Ptb 1	PLS from Aryan
14	Ptb 2	PLS from Ponnaryan
15	Ptb 8	PLS from Veluthanthavalakkannan
16	Ptb 10	PLS from Thekkancheera
17	Ptb 26	PLS from Chenkayama
18	Ptb 28	PLS from Kattamodan
19	Ptb 39/ Jyothi	Ptb 10/IR 8
20	Ptb 41/Bharathi	Ptb 10/IR 8
21	Ptb 43/Swarnaprabha	Bhavani/Triveni
22	Ptb 46/Jayathi	Triveni/IR 2061
23	Ptb 47/Neeraja	IR 20/IR 5
24	Ptb 49/Kairali	IR 36/Jyothi
25	Ptb 51/Aathira	Br 51-46-1/Cul 2332-2
26	Ptb 52/Aiswrya	Jyothi/Br 51-46-1
27	Mangala Mahsuri	Reselection from Mahsuri
28	M 38-4-2	MO 4/Cul. 25331
29	M 38-4-1	MO 4/Cul. 25331
30	M 48-11-3	Thonnuran/IR 8
31	M 61-6-1-1	Pothana/MO 5
32	Jaya	TN 1/T 141
33	Ahalya	(Ptb 10 /TN 1)/TN 1
34	Pankaj	Peta/Tongai Rotan
35	MO 4/Bhadra	IR 8/Ptb 20
36	MO 5/Asha	IR 11/Kochuvithu
37	MO 6/Pavizham	IR 8/Kanivennel
38	MO 7/Karthika	Triveni/IR 15-39
39	MO 8/Aruna	Jaya/Ptb 33
40	MO 9/Makom	ARC-6650/Jaya

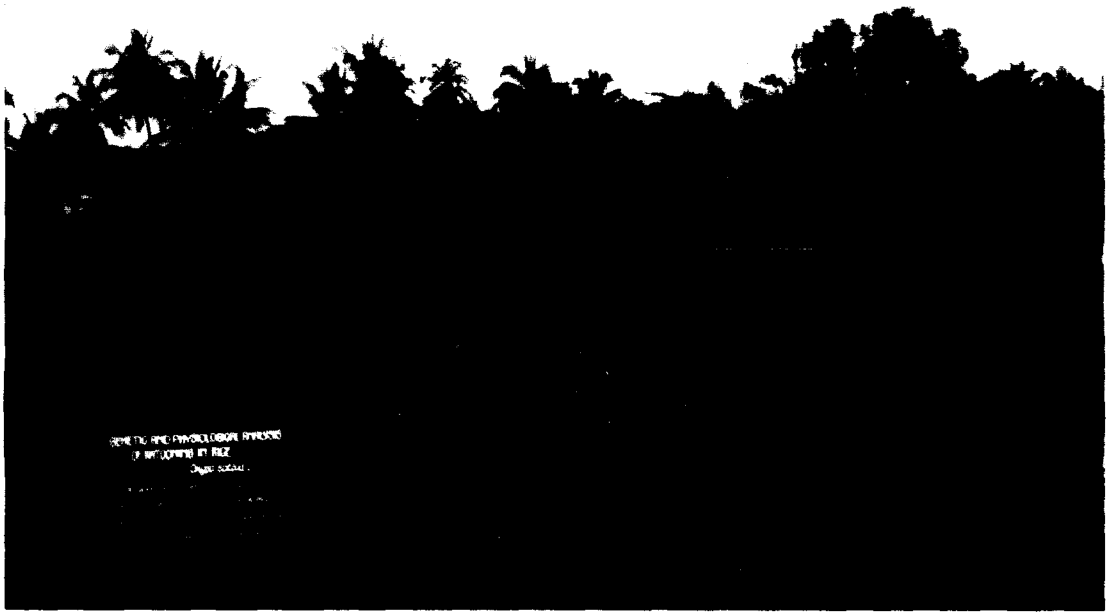


Plate 1. Plot view of the main crop

1. Total number of tillers

Total number of tillers present in each hill was counted at the time of active tillering, panicle initiation and flowering which included both bearing and non bearing tillers.

2. Leaf area index (LAI)

The length and maximum width of all the leaves of the middle tiller was measured and the corresponding area was calculated for each leaf using the formula (Watson, 1947).

leaf area = k.l.b.

where,

k = 0.75 and 0.65 respectively during seedling stage and maturity

l and b are length and maximum width of individual leaf

Area of all the leaves of this tiller was added to get leaf area of the tiller.

Total leaf area of the plant was calculated by multiplying leaf area of the middle tiller by number of tillers $plant^{-1}$ and leaf area indices during active tillering, panicle initiation and flowering were calculated using the formula.

$$LAI = \frac{\text{Sum of leaf area of six hills (cm}^2\text{)}}{\text{Area of land covered by six hills (cm}^2\text{)}}$$

3. Chlorophyll content

Chlorophyll a and b during active tillering, panicle initiation and flowering were estimated in $mg\ g^{-1}$ using method suggested by Arnon (1949) given by the formulae

$$\text{Chlorophyll a} = (12.7 \times OD\ 663 - 2.69 \times OD\ 645)\ \frac{V}{W \times 1000}$$

$$\text{Chlorophyll b} = (22.9 \times OD\ 645 - 4.68 \times OD\ 663)\ \frac{V}{W \times 1000}$$

where

OD 663 and OD 645 are absorbance at 663 and 645 nm wavelength respectively

V = Volume W = Weight of leaf sample

4. Carbohydrate content

Carbohydrate content was estimated using phenol-sulfuric acid method suggested by Sadasivam and Manickam (1992).

5. Anatomical studies of leaf and culm

Anatomical studies of leaf and culm was made by taking the cross sections. The observations were recorded in terms of number of vascular bundles under the high power of an ordinary light microscope.

6. Days to flowering

Number of days were counted from sowing to the day when 50 per cent of the plants in the plot started flowering.

7. Days to harvest

Number of days were counted from sowing to the maturity of the crop.

8. Days taken for completion of flowering within a hill

Number of days were counted from the 1^{st} day of flowering till its completion within a hill, including all the bearing tillers.

9. Plan height

Height of the plants were measured in centimeters from the surface of the soil to the tip of the longest panicle at the time of harvest.

10. Number of productive tillers plant^{-1}

Number of panicle bearing tillers were counted.

11. Number of unproductive tillers plant^{-1}

Number of non panicle bearing tillers were counted.

12. Flag leaf area

Area of flag leaf was calculated by measuring length and maximum width of the flag leaf and using the formula, k.l.b. where k = 0.65 (the constant used at maturity state), l = length of flag leaf, b = maximum width of flag leaf.

13. Leaf area duration (LAD)

LAD can be calculated by using the formula suggested by Radford (1967).

$$LAD = \frac{LAI_1 + LAI_2}{2} \times (t_2 - t_1)$$

LAI_1 = LAI during panicle initiation

LAI_2 = LAI during flowering

t_2-t_1 = Time interval between the two indices

14. Panicle length

Length of the main panicle was measured in centimeters from the panicle base to the tip of the topmost spikelet.

15. Grain panicle^{-1}

The number of grains in the main panicle was counted.

16. Chaff percentage

The number of chaffy grains expressed over the total number of grains in the main panicle.

17. 1000 grain weight

Thousand well filled whole grains were selected randomly from each plot and weight was recorded in grams.

18. Grain density

Volume of 100 g of seed was measured by water displacement method and expressed as g per 100 ml.

19. Grain length

Length of five grains randomly selected from the main panicle was measured in millimeters from the base of the lower most sterile lemma to the tip of the fertile lemma or palea.

20. Grain breadth

The distance across the fertile lemma and the palea at the widest point was measured in millimeters from five randomly selected grains in the main panicle.

21. Grain thickness

Thickness of five randomly selected grains in the main panicle was measured and expressed in millimeters.

22. Straw yield

Straw yield in kg plot^{-1} was recorded.

23. Harvest index

The proportion of economic yield was represented over biological yield, using the formula (Donald and Hamblin, 1976).

$$\frac{\text{Economic yield (Grain yield)}}{\text{Biological yield (Grain + Straw yield)}}$$

24. Reaction to pests and diseases

Incidence of pests and diseases were also noted from each plot.

25. Grain yield

Grain yield in kg plot^{-1} was recorded.

26. Grain production day^{-1}

Calculated using the formula

$$\frac{\text{Grain yield in kg plot}^{-1}}{\text{Number of days to harvest}}$$

and expressed as kg day^{-1} plot^{-1}.

27. Tiller decline percentage

Decline in the total number of tillers from panicle initiation stage to the harvesting stage, expressed as percentage over the number of tillers during panicle initiation stage.

3.2 Evaluation of ratoon crop

Stubbles left over after the harvest of main crop were allowed to regenerate. Fertilizer @ one-fourth of the main crop recommendation were applied to the ratoon crop two days after the harvest of the main crop. Performance of the ratoon crop was studied. For all the characters for which main crop was evaluated. Additionally, the following observations were recorded from ratoon crop. Performance of different genotypes in the ratoon crop are shown in Plate 2a and b.

1. Tiller regeneration

The number of tillers regenerated in each hill was recorded one week after harvest of main crop.

2. Days from harvest to visual panicle initiation

Number of days were counted from the day of harvest of the main crop to the day of visual panicle initiation in the ratoon crop.

3. Ratooning ability

Proportion of tiller regeneration was expressed over the total number of tillers in the main crop at the time of harvest, given by the formula (Nadaf *et al.*, 1994).

$$\frac{\text{Number of regenerated tillers}}{\text{Total number of tillers in the main crop}}$$

4. Total yield

Sum of the grain yield obtained from both the main and ratoon crop was expressed as kg plot^{-1}.

3.3 Statistical analysis

The data were subjected to the following statistical analysis.

Plate 2a. Plot view of the ratoon crop (Pankaj, Mangala Mahsuri and Neeraja)

Plate 2b. Plot view of the ratoon crop (Ponmani, IR 20)

3.3.1 Estimation of selection parameters

3.3.1.1 Components of heritable variation

a) Variability

Variability existing in the various characters under observation was estimated as per procedure suggested by Burton (1952). The estimates of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were classified as

less than 10 per cent	= low
10-20 per cent	= moderate
> 20 per cent	= high

b) Heritability

Heritability in the broadsense was calculated according to the programme suggested by Hanson *et al.* (1956).

The heritability was categorised as

60-100 per cent	= high
30-60 per cent	= moderate
< 30 per cent	= low

c) Genetic advance

The expected genetic advance under selection was estimated by the formula suggested by Johanson *et al.* (1955).

d) Genetic gain

Expected genetic gain under selection was calculated by the formula suggested by Johanson *et al.* (1955).

Genetic gain was categorised as

> 20 per cent	= high
10-20 per cent	= moderate
< 10 per cent	= low

e) Genotypic and phenotypic correlation

Genotypic and phenotypic correlation coefficients between yield and various yield components and among themselves were estimated (Rangaswamy, 1995).

f) Direct and indirect effects of yield attributes on yield through path analysis

Path coefficient analysis suggested by Wright (1923) was applied to study the cause and effect relationship of yield and yield attributes.

g) Evolving a selection index using discriminant function

For selecting suitable genotypes from a highly heterogeneous mass population, the selection should always be based on the minimum number of characters. An estimation of discriminant function based on most reliable and effective character is a valuable tool for rice breeders. Thus discriminant function would ensure a maximum concentration of the desired genes in the plants or in the lines selected (Hazel, 1943).

Results

RESULTS

Fifty rice genotypes were evaluated for various morphological, physiological and anatomical characters. Data were subjected to statistical analysis and the results are presented in this chapter.

4.1 Evaluation of main crop

4.1.1 Genetic variability

In the present study the extent of genetic variability with respect to quantitative and qualitative characters in a set of 50 rice genotypes was estimated.

Abstract of analysis of variance of the characters is given in Appendix I. Results from analysis of variance revealed highly significant differences among the 50 genotypes for all the characters studied except chlorophyll a content during flowering. The range, mean and standard error of mean for the different characters are shown in Table 2. The genotypes showed a large range of variation for all the characters studied.

Mean performance of the 50 genotypes for plant characters viz. plant height, days to flowering, number of productive tillers plant^{-1} and tiller decline percentage are presented in Table 3. Plant height of the genotypes ranged from 78.67 (CO 43) to 153.93 cm (Ptb 1), average being 98 cm. Ahalya with a flowering duration of 77 days was the earliest among the genotypes and Ponmani which took 133 days for flowering was the latest among them. Flowering duration recorded an average of 105.95 days. ADT 38 completed flowering within a hill by 17 days but Ptb 8, ADT 43 and Ptb 26 by 5 days. Range for this character was 5 to 17 days average being 9 days. Number of productive tillers plant^{-1} varied from 5 to 10 with a mean value of 7.33. Ptb 10 and MO 4 recorded the highest value for this character. Varieties such as Ptb 8, Ptb 10 and Ptb 28 did not exhibit any decline in the total number of tillers produced by them.

Table 2. Mean and range for different characters studied (Main crop)

Character (unit)	Mean ± SEM	Range
Total no. of tillers (active tillering)	6.65± 0.646	5-9
Total no. of tillers (panicle initiation)	10.00 ± 0.737	7-16
Total no. of tillers (flowering)	8.91 ± 0.640	6-12
LAI (active tillering)	2.26± 0.324	1.41-3.44
LAI (panicle initiation)	7.13 ± 0.910	4.42-10.86
LAI (flowering)	4.91 ± 0.732	3.03-7.76
Chlorophyll a (active tillering) (mg g^{-1})	1.41 ± 0.125	1.13-1.69
Chlorophyll b (active tillering) (mg g^{-1})	0.61 ± 0.039	0.48-0.76
Chlorophyll a (panicle initiation) (mg g^{-1})	1.78 ± 0.136	1.47-2.39
Chlorophyll b (panicle initiation) (mg g^{-1})	0.75 ± 0.066	0.56-0.92
Chlorophyll a (flowering) (mg g^{-1})	1.06 ± 0.119	0.77-1.36
Chlorophyll b (flowering) (mg g^{-1})	0.47 ± 0.055	0.31-0.72
Days to flowering	105.95 ± 0.614	77-133
Daya taken for completion of flowering within a hill	9.00 ± 0.514	5-17
Plant height (cm)	98.00 ± 4.203	78.67-153.93
No. of productive tillers $plant^{-1}$	7.33± 0.599	5-10
Flag leaf area (cm^2)	31.18 ± 2.533	15.92-63.67
Leaf area duration (days)	145.08 ± 0.646	84.26-264.21
Panicle length (cm)	23.83 ± 0.688	19.29-29.4
Grains $panicle^{-1}$	153.69 ± 11.096	107-206
Chaff (%)	20.78 ± 4.148	5.64-42.98
1000 grain weight (g)	25.82 ± 0.749	17.8-32.1
Grain density (g ml^{-1})	1.03 ± 0.029	0.94-1.10
Grain length (mm)	8.38 ± 0.225	7.32-10.25
Grain breadth (mm)	2.94 ± 0.083	2.27-3.24
Grain thickness (mm)	2.11 ± 0.059	1.70-2.37
Straw yield (kg ha^{-1})	8912±1215	5511-21160
Harvest index	0.46±0.022	0.25-0.59
Grain yield (kg ha^{-1})	7005±322.70	5293-8537
Grain production day^{-1} (kg day^{-1})	0.019 ± 0.001	0.013-0.023

Table 3. Mean performance of 50 rice genotypes for different plant characters (Main crop)

Sl. No.	Variety	Plant height (cm)	Days to flowering	Days taken for completion of flowering within a hill	No. of productive tillers $plant^{-1}$	Tiller decline (%)
1	CO43	78.67	127	8	7	44.42
2	CORH2	87.07	99	7	6	46.67
3	ADT36	85.53	100	8	9	7.44
4	ADT38	106.73	111	17	9	21.18
5	ADT43	84.80	78	5	8	21.18
6	Ponmani	84.53	133	7	7	29.67
7	White Ponni	131.10	114	9	6	45.45
8	ASD20	84.27	92	9	9	22.25
9.	IR8	89.33	96	9	7	26.67
10	IR20	81.90	128	9	7	33.33
11	IR36	99.13	97	7	9	13.33
12	IR64	92.20	101	7	8	38.27
13	Ptb1	153.93	115	7	7	25.89
14	Ptb2	146.27	110	9	7	22.22
15	Ptb8	131.80	96	5	9	0.00
16	Ptb10	137.60	109	9	10	0.00
17	Ptb26	132.13	96	5	6	16.63
18	Ptb28	129.13	78	6	8	0.00
19	Jyothi	87.60	95	8	7	33.36
20	Bharathi	86.47	100	9	6	25.00
21	Swarnaprabha	135.67	97	7	6	29.13
22	Jayathi	95.27	95	8	7	18.52
23	Neeraja	97.73	119	7	6	37.00
24	Kairali	81.87	96	7	9	22.25
25	Aathira	109.67	111	7	6	29.13
26	Aiswara	103.07	96	7	8	20.00
27	Mangala Mahsuri	116.93	114	9	8	23.33
28	Jaya	83.93	109	9	7	30.00
29	Pankaj	98.93	124	7	5	50.00
30	Ahalya	86.73	77	7	8	14.78
31	M 38-4- -2	86.93	108	9	8	21.18
32	M 38-4 –1	88.73	106	8	8	18.52
33	M 48-11-3	99.60	116	10	7	38.92

34	M 61-6-1-1	93.60	110	11	9	16.67
35	MO 4	82.60	115	11	10	37.50
36	MO 5	80.87	109	13	6	33.33
37	MO 6	90.33	109	12	8	16.67
38	MO 7	95.53	111	8	8	26.67
39	MO 8	94.53	107	11	6	43.33
40	MO 9	85.23	99	7	8	27.27
41	MO 10	88.67	113	12	7	33.33
42	MO 11	93.93	109	11	6	25.00
43	MO 12	84.40	112	9	6	25.89
44	MO 13	84.47	108	12	6	33.33
45	MO 14	85.33	111	10	8	27.27
46	MO 15	90.40	105	12	7	26.67
47	MO 16	90.53	115	9	8	11.11
48	MO 17	85.47	110	12	6	40.00
49	MO 18	93.60	109	15	7	38.92
50	MO 19	85.27	109	10	6	40.00

Among the earhead characters earhead length showed a range of 19.29 to 29.4 cm, average being 23.83 cm. Ptb 1, Ptb 10 and Ptb 28 were having the longest panicles. Grains panicle^{-1} and chaff per cent varied from 107 to 206 and from 5.64 to 42.98 respectively and their means were 153.69 and 20.78 respectively. Mangala Mahsuri and Swarnaprabha had highest number of grains panicle^{-1}. Lowest chaff percentage was shown by White Ponni, while highest by MO 8 (Table 4).

With respect to grain characters 1000 grain weight ranged from 17.8 to 32.1 g with an average of 25.82 g and ptb 28 had the highest value. Grain density varied from 0.94 to 1.10 g ml^{-1}, average being 1.03 g ml^{-1}. Ptb 28, MO 5 and ASD 20 showed the highest value for the character. Other characters namely grain length, grain breadth and grain thickness varied from 7.32 to 10.25, 2.27 to 3.24 and 1.70 to 2.37 mm with averages of 8.38, 2.94 and 2.11 mm respectively. Bharathi and ASD 20 had long grains, wider grains for Ptb 28, MO 5 and MO 12, while MO 12 and Ahalya had thicker grains (Table 5). Physiological characters such as LAI at active tillering, panicle initiation and flowering ranged from 1.41 to 3.44, 4.42 to 10.86 and 3.03 to 7.76, averages being 2.26, 7.13 and 4.91 respectively. The genotypes namely Ptb 10, White Ponni, Pankaj, Ptb 1, IR 20 and Aathira showed high values for the character. Leaf area duration showed a range of 84.26 to 264.2 days and had an average of 145.08 days.

Flag leaf area varied from 15.92 to 63.67 cm^2, mean being 31.18 cm^2. Ahalya showed the highest flag leaf area, followed by Ptb 26 and Ptb 28. Chlorophyll a content during active tillering, panicle initiation and flowering varied from 1.13 to 1.69, 1.47 to 2.39 and 0.77 to 1.36 mg g^{-1}, with mean values being 1.41, 1.78 and 1.06 mg g^{-1} respectively. Ptb 28, Jyothi, Ptb 10, MO 10 and MO 18 reported high chlorophyl a content during different stages of growth. Chlorophyll b contents were high for Jyothi, M 38-4-2, Ptb 10 and Jayathi during the above mentioned stages. This character ranged from 0.48 to 0.76, 0.56 to 0.92 and 0.31 to 0.72 mg g^{-1} at active tillering, panicle initiation and flowering with

Table 4. Mean performance of 50 rice genotypes for different earhead characters (Main crop)

Sl. No.	Variety	Earhead length (cm)	Grains panicle^{-1}	Chaff %
1	CO43	20.17	118	13.73
2	CORH2	24.42	202	23.28
3	ADT36	23.84	154	12.62
4	ADT38	24.65	149	19.38
5	ADT43	23.82	167	19.97
6	Ponmani	23.19	173	26.19
7	White Ponni	22.59	200	5.640
8	ASD20	25.61	113	13.33
9	IR8	26.25	139	15.38
10	IR20	22.74	176	14.18
11	IR36	24.83	133	11.72
12	IR64	23.72	107	14.32
13	Ptb1	29.35	133	18.19
14	Ptb2	27.75	133	18.81
15	Ptb8	24.79	191	15.05
16	Ptb10	29.40	137	34.40
17	Ptb26	28.26	194	20.77
18	Ptb28	29.10	146	17.49
19	Jyothi	22.19	134	11.32
20	Bharathi	22.92	146	22.70
21	Swarnaprabha	28.47	204	33.03
22	Jayathi	27.52	175	22.28
23	Neeraja	25.52	137	10.23
24	Kairali	22.12	141	16.49
25	Aathira	25.96	182	16.22
26	Aiswara	22.55	131	16.31
27	Mangala Mahsuri	24.22	206	10.28
28	Jaya	24.30	151	22.73
29	Pankaj	21.81	170	23.82
30	Ahalya	22.97	153	24.81
31	M 38-4- -2	22.21	141	16.74
32	M 38-4 –1	22.90	162	22.25
33	M 48-11-3	21.91	178	24.23
34	M 61-6-1-1	21.97	152	22.34
35	MO 4	19.29	107	32.48
36	MO 5	23.85	114	16.26
37	MO 6	22.53	155	17.22
38	MO 7	23.19	147	27.49

39	MO 8	24.61	145	42.98
40	MO 9	22.19	153	16.04
41	MO 10	23.95	150	33.42
42	MO 11	23.60	174	28.39
43	MO 12	21.91	116	32.48
44	MO 13	21.64	159	19.62
45	MO 14	22.53	146	22.00
46	MO 15	21.14	164	14.69
47	MO 16	21.34	169	21.41
48	MO 17	21.28	139	24.67
49	MO 18	21.88	143	33.14
50	MO 19	21.44	176	26.54

Table 5. Mean performance of 50 rice genotypes for different grain characters (Main crop)

Sl. No.	Variety	1000grain weight (g)	Grain density (g ml^{-1})	Grain length (mm)	Grain breadth (mm)	Grain thick-ness (mm)
1	CO43	19.77	1.023	8.01	3.02	2.11
2	CORH2	25.47	1.027	8.42	2.88	2.11
3	ADT36	22.53	1.000	8.60	2.64	1.95
4	ADT38	20.97	0.936	8.28	2.34	2.03
5	ADT43	17.93	1.047	8.29	2.27	1.87
6	Ponmani	23.67	0.951	7.32	3.17	2.26
7	White Ponni	17.80	1.023	7.74	2.66	1.95
8	ASD20	24.47	1.097	10.01	2.62	2.09
9	IR8	26.67	1.073	8.39	2.91	2.03
10	IR20	21.63	1.053	8.43	3.10	2.09
11	IR36	24.80	1.047	8.81	2.49	1.99
12	IR64	28.80	1.003	9.91	2.40	2.03
13	Ptb1	27.80	0.980	8.46	3.10	2.07
14	Ptb2	28.93	0.970	8.72	3.15	2.09
15	Ptb8	24.83	1.070	7.47	2.92	2.08
16	Ptb10	26.70	1.047	8.75	3.16	2.14
17	PTB26	25.23	1.073	7.79	3.03	2.18
18	Ptb28	32.10	1.097	8.75	3.24	2.22
19	Jyothi	29.90	1.073	9.12	2.99	2.11
20	Bharathi	29.80	1.057	10.25	3.01	2.11
21	Swarnaprabha	30.17	1.027	9.24	2.94	2.04
22	Jayathi	23.73	1.000	8.19	2.86	2.03
23	Neeraja	23.50	1.023	8.89	2.61	1.96
24	Kairali	25.10	1.033	7.91	2.84	2.07
25	Aathira	27.53	1.000	8.42	2.97	2.09
26	Aiswara	29.27	1.047	9.09	2.99	2.09
27	Mangala Mahsuri	20.43	1.047	7.79	2.34	1.70
28	Jaya	29.30	1.047	8.82	3.04	2.16
29	Pankaj	23.47	1.047	7.92	2.96	2.12
30	Ahalya	27.97	1.003	8.15	3.11	2.30
31	M 38-4- -2	28.20	1.000	7.67	3.14	2.28
32	M 38-4 –1	28.77	1.047	8.13	3.08	2.11
33	M 48-11-3	26.67	0.980	7.32	3.13	2.13
34	M 61-6-1-1	26.30	1.070	7.62	3.04	2.15
35	MO 4	25.10	0.960	7.83	2.88	2.18
36	MO 5	31.17	1.097	9.44	3.21	2.26
37	MO 6	23.40	1.070	7.66	3.03	2.09
38	MO 7	27.87	1.023	9.02	2.91	2.09

39	MO 8	26.13	1.023	8.21	3.01	2.26
40	MO 9	25.20	1.047	8.46	2.90	2.04
41	MO 10	31.07	1.047	9.17	3.00	2.10
42	MO 11	26.90	1.000	8.25	3.05	2.22
43	MO 12	25.70	1.023	8.14	3.22	2.37
44	MO 13	27.47	1.047	7.78	3.15	2.20
45	MO 14	27.13	0.972	8.64	3.12	2.05
46	MO 15	23.70	1.047	7.33	3.01	2.10
47	MO 16	24.50	1.070	7.75	3.08	2.20
48	MO 17	23.17	1.047	8.81	2.90	2.11
49	MO 18	25.13	1.023	8.03	3.10	2.17
50	MO 19	26.93	1.047	7.77	3.10	2.17

averages being 0.61, 0.75 and 0.47 mg g^{-1} respectively. Anatomical character viz. number of vascular bundles observed per section ranged from 7 to 13, with an average of 10. Largest number of vascular bundles were observed for MO 17 and Jaya (Table 6).

Economic characters namely grain yield and straw yield varied from 5293 to 8537 kg ha^{-1} and from 5511 to 21160 kg ha^{-1} with averages being 7005 and 8912 kg ha^{-1} respectively. Straw yield was high for Ptb 1, while M-48-11-3 had the highest grain yield. Harvest index and grain production day^{-1} ranged from 0.25 to 0.59 and from 0.013 to 0.023 kg day^{-1}, with means 0.46 and 0.019 kg day^{-1} respectively. Aiswarya and Jyothi recorded the highest harvest index whereas Ptb 28, Aiswarya and Swarnaprabha showed the highest values for grain production day^{-1} (Table 7).

4.1.2 Phenotypic and genotypic coefficients of variation

The estimates of PCV, GCV, heritability, genetic advance and genetic gain are given in Table 8. Among the different characters studied LAI during flowering (35.22, 23.95), days taken for completion of flowering within a hill (27.58, 25.75), number of unproductive tillers $plant^{-1}$ (89.23, 55.10), flag leaf area (37.38, 34.63), plant height (20.42, 20.02), chaff percentage (45.99, 30.33) and straw yield (42.97, 35.89) recorded high magnitudes of PCV and GCV. But total number of tillers during active tillering (19.47, 10.81), panicle initiation (17.86, 12.49) and flowering (18.59, 13.81) days to flowering (11.06, 11.02), number of productive tillers $plant^{-1}$ (19.45, 13.33), panicle length (10.9, 10.0), grains $panicle^{-1}$ (19.42, 14.86), 1000 grain weight (13.25, 12.26) and harvest index (17.78, 15.67) showed moderate values. Low PCV and GCV values were observed for days to harvest, grain density, grain length, grain breadth and grain thickness.

With respect to characters, LAI during active tillering and panicle initiation, chlorophyll b (flowering) and leaf area duration high value of PCV and moderate GCV were reported. Chlorophyll contents during active tillering and

Table 6. Mean performance of 50 rice genotypes for different physiological and anatomical characters (Main crop)

Sl. No.	Variety	LAI (active tillering)	LAI (panicle initiation)	LAI (flowering)	Leaf Area Duration (Days)	Flag leaf area (cm^2)
1	CO43	2.55	8.96	7.02	239.70	25.01
2	CORH2	2.08	6.94	3.68	106.20	34.79
3	ADT36	1.83	5.28	3.45	87.26	32.13
4	ADT38	2.66	6.96	5.85	192.03	28.92
5	ADT43	2.27	6.27	3.81	100.82	33.31
6	Ponmani	1.96	5.85	3.25	136.47	22.82
7	White Ponni	3.20	9.36	7.57	211.63	32.26
8	ASD20	2.50	5.83	3.33	91.62	30.77
9	IR8	2.74	6.65	3.61	102.58	33.06
10	IR20	2.42	8.37	7.76	241.95	30.22
11	IR36	1.99	5.80	4.19	99.92	35.32
12	IR64	1.95	7.22	4.10	141.43	33.36
13	Ptb1	2.88	9.56	6.82	204.73	40.76
14	Ptb2	2.17	7.35	7.24	182.40	44.53
15	Ptb8	2.60	7.38	5.48	128.58	57.87
16	Ptb10	3.44	9.11	6.68	197.40	39.51
17	Ptb26	1.90	7.40	3.88	112.82	61.89
18	Ptb28	1.71	7.25	4.38	116.38	61.77
19	Jyothi	2.14	7.28	3.67	109.56	29.67
20	Bharathi	1.43	4.42	4.01	84.26	28.05
21	Swarnaprabha	2.05	6.97	3.59	105.58	47.07
22	Jayathi	2.26	7.30	3.03	103.30	34.31
23	Neeraja	2.36	8.35	5.64	174.95	22.36
24	Kairali	2.41	6.12	3.85	99.62	30.36
25	Aathira	2.82	7.92	7.59	193.95	39.52
26	Aiswara	1.82	6.61	3.92	105.36	32.56
27	Mangala Mahsuri	2.28	6.94	7.20	176.70	30.00
28	Jaya	2.30	6.96	5.86	160.30	23.33
29	Pankaj	3.01	10.87	6.75	264.21	23.64
30	Ahalya	2.24	8.29	4.45	127.36	63.67
31	M 38-4- -2	2.75	7.10	5.67	142.93	28.80
32	M 38-4 –1	2.30	7.36	6.28	170.45	26.46
33	M 48-11-3	2.33	8.81	6.42	179.13	25.98
34	M 61-6-1-1	2.00	7.14	5.59	159.08	22.08
35	MO 4	2.50	8.79	5.35	176.80	15.92
36	MO 5	1.84	6.16	5.08	140.45	27.04
37	MO 6	1.80	5.95	3.67	120.28	23.43

38	MO 7	1.41	6.49	3.28	122.20	22.73
39	MO 8	2.11	7.56	4.48	150.48	18.18
40	MO 9	2.21	5.79	4.08	123.33	26.17
41	MO 10	2.62	9.32	5.55	185.78	23.77
42	MO 11	2.20	5.95	4.47	130.20	24.71
43	MO 12	1.82	4.84	3.65	106.20	19.62
44	MO 13	1.89	5.55	3.74	116.13	25.31
45	MO 14	2.23	7.84	4.77	157.60	22.95
46	MO 15	1.94	5.70	3.83	119.08	29.74
47	MO 16	2.29	6.05	3.95	124.93	21.65
48	MO 17	1.65	5.41	3.46	110.83	20.77
49	MO 18	2.89	8.53	5.99	181.53	22.28
50	MO 19	2.50	6.41	4.59	137.55	28.46

Continued

Table 6. Continued

Chlorophyll a (active tillering) mg g^{-1}	Chlorophyll a (panicle initiation) mg g^{-1}	Chlorophyll a (flowering) mg g^{-1}	Chlorophyll b (active tillering) mg g^{-1}	Chlorophyll b (panicle initiation) mg g^{-1}	Chlorophyll b (flowering) mg g^{-1}	No.of vascular bundles $section^{-1}$
1.54	2.07	1.07	0.66	0.84	0.46	10
1.36	1.91	1.08	0.63	0.70	0.47	7
1.43	1.68	0.99	0.61	0.84	0.44	9
1.52	1.62	1.06	0.62	0.74	0.45	12
1.33	1.48	0.87	0.52	0.66	0.39	9
1.56	1.79	1.15	0.64	0.69	0.48	9
1.38	1.61	0.99	0.60	0.62	0.45	10
1.15	1.57	0.93	0.51	0.67	0.45	12
1.37	1.78	1.01	0.61	0.75	0.39	10
1.42	1.77	1.02	0.61	0.74	0.44	8
1.40	1.48	0.84	0.57	0.61	0.39	11
1.28	1.63	1.06	0.59	0.61	0.55	11
1.52	1.99	1.09	0.62	0.70	0.41	8
1.30	1.57	0.99	0.54	0.89	0.33	7
1.25	1.76	1.06	0.59	0.72	0.51	7
1.57	2.39	1.03	0.64	0.92	0.49	9
1.22	1.51	0.99	0.59	0.70	0.45	8
1.69	2.10	1.20	0.64	0.81	0.54	8
1.67	2.27	1.29	0.76	0.83	0.72	8
1.38	1.93	0.77	0.57	0.74	0.34	9
1.13	2.19	1.02	0.61	0.81	0.49	8
1.45	2.02	0.98	0.60	0.92	0.47	9
1.41	1.86	0.95	0.62	0.72	0.38	9
1.51	1.68	1.13	0.64	0.84	0.59	11
1.21	1.76	0.95	0.59	0.75	0.52	9
1.56	1.82	1.23	0.66	0.80	0.56	8
1.46	1.73	0.95	0.54	0.72	0.35	8
1.33	1.67	1.16	0.57	0.69	0.44	13
1.38	1.57	0.92	0.52	0.61	0.36	9
1.31	1.73	0.97	0.60	0.77	0.45	10
1.58	1.81	1.32	0.71	0.82	0.54	9
1.48	1.76	1.32	0.61	0.72	0.48	7
1.46	1.73	0.97	0.62	0.90	0.53	10
1.52	1.81	1.22	0.67	0.84	0.45	11
1.36	1.74	1.07	0.59	0.70	0.45	11
1.49	2.01	1.15	0.62	0.71	0.52	12
1.35	1.62	1.23	0.62	0.84	0.55	10
1.25	1.60	1.06	0.51	0.56	0.49	11
1.40	1.68	0.89	0.61	0.79	0.41	12
1.35	1.64	1.17	0.58	0.65	0.52	12
1.50	1.72	1.36	0.61	0.71	0.57	10
1.34	1.81	0.86	0.49	0.68	0.31	8
1.49	1.71	1.15	0.67	0.77	0.50	12
1.31	1.59	0.94	0.48	0.62	0.39	10
1.58	1.85	1.23	0.70	0.80	0.50	11
1.51	1.54	0.96	0.65	0.68	0.43	10
1.39	1.92	1.21	0.65	0.84	0.58	10
1.42	1.65	1.09	0.58	0.63	0.48	13
1.41	1.79	1.33	0.65	0.81	0.55	12
1.34	1.99	0.86	0.61	0.79	0.44	9

Table 7. Mean performance of 50 rice genotypes for different economic characters (Main crop)

Sl. No.	Variety	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index	Grain production day-^{1}(kg day^{-1})
1	CO43	7578	5867	0.56	0.016
2	CORH2	6857	7956	0.47	0.020
3	ADT36	6518	5689	0.53	0.019
4	ADT38	8372	11290	0.43	0.022
5	ADT43	6314	7872	0.45	0.020
6	Ponmani	7600	8800	0.47	0.016
7	White Ponni	6570	16620	0.29	0.017
8	ASD20	6990	8400	0.46	0.020
9	IR8	7411	6311	0.54	0.020
10	IR20	5880	7378	0.44	0.013
11	IR36	6689	8444	0.44	0.018
12	IR64	7169	7111	0.51	0.019
13	Ptb1	6999	21160	0.25	0.019
14	Ptb2	7652	16810	0.32	0.020
15	Ptb8	6617	8824	0.43	0.021
16	Ptb10	6069	19550	0.26	0.016
17	Ptb26	7147	6667	0.52	0.021
18	Ptb28	7251	6533	0.52	0.023
19	Jyothi	7229	5511	0.57	0.021
20	Bharathi	6208	6844	0.48	0.016
21	Swarnaprabha	7884	7467	0.52	0.023
22	Jayathi	6369	6311	0.50	0.017
23	Neeraja	6327	10220	0.38	0.017
24	Kairali	7457	6489	0.54	0.022
25	Aathira	6966	8800	0.44	0.018
26	Aiswara	7906	5511	0.59	0.023
27	Mangala Mahsuri	6376	11910	0.35	0.017
28	Jaya	5293	6222	0.47	0.014
29	Pankaj	5822	10220	0.37	0.015
30	Ahalya	7103	5778	0.55	0.021
31	M 38-4- -2	7714	8000	0.49	0.020
32	M 38-4 –1	7645	7822	0.49	0.020
33	M 48-11-3	8537	12980	0.39	0.023
34	M 61-6-1-1	6277	7733	0.45	0.017
35	MO 4	7208	9156	0.44	0.019
36	MO 5	6737	7822	0.46	0.018
37	MO 6	7135	8089	0.47	0.019

38	MO 7	7502	8889	0.46	0.020
39	MO 8	6980	8178	0.46	0.018
40	MO 9	7692	7467	0.51	0.020
41	MO 10	7665	12890	0.38	0.020
42	MO 11	6340	8711	0.44	0.017
43	MO 12	5886	7733	0.44	0.016
44	MO 13	7704	7022	0.52	0.020
45	MO 14	7086	8356	0.46	0.019
46	MO 15	7297	6400	0.54	0.019
47	MO 16	7572	9867	0.44	0.020
48	MO 17	6226	5956	0.51	0.016
49	MO 18	6977	11110	0.39	0.018
50	MO 19	7498	8844	0.46	0.020

panicle initiation and grain yield recorded moderate PCV and low GCV values, while chlorophyll a (flowering) showed a high value for PCV but low value for GCV.

4.1.3 Heritability

High heritability in the broad sense was estimated for the characters days to flowering (99.19) and harvest (99.96), days taken for completion of flowering within a hill (87.39), plant height (87.01), flag leaf area (86.08), panicle length (79.29), 1000 grain weight (85.86), grain length (73.92), grain breadth (71.21), straw yield (70.28) and harvest index (78.10). The characters viz. total number of tillers during panicle initiation (49.58) and flowering (55.82), LAI during flowering (46.95), number of productive (47.67) and unproductive tillers plant^{-1} (38.87), leaf area duration (49.00), grains panicle^{-1} (59.14), chaff percentage (44.20), grain thickness (48.03) and grain yield (54.75) recorded moderate heritability values. Heritability was low for total number of tillers (active tillering), LAI (active tillering and panicle initiation), chlorophyll contents during different stages and grain density (Table 8).

4.1.4 Genetic advance and genetic gain

The characters namely, total number of tillers during flowering (21.11), LAI during flowering (33.60), days to flowering (22.61), days taken for completion of flowering within a hill (49.56), plant height (36.50), number of unproductive tillers plant^{-1} (70.11), flag leaf area (66.08), leaf area duration (25.81), grains panicle^{-1} (23.42), chaff percentage (41.19), 1000 grain weight (23.36), straw yield (61.64) and harvest index (28.45) showed high expected genetic gain. Total number of tillers during active tillering (10.22) and panicle initiation (18.0), LAI during active tillering (11.49) and panicle initiation (15.44), chlorophyll b during flowering (10.66), days to harvest (17.38), number of productive tillers plant^{-1} (18.83), panicle length (17.71), grain length (13.61), grain breadth (13.28) and grain yield (12.94) recorded moderate genetic gain. Low

Table 8. Estimates of genetic parameters for different characters studied (Main crop)

Sl. No.	Character	PCV (%)	GCV (%)	Heritability (broad sense %)	Genetic advance	Genetic gain (%)
1	Total no. of tillers (active tillering)	19.47	10.81	26.14	0.68	10.22
2	Total no. of tillers (panicle initiation)	17.86	12.49	49.58	1.80	18.0
3	Total no. of tillers (flowering)	18.59	13.81	55.82	1.88	21.11
4	LAI (active tillering)	27.71	12.38	20.70	0.26	11.49
5	LAI (panicle initiation)	26.16	13.97	29.28	1.10	15.44
6	LAI (flowering)	35.22	23.95	46.95	1.65	33.60
7	Chlorophyll a (active tillering)	15.51	2.24	21.0	0.01	0.71
8	Chlorophyll b (active tillering)	12.79	6.14	23.82	0.04	6.60
9	Chlorophyll a (panicle initiation)	15.60	8.25	28.70	0.16	9.0
10	Chlorophyll b (panicle initiation)	17.23	7.80	21.24	0.05	6.71
11	Chlorophyll a (flowering)	20.76	7.27	12.99	0.06	5;64
12	Chlorophyll b (flowering)	23.21	11.29	24.44	0.05	10.66
13	Days to flowering	11.06	11.02	99.19	23.95	22.61
14	Days to harvest	8.44	8.44	99.96	24.30	17.38
15	Days taken for completion of flowering within a hill	27.58	25.75	87.39	4.46	49.56
16	Plant height	20.42	20.02	87.01	35.77	36.50
17	No. of productive tillers plant^{-1}	19.45	13.33	47.67	1.38	18.83
18	No. of unproductive tillers plant^{-1}	89.23	55.10	38.87	1.22	70.11
19	Flag leaf area	37.38	34.63	86.08	20.60	66.08
20	Leaf area duration	25.90	18.00	49.00	1.55	25.81
21	Panicle length	10.90	10.0	79.29	4.22	17.71
22	Grains panicle^{-1}	19.42	14.86	59.14	35.99	23.42
23	Chaff (%)	45.99	30.33	44.20	8.56	41.19
24	1000 grain weight	13.25	12.26	85.86	6.03	23.36
25	Grain density	5.39	2.28	18.70	0.02	1.94
26	Grain length	9.02	7.74	73.92	1.14	13.61
27	Grain breadth	9.16	7.73	71.21	0.39	13.28
28	Grain thickness	6.66	4.58	48.03	0.14	6.64
29	Straw yield	42.97	35.89	70.28	2.06	61.64
30	Harvest index	17.78	15.67	78.10	0.13	28.45
31	Grain yield	14.22	8.66	54.75	0.34	12.94

genetic gain was noted for the traits viz. chlorophyll contents during different stages, grain density and grain thickness (Table 8).

4.1.5 Correlation

The genotypic and phenotypic correlation coefficients among different characters studied are given in Table 9a and b.

Grain yield was found to be positively and significantly correlated both at genotypic and phenotypic levels with grain production day^{-1} (0.729. 0.818) and chlorophyll b content during flowering (0.482, 0.280). It was negatively and significantly correlated at genotypic level with grain density (-0.487).

Total yield showed significant and positive correlation both at genotypic and phenotypic levels with main crop grain yield (0.511, 0.664), days to flowering (0.434, 0.359), days to harvest (0.465, 0.380) and ratoon yield (0.725, 0.511). Grain length exhibited a negative and significant correlation with total yield (-0.391, -0.319) both at genotypic and phenotypic levels.

At genotypic level total yield exhibited negative and significant correlation with 1000 grain weight (-0.334) whereas number of unproductive tillers plant^{-1} (0.430) exhibited positive and significant correlation. Grain production day^{-1} showed a positive and significant correlation (0.337) at phenotypic level.

The characters days to flowering (0.448, 0.352) and days to harvest (0.536, 0.426) showed positive and significant correlation with ratoon yield both at genotypic and phenotypic levels. But negative and significant correlations at genotypic and phenotypic levels were observed for 1000 grain weight (-0.612, -0.474). Significant negative correlations at genotypic level with ratoon yield was recorded by chaff percentage (-0.393) grain production day^{-1} (-0.497), grain length (-0.313) and grain thickness (-0.363). Grains panicle^{-1} (0.394) and number of unproductive tillers plant^{-1} (0.496) were found to be positively and significantly correlated with ratoon yield at genotypic level.

Table 9a. Continued

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
17	1															
18	0.826**	1														
19	0.352**	0..302*	1													
20	-0.514*	-0.482*	-0.275	1												
21	-0.611**	-0.689**	-0.139	0.018	1											
22	-0.450**	0.142	-0.139	0.342	0.329*	1										
23	-0.302*	-0.184	-0.111	0.365	0.017	0.116	1									
24	0.234	0.234	0.094	0.154	-0.071	0.070	-0.226	1								
25	0.107	0.157	0.224	-0.00009	-0.021	0.257	-0.221	0.861**	1							
26	0.419*	0.201	-0.107	-0.354	-0.179	-0.679**	-0.236	0.142	-0.108	1						
27	-0.614**	-0.515**	-0.550**	0.263	0.438**	0.076	0.044	0.042	0.030	0.164	1					
28	0.594**	0.408**	0.094	-0.388	-0.459**	-0.778**	-0.229	0.134	-0.159	1.01**	-0.002	1				
29	0.378	0.179	0.068	-0.405	-0.246	-0.836**	-0.387	-0.069	-0.189	1.01**	0.063	1.00**	1			
30	0.514**	0.313*	0.001	-0.358	-0.341*	-0.745**	-0.221	0.126	-0.156	1.01**	0.076	0.996**	0.985**	1		
31	0.434**	0.465**	0.138	-0.409	0.071	-0.015	-0.391**	-0.104	-0.155	0.170	-0.125	0.178	0.172	0.174	1	
32	0.448**	0.536**	0.001	-0.185	-0.497**	-0.204	-0.313*	-0.257	-0.363*	0.294	-0.111	0.258	0.357	0.285	0.725**	1

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

1. Total no. of tillers (active tillering)
2. Total no. of tillers (panicle initiation)
3. Total no. of tillers (flowering)
4. Plant height
5. Panicle length
6. Grains panicle^{-1}
7. Chaff percentage
8. No. of unproductive tillers plant^{-1}
9. No. of productive tillers plant^{-1}
10. Straw yield
11. 1000 grain weight
12. Grain yield
13. Chlorophyll b (active tillering)
14. Chlorophyll a (panicle initiation)
15. Chlorophyll b (panicle initiation)
16. Chlorophyll b (flowering)
17. Days to flowering
18. Days to harvest
19. Days taken for completion of flowering within a hill
20. Grain density
21. Grain production day^{-1}
22. Harvest index
23. Grain length
24. Grain breadth
25. Grain thickness
26. LAI (panicle initiation)
27. Flag leaf area
28. LAI (flowering)
29. LAI (active tillering)
30. Leaf area duration
31. Total yield
32. Ratoon yield

Table 9b. Phenotypic Correlation (Main crop)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1															
2	0.481*	1														
3	0.355*	0.510*	1													
4	-0.058	-0.290	-0.223	1												
5	-0.190	-0.391*	-0.405*	0.647*	1											
6	-0.224	-0.217	-0.202	0.262	0.185	1										
7	-0.061	0.079	0.025	-0.059	-0.035	-0.003	1									
8	0.181	0.271*	0.638*	-0.223	-0.346*	-0.0005	0.013	1								
9	0.236	0.294*	0.379*	0.009	-0.056	-0.214	-0.016	-0.422*	1							
10	0.259	0.038	0.061	0.582*	0.304	0.007	-0.035	0.0299	0.010	1						
11	-0.183	-0.240	-0.334*	0.057	0.237	-0.209	0.191	-0.268	-0.116	-0.047	1					
12	0.183	0.162	0.059	0.100	-0.058	-0.016	-0.017	-0.120	0.206	0.103	0.162	1				
13	0.092	0.061	0.103	-0.015	-0.097	-0.147	-0.039	-0.010	0.143	-0.032	0.096	0.205	1			
14	0.040	-0.105	-0.088	0.105	0.160	-0.096	0.087	-0.0005	-0.129	0.067	0.274*	-0.054	0.402*	1		
15	-0.072	-0.035	-0.032	0.103	0.116	-0.018	0.043	-0.153	0.146	0.072	0.092	0.135	0.561*	0.491*	1	
16	0.098	0.157	0.085	-0.059	-0.108	-0.102	-0.028	-0.073	0.220	-0.050	0.179*	0.280*	0.479*	0.232	0.313*	1
17	0.092	0.180	0.215	-0.066	-0.315	0.014	0.088	0.413*	-0.251	0.332*	-0.223	-0.027	0.058	0.013	0.042	-0.089
18	0.071	0.174	0.217	-0.262	-0.296	-0.090	-0.038	0.375*	-0.197*	0.099	-0.231	-0.011	0.062	0.027	-0.021	-0.113
19	0.214	0.247	0.298	-0.239	-0.318	-0.166	0.211	0.279	-0.012	0.109	-0.059	0.143	0.046	-0.036	0.028	0.004
20	-0.081	-0.144	-0.093	-0..051	-0.025	0.066	-0.079	-0.019	-0.089	-0.206	0.099	-0.146	-0.039	0.082	-0.045	-0.037
21	0.093	0.027	-0.067	0.236	0.129	0.056	-0.048	-0.303*	0.289*	0.007	0.253	0.818*	0.144	-0.053	0.131	0.308*
22	-0.181	-0.018	-0.078	-0.469*	-0.236	-0.070	-0.033	-0.123	0.074	-0.891*	0.137	0.246	0.154	-0.009	0.019	0.189
23	-0.094	-0.035	-0.064	-0.039	0.256	-0.370*	0.005	-0.035	-0.054	-0.058	0.394*	-0.151	-0.080	0.147	-0.122	0.072
24	-0.173	-0.184	-0.222	-0.012	-0.056	-0.091	0.297*	-0.028	-0.206	0.036	0.502*	0.089	0.216	0.288*	0.236	0.155
25	-0.068	-0.064	-0.175	-0.158	-0.171	-0.265	0.325*	-0.047	-0.132	-0.092	0.356*	0.079	0.091	0.156	0.094	0.185
26	0.229	0.424*	0.121	0.298*	0.143	0.045	0.014	0.155	0.011	0.394*	-0.058	0.038	0.111	0.147	0.121	0.145
27	-0.230	-0.395*	-0.321*	0.568*	0.620*	0.271	-0.141	-0.329*	0.068	0.041	0.181	0.010	-0.016	0.071	0.082	0.017
28	0.191	0.069	0.392*	0.341*	0.058	0.102	-0.174	0.395*	-0.016	0.482*	0.131	0.005	0.058	-0.019	-0.012	-0.135
29	0.681*	0.214	0.192	0.209	0.103	0.029	-0.068	0.191	0.046	0.446*	-0.167	0.025	0.123	0.197	0.102	0.029
30	0.231	0.293*	0.284*	0.374*	0.124	0.089	-0.090	0.311*	-0.006	0.505*	-0.108	0.017	0.089	0.073	0.075	-0.001
31	0.187	0.196	0.204	0.074	-0.194	0.135	-0.143	0.163	0.043	0.159	-0.268	0.664*	0.208	0.007	0.065	0.131
32	0.039	0.079	0.150	0.019	-0.040	0.236	-0.125	0.234	-0.073	0.049	-0.474*	-0.740	0.148	0.026	0.087	-0.059

Contd.

* Significant at 5% level

** Significant at 1% level

Table 9b. Continued

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
17	1															
18	0.823*	1														
19	0.319	0.283	1													
20	-0.241	-0.208	-0.097	1												
21	-0.501*	-0.574*	-0.079	0.011	1											
22	-0.404*	-0.125	-0.107	0.167	0.290	1										
23	-0.253	-0.159	-0.093	0.122	-0.034	0.042	1									
24	0.199	0.198	0.092	0.053	-0.033	0.038	-0.145	1								
25	0.077	0.110	0.132	-0.001	0.002	0.122	-0.033	0.679*	1							
26	0.245	0.111	-0.055	-0.165	-0.017	-0.351*	0.120	0.057	-0.024	1						
27	-0.564*	-0.478*	-0.477*	0.076	0.391*	0.073	0.049	0.031	-0.015	0.094	1					
28	0.407*	0.280	0.102	-0.105	-0.150	-0.456*	-0.159	-0.020	-0.161	0.474*	0.037	1				
29	0.185	0.082	0.026	-0.086	-0.022	-0.398*	-0.186	-0.048	-0.096	0.559*	0.014	0.441*	1			
30	0.371*	0.220	0.024	-0.152	-0.098	-0.466*	-0.152	0.018	-0.118	0.863*	0.080	0.843*	0.577*	1		
31	0.359*	0.380*	0.128	-0.120	0.337*	0.024	-0.319*	-0.073	-0.078	0.133	-0.050	0.187	0.139	0.182	1	
32	0.352*	0.426*	0.014	-0.061	-0.288	-0.103	-0.223	-0.175	-0.204	0.134	-0.114	0.190	0.143	0.192	0.511*	1

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

1. Total no. of tillers (active tillering)
2. Total no. of tillers (panicle initiation)
3. Total no. of tillers (flowering)
4. Plant height
5. Panicle length
6. Grains panicle^{-1}
7. Chaff percentage
8. No. of unproductive tillers plant^{-1}
9. No. of productive tillers plant^{-1}
10. Straw yield
11. 1000 grain weight
12. Grain yield
13. Chlorophyll b (active tillering)
14. Chlorophyll a (panicle initiation)
15. Chlorophyll b (panicle initiation)
16. Chlorophyll b (flowering)
17. Days to flowering
18. Days to harvest
19. Days taken for completion of flowering within a hill
20. Grain density
21. Grain production day^{-1}
22. Harvest index
23. Grain length
24. Grain breadth
25. Grain thickness
26. LAI (panicle initiation)
27. Flag leaf area
28. LAI (flowering)
29. LAI (active tillering)
30. Leaf area duration
31. Total yield
32. Ratoon yield

Among the various yield components grains panicle^{-1} was found to be negatively and significantly correlated at both levels with grain length (-0.499, -0.370). Total number of tillers during the three stages, number of productive tillers plant^{-1} and 1000 grain weight were negatively and significantly correlated, while plant height (0.306) and flag leaf area (0.296) were positively and significantly correlated with grains panicle^{-1} at genotypic level.

1000 grain weight was found to be positively and significantly correlated at both levels with chlorophyll a during panicle initiation (0.482, 0.274), chlorophyll b content during flowering (0.432, 0.179), grain length (0.478, 0.394) grain breadth (0.572, 0.502) and grain thickness (0.570, 0.356). It was negatively and significantly correlated at genotypic and phenotypic levels with total number of tillers during flowering (-0.444, -0.334). 1000 grain weight was negatively and significantly correlated at genotypic level with total number of tillers during the first two stages (-0.434, -0.361), number of unproductive tillers plant^{-1} (-0.446) and LAI during active tillering (-0.411). Grain production day^{-1} (0.351) and chaff percentage (0.394) showed a positive and significant correlation at genotypic level with 1000 grain weight.

Chlorophyll b during flowering exhibited positive and significant correlation with chlorophyll b content during active tillering (1, 0.479) and grain production day^{-1} (0.532, 0.308) both at genotypic and phenotypic levels. Harvest index was correlated at genotypic level with chlorophyll b positively and significantly (0.485).

Straw yield (0.384, 0.332), number of unproductive tillers plant^{-1} (0.682, 0.413), days to harvest (0.826, 0.823), LAI during flowering (0.594, 0.407) and leaf area duration (0.514, 0.371) were positively and significantly correlated with days to flowering at both levels. But grain production day^{-1} (-0.611, -0.501), harvest index (-0.450, -0.404) and flag leaf area (-0.614, -0.564) exhibited negative and significant correlation. At genotypic level, total number of tillers during flowering (0.298), leaf area index during panicle initiation (0.419) and days taken for completion of flowering within a hill (0.352) showed a positive and significant correlation with days to flowering. But panicle length (-0.356), grain length (-0.302) and grain density (-0.514) exhibited significant and negative correlation at genotypic level.

Days to harvest had negative and significant correlation with grain production day^{-1} (-0.689, -0.574) and flag leaf area (-0.515, -0.478) whereas number of unproductive tillers plant^{-1} (0.600, 0.375) showed positive and significant correlation at genotypic and phenotypic levels. Plant height (-0.281), panicle length (-0.331) and grain density (-0.482) were negatively and significantly associated at genotypic level with days to harvest. Leaf area duration (0.313), days taken for completion of flowering within a hill (0.302) and leaf area index during flowering (0.408) had positive and significant correlation at genotypic level with days to harvest.

Grain density was negatively and significantly correlated at genotypic level with straw yield (-0.485). Grain production day^{-1} was found to be negatively and significantly correlated at both levels with number of unproductive tillers plant^{-1} (-0.492, -0.303) but positively and significantly with flag leaf area (0.438, 0.391). Number of productive tillers plant^{-1} (0.289) had positive and significant relation at phenotypic level with grain production day^{-1}. Leaf area duration (0.341) exhibited positive and significant correlation whereas LAI during flowering (-0.459) showed negative and significant correlation at genotypic level.

Grain length was positively and significantly correlated with panicle length (0.341) at genotypic level. Grain breadth (0.861, 0.679) was found to be positively and significantly correlated at genotypic and phenotypic levels with grain thickness. Number of unproductive tillers plant^{-1} was negatively and significantly correlated at genotypic level with plant height (-0.397) and panicle length (-0.590). LAI during panicle initiation and flowering, leaf area duration, days taken for completion of flowering within a hill were positively and significantly correlated at genotypic level with number of unproductive tillers.

4.1.7 Selection Index

A selection model for making selection based on several characters simultaneously was developed. All possible combinations of seven characters were formulated and models with maximum expected genetic gain was selected from models with equal character combinations. Seven models were thus developed and are presented in Table 10.

Maximum expected genetic gain i(0.160) was noted when yield (y) and seven yield components were used in the selection model. The characters included in the order were total number of tillers during panicle initiation (x_1), number of productive tillers plant^{-1} (x_2), 1000 grain weight (x_3), chlorophyll b during flowering (x_4), grain density (x_5), grain production day^{-1} (x_6) and LAI during panicle initiation (x_7).

From the proposed seven models, the model having minimum number of character combination, including four yield components viz., total number of tillers during panicle initiation (x_1), number of productive tillers plant^{-1} (x_2), grain density (x_5) and grain production day^{-1} (x_6) was selected. This model gave an expected genetic gain of i(0.155) approximately same as that given by the seven character model. This selection model was utilized for ranking the 50 genotypes.

Estimates of selection index using the above mentioned four characters and ranking according to index and yield are given in Table 11. According to selection index first 10 ranks were obtained for the varieties, M 48-11-3, ADT 38, Swarnaprabha, Aiswarya, Kairali, MO 4, CORH 2, Ahalya, Jyothi and Ptb 2. According to yield, first 10 ranks were obtained for varieties namely, M 48-11-3, ADT 38, Aiswarya, Swarnaprabha, M 38-4-2, MO 13, MO 9, MO 10, Ptb 2 and M 38-4-1.

Table 10. Selection index for different main crop yield components on main crop yield

Sl. No.	Combination	Selection index	Expected genetic gain
1	y, x_1, x_2, x_3, x_4, x_5, x_6, x_7	$0.0280x_1 + -0.0256x_2 + 0.009x_3 + 0.017x_4 + -0.928x_5 + 50.94x_6 + -0.014x_7$	i.0.160
2	y, x_1, x_2, x_3, x_5, x_6, x_7	$0.0281x_1 + -0.0254x_2 + 0.009x_3 + -0.929x_5 + 51.085x_6 + -0.014x_7$	i.0.160
3	y, x_1, x_3, x_5, x_6, x_7	$0.0231x_1 + 0.010x_3 + -0.9x_5 + 46.879x_6 + -0.014x_7$	i.0.157
4	y, x_1, x_2, x_5, x_6	$0.0235x_1 + -0.0283x_2 + -0.856x_5 + 55.901x_6$	i.0.155
5	y, x_1, x_5, x_6	$0.0173x_1 + -0.818x_5 + 51.675x_6 +$	i.0.151
6	y, x_5, x_6	$-0.898x_5 + 52.01x_6 +$	i.0.148
7	y, x_6	$50.802x_6$	i.0.139

y = main crop yield
x_1 = total number of tillers during panicle initiation
x_2 = number of productive tillers plant^{-1}
x_3 = 1000 grain weight
x_4 = chlorophyll b during flowering
x_5 = grain density
x_6 = grain production day^{-1}
x_7 = LAI (panicle initiation)

Table 11. Estimates of selection index using characters namely, number of tillers during panicle initiation (x_1), number of productive tillers plant^{-1} (x_2), grain density (x_5) and grain production day^{-1} (x_6)

Sl.No.	Variety	Selection index	Rank according to	
			Selection index	Yield
1	M 48-11-3	0.523	1	1
2	ADT 38	0.440	2	2
3	Swarnaprabha	0.443	3	4
4	Aiswarya	0.399	4	3
5	Kairali	0.365	5	16
6	MO 4	0.335	6	21
7	CORH 2	0.321	7	32
8	Ahalya	0.3081	8	25
9	Jyothi	0.308	9	20
10	Ptb 2	0.303	10	9
11	Ptb 28	0.301	11	19
12	MO 19	0.288	12	15
13	M 38-4-2	0.079	13	5
14	MO 13	0.272	14	6
15	MO 7	0.268	15	14
16	MO 10	0.266	16	8
17	MO 14	0.263	17	26
18	Ptb 26	0.259	18	23
19	MO 9	0.253	19	7
20	Ptb 1	0.246	20	27
21	IR 64	0.245	21	22
22	ADT 43	0.238	22	42
23	IR 8	0.230	23	17
24	M 38-4-1	0.223	24	10
25	MO 18	0.206	25	30
26	MO 8	0.203	26	29
27	ASD 20	0.199	27	28
28	MO 15	0.196	28	18
29	MO 16	0.188	29	13
30	Ptb 8	0.184	30	35
31	ADT 36	0.179	31	37
32	Aathira	0.176	32	31
33	White Ponni	0.163	33	36
34	MO 6	0.148	34	24
35	Neeraja	0.125	35	41

36	MO 11	0.113	36	40
37	CO 43	0.112	37	12
38	Ponmani	0.110	38	11
39	MO 5	0.109	39	33
40	Jayathi	0.9998	40	39
41	IR 36	0.098	41	34
42	Mangala Mahsuri	0.0704	42	38
43	MO 17	0.064	43	44
44	MO 12	0.0454	44	47
45	Pankaj	0.035	45	49
46	M 61-6-1-1	0.0309	46	43
47	Bharathi	0.0083	47	45
48	Ptb 10	-0.0395	48	46
49	Jaya	-0.0747	49	50
50	IR 20	-0.1300	50	48

4.2 Evaluation of ratoon crop

4.2.1 Genetic variability

Present investigation was carried out with 24 rice genotypes which exhibited ratoon performance. The extent of genetic variability among these varieties was estimated for different quantitative and qualitative characters. Abstract of analysis of variance of these characters is presented in Appendix II.

Results from analysis of variance revealed highly significant difference among the 24 genotypes for all the characters studied. The genotypes recorded a large range of variation for these characters studied (Table 12).

Tiller regeneration behaviour was estimated with respect to different rice genotypes. Number of tillers (flowering) in the ratoon crop varied from 2 to 10 with an average of 4.81. Ratooning ability recorded a range of 0.29 to 1.12, mean being 0.53. Ratoon crop took 4 to 34 days for visual panicle initiation after the harvest of the main crop with a mean value of 21.25 days. Days to 50 per cent flowering and completion of flowering with in a hill ranged from 16 to 66 days and from 4 to 11 days, their averages being 43.11 and 7.69 days respectively (Table 12).

Plant characters namely plant height and number of productive tillers varied from 39.13 to 91.93 cm and 1 to 8, with averages of 58.64 cm and 3.08 respectively. Panicle length and grains panicle^{-1} showed a range of 11.23 to 20.41 cm and 16 to 64, averages being 14.33 cm and 37.24 respectively. Among physiological characters flag leaf area varied from 5.41 to 15.43 cm^2 with a mean of 8.71 cm^2. LAI and LAD showed a range of 0.09 to 1.47 and from 1.92 to 21.35 days and had averages of 0.46 and 5.82 days respectively (Table 12).

Chlorophyll a content during panicle initiation and flowering varied from 1.28 to 2.31 and 1.06 to 2.11 mg g^{-1} and showed the mean values 1.76 and

Table 12. Mean and range for different characters studied (Ratoon crop).

Character (unit)	Mean ± SEM	Range
Tiller number (flowering)	4.81 ± 0.384	2-10
LAI (flowering)	0.46 ± 0.008	0.09-1.47
Chlorophyll a (panicle initiation) (mg g^{-1})	1.76 ± 0.0016	1.28-2.31
Chlorophyll b (panicle initiation) (mg g^{-1})	0.72 ± 0.0003	0.46-1.01
Chlorophyll a (flowering) (mg g^{-1})	1.52 ± 0.0005	1.06-2.11
Chlorophyll b (flowering) (mg g^{-1})	0.61 ± 0.0005	0.39-0.88
Days to visual panicle initiation	21.25 ± 0.520	4-34
Days to flowering	43.11 ± 0.4065	16-66
Days taken for completion of flowering within a hill	7.69± 0.4095	4-11
Plant height (cm)	58.64 ± 1.021	39.13-91.93
No. of productive tillers $plant^{-1}$	3.08 ± 0.421	1-8
Flag leaf area (cm^2)	8.71 ± 0.0212	5.41-15.43
Leaf area duration (days)	5.82±0.279	1.92-21.35
Panicle length (cm)	14.33 ± 0.3999	11.23-20.41
Grains $panicle^{-1}$	37.24 ± 0.831	16-64
1000 grain weight (g)	21.71 ± 0.1615	17.8-26.53
Grain density (g ml^{-1})	0.91 ± 0.0015	0.79-0.99
Grain length (mm)	7.60 ± 0.218	6.38-9.12
Grain breadth (mm)	2.34 ± 0.0453	2.06-3.01
Grain thickness (mm)	1.42 ± 0.147	1.01-2.01
Straw yield (kg ha^{-1})	1766+78.75	519-6587
Harvest index	0.43 ± 0.0024	0.29-0.55
Grain yield (kg ha^{-1})	1168±29.09	547-2756
Grain production day^{-1} (g day^{-1})	6.99 ± 0.151	2.98-19.64
Total yield (kg ha^{-1})	8203 ± 375.2	7140-10200
Ratooning ability	0.53 ± 0.055	0.29-1.12

1.52 mg g^{-1} respectively, the chlorophyll b content ranged from 0.46 to 1.01 and 0.39 to 0.88 mg g^{-1}, with average being 0.72 and 0.61 mg g^{-1} respectively.

With respect to grain characters, 1000 grain weight and grain density varied from 17.8 to 26.53 g and 0.79 to 0.99 g ml^{-1}, averages being 21.71 g and 0.91 g ml^{-1} respectively. Other characters viz. grain length, grain breadth and grain thickness varied from 6.38 to 9.12 , 2.06 to 3.01 and 1.01 to 2.01 mm with average of 7.60, 2.34 and 1.42 mm respectively.

Economic characters viz. grain and straw yield varied from 547 to 2756 and 519 to 6587 kg ha^{-1} with averages of 1168 and 1766 kg ha^{-1} respectively. Harvest index and grain production day^{-1} ranged from 0.29 to 0.55 and 2.98 to 19.64 g day^{-1} with means 0.43 and 6.99 g day^{-1} respectively. Total yield had a range of 7140 to 10200 kg ha^{-1} average being 8203 kg ha^{-1} (Table 12).

4.2.2 Mean performance

The observations on various characters studied in the ratoon crop were subjected to Duncan's Multiple Range Test (DMRT) and the abstracts are given in Table 13 to 19.

Tiller regeneration behaviour when studied in different genotypes, highest tiller number was reported for Ponmani and CO 43 while Swarnaprabha had the lowest number. Ratooning ability was about 1.12 for Ponmani, 0.8 for CO 43 and Mangala Mahsuri, but Swarnaprabha had the lowest ratooning ability of 0.290 (Table 13). Swarnaprabha and Ptb 8 took about 34 days for visual panicle initiation whereas Ponmani took only 4 days. Similarly for flowering Swarnaprabha and Ptb 8 recorded the longest duration of 66 days, but Ponmani and IR 20 flowered in 16 and 18 days respectively. ASD 20 and Swarnaprabha completed flowering within a hill by 11 days, Pankaj on the other hand completed the same within 4 days (Table 14).

Table 13. Tiller regeneration behaviour of different rice varieties

Sl. No.	Varities	No. of tillers in main crop	No.of tillers regenerated in ratoon crop	Ratooning ability
1	CO43	11^{a}	9^{ab}	0.80^{b}
2	CORH2	8^{def}	6^{d}	0.77^{b}
3	Ponmani	9^{bcdef}	10^{a}	1.12^{a}
4	White Ponni	11^{abc}	8^{c}	0.72^{bc}
5	ADT38	11^{ab}	5^{e}	0.43^{def}
6	ASD20	9^{abcdef}	4^{ef}	0.48^{de}
7	IR8	9^{bcdef}	3^{fg}	0.43^{def}
8	IR20	11^{abc}	8^{c}	0.72^{bc}
9	IR36	8^{def}	3^{fg}	0.38^{ef}
10	IR64	9^{abcdef}	6^{d}	0.68^{bc}
11	MO5	10^{abcde}	4^{ef}	0.45^{def}
12	MO12	8^{cdef}	3^{fg}	0.43^{def}
13	MO15	8^{cdef}	3^{gh}	0.33^{ef}
14	MO16	8^{def}	4^{efg}	0.46^{def}
15	MO18	11^{a}	4^{ef}	0.35^{ef}
16	MO19	8^{cdef}	3^{fg}	0.40^{def}
17	Pankaj	9^{abcdef}	4^{ef}	0.47^{def}
18	Ptb8	7^{ef}	3^{fg}	0.42^{def}
19	Swarnaprabha	8^{def}	2^{h}	0.29^{f}
20	Jayathi	9^{abcdef}	4^{efg}	0.50^{de}
21	Neeraja	8^{cdef}	5^{e}	0.57^{cd}
22	Mangala Mahsuri	10^{abcd}	8^{bc}	0.80^{b}
23	M 48-11-3	10^{abcd}	3^{gh}	0.33^{ef}
24	M 61-6-1-1	7^{f}	4^{efg}	0.37^{ef}

Genotypes with the same alphabets do not differ significantly

Table 14 Flowering behavior of the ratoon crop of 24 rice genotypes

Sl. No.	Varieties	Days to visual panicle initiation	Days to 50% flowering	Days taken for completion of flowering within a hill
1	CO43	5^{m}	20^{m}	8^{defg}
2	CORH2	30^{b}	61^{b}	9^{bcd}
3	Ponmani	4^{m}	16^{o}	7^{hij}
4	White Ponni	25^{e}	47^{f}	8^{efgh}
5	ADT38	24^{f}	44^{h}	7^{hi}
6	ASD20	27^{d}	51^{d}	11^{a}
7	IR8	20^{ij}	41^{jk}	9^{cde}
8	IR20	5^{m}	18^{n}	9^{def}
9	IR36	22^{h}	41^{j}	10^{abc}
10	IR64	23^{fg}	43^{i}	9^{def}
11	MO5	18^{k}	38^{l}	7^{fgh}
12	MO12	16^{l}	37^{l}	5^{jkl}
13	MO15	28^{c}	54^{c}	6^{ijk}
14	MO16	22^{h}	44^{hi}	6^{jk}
15	MO18	26^{d}	52^{d}	8^{fgh}
16	MO19	23^{f}	49^{e}	9^{def}
17	Pankaj	20^{ij}	40^{k}	4^{l}
18	Ptb8	32^{a}	66^{a}	7^{ghi}
19	Swarnaprabha	34^{a}	66^{a}	11^{a}
20	Jayathi	19^{j}	41^{j}	7^{hij}
21	Neeraja	21^{i}	40^{k}	8^{efgh}
22	Mangala Mahsuri	23^{fg}	46^{g}	6^{jk}
23	M 48-11-3	22^{h}	41^{j}	10^{ab}
24	M 61-6-1-1	21^{i}	41^{jk}	5^{kl}

Genotypes with the same alphabets do not differ significantly

Among the plant characters, plant height was highest for Mangala Mahsuri and Swarnaprabha while MO 5 recorded the lowest. IR 20, and Ponmani had the highest number of productive tillers and MO 15 showed the minimum number. Mangala Mahsuri had the longest panicle followed by White Ponni, IR 64 and CO 43. Panicles were comparatively short for MO 15 and Ponmani. Large number of grains panicle^{-1} was recorded by White Ponni and Mangala Mahsuri, while IR 8 showed the lowest value (Table 15).

With respect to the physiological characters Mangala Mahsuri recorded the maximum flag leaf area, while ASD 20 had the minimum area. LAI and LAD were highest for CO 43, but Ptb 8 had the lowest value (Table 16). Chlorophyll a content during panicle initiation and flowering were high for Ptb 8 and M 48-11-3 respectively. ASD 20 recorded low content of chlorophyll during both the stages. Ponmani and MO 16 were having the highest chlorophyll b contents during the above mentioned stages (Table 17).

Grain characters such as 1000 grain weight showed a maximum value for MO 12 and Swarnaprabha, and minimum value for White Ponni and ADT 38. Jayathi and White Ponni reported the highest value for grain density, and the lowest value by IR 8 and ADT 38. ASD 20 and MO 5 had the longest and thickest grains, but Ponmani had the smallest grains. Very thin grains were observed for ADT 38, IR 64, MO 19, CORH 2 etc. Grains had more breadth in case of Mangala Mahsuri, Ponmani, MO 16 and M 61-6-1-1, but less breadth for white Ponni and ASD 20 (Table 18).

Economic character viz. ratoon grain and straw yield was maximum for Mangala Mashuri and White Ponni, IR 36 recorded the minimum value for grain yield and IR 8 for straw yield. Total yield from both the crops was highest for CO 43 and Ponmani. Harvest index was 0.55 for CO 43 and IR 8 but 0.29 for Mangala Mahsuri. Grain production day^{-1} was highest for CO 43 and Ponmani, CORH 2 and Swarnaprabha showed the lowest value (Table 19).

Table 15. Plant characters of the ratoon crop of 24 rice genotypes

Sl.No.	Varieties	Plant height (cm)	No.of productive tillers plant^{-1}	Panicle length (cm)	Grains panicle^{-1}
1	CO43	60.97^{f}	7^{a}	16.84^{cd}	49^{d}
2	CORH2	56.77^{gh}	2^{defg}	13.50^{ghijk}	33^{g}
3	Ponmani	59.73^{fg}	8^{a}	11.23^{n}	40^{e}
4	White Ponni	73.75^{c}	6^{b}	18.72^{b}	64^{a}
5	ADT38	67.67^{de}	2^{defg}	13.43^{ghijkl}	33^{g}
6	ASD20	58.20f^{gh}	1^{g}	12.86^{ijklm}	23^{jk}
7	IR8	56.07^{hi}	2^{defg}	14.17^{fghi}	16^{l}
8	IR20	59.83^{fg}	8^{a}	16.26^{cd}	46^{d}
9	IR36	48.66^{j}	3de	13.77^{ghij}	21^{k}
10	IR64	57.83^{fgh}	2^{defg}	17.38^{c}	38^{ef}
11	MO5	39.13^{l}	1^{fg}	12.13^{lmn}	24^{j}
12	MO12	44.80^{k}	2^{efg}	14.32^{fgh}	31^{gh}
13	MO15	57.83^{fgh}	1^{g}	11.70^{mn}	38^{ef}
14	MO16	56.47^{gh}	3^{d}	12.80^{jklm}	36^{f}
15	MO18	56.03^{hi}	2^{efg}	12.61^{jklm}	29^{hi}
16	MO19	45.55^{k}	2^{defg}	14.40^{fg}	36^{f}
17	Pankaj	64.80^{e}	3^{def}	13.09^{ghijkl}	36^{f}
18	Ptb8	43.27^{k}	2^{defg}	12.4k^{lmn}	31^{gh}
19	Swarnaprabha	81.63^{b}	1^{fg}	14.34^{fgh}	54^{c}
20	Jayathi	59.33^{fgh}	2^{defg}	15.82^{de}	49^{d}
21	Neeraja	69.35^{d}	3^{d}	15.06^{ef}	31^{gh}
22	Mangala Mahsuri	91.93^{a}	5^{c}	20.41^{a}	60^{b}
23	M 48-11-3	53.03^{I}	2^{defg}	13.67^{ghijk}	48^{d}
24	M 61-6-1-1	44.83^{k}	2^{efg}	13.06^{hijkl}	28^{I}

Genotypes with the same alphabets do not differ significantly

Table 16. Physiological parameters of the ratoon crop of 24 rice genotypes

Sl.No.	Varieties	Flag leaf area (cm^2)	LAI	Leaf area duration(days)
1	CO43	9.75^{h}	1.38^{a}	21.35^{a}
2	CORH2	10.06^{g}	0.76^{d}	10.34^{d}
3	Ponmani	6.69^{o}	0.86^{c}	12.12^{c}
4	White Ponni	10.90^{e}	1.06^{b}	14.65^{b}
5	ADT38	9.14^{e}	0.11^{q}	3.52^{ij}
6	ASD20	5.41^{u}	0.14^{p}	2.10^{kl}
7	IR8	5.83^{s}	0.27^{hi}	3.15^{j}
8	IR20	12.77^{b}	0.70^{e}	7.71^{f}
9	IR36	8.16^{l}	0.24^{ijkl}	2.90^{jk}
10	IR64	9.12^{j}	0.50^{f}	7.08^{f}
11	MO5	6.24^{r}	0.23^{klm}	3.34^{ij}
12	MO12	6.81^{n}	0.22^{lm}	2.67^{jkl}
13	MO15	6.31^{q}	0.25^{hijk}	3.60^{ij}
14	MO16	6.43^{p}	0.18^{no}	3.22^{ij}
15	MO18	8.01^{m}	0.25^{hijkl}	4.08^{hi}
16	MO19	11.09^{d}	0.23^{jklm}	3.37^{ij}
17	Pankaj	8.15^{l}	0.22^{lm}	4.81^{gh}
18	Ptb8	5.63^{t}	0.16^{op}	1.92^{l}
19	Swarnaprabha	12.20^{c}	0.23^{klm}	2.99^{j}
20	Jayathi	9.00^{k}	0.39^{g}	4.54^{gh}
21	Neeraja	10.31^{f}	0.26^{hij}	4.95^{g}
22	Mangala Mahsuri	15.43^{a}	0.27^{hi}j	9.00^{le}
23	M 48-11-3	6.34^{q}	0.23^{h}	3.30^{ij}
24	M 61-6-1-1	9.35^{I}	0.20^{klm}	3.04^{j}

Genotypes with the same alphabets do not differ significantly

Table 17. Chlorophyll 'a' and 'b' content of ratoon crop during different stages (mg g^{-1})

Sl No.	Variety	Chlrophyll a (panicle initiation)	Chlorophyll a (flowering)	Chlorophyll b (panicle initiation)	Chlorophyll b (flowering)
1	CO 43	1.83^{l}	1.66^{f}	0.86^{d}	0.85^{b}
2	CORH 2	1.65^{q}	1.26^{u}	0.62^{u}	0.60^{jk}
3	Ponmani	2.03^{d}	1.73^{c}	1.01^{a}	0.81^{c}
4	White Ponni	1.38^{v}	1.20^{v}	0.68^{n}	0.67^{f}
5	ADT 38	1.53^{t}	1.45^{p}	0.64^{q}	0.60^{j}
6	ASD 20	1.28^{x}	1.06^{w}	0.46^{x}	0.39^{v}
7	IR 8	1.92^{g}	1.49^{o}	0.77^{h}	0.53^{p}
8	IR 20	1.75^{l}	1.58^{i}	0.78^{g}	0.77^{e}
9	IR 36	1.66^{p}	1.59^{j}	0.66^{o}	0.53^{p}
10	IR 64	1.32^{w}	1.32^{t}	0.63^{t}	0.55^{o}
11	MO 5	1.68^{o}	1.52^{m}	0.69^{m}	0.66^{g}
12	MO 12	1.81^{j}	1.45^{q}	0.65^{p}	0.60^{k}
13	MO 15	1.80^{k}	1.59^{h}	0.72^{l}	0.58^{m}
14	MO 16	2.19^{c}	1.73^{d}	0.94^{c}	0.88^{a}
15	MO 18	1.58^{s}	1.51^{n}	0.85^{e}	0.49^{r}
16	MO 19	1.88^{h}	1.26^{u}	0.75^{j}	0.45^{u}
17	Pankaj	1.58^{r}	1.54^{l}	0.64^{r}	0.58^{l}
18	Ptb 8	2.31^{a}	1.65^{g}	0.97^{b}	0.55^{n}
19	Swarnaprabha	1.96^{f}	1.57^{k}	0.76^{i}	0.51^{q}
20	Jayathi	1.73^{m}	1.36^{s}	0.61^{v}	0.46^{t}
21	Neeraja	1.72^{n}	1.69^{e}	0.72^{k}	0.62^{h}
22	Mangala Mahsuri	1.50^{u}	1.41^{r}	0.52^{w}	0.48^{s}
23	M 48-11-3	2.22^{b}	2.11^{a}	0.83^{f}	0.78^{d}
24	M 61-6-1-1	1.98^{e}	1.81^{b}	0.64^{s}	0.61^{l}

Genotypes with the same alphabets do not differ significantly

Table 18. Grain characters of the ratoon crop of 24 rice genotypes

Sl No.	Variety	1000 grain weight	Grain density (g ml^{-1})	Grain length (mm)	Grain breadth (mm)	Grain thickness (mm)
1	CO 43	21.17^{fg}	0.966^{d}	8.00^{bc}	2.14^{efg}	1.44^{bc}
2	CORH 2	21.10^{g}	0.920^{h}	8.00^{bc}	2.40^{d}	1.14^{c}
3	Ponmani	19.17^{k}	0.866^{h}	6.38^{e}	3.00^{ab}	1.71^{ab}
4	White Ponni	17.80^{m}	0.992^{a}	7.39^{cd}	2.06^{fg}	1.15^{c}
5	ADT 38	18.70^{l}	0.790^{p}	7.89^{bc}	2.11^{efg}	1.09^{c}
6	ASD 20	20.40^{h}	0.942^{f}	9.12^{a}	2.06^{g}	2.01^{a}
7	IR 8	25.17^{b}	0.791^{p}	7.74^{cd}	2.15^{efg}	2.01^{a}
8	IR 20	20.37^{h}	0.863^{l}	7.11^{d}	2.11^{efg}	1.15^{c}
9	IR 36	24.00^{c}	0.976^{c}	8.03^{bc}	2.09^{efg}	2.01^{a}
10	IR 64	22.10^{e}	0.814^{o}	8.83^{a}	2.15^{efg}	1.01^{c}
11	MO 5	23.97^{c}	0.933^{g}	8.85^{a}	2.17^{efg}	2.01^{a}
12	MO 12	26.53^{a}	0.913^{i}	7.98^{bc}	2.22^{ef}	1.45^{bc}
13	MO 15	19.47^{jk}	0.963^{d}	7.08^{d}	2.16^{efg}	1.18^{c}
14	MO 16	21.07^{g}	0.984^{b}	7.07^{d}	3.00^{ab}	2.00^{a}
15	MO 18	19.57^{jk}	0.950^{e}	7.04^{d}	2.10^{efg}	1.17^{c}
16	MO 19	21.60^{f}	0.948^{e}	7.42^{cd}	2.69^{c}	1.11^{c}
17	Pankaj	22.10^{e}	0.875^{k}	7.75^{cd}	2.15^{efg}	1.17^{c}
18	Ptb 8	19.77^{ij}	0.940^{f}	7.17^{d}	2.14^{efg}	1.45^{bc}
19	Swarnaprabha	26.40^{a}	0.920^{h}	8.50^{ab}	2.23^{e}	1.15^{c}
20	Jayathi	21.00^{g}	0.993^{a}	7.14^{d}	2.14^{efg}	1.15^{c}
21	Neeraja	20.20^{hi}	0.912^{i}	8.11^{bc}	2.08^{efg}	1.14^{c}
22	Mangala Mahsuri	23.00^{d}	0.903^{j}	7.72^{cd}	3.01^{a}	1.49^{bc}
23	M 48-11-3	22.67^{d}	0.851^{m}	7.11^{d}	2.87^{b}	1.12^{c}
24	M 61-6-1-1	23.77^{c}	0.822^{n}	7.113^{d}	3.00^{ab}	1.73^{ab}

Genotypes with the same alphabets do not differ significantly

Table 19. Economic characters of the ratoon crop of 24 rice genotypes

Sl No.	Variety	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Total grain yield (kg ha^{-1})	Harvest index	Grain production day^{-1} (g day^{-1})
1	CO 43	2619.00^{b}	2117.00^{e}	10200^{a}	0.55^{a}	19.64^{a}
2	CORH 2	788.40^{fg}	979.60^{ijkl}	7645^{ef}	0.45^{g}	2.99^{m}
3	Ponmani	2564.00^{b}	3484.00^{b}	10160^{a}	0.42^{j}	19.23^{a}
4	White Ponni	2748.00^{a}	6400.00^{a}	9318^{ab}	0.30^{p}	12.12^{d}
5	ADT 38	808.00^{fg}	1382.00^{fg}	9180^{abcd}	0.37^{o}	4.66^{I}
6	ASD 20	662.20^{jk}	774.20^{klm}	7653^{ef}	0.46^{f}	3.36^{lmn}
7	IR 8	626.70^{kl}	519.10^{n}	8038^{bcdef}	0.55^{a}	3.79^{kl}
8	IR 20	1898.00^{c}	2387.00^{d}	7778^{cdef}	0.44^{gh}	14.23^{e}
9	IR 36	546.70^{l}	765.30^{lm}	7236^{f}	0.42^{k}	3.31^{mn}
10	IR 64	782.20^{fgh}	985.80^{ijkl}	7951^{bcdef}	0.44^{gh}	4.51^{ij}
11	MO 5	689.80^{hijk}	709.30^{mn}	7427^{f}	0.49^{c}	5.17^{gh}
12	MO 12	733.30^{ghij}	807.10^{klm}	7244^{f}	0.48^{e}	5.50^{fg}
13	MO 15	746.70^{ghij}	888.90^{jklm}	8044^{bcdef}	0.46^{f}	3.73^{klm}
14	MO 16	848.90^{f}	1197.00^{ghi}	8421^{bcdef}	0.42^{k}	4.90^{hi}
15	MO 18	813.30^{fg}	1255.00^{fgh}	7790^{cdef}	0.39^{m}	4.12^{jk}
16	MO 19	1089.00^{e}	1446.00^{f}	8587^{bcdef}	0.43^{ij}	5.67^{f}
17	Pankaj	1318.00^{d}	2987.00^{c}	7140^{f}	0.31^{p}	8.10^{e}
18	Ptb 8	768.90^{fghi}	1130.00^{hij}	7386^{f}	0.41^{l}	3.28^{ml}
19	Swarnaprabha	733.30^{ghij}	644.40^{mn}	8617^{bcdef}	0.53^{b}	3.13^{n}
20	Jayanthi	822.20^{ig}	872.00^{klm}	7191^{f}	0.49^{d}	4.97^{h}
21	Neeraja	1333.00^{d}	2163.00^{de}	7660^{def}	0.38^{ln}	8.06^{e}
22	Mangala Mahsuri	2756.00^{a}	6587.00^{a}	9129^{abcde}	0.29^{q}	15.19^{b}
23	M 48-11-3	660.40^{jk}	1030.00^{hijk}	9198^{abc}	0.39^{m}	3.99^{k}
24	M 61-6-1-1	680.00^{ijk}	881.80^{jklm}	7847^{bcdef}	0.44^{hi}	4.11^{j}

Genotypes with the same alphabets do not differ significantly

4.2.3 Phenotypic and genotypic coefficients of variation

The characters viz. tiller number during panicle initiation (49.14, 47.78) and flowering (45.62, 43.87), LAI during panicle initiation (83.85, 83.74) and flowering (80.25, 80.19), days to flowering (19.38, 29.34), days taken for completion of flowering within a hill (25.35, 23.61), plant height (20.98, 20.76), number of productive tillers plant^{-1} (71.70, 67.70), number of unproductive tillers plant^{-1} (69.79, 54.94), grains panicle^{-1} (32.71, 32.48), chaff percentage (67.19, 66.92), grain thickness (29.37, 23.28), chlorophyll b content during flowering (21.43, 21.43), flag leaf area (29.38, 29.37), grain yield (63.97, 63.82), grain production day^{-1}(73.34, 73.24) and ratooning ability (41.11, 36.92) showed high PCV and GCV values. But days to harvest, panicle length, 1000 grain weight, grain breadth and chlorophyll contents during different stages recorded moderate magnitudes for PCV and GCV. Low values of PCV and GCV were observed for grain length and grain density (Table 20).

4.2.4 Heritability

Almost all characters exhibited high heritability values except total yield which had moderate value (52.06). 100 per cent heritability was observed for chlorophyll contents during panicle initiation and flowering (Table 20).

4.2.5 Genetic advance and genetic gain

All the characters studied reported high values for genetic gain, except grain density (14.3), grain length (14.82) and total yield (13.98), which had moderate values. Very high values were exhibited by grain production day^{-1} (150.62), grain yield (131.18), straw yield (190.62), leaf area duration (163.12), number of productive tillers plant^{-1} (131.69). LAI during panicle initiation (172.24) and LAI during flowering (165.94). Ratooning ability reported a genetic gain value of 68.05 per cent (Table 20).

Table 20. Estimates of genetic parameters for different characters studied (Ratoon crop)

Sl. No.	Character	PCV (%)	GCV (%)	Heritability (broad sense %)	Genetic advance	Genetic gain (%)
1	Number of tillers (panicle initiation)	49.14	46.78	91.02	3.90	91.76
2	Number of tillers (flowering)	45.62	43.87	91.17	4.10	85.31
3	LAI (panicle initiation)	83.85	83.74	99.75	0.67	172.24
4	LAI (flowering)	80.25	80.19	99.86	0.76	165.94
5	Chlorophyll a (panicle initiation)	15.43	15.43	99.99	0.56	31.80
6	Chlorophyll b (panicle initiation)	18.67	18.67	100.00	0.28	38.67
7	Chlorophyll a (flowering)	14.59	14.59	100.00	0.46	30.22
8	Chlorophyll b (flowering)	21.43	21.43	100.00	0.27	44.62
9	Days to visual panicle initiation)	41.80	41.69	99.48	25.05	85.64
10	Days to floweing	29.38	29.34	99.70	26.01	60.33
11	Days to harvest	19.84	19.80	99.65	27.01	40.73
12	Days taken for completion of flowering within a hill	25.35	23.61	87.28	3.49	45.36
13	Plant height	20.98	20.76	98.02	24.82	42.32
14	No. of productive tillers plant^{-1}	71.70	67.70	89.56	4.06	131.69
15	No. of unproductive tillers plant-^{1}	69.79	54.94	63.18	1.56	108.33
16	Flag leaf area	29.38	29.37	99.98	5.27	60.48
17	Leaf area duration	78.67	78.64	99.94	0.69	163.12
18	Panicle length	16.18	15.44	91.43	4.35	30.35
19	Grains panicle^{-1}	32.71	32.48	98.66	24.74	66.46
20	Chaff %	67.19	66.92	99.22	10.95	137.29
21	1000 grain weight	10.84	10.77	98.64	4.78	22.02
22	Grain density	6.87	6.86	99.84	0.13	14.30
23	Grain length	9.70	8.36	75.25	1.14	14.82
24	Grain breadth	15.54	15.18	95.55	0.72	30.73
25	Grain thickness	29.37	23.28	64.00	0.54	38.08
26	Straw yield	93.17	92.85	99.34	1262.64	190.62
27	Harvest index	16.42	10.39	99.66	0.14	32.71
28	Grain yield	63.98	63.82	99.56	574.65	131.18
29	Grain production day^{-1}	73.34	73.24	99.75	10.53	150.62
30	Total yield	13.53	9.63	52.06	0.43	13.98
31	Ratooning ability	41.11	36.92	81.38	0.36	68.05

4.2.6 Correlation

The genotypic and phenotypic correlation among different characters studied in the ratoon crop are presented in Table 21a and b.

Ratoon yield was positively and significantly correlated at genotypic and phenotypic levels with tiller number during panicle initiation (0.545, 0.515) and flowering (0.890, 0.848), plant height (0.549), 0.542), number of productive tillers (0.879, 0.833), panicle length (0.587, 0.566), grains panicle^{-1} (0.668, 0.661), flag leaf area (0.524, 0.523), LAI during panicle initiation (0.722, 0.719) and flowering (0.896, 0.893), straw yield (0.875, 0.875), grain production day^{-1} (0.942, 0.942), leaf area duration (0.845, 0.843) and ratooning ability (0.818, 0.736). Days to flowering (-0.501, -0.500) and days to visual panicle initiation (-0.506, -0.504) had negative and significant correlation with ratoon yield. At genotypic level chlorophyll b content during flowering (0.380) showed significant positive correlation with ratoon yield whereas 1000 grain weight (-0.371) showed negative significant correlation.

Total yield was found to be significantly and positively correlated with tiller number during flowering (0.661, 0.458), number of productive tillers (0.690, 0.488), grains panicle^{-1} (0.627, 0.445), LAI during panicle initiation (0.628, 0.453), ratoon yield (0.75, 0.551), grain production day^{-1} (0.738, 0.540) and leaf area duration (0.754, 0.544) at genotypic and phenotypic levels. Grain breadth (0.481), straw yield (0.535), LAI during flowering (0.810), plant height (0.474), tiller number during panicle initiation (0.534), chlorophyll b during panicle initiation and flowering (0.412, 0.564) and ratooning ability (0.610) exhibited positive and significant correlation with total yield at genotypic level.

Ratooning ability had positive and significant correlation at both levels with tiller number during panicle initiation (0.856, 0.738) and flowering (0.961, 0.921), number of productive tillers plant^{-1} (0.847, 0.726), LAI during panicle initiation (0.774, 0.700) and flowering (0.887, 0.803), straw yield (0.622, 0.559),

Table 21a. Genotypic correlation (Ratoon Crop)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1															
2	0.798**	1														
3	0.072	0.372*	1													
4	0.640**	0.886**	0.313	1												
5	0.343	0.253	0.122	-0.227	1											
6	0.154	0.479**	0.606**	0.410*	0.160	1										
7	0.217	0.437*	0.665**	0.491**	-0.091	0.665*	1									
8	0.295	0.160	-0.068	0.013	0.321	0.065	0.097	1								
9	-0.366*	-0.422*	-0.138	-0.367*	-0.123	0.023	-0.207	0.172	1							
10	0.112	0.407*	0.663**	0.390*	0.046	0.753**	0.635**	0.066	0.016	1						
11	0.861**	0.810**	0.190	0.791**	0.051	0.409*	0.482**	0.178	-0.333	0.275	1					
12	0.758**	0.941**	0.472**	0.812**	0.274	0.519**	0.558**	0.156	-0.381*	0.435**	0.851**	1				
13	-0.369*	-0.613**	0.077	-0.736**	0.232	-0.135	-0.068	-0.083	0.068	-0.035	-0.479**	-0.495**	1			
14	0.054	-0.252	0.232	-0.365*	0.220	0.001	0.145	-0.110	-0.203	0.131	-0.075	-0.152	0.874**	1		
15	0.193	-0.102	0.022	-0.055	-0.068	0.046	-0.043	0.347	0.133	0.038	0.107	-0.134	0.195	0.291	1	
16	-0.369*	-0.607**	0.082	-0.742**	0.256	-0.140	-0.076	-0.077	0.052	-0.026	-0.492**	-0.498**	0.999**	0.874**	0.178	1
17	0..545**	0.890**	0.549**	0.879**	0.031	0.587**	0.668**	0.005	-0.371*	0.524**	0.722**	0.896**	-0.501**	-0.189	-0.209	-0.506**
18	0.322	0.691**	0.651**	0.627**	0.140	0.642**	0.670**	-0.052	-0.350	0.561**	0.425*	0.697**	-0.215	0.024	-0.306	-0.213
19	0.032	-0.211	-0.373*	-0.151	-0.135	-0.256	-0.306	0.116	0.436**	-0.291	0.124	-0.197	-0.097	-0.174	0.389*	-0.110
20	0.555**	0.905**	0.395*	0.934**	-0.0497	0.443**	0.530**	0.043	-0.288	0.406*	0.732**	0.877**	-0.717**	-0.440**	-0.213	-0.723**
21	0.838**	0.915**	0.352	0.834**	0.176	0.484**	0.541**	0.173	-0.371*	0.374*	0.957**	0.967**	-0.508**	-0.122	-0.021	-0.516**
22	-0.049	-0.130	0.073	-0.382*	0.518**	0.190	-0.247	0.491**	0.404*	0.034	-0.144	-0.135	0.243	0.067	0.473**	0.240
23	0.017	0.137	0.035	0.175	-0.067	-0.046	0.202	-0.106	0.108	0.122	-0.069	0.157	-0.143	-0.113	-0.264	-0.137
24	-0.112	-0.069	-0.366	-0.076	-0.011	-0.369	-0.583**	-0.176	0.339	-0.505**	-0.195	-0.197	-0.187	-0.316	0.017	-0.203
25	0.021	-0.050	-0.028	0.030	-0.142	0.043	0.224	-0.044	-0.203	-0.003	0.178	0.028	0.225	0.260	0.006	0.194
26	0.534**	0.661**	0.474*	0.690**	-0.034	0.273	0.627**	0.141	-0.321	0.279	0.628**	0.810**	-0.384	-0.114	0.104	-0.379
27	-0.231	-0.303	-0.351	0.021	-0.677**	-0.432*	-0.052	-0.264	0.194	-0.300	-0.130	-0.251	-0.004	-0.060	-0.098	-0.028
28	-0.219	-0.140	-0.170	0.144	-0.572**	-0.318	0.007	-0.093	0.148	-0.207	-0.86	-0.068	-0.289	-0.357	-0.153	-0.310
29	0.126	0.089	-0.245	0.375*	-0.601**	-0.369*	0.021	-0.016	-0.203	-0.301	0.228	0.113	-0.210	-0.109	-0.05	-0.226
30	0.390*	0.430*	-0.084	0.634**	-0.401*	-0.067	0.233	0.086	-0.179	-0.111	0.510**	0.442**	-0.594**	-0.410*	-0.162	-0.607**
31	0.856**	0.961**	0.340	0.847**	0.249	0.388*	0.385*	0.190	-0.373*	0.329	0.774**	0.887**	-0.567**	-0.192	-0.089	-0.559**

Contd.

* Significant at 5% level

** Significant at 1% level

Table 21a. Continued

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
17	1														
18	0.875**	1													
19	-0.348	-0.684**	1												
20	0.942**	0.697**	-0.157	1											
21	0.845**	0.590**	-0.046	0.841**	1										
22	-0.276	-0.236	0.270	-0.287	-0.145	1									
23	0.201	0.229	-0.227	0.210	0.054	-0.497**	1								
24	-0.147	-0.185	0.295	-0.047	-0.203	0.187	0.223	1							
25	0.126	0.106	0.007	0.031	0.101	-0.051	-0.158	0.084	1						
26	0.750**	0.535**	-0.080	0.738**	0.754**	-0.273	0.481*	-0.183	-0.122	1					
27	-0.167	-0.305	0.264	-0	-0.200	-0.579**	0.468**	0.176	-0.007	0.154	1				
28	-0.051	-0.164	0.030	0.099	-0.078	-0.495**	0.429*	0.077	-0.232	0.247	0.742**	1			
29	0.142	-0.089	0.162	0.247	0.174	-0.621**	0.227	0.057	0.0716	0.412*	0.750**	0.604**	1		
30	0.380*	0.135	0.046	0.508**	0.493**	-0.388*	0.324	0.099	-0.047	0.564**	0.444**	0.612**	0.617**	1	
31	0.818**	0.622**	-0.153	0.843**	0.867**	-0.151	0.218	-0.048	-0.061	0.610**	-0.214	-0.154	0.120	0.404*	1

* Significant at 5% level

** Significant at 1% level

1. Total no. of tillers (panicle initiation)
2. Total no. of tillers (flowering)
3. Plant height
4. No. of productive tillers plant^{-1}
5. No. of unproductive tillers plant^{-1}
6. Panicle length
7. Grains panicle^{-1}
8. Chaff percentage
9. 1000 grain weight
10. Flag leaf area
11. LAI (panicle initiation)
12. LAI (flowering)
13. Days to flowering
14. Days to harvest
15. Days taken for completion of flowering within a hill
16. Days taken for visual panicle initiation
17. Grain yield
18. Straw yield
19. Harvest index
20. Grain production day^{-1}
21. Leaf area duration
22. Grain length
23. Grain breadth
24. Grain thickness
25. Grain density
26. Total yield
27. Chlorophyll a (panicle initiation)
28. Chlorophyll a (flowering)
29. Chlorophyll b (panicle initiation)
30. Chlorophyll b (flowering)
31. Ratooning ability

Table 21b. Phenotypic correlation (Ratoon Crop)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	1															
2	0.718*	1														
3	0.070	0.353	1													
4	0.574*	0.831*	0.301	1												
5	0.249	0.294	0.086	-0.277	1											
6	0.130	0.456*	0.572*	0.390	0.115	1										
7	0.204	0.422	0.655*	0.463*	-0.061	0.635*	1									
8	0.284	0.156	-0.067	0.014	0.259	0.063	0.099	1								
9	-0.355	-0.409	-0.135	-0.341	-0.120	0.017	-0.207	0.169	1							
10	0.106	0.389	0.656*	0.369	0.038	0.720*	0.630*	0.065	0.016	1						
11	0.821*	0.773*	0.191	0.744*	0.046	0.389	0.478*	0.177	-0.333	0.275	1					
12	0.720*	0.899*	0.467	0.767*	0.221	0.498*	0.554*	0.155	-0.378	0.435	0.849*	1				
13	-0.355	-0.585*	0.077	-0.696*	0.186	-0.127	*0.069	-0.083	0.065	-0.035	-0.477*	-0.494*	1			
14	0.049	-0.239	0.230	-0.348	0.180	0.001	0.144	-0.110	-0.202	0.131	-0.075	-0.151	0.871*	1		
15	0.168	-0.103	0.023	-0.040	-0.097	0.053	-0.048	0.322	0.122	0.034	0.100	-0.125	0.182	0.277	1	
16	-0.346	-0.576*	0.083	-0.698*	0.204	-0.133	-0.075	-0.076	0.051	-0.026	-0.489*	-0.495*	0.995*	0.870*	0.166	1
17	0.515*	0.848*	0.542*	0.833*	0.018	0.566*	0.661*	0.005	-0.367	0.523*	0.719*	0.893*	-0.500*	-0.188	-0.192	-0.504*
18	0.302	0.660*	0.642*	0.597*	0.103	0.621*	0.663*	-0.052	-0.346	0.559*	0.423	0.694*	-0.215	0.023	-0.279	-0.212
19	0.029	-0.202	-0.368	-0.146	-0.104	-0.248	-0.305	0.115	0.432	-0.291	0.124	-0.196	-0.097	-0.174	0.360	-0.111
20	0.526*	0.864*	0.391	0.885*	-0.043	0.427	0.525*	0.043	-0.285	0.406	0.729*	0.875*	-0.716*	-0.439	-0.197	-0.721*
21	0.798*	0.873*	0.350	0.787*	0.144	0.464*	0.537*	0.172	-0.370	0.374	0.956*	0.966**	-0.507*	-0.122	-0.020	-0.513*
22	-0.051	-0.117	0.078	-0.344	0.398	0.138	-0.219	0.427	0.343	0.029	-0.121	-0.120	0.213	0.060	0.347	0.206
23	0.017	0.133	0.031	0.154	-0.032	-0.031	0.198	-0.103	0.102	0.119	-0.068	0.153	-0.140	-0.111	-0.239	-0.134
24	-0.059	-0.040	-0.284	0.003	-0.094	-0.239	-0.454*	-0.149	0.277	-0.404	-0.157	-0.156	-0.150	-0.252	0.006	-0.164
25	0.017	-0.049	-0.029	0.006	-0.117	0.0417	0.222	-0.043	-0.202	-0.032	0.178	0.0287	0.224	0.259	0.006	0.194
26	0.326	0.458*	0.351	0.488*	-0.074	0.245	0.445*	0.087	-0.237	0.202	0.453*	0.588	-0.269	-0.091	0.083	-0.282
27	-0.220	-0.290	-0.348	0.019	-0.537*	-0.413	-0.051	-0.263	0.192	-0.2997	-0.129	-0.250	-0.0042	-0.060	-0.090	-0.028
28	-0.209	-0.134	-0.168	0.137	-0.455*	-0.304	0.007	-0.092	0.147	-0.207	-0.086	-0.068	-0.289	-0.356	-0.142	-0.309
29	0.120	0.082	-0.242	0.355	-0.478*	-0.352	0.021	-0.016	-0.202	-0.301	0.228	0.113	-0.210	-0.109	-0.047	-0.225
30	0.372	0.411	-0.084	0.601*	0.320	-0.064	0.232	0.086	-0.177	-0.111	0.510*	0.442	-0.593*	-0.409	-0.151	-0.605*
31	0.738*	0.921*	0.307	0.726*	0.336	0.359	0.352	0.180	-0.340	0.296	0.700*	0.803*	-0.506*	-0.171	-0.083	-0.496*

Contd.

* Significant at 5% level

** Significant at 1% level

Table 21b. Continued

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
17	1														
18	0.875*	1													
19	-0.349	-0.684*	1												
20	0.942*	0.697*	-0.158	1											
21	0.843*	0.587*	-0.046	0.839*	1										
22	-0.247	-0.219	0.245	-0.254	-0.125	1									
23	0.194	0.221	-0.220	0.204	0.052	-0.414	1								
24	-0.122	-0.155	0.245	-0.041	-0.162	0.085	0.169	1							
25	0.125	0.105	0.0068	0.031	0.101	-0.042	-0.154	0.065	1						
26	0.551*	0.402	-0.063	0.540*	0.544*	-0.260	0.342	-0.004	-0.088	1					
27	-0.167	-0.304	0.263	-0.0597	-0.200	-0.502*	0.457	0.142	-0.007	0.110	1				
28	-0.051	-0.163	-0.030	0.099	-0.078	-0.430	0.420	0.0618	-0.232	0.178	0.742	1			
29	0.141	-0.088	0.162	0.247	0.174	-0.539*	0.222	0.046	0.071	0.298	0.750*	0.604*	1		
30	0.379	0.135	0.046	0.507*	0.493*	-0.337	0.317	0.079	-0.047	0.407	0.444	0.612*	0.617*	1	
31	0.736*	0.559*	-0.139	0.759*	0.785*	-0.126	0.208	-0.013	-0.057	0.368	-0.193	-0.139	0.108	0.364	1

* Significant at 5% level

** Significant at 1% level

1. Total no. of tillers (panicle initiation)
2. Total no. of tillers (flowering)
3. Plant height
4. No. of productive tillers plant^{-1}
5. No. of unproductive tillers plant^{-1}
6. Panicle length
7. Grains panicle^{-1}
8. Chaff percentage
9. 1000 grain weight
10. Flag leaf area
11. LAI (panicle initiation)
12. LAI (flowering)
13. Days to flowering
14. Days to harvest
15. Days taken for completion of flowering within a hill
16. Days taken for visual panicle initiation
17. Grain yield
18. Straw yield
19. Harvest index
20. Grain production day^{-1}
21. Leaf area duration
22. Grain length
23. Grain breadth
24. Grain thickness
25. Grain density
26. Total yield
27. Chlorophyll a (panicle initiation)
28. Chlorophyll a (flowering)
29. Chlorophyll b (panicle initiation)
30. Chlorophyll b (flowering)
31. Ratooning ability

grain production day^{-1} (0.843, 0.759) and leaf area duration (0.867, 0.785). Days to flowering (-0.5657, -0.506) and days to visual panicle initiation (-0.559, -0.496) showed negative and significant association at both levels. Panicle length (0.388), grains panicle^{-1} (0.385) and chlorophyll b during flowering (0.404) were positively and significantly associated with ratooning ability at genotypic level, while 1000 grain weight (-0.373) showed but negative significant correlation.

Tiller number during flowering was positively and significantly associated at genotypic and phenotypic levels with number of productive tillers plant^{-1} (0.886, 0.831), panicle length (0.479, 0.456), LAI during both stages, straw yield (0.691, 0.660), grain production day^{-1} (0.905, 0.864) and leaf area duration (0.915, 0.873). But negative and significant association at both levels were showed by days to visual panicle initiation (-0.607, -0.576). Plant height (0.372), grains panicle^{-1} (0.437). flag leaf area (0.407) and chlorophyll b during flowering (0.430) had positive and 1000 grain weight (-0.422) had negative and significant correlation with tiller number.

Number of productive tillers was found to be positively and significantly correlated at both levels with tiller number during panicle initiation (0.640, 0.574), grains panicle^{-1} (0.491, 0.463), LAI during the two states, straw yield (0.627, 0.597), grain production day^{-1} (0.934, 0.885), leaf area duration (0.834, 0.787) and chlorophyll b during flowering (0.634, 0.601). Days to visual panicle initiation (-0.742, -0.698) showed negative and significant correlation. Panicle length (0.410) and flag leaf area (0.390) had positive and 1000 grain weight (-0.367), days to flowering (-0.736), days to harvest (-0.365) and grain length (-0.382) had negative and significant association with number of productive tillers.

Grains panicle^{-1} (0.665, 0.635), flag leaf area (0.753, 0.720), LAI during flowering (0.519, 0.498), straw yield (0.642, 0.621) and leaf area duration (0.484, 0.464) showed positive and significant correlation at genotypic and phenotypic levels with panicle length. LAI during panicle initiation (0.409) and grain production day^{-1} (0.443) had positive, while chlorophyll a and b during panicle initiation had negative and significant association with panicle length at genotypic level.

Flag leaf area (0.635, 0.630), LAI during panicle initiation (0.482, 0.478) and flowering (0.558, 0.554), straw yield (0.670, 0.663), grain production day^{-1} (0.530, 0.525) and leaf area duration (0.541, 0.537) exhibited positive, while grain thickness (-0.583, -0.454) had negative and significant correlation at genotypic and phenotypic levels with grains panicle^{-1}.

Straw yield (0.561, 0.559) showed positive and significant correlation at both levels with flag leaf area. LAI during flowering (0.435), grain production day^{-1} (0.406) and leaf area duration (0.374) had positive significant genotypic correlation with flag leaf area while grain thickness had negative (-0.505), correlation at genotypic level with this trait.

LAI during flowering was found to be positively and significantly associated at both levels with LAI during panicle initiation, straw yield, grain production day^{-1} and leaf area duration. But the relationship was negative for days to flowering and visual panicle initiation.

Days to flowering was positively and significantly associated with days to harvest and visual panicle initiation, but negatively with grain production day^{-1}, leaf area duration and chlorophyll b during flowering at both levels. Straw yield also exhibited positive and significant correlation with leaf area duration and grain production day^{-1}, but negative correlation with harvest index at both levels.

Grain production day^{-1} recorded positive and significant association with leaf area duration (0.841, 0.839) and chlorophyll b during flowering (0.508, 0.507) at genotypic and phenotypic levels.

Table 22. Direct and indirect effect of ratoon characters on ratoon yield

Characters	Tiller No. at the time of flowering	Plant height	No. of productive tillers $plant^{-1}$	Panicle length	Grains $panicle^{-1}$	1000 grain weight	Flag leaf area	LAI (flowering)	Days to flowering	Straw yield	Ratooning ability	Correlation coefficient with ratoon yield
Tiller No. at the time of flowering	**0.299**	0.005	0.394	-0.027	0.030	-0.033	-0.017	0.257	-0.041	0.289	-0.265	0.890
Plant height	0.111	**0.013**	0.139	-0.034	0.046	-0.011	-0.028	0.129	0.005	0.272	-0.094	0.549
Number of productive tillers $plant^{-1}$	0.265	0.004	**0.444**	-0.023	0.034	-0.029	-0.017	0.222	-0.049	0.262	-0.234	0.879
Panicle length	0.143	0.008	0.182	**-0.057**	0.046	0.002	-0.032	0.142	-0.009	0.268	-0.107	0.587
Grains $panicle^{-1}$	0.131	0.009	0.218	-0.038	**0.070**	-0.016	-0.027	0.153	-0.005	0.280	-0.106	0.668
1000 grain weight	-0.126	-0.002	-0.163	-0.001	-0.014	**0.079**	-0.001	-0.104	0.005	-0.146	0.103	-0.371
Flag leaf area	0.222	0.009	0.173	-0.043	0.044	0.044	**-0.043**	0.119	-0.002	0.234	-0.091	0.524
LAI (flowering)	0.281	0.006	0.361	-0.029	0.039	-0.030	-0.019	**0.273**	-0.033	0.291	-0.245	0.896
Days to flowering	-0.183	0.001	-0.327	0.008	-0.005	0.005	0.001	-0.135	**0.067**	-0.090	0.157	-0.501
Straw yield	0.207	0.009	0.278	-0.036	0.047	-0.028	-0.024	0.191	-0.014	**0.418**	-0.172	0.875
Ratooning ability	0.287	0.005	0.377	-0.022	0.027	-0.029	-0.014	0.243	-0.038	0.260	**-0.276**	0.818

Bold figures represent direct effects

flowering through tiller number during flowering (-0.183) and straw yield through ratooniong ability (-0.172).

Path analysis was also carried out using significant genotypic correlations of nine main crop characters viz. grains panile^{-1}, number of unproductive and productive tillers plant^{-1}, 1000 grain weight, main crop grain yield, days to flowering, grain production day^{-1}, grain length and grain thickness with ratoon yield. This was performed in order to find out the interaction of various main crop characters with ratoon yield. Results of the path analysis are presented in Table 23.

The residual effect of the analysis was found to be 0.37. The highest positive direct effect was exhibited by grains panicle^{-1} (0.921) on ratoon yield. This was followed by grain length (0.849), grain thickness (0.586) and main crop yield (0.584). The highest negative direct effect on ratoon yield was obtained for 1000 grain weight (-0.841) followed by grain production day^{-1} (-0.665). Days to flowering exhibited the lowest positive direct effect and indirect effect of other characters through this trait was also found to be negligible.

The highest positive indirect effect was observed for grains panicle^{-1} via. grain length (0.425) and grain production day^{-1} via. main crop yield (0.425). This was followed by days to flowering through grain production day^{-1} (0.407), 1000 grain weight through grain length (0.406), number of unproductive tillers plant^{-1} through 1000 grain weight (0.377), 1000 grain weight through grain thickness (0.335) and number of unproductive tillers through grain production day^{-1} (0.329). Main crop grain yield exhibited the highest negative indirect effect via grain production day^{-1} (-0.484) and grain thickness via 1000 grain weight (-0.481). This was followed by grain length through grains panicle^{-1} (-0.462), grain length through 1000 grain weight (-0.402), number of productive tillers through grains panicle^{-1} (-0.325), grain production day^{-1} via 1000 grain weight (-0.295) and 1000 grain weight via grains panicle^{-1} (-0.292).

Table 23. Direct and indirect effects of main crop characters on ratoon yield

Characters	Grains panicle^{-1}	No. of unproductive tillers plant^{-1}	No. of productive tillers plant^{-1}	1000 grain weight	Main crop grain yield	Days to flowering	Grain production day^{-1}	Grain length	Grain thickness	Correlation coefficient with ratoon yield
Grains panicle^{-1}	**0.921**	-0.015	-0.112	0.266	-0.029	0.000	-0.043	-0.425	-0.168	0.394
No. of unproductive tillers plant^{-1}	-0.062	**0.227**	-0.086	0.377	-0.075	0.007	0.329	-0.174	-0.043	0.496
No. of productive tillers plant^{-1}	-0.325	-0.061	**0.318**	0.111	0.073	-0.004	-0.195	-0.064	-0.147	-0.292
1000 grain weight	-0.292	-0.102	-0.042	**-0.841**	0.157	-0.002	0.234	0.406	0.335	-0.612
Main crop grain yield	-0.045	-0.029	0.039	-0.227	**0.584**	0.000	-0.484	-0.121	0.066	-0.215
Days to flowering	0.019	0.156	-0.122	0.203	-0.028	**0.010**	0.407	-0.257	0.063	0.448
Grain production day^{-1}	0.059	-0.112	0.093	-0.295	0.425	-0.006	**-0.665**	0.015	0.013	-0.497
Grain length	-0.462	-0.046	-0.024	-0.402	-0.083	-0.003	-0.012	**0.849**	-0.131	-0.313
Grain thickness	-0.265	-0.017	-0.080	-0.481	0.066	0.001	0.014	-0.190	**0.586**	-0.363

Bold figures represent direct effects

4.2.8 Selection index

A selection model for making selection based on several characters simultaneously was developed. All possible combinations of eleven ratoon crop characters were formulated and models with maximum expected genetic gain were selected from models with equal character combinations. Eleven models were thus developed and are presented in Table 24.

Maximum expected genetic gain i(274.197) was noted when ratoon yield (y) and 11 yield components were used in the selection model namely, total number of tillers during flowering (x_1), plant height (x_2), number of productive tillers plant^{-1} (x_3), panicle length (x4), grains panicle^{-1} (x_5), 1000 grain weight (x_6), flag leaf area (x_7), LAI (flowering) (x_8), days to flowering (x_9), straw yield (x_{10}) and ratooning ability (x_{11}).

From the proposed 11 models, the model having minimum number of character combination including three yield components namely number of productive tillers plant^{-1} (x_3), LAI (flowering) (x_8) and straw yield (x_{10}) was selected. This model gave an expected genetic gain of i(273.212) approximately same as that given by the eleven character model. This selection model was used for ranking the 24 genotypes.

Estimates of selection index using the above mentioned three characters and ranking according to index and yield are given in Table 25. According to selection index first five ranks were obtained for the varieties White Ponni, Mangala Mahsuri, Ponmani, CO 43 and IR 20. According to yield, first five ranks were obtained for varieties viz. Mangala Mahsuri, White Ponni, CO 43, Ponmani and IR 20.

A selection model was also worked out using all possible combinations of nine main crop characters and models with maximum expected genetic gain

Table 24. Selection index for different ratoon crop yield components on ratoon crop yield

Sl. No.	Combination	Selection index	Expected genetic gain
1	y, x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}	-2.824 x_1 + -.0449 x_2 + 27.336 x_3 + -8.334 x_4 + 2.132 x_5 + 2.325 x_6 + 3.480 x_7 + 288.379 x_8 + -1.786 x_9 + 0.210 x_{10} + -9.865 x_{11}	i.274.197
2	y, x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}	-4.033 x_1 + -0.459 x_2 + 27.402 x_3 + -8.261 x_4 + 2.120 x_5 + 2.240 x_6 + 3.556 x_7 + 289.120 x_8 + -1.799 x_9 + 0.211 x_{10}	i.274.197
3	y, x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_9, x_{10}	34.485 x_1 + 0.421 x_2 + 25.799 x_3 + -8.879 x_4 + 3.753 x_5 + 2.403 x_6 + 1.241 x_7 + 2.175 x_9 + 0.216 x_{10}	i.274.116
4	y, x_1, x_3, x_4, x_5, x_8, x_9, x_{10}	-4.763 x_1 + -0.174 x_2 + 27.605 x_3 + -5.429 x_4 + 2.173 x_5 + 285.447 x_8 + -1.885 x_9 + 0.207 x_{10}	i.274.091
5	y, x_2, x_3, x_4, x_5, x_8, x_9, x_{10}	-0.138 x_2 + 26.072 x_3 + -5.759 x_4 + 2.330 x_5 + 267.120 x_8 + -1.872 x_9 + 0.205 x_{10}	i.274.067
6	y, x_3, x_4, x_5, x_8, x_9, x_{10}	26.106 x_3 + -5.875 x_4 + 2.288 x_5 + 266.424 x_8 + -1.903 x_9 + 0.204 x_{10}	i.274.064
7	y, x_3, x_5, x_8, x_9, x_{10}	26.840x_3 + 1.835 x_5 + 262.833 x_8 + -1.838 x_9 + 0.197 x_{10}	i.273.889
8	y, x_3, x_8, x_9, x_{10}	29.518 x_3 + 275.917 x_8 + -1.292 x_9 + 0.212 x_{10}	i.273.432
9	y, x_3, x_8, x_{10}	35.64 x_3 + 279.917 x_8 + 0.203 x_{10}	i.273.212
10	y, x_3, x_{10}	61.192 x_3 + 0.264 x_{10}	i.266.845
11	y, x_{10}	243.864 x_{10}	i.248.864

y = ratoon crop yield
x_1 = total no. of tillers during flowering
x_2 = plant height
x_3 = number productive tillers plant^{-1}
x_4 = panicle length
x_5 = grains panicle^{-1}
x_6 = 1000 grain weight
x_7 = flag leaf area
x_8 = LAI (flowering)
x_9 = days to flowering
x_{10} = straw yield
x_{11} = ratooning ability

Table 25. Estimates of selection index using characters namely, number of productive tillers plant^{-1} (x_3), LAI during flowering (x_8) and straw yield (x_{10})

Sl.No.	Variety	Selection index	Rank according to	
			Selection index	Yield
1	White Ponni	995.85	1	2
2	Mangala Mahsuri	951.34	2	1
3	Ponmani	874.31	3	4
4	CO 43	833.13	4	3
5	IR 20	619.99	5	5
6	Pankaj	453.16	6	7
7	Neeraja	412.95	7	6
8	CORH 2	347.97	8	13
9	IR 64	330.81	9	14
10	ADT 38	317.89	10	12
11	MO 16	287.40	11	9
12	MO 19	265.93	12	8
13	MO 18	252.94	13	11
14	M 48-11-3	221.11	14	22
15	Jayathi	210.46	15	10
16	IR 36	207.20	16	24
17	M 61-6-1-1	199.33	17	20
18	Ptb 8	182.49	18	15
19	MO 15	176.09	19	16
20	IR 8	173.80	20	23
21	MO 5	171.39	21	19
22	MO 12	171.22	22	18
23	Swarnaprabha	144.06	23	17
24	ASD 20	139.37	24	21

were selected from models with equal character combinations. Nine models were thus developed and are presented in Table 26.

Maximum expected genetic gain i(224.65) was observed when ratoon yield (y) and nine main crop yield components were used in the selection model viz., grains panicle^{-1} (x_1), number of unproductive tillers plant^{-1} (x_2), number of productive tillers plant^{-1} (x_3), 1000 grain weight (x_4), main crop grain yield (x_5), days to flowering (x_6), grain production day^{-1} (x_7), grain length (x_8) and grain thickness (x_9).

From the proposed nine models, the model having minimum number of character combination, including six yield components viz., grains panicle^{-1} (x_1), number of productive tillers plant^{-1} (x_3), 1000 grain weight (x_4), grain yield (x_5), grain production day^{-1} (x_7) and grain thickness (x_9) was selected. This model gave an expected genetic gain of i(224.306) approximately same as that given by the nine character model. This selection model was utilized for ranking of the 24 genotypes.

Estimation of selection index using the above mentioned six characters and ranking according to index and yield are given in Table 27. According to selection index first 5 ranks were obtained for the varieties viz., White Ponni, CO 43, IR 20, Ponmani and Mangala Mahsuri. According to yield first five ranks were obtained for varieties namely, Mangala Mahsuri, White Ponni, CO 43, Ponmani and IR 20.

Table 26. Selection index for different main crop yield components on ratoon crop yield

Sl. No.	Combination	Selection index	Expected genetic gain
1	y, x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9	2.269 x_1 + -2.066 x_2 + -25.008 x_3 + -34.982 x_4 + 622.647 x_5 + -1.841 x_6 + -95563.95 x_7 + 0.049 x_8 + -228.362 x_9	i.224.650
2	y, x_1, x_3, x_4, x_5, x_6, x_7, x_8, x_9	2.286 x_1 + -24.019 x_3 + -34.671 x_4 + 623.052 x_5 + -1.925 x_6 + -95689.95 x_7 + 5.661 x_8 + -227.340 x_9	i.224.646
3	y, x_1, x_3, x_4, x_5, x_7, x_8, x_9	2.249 x_1 + -22.836 x_3 + -34.645 x_4 + 541.538 x_5 + -83945.21 x_7 + 0.180 x_8 + -226.157 x_9	i.224.378
4	y, x_1, x_3, x_4, x_5, x_7, x_9	2.157 x_1 + -23.410 x_3 + -33.835 x_4 + 533.866 x_5 + -83423 x_7 + -239.574 x_9	i.224.306
5	y, x_1, x_4, x_5, x_7	2.391 x_1 + -20.413 x_3 + -36.880 x_4 + 509.840 x_5 + -80816.09 x_7	i.222.409
6	y, x_1, x_4, x_5, x_7	2.691 x_1 + -34.516 x_4 + 527.275 x_5 + -86523.83 x_7	i.219.964
7	y, x_4, x_5, x_7	-40.539x_4 + 470.144 x_5 + -7755.61 x_7	i.206.067
8	y, x_4, x_8	-42.462 x_4 + -32737.12 x_8	i.188.508
9	y, x_4	-48.799 x_4	i.168.226

y = ratoon crop yield
x_1 = grain panicle^{-1}
x_2 = number of unproductive tillers plant^{-1}
x_3 = number productive tillers plant^{-1}
x_4 = 1000 grain weight
x_5 = grain yield
x_6 = days to flowering
x_7 = grain production day^{-1}
x_8 = grain length
x_9 = grain thickness

Table 27. Estimates of selection index using characters viz., grains panicle^{-1} (x_1), number of productive tillers plant^{-1} (x_2), 1000 grain weight (x_4), grain yield (x_5), grain production day^{-1} (x_7) and grain thickness (x_9)

Sl.No.	Variety	Selection index	Rank according to	
			Selection index	Yield
1	White Ponni	-890.18	1	2
2	CO 43	-899.58	2	3
3	IR 20	-929.37	3	5
4	Ponmani	-945.21	4	4
5	Mangala Mahsuri	-986.88	5	1
6	Pankaj	-1150.91	6	7
7	MO 17	-1226.29	7	-
8	Jayathi	-1231.44	8	10
9	MO 15	-1241.67	9	16
10	ADT 38	-1257.55	10	12
11	Neeraja	-1259.87	11	6
12	ADT 43	-1290.59	12	-
13	Aathira	-1295.67	13	-
14	MO 6	-1303.61	14	-
15	MO 16	-1335.52	15	9
16	MO 18	-1343.16	16	11
17	MO 9	-1343.93	17	-
18	MO 11	-1360.79	18	-
19	MO 8	-1362.61	19	-
20	CORH 2	-1363.46	20	13
21	MO 19	-1366.38	21	8
22	ADT 36	-1386.86	22	-
23	MO 13	-1394.73	23	-
24	IR 36	-1408.25	24	24
25	M 48-11-3	-1415.91	25	22
26	Ptb 26	-1429.70	26	-
27	Bharathi	-1440.28	27	-
28	IR 8	-1442.62	28	23
29	M 61-6-1-1	-1452.32	29	20
30	M 38-4-1	-1453.82	30	-
31	MO 14	-1454.75	31	-
32	Jaya	-1458.15	32	-
33	Ptb 10	-1472.54	33	-
34	MO 4	-1483.02	34	-
35	Ptb 2	-1493.85	35	-
36	MO 12	-1494.60	36	18
37	Ptb 1	-1499.33	37	-

38	MO 4	-1519.26	38	-
39	M 38-4-2	-1525.32	39	-
40	MO 10	-1542.27	40	-
41	Swarnaprabha	-1554.10	41	17
42	Ptb 8	-1559.76	42	15
43	IR 64	-1568.62	43	14
44	ASD 20	-1570.68	44	21
45	Kairali	-1608.17	45	-
46	MO 5	-1661.10	46	19
47	Ahalya	-1691.35	47	-
48	Jyothi	-1714.70	48	-
49	Aiswarya	-1734.66	49	-
50	Ptb 28	-1966.62	50	-

Discussion

DISCUSSION

Ratoon cropping of rice is one among the different ways of increasing rice production without increasing the land area. Successful ratooning is a complex trait and the factors contributing to it are numerous. In order to get an idea about the ratoon performance and the inter-relations among the main crop and ratoon crop characters, the present study was conducted utilizing 50 diverse rice genotypes.

Among the rice genotypes evaluated, only 24 exhibited regrowing ability and genotypes viz. CO 43, IR 20, White Ponni, Ponmani and Mangala Mashuri showed better ratoon performance as compared to the others. Genetic variability, PCV, GCV, heritability, genetic advance, genetic gain, character association, path analysis and selection indices were estimated for the main and ratoon crop characters and the results are discussed in this chapter.

5.1 Genetic variability

In the process of crop improvement, desirable plants are continuously being selected from genetically variable population. Genetic improvement thus depends on the existence of genetic variability. Therefore an insight into the magnitude of variability present in a crop species is of utmost importance as it is a key factor which determines the amount of progress expected from selection.

In the main crop, all characters except chlorophyll a during flowering exhibited significant difference among the different genotypes studied. The range for these traits was also found to be wide, indicating that the genotypes selected for the present study were genetically diverse. Variability among different characters were previously observed by several workers like Lal *et al.* (1983), Singh *et al.* (1984), Sardana and Sasikumar (1987), Chaubey and Riccharia (1990), Gomathinayagam *et al.* (1990), Bashar *et al.* (1991) and Satpute (1996) for the characters viz. flowering duration, grains panicle^{-1}, days to maturity, 1000 grain weight, panicle length, plant height, harvest index, flag leaf area and grain yield.

Ratoon crop in the present investigation showed significant difference among the different genotypes with respect to the characters studied. Range for the characters was also wide, which reflects that the genotypes included in the study are not genetically similar. Variability for ratooning ability was previously observed by Gupta and Mitra (1948).

Ratooning ability which is a measure of the plants to regenerate after harvest, was estimated in the present study. Wide variation was noted for this character among the varieties studied. Chang *et al.* (1985), in a study of 163 varieties recorded ratooning ability varying from 0 to 122.9 per cent. Tiller decline percentage was also calculated. Fig. 1 indicates the ratoon performance of different rice genotypes having varying values of tiller decline percentage and ratooning ability, reflecting that varieties with higher ratoon yield have a good ratooning ability and tiller decline.

The physiological character viz. carbohydrate contents of leaves and stubbles were estimated (Table 28). But no significant difference was observed in the carbohydrate contents of ratooned and non ratooned varieties. Supporting evidence was reported by Arumugachamy *et al.* (1990) that the effect of stubble carbohydrate content on ratoon yield was not significant.

Anatomical trait namely number of vascular bundles were studied in both crops. The varieties with a well developed conduction system in the ratoon crop were found to be giving a better performance. These varieties included CO 43, White Ponni, Ponmani, IR 20 and Mangala Mahsuri. Their anatomical cross section showing the vascular bundles are shown in Plate 3.

Table 28. Carbohydrate contents of rice genotypes during different stages (mg g^{-1})

a) Ratooned varieties

Sl. No.	Variety	Main crop				Ratoon crop		
		1	2	3	4	5	6	7
1	CO 43	0.502	0.833	0.525	0.346	0.380	0.357	0.335
2	IR 20	0.458	0.646	0.296	0.567	0.332	0.307	0.499
3	Ponmani	0.348	0.883	0.561	0.325	0.333	0.278	0.351
4	White Ponni	0.512	0.809	0.392	0.671	0.525	0.317	0.356
5	Mangala Mahsuri	0.566	0.835	0.315	0.778	0.567	0.294	0.436

b) Varieties with regrowing ability

Sl. No.	Varieties	Carbohydrate contents			
		1	2	3	4
1	M 48-11-3	0.265	0.755	0.548	0.260
2	IR 8	0.280	0.815	0.525	0.332
3	Ptb 8	0.292	0.640	0.522	0.321
4	Pankaj	0.294	0.800	0.556	0.317
5	MO 19	0.366	0.758	0.564	0.320

c) Non ratooned varieties

Sl. No.	Varieties	Carbohydrate contents			
		1	2	3	4
1	Kairali	0.301	0.722	0.536	0.406
2	Ahalya	0.362	0.732	0.512	0.521
3	Ptb 1	0.315	0.786	0.535	0.705
4	MO 8	0.279	0.758	0.503	0.616
5	ADT 36	0.260	0.635	0.397	0.559

1 – Active tillering
2 – Panicle initiation
3 – Flowering
4 – Stubbles
5 – Panicle initiation
6 – Flowering
7 – Stubbles

5.2 Phenotypic and genotypic coefficients of variation

The characters namely, LAI (flowering), days taken for completion of flowering within a hill, plant height, number of unproductive tillers plant^{-1}, flag leaf area and straw yield recorded high magnitudes of PCV and GCV in the main crop. Similar results were reported for LAI by Rao *et al.* (1996) and for flag leaf area and plant height by Kumar *et al.* (1998), which confirmed that there is scope for genetic improvement of these characters through selection. On the other hand tiller number during different stages, days to flowering, number of productive tillers plant^{-1}, panicle length, grains panicle^{-1}, 1000 grain weight and harvest index recorded moderate values for PCV and GCV, indicating the usefulness of the characters in selection. Supporting results were obtained by Sarsdana and Sasikumar (1987) for panicle length and grains panicle^{-1} and Reddy *et al.* (1997) for grains panicle^{-1} and 1000 grain weight. Mishra *et al.* (1996) indicated high estimates of PCV and GCV for grains panicle^{-1} from the trials of ten scented rice genotypes.

Low values of variability for days to harvest, grain density, length, breadth and thickness of grains reflects the meagre possibility of using these traits in the selection programme. Pathak and Patel (1989) reported a similar finding of low variability for days to harvest. Reports of Vanaja (1998) also supported the results. The characters tiller number during active tillering, LAI (active tillering and panicle initiation), chlorophyll contents during different stages and grain yield showed a large difference between PCV and GCV, indicating the great influence of environmental factors on these traits. This is in agreement with the results of Singh *et al.* (1986), who reported higher PCV values for yield and tiller number. Similarly Chaubey and Singh (1994) obtained PCV greater than GCV for many yield related components.

PCV was found to be equal to or very near to that of GCV in the case of days to flowering, days to harvest, days taken for completion of flowering within a hill, plant height and panicle length. Hence the influence of environment on these characters was found to be little as suggested by Maurya *et al.* (1986). Deviating from this Vanaja (1998) reported high influence of environment on plant height.

In the ratoon crop different characters namely, total number of tillers during panicle initiation and flowering, LAI during these two stages, chlorophyll b during flowering, days to flowering, days taken for completion of flowering within a hill, plant height, number of productive tillers plant^{-1}, flag leaf area, grains panicle^{-1}, grain thickness, straw and grain yield, grain production day^{-1} and ratooning ability recorded high magnitudes of PCV and GCV which confirmed that there is immense chance for improvement of these characters through selection. In other words selection is possible for ratoon crop based on these traits. But chlorophyll a and b during panicle initiation, chlorophyll a during flowering, days to harvest, panicle length, grain breadth and harvest index exhibited moderate values for PCV and GCV, reflecting their moderate usefulness in selection. Other traits namely, grain density and grain length showed low values, indicating their least preference while making selection.

Number of productive tillers plant^{-1}, grain thickness, total yield and ratooning ability showed difference between PCV and GCV, indicating influence of environmental factors on these traits. All other characters had PCV almost equal to GCV, reflecting the little influence of environment and more usefulness in selection. Main crop characters showed low to high values for PCV and GCV, but ratoon crop recorded high GCV values for most of the characters (Fig.2), indicating that ratoon characters are more useful in selection.

5.3 Heritability

Heritability indicates the extent to which the parents are capable of transferring their characters to the next generation. The estimates of heritability help the plant breeder in the selection of elite genotypes from diverse genetic

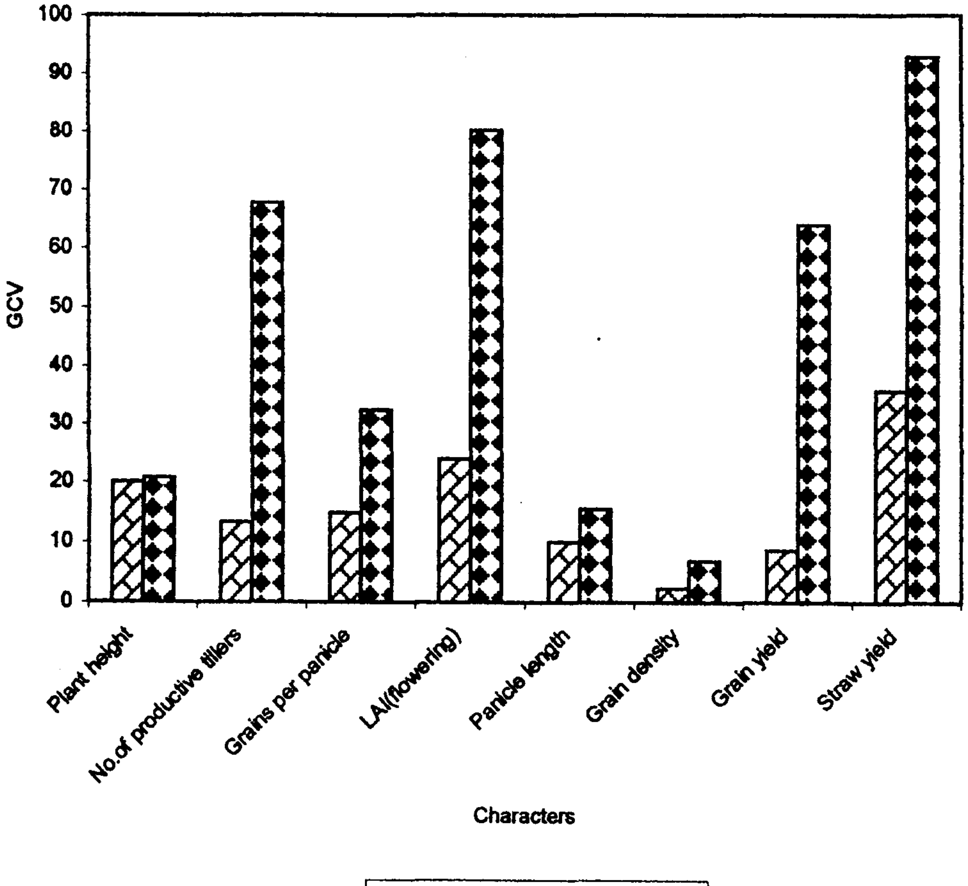


Fig. 2. Comparison of GCV values for different main crop and ratoon crop characters

heritability values for ratoon tillers. The heritability for different characters in main and ratoon crop are represented in Fig. 3.

5.4 Genetic advance and genetic gain

Genetic advance refers to the improvement in genotypic value of new population as compared with the base population and when it is expressed as percentage of means the new parameter is termed as genetic gain. So to have an effective selection along with heritability genetic gain measurement is also important.

Total number of tillers during flowering, LAI (flowering), days to flowering, days taken for completion of flowering within a hill, plant height, flag leaf area, leaf area duration, grains panicle^{-1}, 1000 grain weight, straw yield and harvest index showed high expected genetic grain. Hence there characters will have a good response to selection and can be improved by selection from the base population. Supporting results were reported by Remina *et al.* (1992), Roy and Kar (1992), Chauhan *et al.* (1993), Sawanth and Patil (1995), Shanthakumar *et al.* (1998) and Kumari *et al.* (1999).

The characters viz. total number of tillers during active tillering and panicle initiation, LAI, days to harvest, number of productive tillers plant^{-1}, panicle length, grain length, grain breadth and grain yield recorded moderate values for genetic gain, indicating that they are moderate in their usefulness to selection. Similar results were reported for grain yield by Sahu and Sahu (1990) and for panicle length by Vanaja (1998). Characters viz. chlorophyll contents, grain thickness and grain density recorded a low genetic gain and can be considered as having little value in selection.

Singh and Narayanan (1993) suggested that estimates of heritability and genetic advance when considered together is more useful than heritability alone. If the heritability is due to additive genetic effects i.e., the part which is useful to the

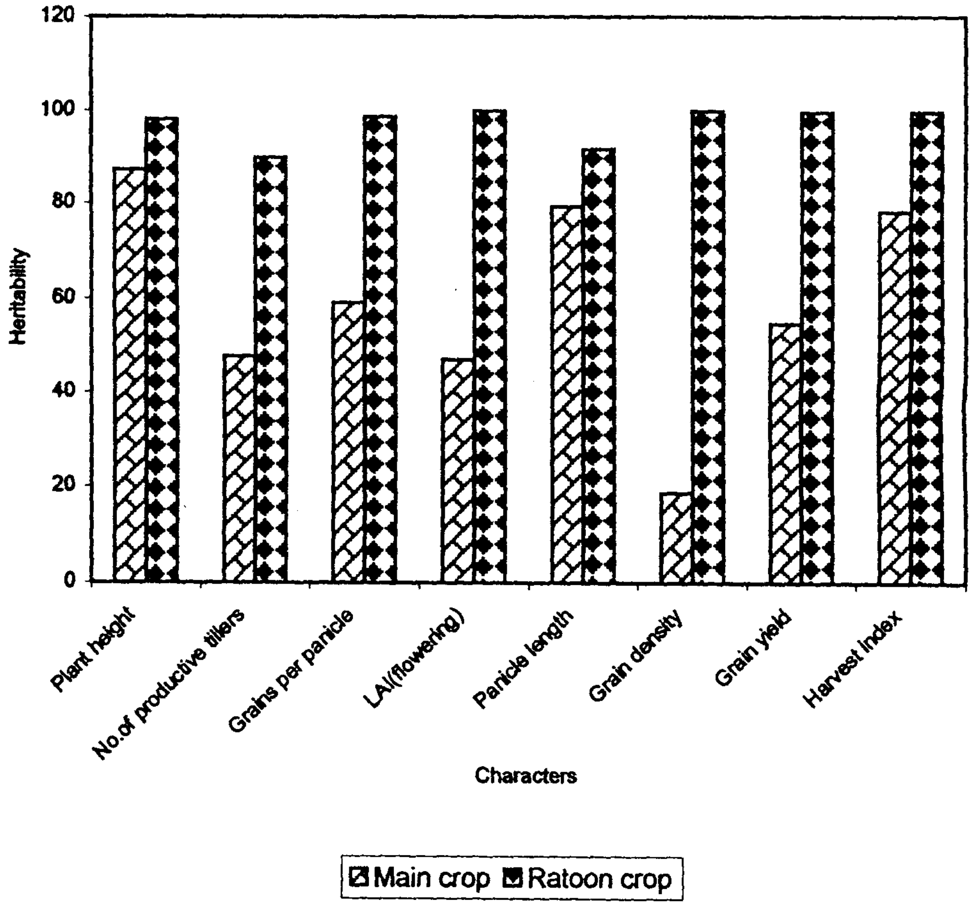


Fig. 3. Comparison of heritability values for different main crop and ratoon crop characters

breeder, the expected genetic gain would be high and if it is due to non aditive effects, the genetic gain would be low. So to have a more reliable conclusion for the present study, the characters which have high heritability, high genetic gain and high GCV were considered. These included days taken for completion of flowering within a hill, plant height, flag leaf area and straw yield. High heritability and high expected genetic gain coupled with moderate GCV were observed for harvest index and 1000 grain weight. These results suggest that the above mentioned characters are under the control of additive genetic effects. Findings of Subramanian and Rathinam (1984) and Vanaja (1998) support the above results. So these characters are useful for direct selection from phenotypic performance.

Very high genetic gain was exhibited by all ratoon crop characters, hence selection will be rewarding for the improvement of these traits. But total yield, grain density and grain length showed moderate genetic gain, suggesting their moderate role in improvement through selection. Wali and Mahadevappa (1995) reported high genetic gain for plant height and ratooning ability, supporting the results.

5.5 Correlation and path analysis

Correlation coefficient measures the intensity of linear relationship between variables. In genetic studies it is common to find the correlation between two or more characters. Genotypic correlation between two or more characters may result from pleiotropic effects of genes or linkage of genes governing the inheritance of the characters. Phenotypic correlation on the other hand is determined by genotypic and environmental effects. Thus estimation of correlation coefficients among different characters is very much important to know the type of relationship existing between the variables. Sometimes correlation coefficients may not be due to the direct effect of the characters, but due to the indirect effects through other characters. Hence in order to identify the direct and indirect effects of the variables path analysis was conducted.

Main crop yield and different other characters were subjected to correlation analysis. Phenotypic and genotypic correlations among different characters of main crop is obtained. Significant positive correlation at genotypic and phenotypic levels were observed for the characters viz. chlorophyll b during flowering and grain production day^{-1} with main crop yield. Significant negative correlation at genotypic level was observed for grain density. Grain production day^{-1} showed a higher phenotypic correlation than genotypic, indicating the influence of environment on this character (Fig. 4). Among the various components, the highest genotypic association with yield was recorded by grain production day^{-1} followed by chlorophyll b during flowering. Grain production day^{-1} was positively correlated with flag leaf area and negatively and significantly with number of unproductive tillers plant^{-1} and LAI (flowering). When the number of unproductive tillers increase, the plant is continuing its vegetative growth and hence the contribution towards grain production decrease. Flag leaf or boot leaf is the place for preparation of photosynthates for grain filling. So when the area increase, photosynthesis also will be more leading to an increased grain production day^{-1}. LAI (flowering) showed a negative association with grain production day^{-1} which can be explained as the result of mutual shading and non effective light interception. This was found to be in agreement with the results of Chau and Bhargava (1993). They reported a negative correlation of LAI (flowering) with grain yield. Present study, also revealed that content of chlorophyll b during flowering exhibited positive and significant correlation with content of chlorophyll b during active tillering, chlorophyll a during flowering, grain production day^{-1} and harvest index. This reflects that the photosynthetic pigment contents are correlated among themselves and also with harvest index and grain production day^{-1}. When the pigment content is high, the source activity will be more, leading to increased photosynthesis and high grain yield. So a chlorophyll rich plant performs better and harvest more sunlight than the others, leading to high grain yield through more grain production day^{-1}. Sarwagi *et al.* (1997) indicated that grain yield of rice had a positive correlation with harvest index.

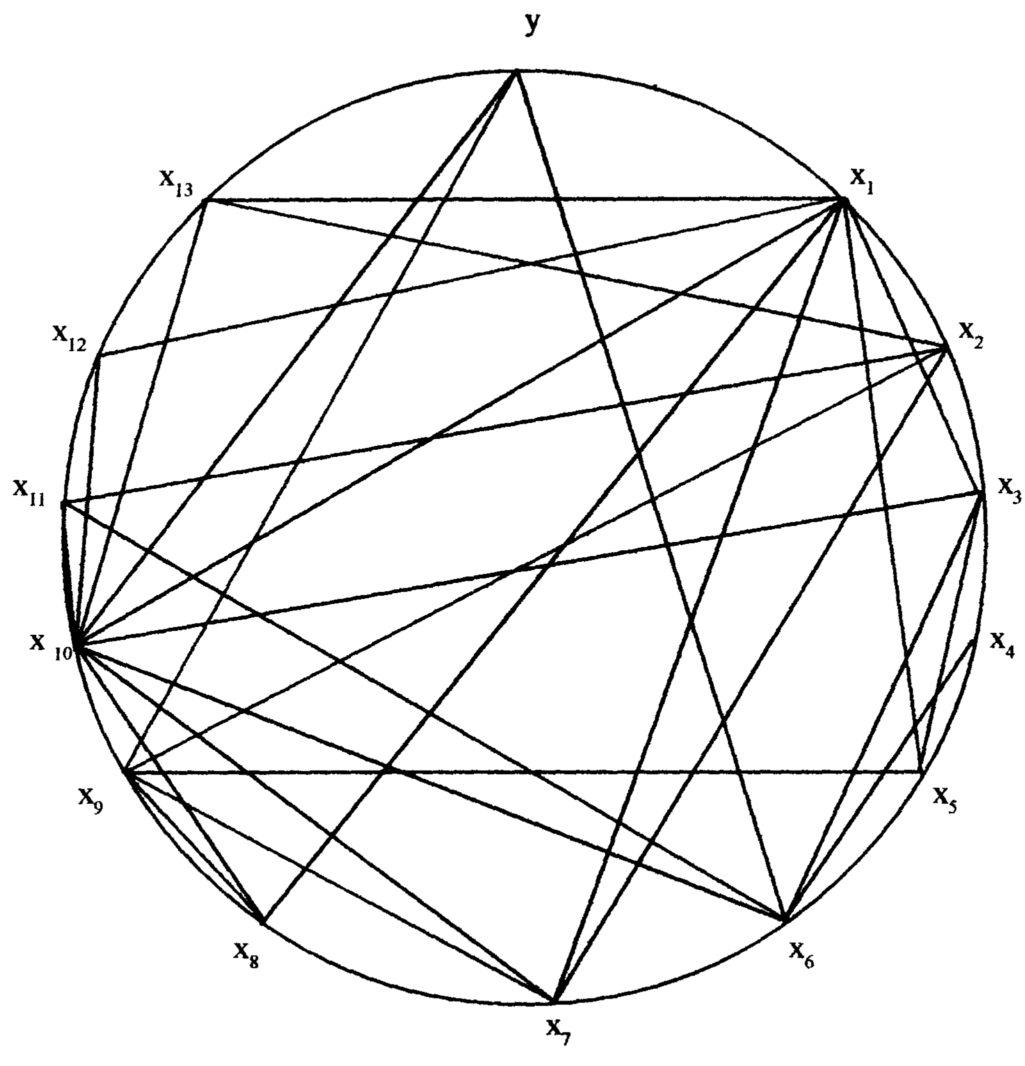


Fig. 4. Genotypic correlation of main crop yield and different main crop characters

x_1 - Number of unproductive tillers plant^{-1}
x_2 - Straw yield
x_3 - 1000 grain weight
x_4 - Chlorophyll b (active tillering)
x_5 - Tiller number (panicle initiation)
x_6 - Chlorophyll b (flowering)
x_7 - Days to flowering
x_8 - Days to harvest
x_9 - Grain density
x_{10} - Grain production day^{-1}
x_{11} - Harvest index
x_{12} - Flag leaf area
x_{13} - LAI (flowering)
y - Main crop grain yield

——— Positive correlation
——— Negative correlation

Ratoon yield was positively and significantly correlated at genotypic and phenotypic levels with tiller number during panicle initiation and flowering, plant height, number of productive tillers plant^{-1}, panicle length, grains panicle^{-1}, flag leaf area, LAI during panicle initiation and flowering, straw yield, grain production day^{-1} and ratooning ability, which indicate that there is a strong association between ratoon yield and these characters.Days to flowering and visual panicle initiation had negative and significant correlation with yield at both levels. At genotypic level chlorophyll b content during flowering recorded positive correlation with yield where as 1000 grain weight showed a significant negative correlation (Fig.5). Positive correlation of yield with most of the earhead characters and negative correlation with 1000 grain weight reflects that the improvement in ratoon yield is possible by increasing the earhead characters, plant height, number of productive tillers, LAI (flowering) and chlorophyll b content; and not by increasing the weight of grains or duration. Supporting result was reported by Prakash and Prakash (1987) in an association analysis among ratoon yield and different characters in which he obtained positive and significant correlation for number of tillers and ratoon plant height with yield.

In the present investigation path analysis was performed, using 11 ratoon crop characters which were significantly correlated with ratoon yield at genotypic levels. The direct and indirect effects of 11 components are given in Fig. 6. The low residual effect of 0.02 obtained in the analysis indicate that the characters included in the study are enough to explain the variability in ratoon yield. Ninety eight per cent of variation in yield was contributed genotypically by the 11 components included in the study viz. tiller number during flowering, plant height, number of productive tillers plant^{-1}, panicle length, grains panicle^{-1}, 1000 grain weight, flag leaf area, LAI (flowering), days to flowering, straw yield and ratooning ability.

The highest positive direct effect on ratoon yield was observed for number of productive tillers plant^{-1}. This character was having high positive

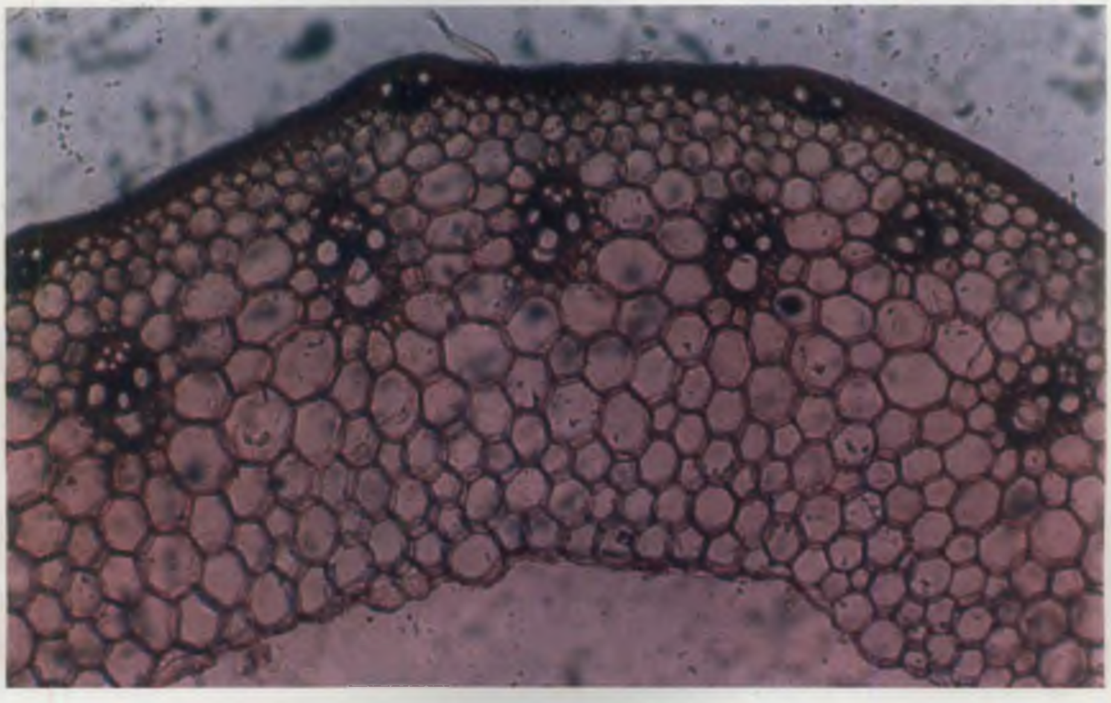


Plate 3a. Anatomical characteristics of ratooned variety (CO 43)

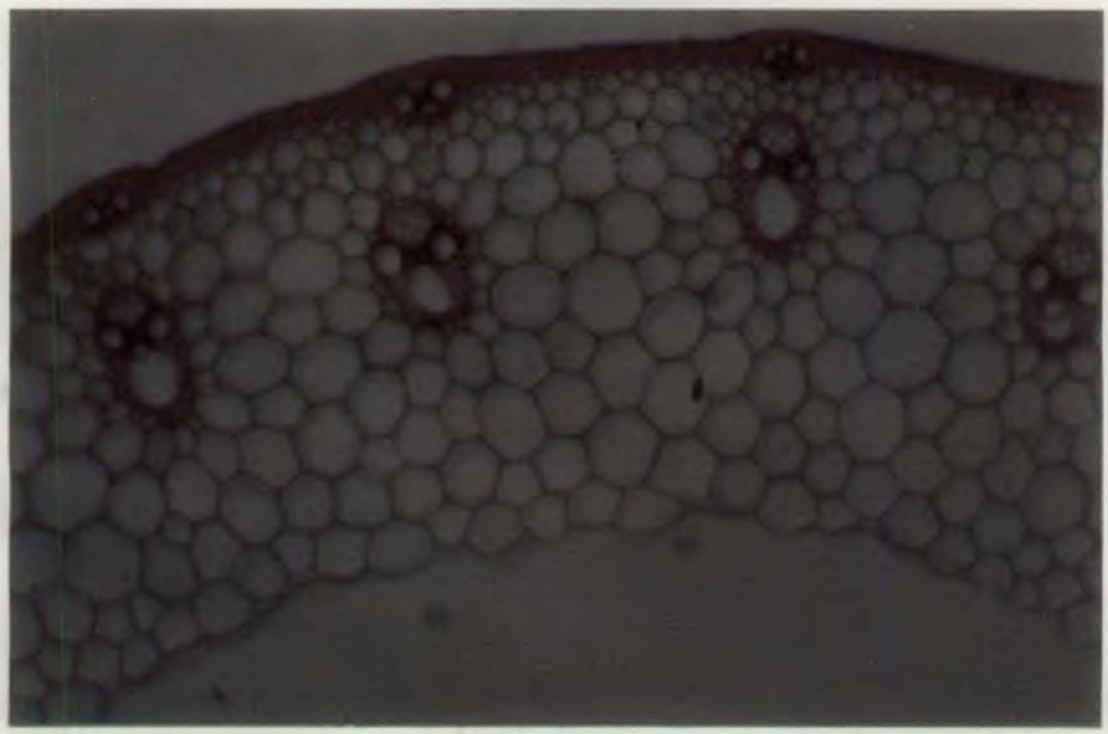


Plate 3b. Anatomical characteristics of ratooned variety (Mangala Mahsuri)

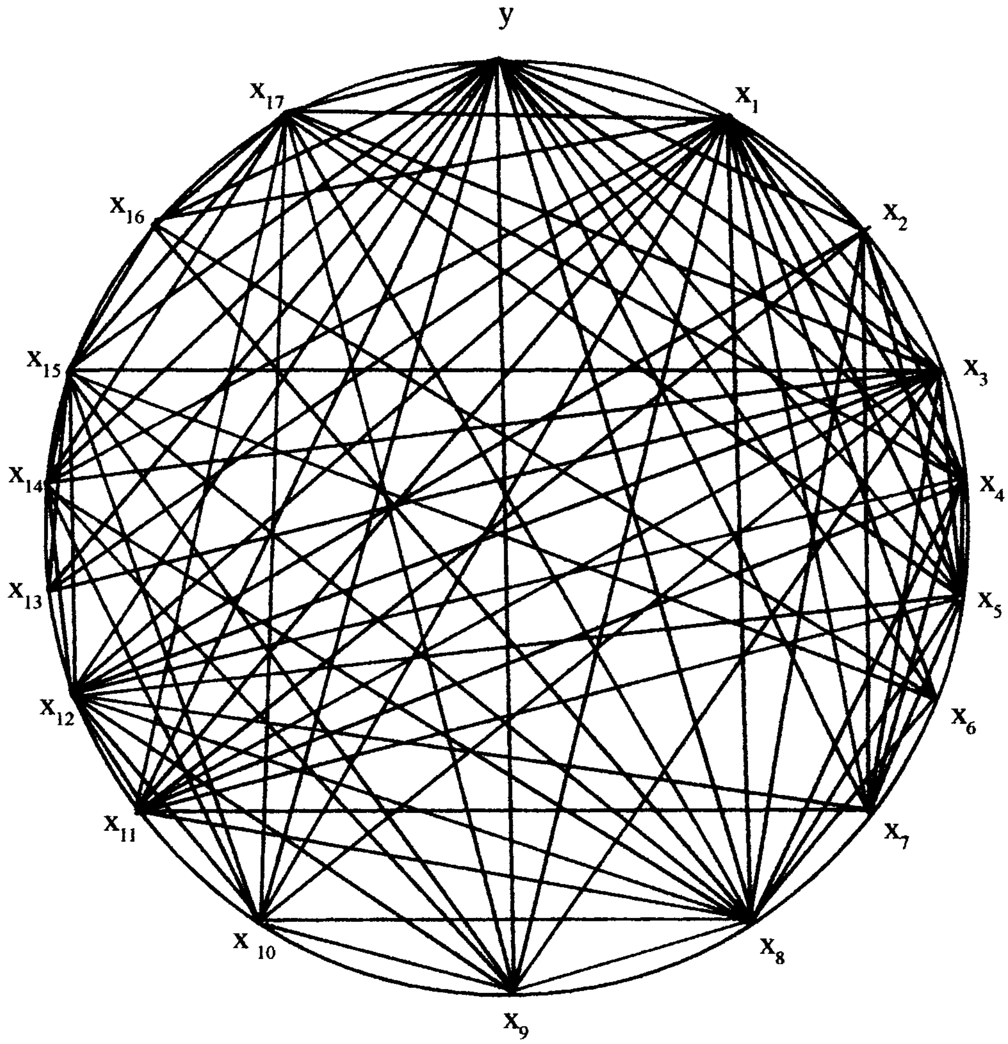
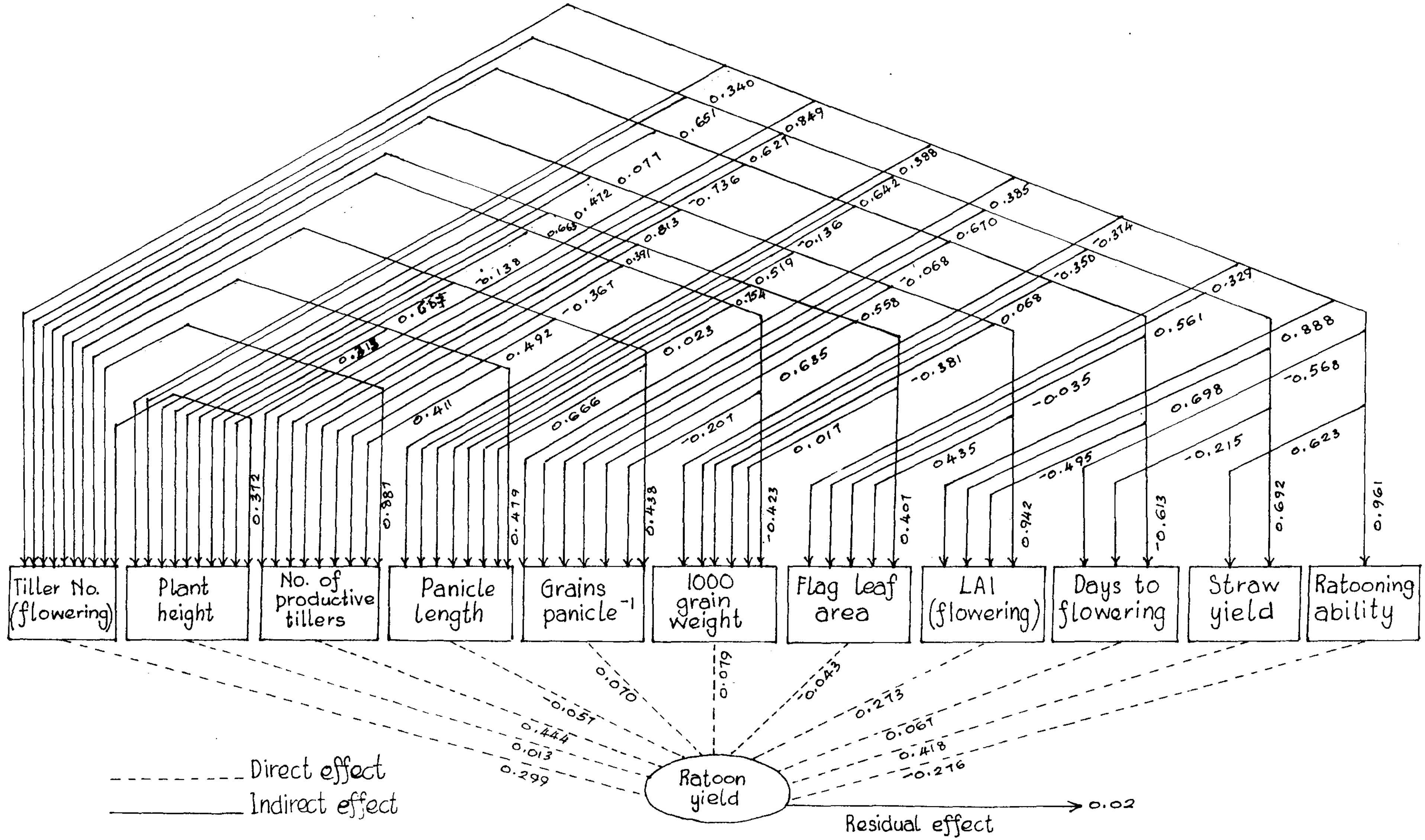


Fig. 5. Genotypic correlation among ratoon yield and different ratoon crop characters

x_1 - No. of tillers (flowering)
x_2 - Plant height
x_3 - No. of productive tillers plant^{-1}
x_4 - Panicle length
x_5 - Grains panicle^{-1}
x_6 - 1000 grain weight
x_7 - Flag leaf area
x_8 - LAI (flowering)
x_9 - Days to flowering
x_{10} - Days taken for visual panicle initiation
x_{11} - Straw yield
x_{12} - Grain production day^{-1}
x_{13} - Total Yield
x_{14} - Chlorophyll b (flowering)
x_{15} - No. of tillers (panicle initiation)
x_{16} - Ratooning ability
x_{17} - LAI (panicle initiation)
y - Ratoon yield

——— Positive correlation ——— Negative correlation

Fig. 6. Path diagram showing the direct and indirect effects of ratoon crop characters on ratoon yield



indirect effect through tiller number during flowering, LAI (flowering) and straw yield. Prakash and Prakash (1987) also reported the high direct effect of productive tillers on ratoon yield. High positive direct effects were also recorded by straw yield, LAI (flowering) and number of tillers at the time of flowering. These characters had high and positive correlation coefficients and indirect effects through other characters were also found to be high.

Even though ratooning ability was having high positive correlation with yield, it recorded a high negative direct effect. Indirect effect of this character through number of tillers during flowering, number of productive tillers, LAI (flowering) and straw yield were positive and high explaining the correlation coefficient. Ratooning ability is expressed as the proportion of regenerated tillers over the main crop stubbles. So an increased ratooning ability may not be due to the increased regeneration, it may be due to the low number of main crop stubbles. Hence the ratooning ability cannot be considered as a true index to assess the ratoon performance in the present investigation. This also indicate that better regeneration of a genotype need not lead to higher ratoon yield as evidenced from the present study. Some of the entries in the present investigation such as CORH 2 and IR 64 had higher regenerated tillers, but later they did not produce a considerably high grain yield. This was found to be in contrary to the results of Haque 1975, who considered ratooning ability as an index for early screening of genotypes for ratoon grain yield.

Results of path analysis revealed that greater emphasis has to be laid for characters of ratoon crop such as number of tillers during flowering, number of productive tillers plant^{-1}, LAI (flowering) and straw yield which have exerted positive and high direct effects towards yield. Reports of Singh (1988) and Zheng and Zhang (1996) are also in confirmity with the above results.

Ratoon yield was subjected to correlation analysis using main crop characters. The genotypic correlation of ratoon yield with various main crop characters are represented in Fig. 7. Higher positive correlation coefficient was observed for days to harvest, followed by days to flowering, number of unproductive tillers plant^{-1}and grains panicle^{-1}. Hence high ratoon yield could be achieved by a simultaneous selection for a long duration crop variety having more number of grains panicle^{-1} and unproductive tillers plant^{-1}. Sompaew (1979) also reported the better ratooning performance of long duration cultivars. Inter correlation studies revealed that days to harvest had a negative and significant correlation at both levels with grain production day^{-1} and flag leaf area. These in turn can contribute to more number of unproductive tillers plant^{-1} which was associated positively with ratoon yield. These tillers which remain dormant for the first crop may give rise to fresh productive tillers during ratoon period there by contributing to an increased ratoon yield. The unproductive tillers can also be produced by the increased number of days taken for completion of flowering within a hill. This staggered flowering behaviour itself may thus provide to ratoon yield. Thus a long duration crop with more unproductive tillers can be considered as a food reserve for the next crop.

Path analysis was conducted with ratoon yield and nine main crop characters viz. grains panicle^{-1} , number of unproductive tillers plant^{-1} , 1000 grain weight, grain yield, days to flowering, grain production day^{-1}, grain length and grain thickness. Grains panicle^{-1} in the main crop exhibited the highest positive direct effect on ratoon yield followed by grain length, grain thickness, grain yield, number of productive tillers plant^{-1} and number of unproductive tillers plant^{-1} (Fig. 8). These results indicate that genotypes having superior grain and earhead characters along with high tillering ability in main crop can produce high ratoon yield. Number of unproductive tillers in the main crop had high positive direct effect on ratoon yield. This character even though does not correlate with main crop yield can produce a better ratoon crop by producing more number of productive tillers in the ratoon crop. Highest negative direct effect was manifested by 1000 grains weight followed by grain production day^{-1}. Both these characters

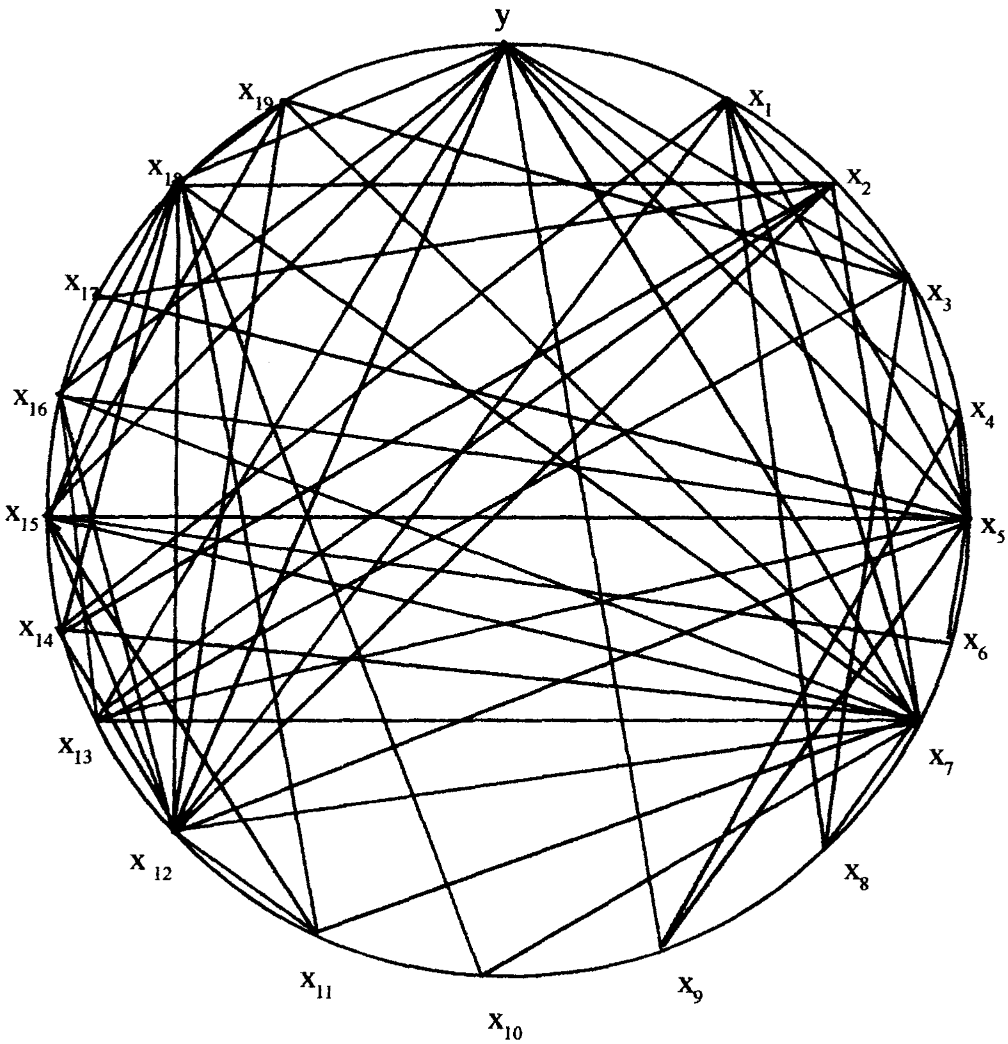
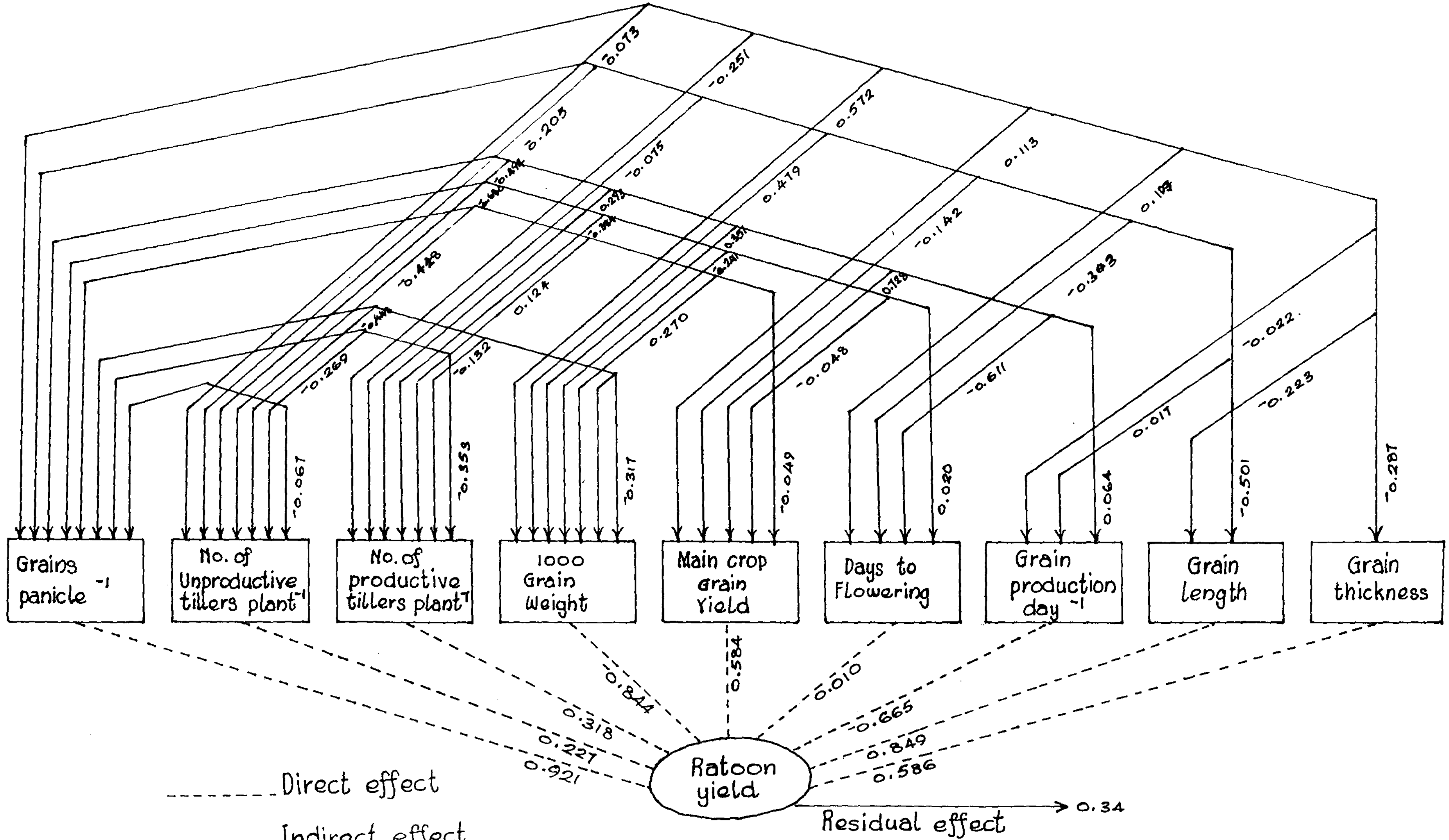


Fig. 7. Genotypic correlation among ratoon yield and different main crop characters

x_1 - No. of tillers (flowering)
x_2 - Panicle length
x_3 - Grains panicle^{-1}
x_4 - Chaff percentage
x_5 - 1000 grain weight
x_6 - Chlorophyll b flowering
x_7 - Days to flowering
x_8 - No. of productive tillers plant^{-1}
x_9 - Grain thickness
x_{10} - Grain density
x_{11} - LAI (flowering)
x_{12} - No. of unproductive tillers plant^{-1}
x_{13} - Grain length
x_{14} - Days taken for completion of flowering within a hill
x_{15} - Grain production day^{-1}
x_{16} - Total yield
x_{17} - Chlorophyll a (panicle initiation)
x_{18} - Days to harvest
x_{19} - Flag leaf area
y - Ratoon yield

——Positive correlation ——— Negative correlation

Fig. 8. Path diagram showing the direct and indirect effects of main crop characters on ratoon yield.



were negatively correlated with ratoon grain yield. Even though 1000 grain weight had negative direct effect, its indirect effect through grain length and grain thickness were positive and high. When grain production day^{-1} is lower in the main crop, then there will be more chance for diversion of food to the carry over crop, thus explain in the negative direct effect and significant negative correlation. This can also be explained by the high correlation between days to maturity of the main crop and ratoon yield. Hence we can select a better performing ratoon genotype based on the main crop characters such as long duration, more number of grains panicle^{-1}, more number of unproductive tillers plant^{-1} and reduced grain production day^{-1}. Prakash and Prakash (1987), Arumugachamy *et al.* (1993) and Liang (1997) also reported similar results supporting the above findings.

In order to find out the characters of the main crop as well as ratoon crop which contribute to total yield it was subjected to correlation analysis with main crop characters and ratoon crop characters. The highest positive and significant correlation with total yield was exhibited by main crop yield followed by days to flowering and number of unproductive tillers plant^{-1}. Significant negative association was observed for 1000 grain weight and grain length. Main crop yield showed a high phenotypic correlation coefficient than genotypic showing the environmental effect on this trait (Fig.9). Manuel and Palanisamy (1989) Sardana *et al.* (1989), Rather *et al.* (1997) and Selvamani and Rengasamy (1998) also reported similar results. But a positive significant association of 1000 grain weight was reported by Paul and Nanda (1994) and Yolanda and Das (1995). Among the different yield components straw yield, number of unproductive tillers plant^{-1}, days to harvest LAI, total number of tillers during flowering and days taken for completion of flowering within a hill recorded positive and significant correlation while panicle length, grain length, grain production day^{-1} and flag leaf area exhibited negative and significant correlation with days to flowering. Thousand grain weight showed a positive and significant correlation with chlorophyll a (panicle initiation), chlorophyll b (flowering), grain length, grain breadth and grain thickness, whereas negative and significant correlation with total number of tillers during different stages, number of unproductive tillers and LAI (active tillering). So longer, wider and thicker grains will lead to increased 1000 grain weight. The effect of chlorophyll contents may be due to the increased photosynthesis and grain production day^{-1}. When tiller number increases, 1000 grain weight will reduce, which can be explained by the partitioning of food materials for the increased production of tillers. When the number of unproductive tillers decrease, 1000 grain weight will increase. But the reduced number of unproductive tillers in turn can cause a reduced ratoon and total yield. This may be the possible reason for negative correlation between 1000 grain weight and total yield.

There results indicate that when we are aiming at increasing the total yield by raising a ratoon crop, duration and tiller production of the main crop are the major factors to be considered.

Ratoon crop characters viz. tiller number (flowering), number of productive tillers plant^{-1}, grains pancle^{-1}, LAI, ratoon yield, grain production day^{-1}, grain breadth, straw yield, plant height, chlorophyll b during panicle initiation and flowering and ratooning ability were found to be positively and significantly correlated with total yield. Characters considered here recorded higher genotypic correlation coefficients than phenotypic correlation coefficients, reflecting little influence of environment. Among these variables, LAI (flowering) had the highest positive genotypic correlation coefficient followed by ratoon yield, grain production day^{-1}, number of productive tillers plant^{-1} and tiller number during flowering. So simultaneous selection for these characters can lead to maximum total yield. Number of productive tillers was found to be positively and significantly correlated at genotypic level with tiller number during panicle initiation, grains panicle^{-1}, LAI, straw yield, grain production day^{-1}, chlorophyll b (flowering), panicle length and flag leaf area. Hence increase in total number of productive tillers in the ratoon crop can lead to a high ratoon yield and total yield as a result of its intercorrelation with other characters. When panicle length increases, grains panicle^{-1} will be more leading to an increased grain production day^{-1} and high ratoon yield. Similarly when its area increases flag leaf captures more sunlight giving a high ratoon yield by increased grain production day^{-1}. It was also observed that early flowering of the ratoon crop was more favourable to obtain a better ratoon yield (Fig. 5). Hence an early ratoon cultivar having increased tiller number, LAI, flag leaf area, panicle length, plant height, grains pacicle^{-1} and grain production day^{-1} can contribute to high total yield. Zheng and Zhang (1996) also reported similar results.

Superior genotypes identified for different characters in the main and ratoon crops are presente 29, This indicate that varieties namely CO 43, Ponmani, White Ponni, IR 20 and Mangala Mahsuri having higher intensity of character expression in both the crops, can be recommended for yield improvement in rice. Various characters viz. plant height, number of productive tillers plant^{-1}, flag leaf area, chlorophyll b during flowering, grains panicle^{-1}, 1000 grain weight, grain density, grain yield, grain production day^{-1} and harvest index of the main and ratoon crop are compared in Fig. 10 and Plate 4. All characters were more pronounced in the main crop except chlorophyll contents, which were comparable with that of ratoon crop. Saran and Prasad (1952) reported that the characters like plant height, panicle length and number of productive tillers were less pronounced in ratoon crop than main crop, supporting the above results.

Varieties identified for superior performance viz. CO 43, IR 20, Mangala Mahsuri, White Ponni and Ponmani exhibited an above average expression for characters namely, number of tillers (flowering) and number of productive tillers. These in turn contribute to their high ratoon yield as explained by the character association studies.

Table 29. Superior genotypes for different characters studied

Sl. No.	Character	Genotypes	
		Main crop	Ratoon crop
1	Total no. of tillers (flowering)	MO 4, CO 43, MO 18, ADT 43, Kairali	Ponmani, CO 43, Mangala Mahsuri, White Ponni, IR 20
2	LAI (flowering)	IR 20, Aathira, White Ponni, Ptb 2, Mangala Mahsuri	CO 43, Ponmani, White Ponni, Mangala Mahsuri, CORH 2
3	Chlorophyll a (panicle initiation)	Ptb 10, Jyothi, Swarnaprabha, Ptb 28, CO 43	Ptb 8, M 48-11-3, MO 16, Ponmani, M 61-6-1-1
4	Chlorophyll b (panicle initiation)	Ptb 10, Jayathi, M 48 - 11- 3, Ptb 2, Kairali	Ponmani, Ptb 8, CO 43, MO 18, M 48-11-3
5	Chlorophyll a (flowering)	MO 10, MO 18, M 38-4-1, M 38-4-2, Jyothi	M 48-11-3, M 61-6-1-1, Ponmani, MO 16, Neeraja
6	Chlorophyll b (flowering)	Jyothi, Kairali, MO 16, MO 10, Aiswarya	MO 16, CO 43, Ponmani, M 48-11-3, IR 20
7	Days to flowering	Ponmani, IR 20, CO 43, Pankaj, Neeraja,	Swarnaprabha, Ptb 8, CORH 2, MO 15, MO 18
8	Plant height	Ptb 1, Ptb2, Ptb 10, Swarnaprabha, Ptb 26	Mangala Mahsuri, Swarnaprabha, White Ponni, Neeraja, ADT 38
9	No. of productive tillers plant^{-1}	Ptb 10, MO 4, Kairali, ADT 38, ASD 20	IR 20, Ponmani, CO 43, White Ponni, Mangala Mahsuri

10	Flag leaf area	Ahalya, Ptb 26, Ptb 28, Ptb 8, Swarnaprabha	Mangala Mahsuri, IR 20, Swarnaprabha, MO 19, White Ponni
11	Leaf area duration	Pankaj, IR 20, CO 43, White Ponni, Ptb 1	CO 43, White Ponni, Ponmani, CORH 2, Mangala Mahsuri
12	Panicle length	Ptb 10, Ptb 1, Ptb 28, Swarnaprabha, Ptb26	Mangala Mahsuri, White Ponni, IR 64, CO 43, IR 20
13	Grain panicle^{-1}	Mangala Mahsuri, Swarnaprabha, CORH 2, White Ponni, Ptb 26	White Ponni, Mangala Mahsuri, Swarnaprabha, CO 43, Jayathi
14	1000 grain weight	Ptb 28, MO 5, MO 10, Swarnaprabha, Jyothi	MO 12, Swarnaprabha, IR 8, MO 5
15	Grain density	Ptb 28, MO 5, ASD 20, Jyothi, Ptb 26	Jayathi, White Ponni, MO 16, IR 36, CO 43
16	Grain length	Bharathi, ASD 20, IR 64, MO 5, Swarnaprabha	ASD 20, MO 5, IR 64, Swarnaprabha, Neeraja
17	Grain breadth	Ptb 28, MO 12, MO 5, Ponmani, Ptb 10	Mangala Mahsuri, Ponmani, MO 16, M 61-6-1-1, M 48-11-3
18	Grain thickness	MO 12, Ahalya, M 38-4-2, MO 5, Ponmani	ASD 20, MO 5, IR 8, IR 36, MO 16
19	Straw yield	Ptb 1, Ptb 10, Ptb 2, White Ponni, M 48-11-3	Mangala Mahsuri, White Ponni, Ponmani, Pankaj, IR 20
20	Grain yield	M 48-11-3, ADT 38, Aiswarya, Swarna-prabha, M 38-4-2	Mangala Mahsuri, White Ponni, CO 43, Ponmani, IR 20

21	Harvest index	Aiswarya, Jyothi, CO 43, Ahalya, IR 8	CO 43, IR 8, Swarnaprabha, MO 5, Jayathi
22	Grain production day^{-1}	Ptb 28, Aiswarya, Swarnaprabha, M 48-11-3, ADT 38	CO 43, Ponmani, Mangala Mahsuri, IR 20, White Ponni

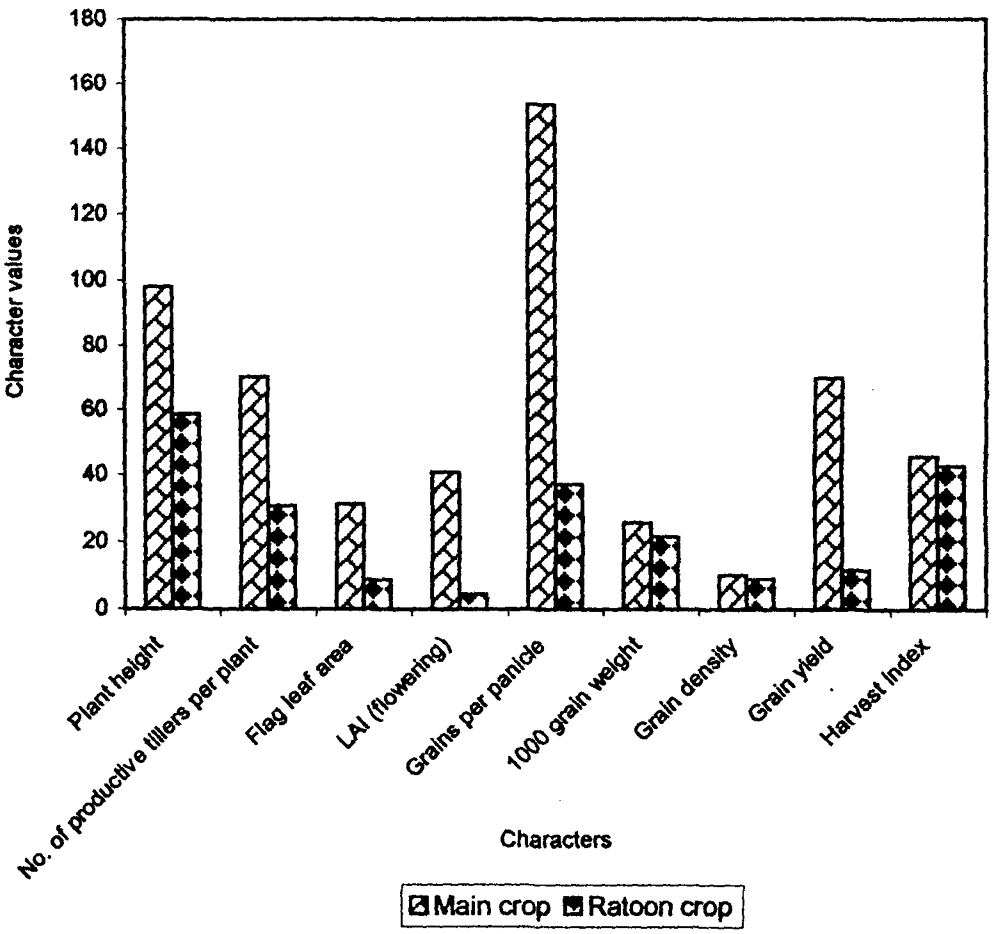


Fig.10. Comparison of main and ratoon crop for different characters

Plate 4a and b. Earhead characters of main crop and ratoon crop

A - Main crop **B - Ratoon crop**

SUMMARY

Rice is the principal food for nearly 65 per cent of the population in India. At the present rate of population growth, India requires to add not less than 2.5 million tonnes of milled rice every year to sustain the present level of self-sufficiency. It is a challenging task to achieve the targetted production, since there is meagre possibility of bringing more area under rice cultivation. Under such a situation ratoon cropping of rice has been suggested as one of the ways of increasing rice production without increasing land area. In other words ratoon cropping can be considered as a promising method in certain areas with limited duration of available moisture or growing season.

This is practiced in several parts of India, and in Kerala, the Koottumundakan cultivation points towards the scope for ratoon cropping in our state. The success of such a system depends on the identification of superior ratooning genotypes combined with satisfactory main crop yielding ability and other desirable attributes. Hence the present study was conducted at Agricultural Research Station, Mannuthy during 1999-2000 to study the main crop as well as ratoon crop behaviour of different rice genotypes. The investigation was carried out to determine the genetic variability among the different genotypes used. The study was also aimed at identifying morphological and physiological characters for a genotype of rice with high productivity when main crop and ratoon crop yields are combined together, through correlation and character association studies. Suitable selection indices were also formulated for identifying superior genotypes. The results obtained are summarised as follows.

1. High variability was observed among different gentypes for all the characters studied reflecting diversity of the experimental material used for the study.
2. Among the 50 genotypes evaluated in the main crop, 24 showed regrowing ability. Of these five varieties viz. CO 43, IR 20, White Ponni, Ponmani and

Mangala Mahsuri recorded better ratoon performance. The ratoon crop characters were less pronounced compared to the main crop characters except the chlorophyll contents. The above mentioned five genotypes exhibited a higher intensity of character expression compared to the remaining genotypes.

3. The estimates of GCV, heritability and genetic gain were high in the case of ratoon crop for most of the characters studied.
4. Character association studies revealed that main crop yield can be improved by increasing the pigment contents and grain production day^{-1}. On the other hand, number of productive tillers plant^{-1}, LAI (flowering) and straw yield were the major factors contributing towards ratoon yield.
5. Higher total yield can be achieved with a main crop having long duration and increased number of unproductive tillers plant^{-1}. Ratoon yield can be improved by a better performing main crop with characters such as long duration, more number of grains panicle^{-1}, more number of unproductive tillers plant^{-1} and reduced grain production day^{-1}.
6. Ratooning ability was considered as an index of the ratoon performance, but in the present study ratooning ability recorded a negative direct effect on yield, indicating that this can not be used as a true index to assess the ratoon performance and early screening of genotypes for ratoon grain yield.
7. Selection indices worked out, showed that a high yielding main crop can be selected based on characters viz. total number of tillers during panicle initiation, number of productive tillers plant^{-1}, grain density and grain production day^{-1}. On the other hand characters namely, number of productive tillers plant^{-1}, LAI (flowering) and straw yield can be used to select a superior ratoon crop genotype. From the main crop varieties by using the traits namely, number of productive tillers plant^{-1}, grains panicle^{-1}, 1000 grain weight, grain yield, grain production day^{-1} and grain thickness we can select a good ratoon crop.
8. The various genetic and physiological analysis thus revealed that the varieties viz. IR 20, Mangala Mahsuri, White Ponni and Ponmani can be recommended

as the genotypes suitable for ratooning in Kerala. By using these, about one third of the main crop yield can be achieved without increasing the land area. Total yield recorded by these genotypes were also significantly high.

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Appendices

Appendix I Analysis of variance for different characters studied (Main crop)

Source of variation	Degrees of freedom	Mean sum of squares					
		Total number of tillers			LAI		
		Active tillering	Panicle initiation	Flowering	Active tillering	Panicle initiation	Flowering
Replication	2	101.647	5.420	1.787	26.167	13.499	4.415
Treatment	49	2.530	6.313	5.769	0.550	5.457	5.759
Error	98	1.252	1.631	1.229	0.315	2.483	1.608

Source of variation	Degrees of freedom	Mean sum of squares					
		Chlorophyll a (active tillering)	Chlorophyll b (activie tillering)	Chlorophyll a (panicle initiation	Chlorophyll b (panicle initiation)	Chlorophyll a (flowering)	Chlorophyll b (flowering
Replication	2	0.343	0.016	0.020	0.008	0.165	0.018
Treatment	49	0.045	0.009	0.120	0.023	0.061	0.017
Error	98	0.047	0.005	0.055	0.013	0.043	0.009

Source of variation	Degrees of freedom	Mean sum of squares					
		Days to flowering	Days to harvest	Days taken for completion of flowering within a hill	Plant height	No. of productive tillers plant^{-1}	No. of unproductive tillers plant^{-1}
Replication	2	11.947	0.740	10.220	264.173	2.247	0.027
Treatment	49	410.019	417.731	16.898	1985.679	3.939	0.494
Error	98	1.130	0.060	0.791	53.006	1.077	0.183

Source of variation	Degrees of freedom	Mean sum of squares					
		Flag leaf area	Leaf area duration	Panicle length	Grains panicle^{-1}	Chaff percentage	1000 grain weight
Replication	2	79.945	0.418	0.902	536.047	2.247	1.236
Treatment	49	368.866	4.757	17.391	1933.760	170.825	31.727
Error	98	19.254	1.250	1.421	369.346	51.624	1.685

Source of variation	Degrees of freedom	Mean sum of squares					
		Grain density	Grain length	Grain breadth	Grain thickness	Straw yield	Grain yield
Replication	2	0.003	0.208	0.025	0.012	3.316	0.143
Treatment	49	0.004	1.412	0.175	0.038	4.940	0.199
Error	98	0.003	0.152	0.021	0.010	0.623	0.044

Source of variation	Degrees of freedom	Mean sum of squares		
		Harvest index	Grain production day^{-1}	Total yield
Replication	2	0.016	0.0001	0.201
Treatment	49	0.017	0.0002	0.398
Error	98	0.00139	0.00002	0.059

Appendix II Analysis of variance for different characters studied (Ratoon crop)

Source of variation	Degrees of freedom	Mean sum of squares					
		Tiller regeneration		LAI		Chlorophyll a (panicle initiation)	Chlorophyll b (panicle initiation
		Panicle initiation	Flowering	Panicle initiation	Flowering		
Replication	2	0.292	0.847	0.0005	0.00007	0.0000096	0.0000004
Treatment	23	12.268	13.534	0.319	0.405	0.222	0.055
Error	46	0.408	0.441	0.00028	0.00019	0.0000073	0.0000003

Source of variation	Degrees of freedom	Mean sum of squares					
		Chlorophyll a (flowering)	Chlorophyll b (flowering)	Days to			
				Visual panicle initiation	Panicle initiation	Flowering	Harvest
Replication	2	0.000001	0.0000004	0.667	1.264	2.264	0.431
Treatment	23	0.148	0.05	446.906	480.425	518.159	10.403
Error	46	0.0000007	0.0000007	0.812	0.496	0.641	0.503

Source of variation	Degrees of freedom	Mean sum of squares					
		Days taken for completion of flowering within a hill	Plant height	No. of productive tillers plant^{-1}	No. of unproductive tillers plant^{-1}	Flag leaf area	Leaf area duration
Replication	2	3.143	0.125	0.022	0.033	0.239	0.726
Treatment	23	447.746	13.601	0.40	19.657	66.146	15.175
Error	46	3.126	0.531	0.061	0.001	0.234	0.480

Source of variation	Degrees of freedom	Mean sum of squares					
		Panicle length	Grains $panicle^{-1}$	Chaff percentage	1000 grain weight	Grain density	Grain length
Replication	2	0.389	0.393	0.059	0.00001	0.582	0.009
Treatment	23	440.825	85.700	16.471	0.012	1.384	0.385
Error	46	2.070	0.234	0.078	0.00001	0.143	0.006

Source of variation	Degrees of freedom	Mean sum of squares					
		Grain breadth	Grain thickness	Straw yield	Grain yield	Harvest index	Grain production day^{-1}
Replication	2	0.009	0.004	1456.056	68.097	0.00001	0.009
Treatment	23	0.385	0.392	1137470.077	234875.710	0.015	78.723
Error	46	0.006	0.065	2616.461	357.025	0.0000217	0.068

Source of variation	Degrees of freedom	Mean sum of squares	
		Total yield	Ratooning ability
Replication	2	0.211	0.011
Treatment	23	0.349	0.123
Error	46	0.085	0.009

"GENETIC AND PHYSIOLOGICAL ANALYSIS OF RATOONING IN RICE (*Oryza sativa* L.)"

By

AMBILI S. NAIR

ABSTRACT OF THE THESIS

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Kerala Agricultural University

DEPARTMENT OF PLANT BREEDING AND GENETICS
COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR - 680 656
KERALA, INDIA

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ABSTRACT

The present investigation 'Genetic and physiological analysis of ratooning in rice (*Oryza sativa* L.)' was conducted at the Agricultural Research Station, Mannuthy during 1999-2000 to study the main crop as well as ratoon crop behaviour of different rice genotypes. The study was carried out to determine genetic variability among the different genotypes used. The study was also aimed at identifying morphological and physiological characters for a genotype of rice with high productivity when main and ratoon crop yields are combined together, through correlation and character association studies. Suitable selection indices were also formulated for identifying superior genotypes.

Among the 50 genotypes evaluated in the main crop 24 showed regrowing ability. Of these five varieties viz. CO 43, IR 20, White Ponni, Ponmani and Mangala Mahsuri recorded better ratoon performance. The ratoon crop characters were less pronounced compared to the main crop characters except chlorophyll contents. But the above mentioned genotypes exhibited a higher intensity of character expression in both crops compared to the remaining genotypes. The estimates of GCV, heritability and genetic gain were high in the case of ratoon crop for most of the characters studied.

Present study revealed that higher total yield can be achieved with a main crop having long duration and increased number of unproductive tillers plant^{-1}. Ratoon yield can be improved by a better performing main crop with characters such as long duration, more number of grains panicle^{-1}, more number of unproductive tillers plant^{-1} and reduced grain production day^{-1}. Ratooning ability was considered as an index of the ratoon performance but in the present study ratooning ability recorded a negative direct effect on yield, indicating that this cannot be used as a true index to assess the ratoon performance. The various genetic and physiological analysis thus revealed that the varieties viz. IR 20, Mangala Mahsuri, White Ponni and Ponmani can be recommended as genotypes

suitable for ratooning in Kerala. By using these about one third of the main crop yield can be achieved without increasing the land area. Total yield recorded by these genotypes were also significantly high.