REVIEW OF LITERATURE
CHAPTER- II

REVIEW OF LITERATURE

The Relevant literature on various aspects of the present investigation has been reviewed under the following two major heads.

(i) Biometrical approaches

(ii) Work done on the crop

Biometrical approaches:

The study of quantitative characters in plant originated with the work of Johannsen (1909), Nilson Ehle (1909) and East (1916). The contribution of some early workers like Fisher (1918, 1938), Freeman (1919), Fisher et al. (1932), Wright (1921, 1934a, 1934b, 1935), Whitehouse et al. (1958), Quinsenbury (1926), Haldane (1932, 1937, 1939, 1954, 1956), Rasmusson (1933), Smith (1937, 1944, 1950, 1952), Mather (1939, 1941, 1942, 1943, 1946, 1948), Mather and associates (1952, 1958), Charles and Smith (1939), Powers et al. (1950), Lush (1940, 1949), Hazel and Lush (1942), Hazel (1943), Robinson and associates (1948, 1949, 1955) Singh (1949), and Mohammad (1959) are the milestones in the history of biometrical genetics. Such information has played a vital role in the synthesis of more efficient...
genotype. Genetic variances serve as basis for major plant breeding decision since they provide a greater array of genotypes among which selection can be practised to develop still better new variety or breeding material (Jink and Stenens 1959), Cockerhan (1954) and Kempthorne (1955) further partitioned epistatic variance in to factorial components of digenic and higher order interaction, such as additive x additive, additive x dominance, dominance x dominance for the two loci situation and additive x additive x additive for three loci and so on. Gardner (1963) gave the following genetic parameters useful to the plant breeder.

(i) Additive genetic variance \((\sigma^2 A)\) which results from, the additive effects of genes at all the segregating loci.

(ii) Dominance variance \((\sigma^2 D)\) which results from the inter-allelic interaction of genes at segregating loci.

(iii) Epistatic variance which results from inter allelic interaction of genes at two or more segregating loci and which is divisible in to additive x additive \((\sigma^2 aa)\), additive x dominance \((\sigma^2 AD)\) and dominance x dominance \((\sigma^2 DD)\) for two loci situation and into additive x additive etc. for three or more loci.

(iv) Average degree of dominance represented by the ratio of dominance variance into additive genetic variance.

(v) Genotype x environmental interaction which may be divided into additive genetic variance x environmental effects and non-additive genetic variance x environmental effects.
(vi) Genotypic correlations among important quantitative characters for the particular crop.

Diallel cross analysis:

Hull (1945) was the first to analyse data from diallel crosses of homozygous lines using regression technique. Yates (1947) defined diallel as "set of all possible combinations among 'n' genotypes" Arunachalam (1976) reviewed different approaches of diallel cross technique and discussed their merits in relation to plant breeding. Baker (1978) discussed the use of diallel analysis and the range of validity of different assumptions. Hayman (1954, 1958, 1960) pointed out critically the various aims of diallel cross experiment and extended the analysis of the fixed set of inbred lines of Jinks and Hayman (1953) to a random sample of inbred lines. Nassar (1965) studied the effects of correlated gene distribution due to small samples of variance of general and specific combining ability effects arising from differences among samples of parents.

Component analysis:

Variance component analysis developed by Jinks and Hayman (1954) has been used for estimating genetic components and their parameters from second degree statistic. Anderson and Kempthorne (1954), Cockerham (1954) proposed genetic model for estimation of different types of gene effects namely, additive, dominance and epistasis. Horner (1955), Cockerham (1954), Kempthorne
et al. (1955) further partitioned the epistatic effects into additive x additive, additive x dominance and dominance x dominance components. Dickinson and Jinks (1956) proposed analysis which estimates degree of parental heterozygosity and comparable genetic component of variation of those of the homozygous analysis. Kempthorne (1956) extended the Model II of Eisenhard (1947) to incorporate epistasis and multiple alleles and discussed only diploid cases assuming that there was no selection. Gilbert (1958) criticised the basis genetical assumptions of diallel technique. He concluded that the value of this technique is exaggerated and the information gained from it, is little more than that obtained from the parent themselves. Diessureaux (1959) extended the diallel analysis to over auto-tetraploid chromosomal segregation, random mating and equal allelic frequency. Allard (1956) measured the stability of certain genetic parameters under different environments.

Degree of dominance:

Among the various biometrical approaches based on different mating designs, generation mean analysis, biparental, line x tester, diallel, partial diallel and triple test crosses are some of the techniques employed together genetic potential of the genotypes. Out of these diallel cross method is an elegant tool for ascertaining the genetic information within a considerable short period in early segregating generations (Paroda and Joshi 1970, Joshi 1979). Among the diallel technique Wr-Vr graphic approaches
(Jinks and Hayman 1953), component analysis (Hayman 1954, Jinks 1956) have proved importance for obtaining various information. In polygenic inheritance, the effect of individual gene can not ordinarily be distinguished from one another. Consequently, it is not possible to determine the mode of action of single gene. By studying their combined effects in segregating population however, one can gain some insight into their behaviour and can draw inferences about the average level of dominance involved in the expression of particular quantitative characters.

Gardner (1963) and Robinson et al. (1949) reported that the estimates of degree of dominance in over dominance range for yield could be obtained as a result of repulsion phase of linkage even though none of the genes involved were more than complementary or partially dominance to their alleles. Mather (1949) developed a formula for estimating the degree of dominance. If the measure of degree of dominance is greater than zero, a certain degree of dominance in the action of genes conditioning the characters is indicated. If the value is greater than unity, there is over dominance of genes at one or more loci, but if the value of degree of dominance is less than one, there is either no dominance or partial dominance if the value of measure of dominance equals to zero, the dominance is absent.

The evidence concerning over-dominance have provided over-dominance is remain unsolved. Some differences of opinion about it may arise from different views of what phenomenon are to be included under the term whether apparent over-dominance due to linkage, or over-dominance
due to pleiotropy are to be regarded as over-dominance or not.

Combining ability:

Sprague and Tatum (1942), however, gave clear exposition of combining ability viz., general and specific combining abilities. The general combining ability (gca) refers to "the average performance of a line or lines in a series of hybrid combinations", while specific combining ability (sca) was designated to cover those cases in which certain combinations do relatively better or worse than that would be expected on the basis of average performance of the lines involved. Henderson (1952) reported gca as the average merit with respect to some traits or weighted combinations of traits of an indefinitely large number of individuals/lines when mated in a random sample from some predeicated population under a specific environment. He defined sca as deviation of average value of cross from the value which would be expected on the basis of known gca of two lines.

Griffing (1956b) used diallel technique for the estimation of general and specific combining ability. He divided the combinations obtained by crossing genotypes into the following four methods:

(i) Method 1: Parent and one set of $F_1$'s plus reciprocal $F_1$'s ($n^2$ combinations).

(ii) Method 2: Parents and one set of $F_1$'s only ($n(n+1)/2$ combinations).

(iii) Method 3: One set of $F_1$'s and reciprocal $F_1$'s ($n^2-n$ combinations).
(iv) Method 4: One set of $F_1$'s only $(n(n-1)/2$ combinations).

He assumed broadly two basic situations first, the experimental material assumed to be random sample from a population about which the inferences were to be drawn and secondly, the situation in which line was deliberately chosen and could not be regarded as a random sample from any population. The former assumption is considered to be random model and the latter one as fixed effect model. Thus, there are 8 possible situations which are to be considered for the use in diallel analysis of gca and sca.

Griffing (1956) pointed out that gca involved additive effects and additive x additive interaction. Kempthorne (1957) defined the gca and sca in terms if half sibs and full-sibs variances, respectively which is analogous to Design II of Comstock and Robinson (1948, 1952), Hayman (1957) observed that in the absence of epistasis gca comprises additive portion while sca involves dominance. Both combining abilities will contain epistatic portions while sca is mainly a measure of dominance and epistasis in unselected and selected materials respectively. Moll et al. (1960) reported that magnitude of gene action based on combining ability variance is not much reliable due to serious bias from genotypes x environmental interaction.

Jensen (1970) proposed a set of diallel selective mating procedures to serve as a supplement to conventional breeding system for autogamous crop. In this system, multiple parents in put into a central gene pool is used and advanced by selective mating of individuals through successive generations.
Mahapatra and Mohanty (1986) conducted a study of 12 early varieties crossed in a half diallel fashion to study 30 characters for gca and sca variances. The gca and sca variances were highly significant for all the characters.

Combining ability for yield and its components was studied in a seven parent half diallel (Lokaparkash et al. 1991). Both gca and sca variances were highly significant for all the characters.

Singh et al. (1992) studied a diallel cross of eight parents and observed that gca and sca effects were highly significant for grain yield and its components viz., effective tillers per plant, panicle length, number of grains per panicle and 1000-grain weight.

Naguyen and Bui (1992) evaluated 7 high yielding genotypes crosses in a half diallel fashion for 7 physiological and yield characters. Highly significant mean squares of all the traits for gca and sca indicated the importance of additive and non-additive genes action.

From 9 x 9 diallel in $F_2$ generation significant differences for general and specific combining ability were reported for all the characters by Verma et al. (1995). Predominance additive gene action was observed for most of the characters except grain yield per plant and number of effective tillers per plant.

An experiment was conducted by Lavanya and Vijay Kumar (1999) with 5 CMS lines and 6 restorers lines to study the selection of parents with
high general combining ability. Majoring of the superior combinaers for grain yield involved at least one good combiner and the other either good or low combining parent indicating additive x additive and additive x dominance type of genetic inter actions.

Bidhan, Mandal and Roy (2001) crossed rice cultivars in all possible combinations excluding reciprocals and grew the 41 F1 hybrids and reported that the general combining ability (gca) and specific combining ability (sca) were significant indicating prevalence of genetic diversity among parent and F1 hybrids.

Annadurai Nadarajan (2001) studied rice hybrids to determine the general combining ability (gca) of parents and the specific combining ability (sca) of hybrids for grain yield and other yield components including physiological characteristics. They found that PMS9A, IR 62829 A and IR 58025 A were good general combiners.

Combining ability effects were assessed by Bansal et al. (2000) in an 11 parents diallel cross involving 8 scented and 3 non-scented rice varieties. The estimates of general combining ability (gca) and specific combining ability indicated predominance of non-additive gene effects for days to 50% flowering, plant hight, panicle length, tillers/plant, number of fertile tillers/plant, grain yield per plant, 1000-grain weight. Cultivar karnal local showed good gca for panicle length, tillers/plant, number of fertile tillers per plant, grain yield per plant. Bindli and Basmati 372 showed good gca for earliness and dwarfing.
A study was conducted by Janardhanan et al. (2000) estimates the combining ability effects for yield and its component in rice genotypes. Eight strains of rice were crosses in a 4 x 4 line x tester design to obtain 16 hybrids and reported the combining ability variance due to lines was significant for plant height only, indicating greater diversity among them. Three parent for plant height and number of grains per panicle, 2 for single plant yield and only one for number of spikelets per panicle were good combiner.

Thirumeni et al. (2000) reported the combining ability for eight quantitative traits and Na-K ratio in rice genotypes under salinity studied through line x tester analysis involving four salt-tolerant genotypes as lines and four locally adapted cultivars as testers. The study revealed that variance due to lines x testers was significant for all the characters except panicle length and estimates of sca and gca and their ratio indicated preponderance of non-additive gene preponderance of non-additive gene action for all the characters.

Mehta et al. (2000) studied eleven parents and their 30 hybrids and observed the high values of specific combining abilities (sca) that revealed the predominance of non-additive gene action for all characters and identified as the best general combiners for yield and yield-contributing characters. They recorded highly significant sca values for number of grains for panicle and 1000-grain weight.
Heterosis and inbreeding depression:

The first report on heterosis in rice was that by Jones (1926) who observed that some F₁ hybrids had more culms and yield than their parents.

The term heterosis refers to the phenomenon in which the F₁ population obtained by crossing of the two genetically dissimilar gameters or individuals show increased or decreased vigour over the better parent or over the standard-parent value.

Mather and Jinks (1971) defined the heterosis as the amount by which the F₁ hybrid mean exceeds its better parent.

In plant breeding programme, conventionally, heterosis is referred to denote the expression of increased vigour of the hybrid over the better parent. But since heterosis is also expressed over the mid parent value, some distinction is necessary between the two. Bardhan Roy et al. (1975) observed negative heterosis for days flowering but positive heterosis for number of tillers/plant and grain yield in NC 1281 x Ratna. Positive heterosis for plant height in NC 1281 x IR 22 and for ear length in NC 1281 x Conver, was also observed by them.

Yap and Chang (1976) crossed low land and upland varieties in a 5 x 5 diallel without reciprocals and found positive heterosis for grain yield, panicle number, plant height and earliness and negative heterosis for spikelets fertility and grain number/plant.

Kumar and Saini (1983) reported five varieties in a half diallel crossing programme for grain yield/plant and its components like number of...
panicle/plant, panicle length, number of grains/panicle and 100 seed weight. The highest yielding hybrids showed heterosis for panicle length, number of grains/panicle and 100 seed weight.

Murai et al. (1997) evaluated F1 hybrids from the cross Ishikari/Shiokari and its parental cultivars under eight environments involving different locations, fertilizer levels and planting densities. The F1 gave the highest yield among three genotypes in most environments. Fertilizer level was a predominant environmental factor affecting yield. Percentage of ripened grains was the highest in the F1 contributing to heterosis for yield. A similar degree of heterosis was recognized in harvest index. For dry weight at heading, however, the value of the F1 was smaller than the midparent in most environments. Therefore, it was conducted that the high yield of the F1 depended on high dry matter production after reading and good seed filling.

Dwivedi et al. (1997) studied heterosis for yield and ten selected characters in 45 crosses involving six Indica and four tropical Japonica varieties of rice under three environments. Trends of magnitude of heterosis for grain yield and plant height were I/J>I>I>J/J and for days to 50% flowering I/J>I>I>J/J hybrids. Estimates of standard heterosis (%) for grain yield were -64.5 to 146.10 in first environment -70.4 to 82.2 in second environment and -67.2 to 63.8 in the third environment. Environment seemed to be more favourable for higher heterosis expression than others. Higher heterosis in yield also accompanied heterosis in panicle number, dry matter and spikelet and grain number per panicle. Most estimates for days to flower
were negative. Heterosis in hybrids also recorded maximum heterosis for earlobes. Moderate to low standard heterosis for plant height across environments was recorded. Hybrids were identified in specific environments for direct exploitation in hybrid breeding. Hybrids B4122/Saryu 52/ B4122PD4/B4122/Narendra 359 were more stable than others over three environments.

Stalin et al. (1999) evaluated 15 rice hybrids and reported significant negative standard heterosis for days to 50% flowering. The hybrids IR62829 x TKN9, IR58025A x TKM9, PM53A x TKM9 showed significant heterosis for plant height and positive significant heterosis for number of productive tillers per plant. The cross IR58025A x IR 64 recorded significant positive heterosis for number of spikelets/panicle and 1000-grain weight.

Lavanga and Vijay Kumar (1999) reported the potential heterosis rice hybrids at 2 N levels in Ds (60 and 120 Kg N/ha) and reported that the significant value for grain yield/plant.

Lingarajan et al. (1999) studied to yield-related traits in 4 lines, 8 testers and their 32 hybrids and reported good heterosis for earliness, plant height, filled spikelets per panicle, and grain yield.

Five testers and seven lines were crossed in line x tester mating design by Suresh et al. (1999). All the hybrids showed negative heterosis over mid and better parent for days to 50% flowering, but only 12 of these hybrids showed negative heterosis over standard parent L1 x T4 showed the highest positive heterosis for plant height, nine hybrids, showed positive heterosis for
productive tillers per plant and panicle length, 100 g. ain weight, grain yield/plant.

Sohane and Singh (2000) studied a diallel cross among two varieties of rice and reported that the heterosis over mid parent, better parent and inbreeding depression was determined negligible.

Chen-liang, Sum-chuanqing et al. (2000) evaluated the F1's from crosses of photoperiod sensitive genetic male sterile lines and new plant type lines. They deserved the strong heterosis for filled grains per plant, number of spikleters per plant and grain weight per plant.

Singh and Singh (2000) reported the occurrence of heterosis for yield of most of the hybrids were promising as they displayed 23 to 70% heterosis over the standard variety for grain yield per plant and heterosis for earliness and dwarfness.

Bansal et al. (2000) reported that an 11 parent diallel cross involving 8 scented and 3 non-scented rice varieties showed heterosis that was significant for grain yield and its component characters in most of the hybrids.

Sarkar et al. (2001) evaluated the 12 rice hybrids including 5 Basmati and 7 non-Basmati hybrids and observed significant, high and positive heterosis for grain yield over the Basmati locations (Delhi, Pantnagar, Karnal and Kaul).

Chaudhary et al. (2002) evaluated seven highly variable cold tolerant advanced breeding lines of different ecogeographical regions. These lines were crossed to three widely cultivated boro rice varieties in line x tester
design of experiment. They reported significant heterosis for various cold temperature associated indices for non-viability of pollen grains, spikelets sterility index, anther indehiscence, panicle exsettion, grain density.

**Selection Parameters:**

**Heritability and genetic advance:**

Fisher (1918) developed first basic idea about partitioning of total variation into different components like fixable and non-fixable or heritable and non-heritable. Total genetic variation could be divided into additive and non-additive components. The ratio of total additive genetic variance was termed 'heritability' and symbolized as 'h²' by Wright (1921). This information since then, has been extensively used for the estimation of heritability and genetic advance in selection programmes. Heritability estimates in 'broad' and 'narrow' sense was classified by Lush (1940), while Dudley and Moll (1969) defined heritability in broad sense as the ratio of total genetic variance to the phenotypic variance and in 'narrow sense' as the ratio of additive genetic variance to the phenotypic variance. The genetic gain in a character is a product of the heritability and selection differential expressed in terms of phenotypic standard deviation of that character. Heritability value itself does not have such significance as it fails to account for the estimates of absolute variability. It is therefore, necessary to utilize heritability estimates in conjunction with selection differential which would then indicate the expected genetic gain resulting from selection. The heritability
of a metric character is one of the most important properties. It is expresses
the proportion ok the total variance that is attributable to the average effects
of gene. The most important function of heritability in genetic study of
metric characters is its predictive role, expressing reliability of the phenotypic
value as a guide to the breeding value.

Johanson et al. (1955) suggested that heritability estimates and
genetic advance as percent of mean together, would provide a better
judgement rather than heritability alone in predicating the resultant effects in
selection. Genetic advance refers to the improvement in the mean genotypic
value of selected individual over the parental populations.

Reddy et al. (1988) studied 18 genotypes for six yield components
viz. plant height, number of tillers/plant, number of grains/panicle, panicle
length, 100-grain weight and grain yield/plant and reported high estimates of
heritability and high genetic advance as per cent of mean for plant height and
100-grain weight, respectively.

In a study of 30 lines for ten yield characters, Deosarkar (1989)
reported high heritability and genetic advance for plant height, 1000-grain
weight and grains/panicle.

Li (1991) studied nine rice cultivars and obtained high estimates
for heritability for days to flowering and 1000-grain weight.

Chauhan et al. (1993) carried out a study using 21 advanced breeding
lines. High heritability coupled with high genetic advance were observed for
1000-grain weight, days to 50% flowering, percent filled spikelets and panicle
Rao and Shrivastava (1994) reported 21 early maturing rice genotypes and reported high heritability coupled with high genetic advance for plant height, high heritability coupled with low genetic advance for days to flowering and days to maturity and low heritability coupled with low genetic advance for number of tillers/M², spikelets/panicle grain yield/plant and panicle length.

Honarnejad (1995) used variance and regression analysis estimate heritability value for yield in rice.

Gravois and Bernhardt (2000) studied a genotypes x environment interaction for discolored rice kernels and reported that breeding for improved kernel quality traits will have certain difficulties because of low heritability. The availability of good germplasm and a proper screening programme should minimize this problem.

Correlation between yield and yield components:

Information on geneotypic, phenotypic and environmental correlations between yield and its component traits is useful in selection breeding programme. This may be used in estimation and construction of correlated response and selection indices. Genotypic correlation is the net effect of all segregating genes that affect the characters, some causing positive and negative correlations. The major causes under lying genetic correlation is pleiotropy linkage and developmentally induced relationship.
Grain yield in rice is function of number of panicles/plant, number of grains in a panicle and 100-grain weight (Abraham et al. 1954; Roy Chaudhary 1968; Anonymous 1964; Mastshusime 1967). They reported that in addition to the above mentioned characters percentage of ripened grains and their weight should also be considered in the determination of grain yield.

Jain et al. (1983) reported that grain weight/plant was correlated with grain set and the grain straw ratio. Panicle number was negatively correlated with grain number/panicle, panicle weight and grain weight.

Auiecho et al. (1983) observed that grain yield and ears per plant were positively correlated while yield components were negatively inter-related. Grain yield had no correlation with malting qualities. Negative correlation existed between grain weight and grain water content.

Habgood (1983) analysed yield components of parental and F2 population and recorded that grain yield per plant was affected primarily by tiller number.

Singh and Patil (1983) reported dry matter content to be highly correlated with green for age yield, plant height and number of tillers.

Czaplewski (1983) observed a duration up to nine days for grain filling (i.e. from anthesis to maturity) and reported that the grain filling index (ratio of grain filling duration to number of days from ear emergence to maturity) varied up to the extent of 11 per cent.
Balan; Muthiah and Boopathi (1999) evaluated 21 rice genotypes for 4 genetic parameters under upland conditions and reported the high positive significant association with grain yield.

Sadhukhan and Chattopadhyay (2000) observed twenty six aromatic rice genotypes and reported that the yield per plant had a very strong genotypic correlation with test grain weight and positive correlation with grain length and grain breadth.

Bala et al. (2001) made a study of economic traits in upland rice in saline alkaline condition and results indicated that grain yield/M² and panicle length recorded positive significant correlation.

Shanti and Shingh (2001) studied 17 rice genotypes and reported that the genotypic correlation were generally higher than phenotypic correlation and yield per plant was significantly and positively associated with the number of grains per panicle, plant height, panicle length.

Path analysis:

The technique of path-coefficient analysis was originally developed by Wright (1921) who defined the path coefficient technique as the ratio of the standard deviation of effect to the total standard deviation when all the causes are constant except that in question the variability of which kept unchanged.

Dewey and Lu (1959) employed the path-coefficient technique in crested wheat grass to establish the relative importance of seed size, fertility
and plant size as the determinant of seed yield.

Sarkar et al. (1999) studied seven traits in 31 rice cultivars and reported the analysed path coefficients. It revealed that non-structural carbohydrate percentage showed the greatest direct effect on survival percentage, followed non-structural carbohydrate content/mothershoot, plant height area ratio and plant height before submergence.

Balan et al. (1999) evaluated 21 rice genotypes for 4 genetic parameters under upland conditions and reported the high positive direct effect on grain yield. Days to 50% flowering and number of panicles/M² through indirect effect on grain yield.

Bala et al. (2000) study of 42 rice genotypes during the last week of September 1997-98 and reported the positive significant direct effect on grain yield/plant.

Shanthi and Shingh (2001) evaluated 17 rice genotypes for six quantitative characters and reported that number of grain per panicle affected the panicle length. It is concluded that the yielding ability in rice might be improved by selecting taller plants with longer panicles coupled with a higher number of grain per panicle.