STUDIES ON LINE x TESTER ANALYSIS OF YIELD AND YIELD CONTRIBUTING TRAITS IN MAIZE (*Zea mays* L.)

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SYNOPSIS

STUDIES ON LINE x TESTER ANALYSIS OF YIELD AND YIELD CONTRIBUTING TRAITS IN MAIZE (*Zea mays* L.)

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Introduction

Maize (*Zea mays* L., 2n=20) is one of the most important cereal crops of the world. It ranks third after wheat and rice. It also entered in more industrial products.
It possesses one of the most well studied genetic systems among cereals which have motivated a rich history of research into the genetics of various traits in maize. In fact, maize has been subjected to extensive genetic studies than any other crop. Maize has the highest genetic potential, production and productivity among the cereal crops. It's adaptability to varied agro-ecologies serves as one of the driving force for crop diversification. In India, maize is cultivated over an area of 9.43 million hectares, with a production of 24.35 million tonnes and productivity of 2.58 tonnes/ha. In Telangana, it covers an area of 7.52 lakh hectares with production of 3.52 million tonnes and productivity of maize in punjab about 4.71 lakh metric tonnes in 1.29 lakh hectares. around 850 million tonnes of grain maize is produced from around 162 million hectares at an average of 5.2 t/ha. Maize has assumed a place of prominence in Indian agriculture owing to its varied uses *viz*., human consumption, poultry feed, green fodder, value added products and industrial usage. In addition to staple food for human being and quality feed for animals, maize serves as a basic raw material as an ingredient to thousands of industrial products that includes starch, oil, protein, alcoholic beverages, food sweeteners, pharmaceutical, cosmetic, film, textile, gum, package and paper industries etc. Globally 67 per cent of maize is used for livestock feed, 25 per cent for human consumption and rest for industrial purposes.

Oil content of maize grain is about 4.5 per cent, which has a high nutritional quality *i.e.*, it is being considered as the highest Poly Unsaturated Fatty Acid (PUFA), linoleic acid (61.99%).

A thorough knowledge of association of characters species is a pre-requisite for a successful breeding programme. Information on direct and indirect effects contributed by each character towards yield will be an added advantage in aiding the selection process.

Combining ability is one of the most effective tool in deciding the appropriate parents for hybridization especially when a large number of parental lines are available and most promising ones are to be identified on the basis of their ability to give superior hybrids. In order to identify potential cross combinations, it is very important to screen out the parent materials for their genetic diversity and combining ability. Hybrid cultivars have played a vital role in increasing acreage and productivity of maize. Combining ability is the relative ability of a genotype to transmit its desirable performance to its crosses. Combining ability analysis is not only the quickest method of understanding the genetic nature of quantitatively inherited traits, but also gives essential information about the selection of parents which in turn throws better segregants.

Exploitation of heterosis on commercial for a particular locally requires isolation of suitable inbred and development of hybrids. To accomplish this task, one has to know the genetic diversity of the available germplasm and the combining ability of the parents. For improving the yield potential of varieties and hybrids, the decision should be made on the choice of the right parent for hybridization.

Line × tester mating design is an appropriate method to identify superior parents and hybrids based on general & specific combining ability respectively and to study nature of gene action. This design provides information on more number of parents with limited number of single crosses. Hence, the present investigation is planned to understand the genetic nature of yield & yield components through studies involving 24 lines and 4 testers in line × tester mating design with following objectives.

OBJECTIVES:

1. To identify best performing experiment hybrid.

2. To estimate the combining ability of of various parent involved in breeding program.

3. To study the character association between yield and its component traits through correlation & path analysis.

REVIEW OF LITERATURE

Maize is one of the most intensively studied crop and hence, a wealth of information is available on genetics of several hereditary parameters. The literature available on genetic analysis of yield and yield components in maize (*Zea mays* L.) is reviewed under the following headings.

1 Heterosis

2 Combining ability analysis

3 Correlation studies

4 Path coefficient analysis

1 HETEROSIS

The word heterosis using widely . the concept that oppsprings that which came from the two genetically non similar parents which show the more vigour then the parents .

Shull (1908) referred to this phenomenon as the stimulus of heterozygosis. Generally the term hybrid vigour is used to denote heterosis in the desirable direction. The heterosis over mid parent, better parent and standard check are designated as average heterosis, heterobeltiosis and standard heterosis (Field heterosis), respectively. In practical plant breeding, superiority of F1 over mid parent is of little value since it does not offer any advantage. However, the exploitation of hybrid would primarily depend on its performance in comparison to the best existing commercial hybrids/varieties (standard heterosis). Heterosis breeding provides opportunity for improvement in productivity, earliness, uniformity, quality and resistance to diseases and pests. Therefore, heterosis breeding has received more attention than any other plant breeding methods in several crop plants. Since maize, is a cross fertilized crop which has paid rich dividends, an array of hybrids can be released.

Shull (1952) discussed the beginning of the heterosis concept in maize. Heterosis results in the general stimulus to the hybrid plant and affects it in variety of ways. It often results in increased yield, early maturity, greater resistance, taller plants and larger number and weight of seed.

Moll *et al.* (1962) found that the success of heterosis breeding depends on the amount of genetic diversity present in the material.

Mukherjee *et al.* (1974) reported heterosis for ear girth, kernel number per ear and grain yield. Heterosis for grain yield in relation to parental population ranged from 6.7 to 18.6 per cent and from -7.69 to 8.31 per cent when compared to better yielding parent.

Mabo (1977) reported heterosis in maize hybrids in relation to number of grain rows in the parental forms. The degree of heterosis for such characters as number of grain rows per ear, number of grains per row, plant height and grain yield depended on the number of grain rows per ear in the parents. The best results were obtained by selecting parents with a large number of grain rows per ear.

Debnath (1984) reported highly significant heterosis for ear length and grains per ear. He also reported the heterosis for grain yield ranging from 21.07 to 123.58 per cent over mid-parent and from -2.69 to 95.07 per cent over better parent.

Ganguli *et al.* (1989) reported positive heterosis over the better parent for grain yield, ear height, plant height and days to silking.

Beck *et al.* (1990) reported that based on 10 parental diallel in maize, the average heterosis was significant for grain yield, plant height and ear height, though heterosis over the better parent was low in most crosses. Heterosis was generally low for plant and ear height and days to silking.

Subba Rao (1992) reported significant positive heterosis over mid-parent as well as better parent for yield and yield components, number of leaves per plant, stomatal diffusive resistance and specific leaf weight.

Bhalla and Sharma (1993) studied on 13 composites, 9 inbred lines from USA, 7 Indian composites and their hybrids from crosses with 3 testers and reported that highest heterosis in crosses between Indian and foreign material.

Nagda *et al.* (1995) in their study on line x tester analysis found that out of 20 crosses, 15 crosses significantly out yielded the best check (Arun) for grain yield in maize. Out of these crosses, 14 crosses revealed significant negative heterosis for days to silk.

Joshi *et al.* (1998) reported that single cross population had positive significant *gca* effects for oil content along with grain yield per plant and 100grain weight with highest estimate of economic heterosis for oil content.

Netaji *et al.* (2000) obtained significant and positive heterosis and heterobeltiosis for grain and moreover the expression of heterobeltiosis was evident for grain yield per plot followed by test weight, ear length, plant height and number of grain rows per ear.

Geetha (2000) stated that hybrids exhibited maximum heterosis for grain yield per plant followed by cob weight and number of grain rows per cob. The highest value of heterobeltiosis (97.45%) was recorded for grain yield per plant.

Venugopal *et al.* (2002) reported that 42 out of 45 hybrids exhibited significant positive heterobeltiosis with a maximum of 136.97 per cent. Whereas in standard heterosis, only 8 crosses were significantly positive with a maximum of 18.48 percent. Magnitude of heterosis and heterobeltosis indicated that grain yield per plant was the most heterotic character among all characters studied.

Silva *et al.* (2003) stated that analysis of variance grouped over environments showed high significance for heterosis and its components, although mid parent heterosis was of low expression. The interaction of treatments x environments was not significant. The mid parent heterosis effects ranged from -4.3 to 17.3 per cent, with an average heterosis of 3.37 per cent.

Kaushik *et al.* (2004) reported from their study of L x T analysis of 72 crosses that 30 crosses exhibited standard heterosis for grain yield per plant mostly associated with significant estimates of *sca* effects. Standard heterosis was observed either for maturity traits or for protein and oil concentrations.

Malik *et al.* (2004) observed high heterotic effects for plant height, ear weight, kernel rows per ear, 100 kernel weight and grain yield. The average mid parent and high parent heterosis for grain yield was 17.2 and 2.8 per cent, respectively.

2 COMBINING ABILITY

The combining ability generates valuable information on potential genetic stocks involved, thus enabling plant breeders to take critical decision regarding selection of parents and employing suitable procedures in various crop improvement programmes. In relation to single cross of corn, Sprague and Tatum (1942) formulated the concepts of combining abilities. General combining ability (*gca*) is the average performance of a strain in a series of cross combinations estimated from the performance of F1s from the crosses, whereas specific combining ability (*sca*) is used to designate those cases in which certain combinations do relatively better or worse than would be expected on the basis of average performance of lines involved.

Griffing (1956) assessed the relationship between various heritable variance components and *gca* and *sca* variances. He reported that *gca* variance is due to additive variance and additive x additive interaction variance, while *sca* variance is due to dominance variance, additive variance x dominance variance and dominance x dominance variance components. Estimates of the variance due to *gca* and *sca* provide an appropriate diagnosis of the predominant role of additive or non-additive variance of genes.

Ratio of additive to non-additive gene action is to be considered in order to decide the predominance of the kind of genetic variation for a given character. If the ratio of additive to non-additive gene action is more than unity, indicates the major role of additive variance in controlling the expression of a character, whereas, less than unity indicates the importance of non-additive variance. (Gardner, 1963).

Ottaviano *et al.* (1970) reported preponderance of additive gene action for ear weight, whereas for other yield components a complex of gene interactions along with additive effect was noticed.

Pioviarci (1972) analyzed diallel crosses involving eight maize inbred lines and reported that *gca* predominated over *sca* for grain yield and concluded that additive gene action was more important than non-additive gene action.

Debnath and Sarkar (1990) reported non-additive gene action to be important in the inheritance of grain yield, ear diameter and 100-grain weight. Additive and non-additive gene actions were equally important for ear length, grain rows per ear, and number of grains per row.

Vasal *et al.* (1992) studied combining ability of CIMMYT's tropical x subtropical maize germplasm and reported that general combining ability of eight characters under study were found to be significant for all lines taken. Where as specific combining ability was rarely of great importance.

Pal and Prodhan (1994) reported that the mean square estimates for both *gca* and *sca* were significant for maturity, oil content and grain yield. The *sca* components were higher than *gca* components for above characters indicating the importance of non-additive gene effects in controlling these traits.

Nagda *et al.* (1995) revealed that there was high significant *gca* and *sca* variance denoting importance of additive and non additive gene action for seven traits *sca* variances were higher in magnitude for all the traits, except for days to 50 percent silking indicating the predominance of non-additive gene action.

Prodhan and Rai (1999) reported that additive gene effects exhibited a predominant role in the expression of all the characters except kernel rows per ear and kernels per row, where non- additive gene effects were more important in maize.

Choudhary *et al.* (2000) studied on inbreds (S1-lines) and their respective crosses, revealed that the crosses usually had at least one parent with high *gca* for ear length. Based on the mean performance and *sca* effects, 9 best crosses (20 % selection intensity) were used to establish a heterotic group for grain yield which could be used for future improvement.

Geetha and Jayaraman (2000) reported that additive and dominance components were significant for plant height, number of grains per ear, number of grains per row, ear weight, days to 50 per cent silk and 100 grain weight in maize.

Suneetha *et al.* (2000) studied variances for general combining ability (GCA) and specific combining ability (SCA) were significant for days to 50 per cent tasseling and plant height. However, non additive gene action was preponderant for all traits in maize.

Venugopal *et al.* (2002) revealed that non additive gene effects were more important for grain yield, days to silking, days to tasseling, plant height, ear height, ear length, ear girth, 100 grain weight, number of kernel per row and number of kernel rows per ear in maize.

Aguiar *et al.* (2003) reported that *gca* were significant for all traits, while *sca* were not significant only for ear placement. For grain yield, both additive (*gca*) and non additive (*sca*) effects were important. Both *gca* and *sca* effects were significant for grain yield, plant height, ear length, days to maturity and 100-kernel weight. (Gautam, 2003).

Kabdal *et al.* (2003) reported that the general combining ability variances for all the characters studied was higher than the specific combining ability variances except for ear height.

Yousif *et al.* (2003) reported that maximum heterosis was recorded for grain yield. General combining ability (*gca*) variances and specific combining ability (*sca*) variances and genotype x environment interaction were significant.

Singh *et al.* (2004) showed that variation due to genotypes, parents, crosses and parents vs. crosses was highly significant for all characters studied. Crosses exhibiting high heterosis generally recorded high to medium specific combining ability effects.

Singh and Janwal (2004) reported that variances due to general combining ability (*gca*) and specific combining ability (*sca*) were highly significant for the traits like days to silking and days to maturity.

Fan-Xing Ming *et al.* (2005) reported that the difference in general combining ability and specific combining ability for yield per plant, plant height, ear height, ear length, ear diameter, number of rows per ear, number of kernels per row, 1000-seed weight and endosperm hardness was highly significant.

Alamnieatanaw *et al.* (2006) observed that the variance components of general combining ability (*gca*) and specific combining ability (*sca*) were significant for most of the characters, indicating the role of both additive and non-additive gene Action in the inheritance of these characters. However, non-additive gene effects showed predominance for characters *viz*., ear length, number of kernel rows per cob, number of kernels per row, grain yield per plant.

Todkar and Navale (2006) observed that the magnitude of variance due to SCA were larger than GCA for all the characters except days to 50% flowering indicating predominance of non-additive gene action for all the traits studied.

Farzana Jabeen *et al.* (2007) studied combining ability analysis revealed that importance of both additive and non-additive gene action in governing all characters, but non additive gene action found to be predominant.

Gowhar Ali *et al.* (2007) reported for grain yield per plant crosses showing high *sca* effect in the favourable direction involved either high x low or low x low or high x high *gca* effects and the results therefore revealed that high *gca* value of parent is no guarantee of high *sca* effect of their crosses and thus selection of parent should based on their specific combining ability tests.

Jaya kumar *et al.* (2007) reported combining ability studies for grain yield and other yield component characters were conducted using L x T mating design revealed that the existence of specific combining ability variances was higher than general combining ability variances for all characters studied.

Sheena Lukose and Godwat (2007) reported the *sca* effects were greater than *gca* effects due to lines as well as testers indicating the preponderance of non-additive gene effects in the expression of all the characters in moisture stress environment.

Lata *et al.* (2008) conducted combining ability analysis using line x tester design in medium maturity inbred lines of maize for yield and yield contributing traits. The sca variance was observed to be more important for all traits studied.

Jagadish kumar *et al.* (2010) reported that the estimates of genetic variance though revealed the importance of both additive and dominance genetic variances for yield and some other traits, however the dominance components were higher in magnitude and predominant for all traits, thus signifying the importance of non additive gene action in controlling the inheritance of these traits.

3 CORRELATION

Grain yield of plant is the net result of several genetic factors and their individual or combined interplay with environmental factors. Hence knowledge of association of the yield and yield component traits with each other would be of great help in formulating a selection criterion useful in crop improvement.

Jenkins (1929) reported that ear length, ear diameter, ears per plant and plant height were significantly and positively correlated with yield. The characters which were significantly and negatively correlated with yield were moisture percentage of the ears and date of silking indicating the association of late maturity with low yield.

Stuber *et al.* (1966) reported that there is strong genetic association between plant height and ear height since tall plants normally have high ear heights.

Patil *et al.* (1969) Grain yield was positively and significantly correlated with ear height.

Ahmed *et al.* (1978) reported positive correlation for ear length and diameter with both 100-grain weight and grain yield.

Panchanathan *et al.* (1978) reported in maize that three yield attributes *viz.,* grains per ear, ear length and 100 grain weight exhibited positive and highly significant correlation with grain yield. Significant positive correlation under stress was reported between grain yield and plant height, number of leaves, ear girth, ear length and 100-grain weight **(Mahaboobali and Naidu, 1983).** The genotypic correlations were relatively higher than phenotypic ones, indicating a strong inherent association of the characters under study with a probable influence of environment on their expression. Plant height had highly significant genotypic correlation with ear length. Further, highly significant and positive genotypic correlations were also noticed for ear length and dry weight of ears with grain yield. (Bhole and Patil, 1984).

Sharma and Kumar (1987) reported that under drought conditions, grain yield had positive correlation with harvest index, plant height, ear height, leaf area per plant and cob length. Proline content, harvest index, 100-grain weight, cob length, ear height, plant height and leaf area per plant had high direct contribution to grain yield.

Tyagi *et al.* (1988) reported that ear weight, ear length, plant height and 100-grain weight were positively correlated with grain yield in maize.

Farhatullah (1990) reported significant and positive correlation between grain yield and ear height in maize.

Jadhav *et al.* (1991) reported grain yield was significantly and positively correlated with plant height, 100-kernel weight and leaves per plant.

Altinbas and Algan (1993) reported non significant partial correlations between earliness and other traits except for days to silking and grain row number. Multiple correlations of earliness with grain yield per plant, ear diameter and 100-grain weight were significant. Ear diameter was the major component of grain yield and both grain yield per plant and grain oil percentage were positively affected by 100-grain weight. Yield was significantly and positively correlated with 100-grain weight, ear height,plant height and negatively correlated with days to 50 per cent silking, days to 50 per cent tasseling and anthesis-silking interval. (Arefi, 1993).

Krishnan and Natarajan (1995) reported significant and positive association of grain yield with plant height, ear length, ear weight and number of kernel rows per ear in maize.

Kumar and Kumar (1997) determined that in general, values of genotypic correlations were slightly higher than the corresponding phenotypic values. Significant positive correlations were reported for plant height, days to 50 per cent maturity, ear length and cob height with yield per plant in maize.

Gautam *et al.* (1999) reported that grain yield was positively correlated with ear length, ear girth, grain rows, 1000-grain weight, plant height and ear height.

Geetha and Jayaraman (2000) concluded that number of grains per row exerted a maximum direct effect on grain yield in maize. Hence, selection for number of grains will be highly effective for improvement of grain yield.

Umakanth and Sunil (2000) reported that grain yield was significantly correlated with yield contributing characters except ear girth and days to 50 per cent silking. Correlation of yield was highest with plant height followed by ear weight and ear length.

Kumar and Satyanarayana (2001) observed that yield was positively associated with plant height, ear height, ear length, ear girth, number of seed rows per ear and test weight. Test weight was positively associated with ear length and ear girth. The number of seed rows per ear and test weight was positively associated with ear girth.

Choudhary and Chaudary (2002) reported days to tassel and ear weight showed no association with other traits at phenotypic level. Plant height was significantly correlated with ear length, grain yield per plant and grain yield per plot in the negative direction. Ear length had significant and positive correlations with grain yield per plant.

PATH COEFFICIENT ANALYSIS

The technique of path analysis was outlined by Wright (1921) for partitioning the observed correlation into direct and indirect effects. It was applied in plant breeding for the first time by Dewey and Lu (1959).

Panchanathan *et al.* (1978) reported that the 1000-grain weight had the maximum direct effect towards increase in grain yield.

Rupak *et al.* (1979) studied path coefficients and revealed that there was

maximum direct effect of plant height on yield followed by 100- seed weight, ear girth and ear length.

Kang Manjit *et al.* (1983) reported positive effect of ear weight on grain yield at both phenotypic and genotypic levels. The direct effect of plant height on grain yield was also positive and highly desirable.

Swarnalatha Devi (1990) studied path coefficients indicated maximum direct effect of 100-seed weight and total number of seeds per ear on grain yield. Dwivedi and Godawat (1994) observed that the total number of grains per ear, ear girth, shelling percentage and 100 -kernel weight showed maximum positive direct effect on grain yield of maize. Netaji (1998) found significant and positive correlation between grain yield and 50 per cent tasseling, silking and maturity.

Alok Kumar *et al.* (1999) in their study on path coefficient analysis revealed that number of grains per row, number of rows per ear, ear diameter, ear length and days to 50% maturity had high direct effect on grain yield. It was concluded that improvement in grain yield of maize hybrids was possible through selection for number of grains per row, number of rows per ear, ear diameter, ear length and days to 50% maturity.

Chandramohan (1999) reported that the number of kernels per row, 100 grain weight and ear girth had direct effect on grain yield while oil content and protein content had direct negative effects on yield.

Mohan *et al.* (2002) reported that the number of kernels per row, 100-kernel weight, kernel rows per cob and ear length exhibited the highest positive direct effects on grain yield. However, ear height recorded the maximum negative direct effect on grain yield followed by plant height and days to 50% tasseling. The characters which had negative direct effects on grain yield showed strong positive indirect effects through the number of kernels per row, 100-kernel weight and kernel rows per cob.

MATERIALS AND METHODS

The present investigation entitled "Studies on Line x Tester Analysis of Yield and Yield contributing traits in Maize (*Zea mays* L.)" was carried out with an objective of identifying the most suitable parents and single cross hybrids which could Surpass the yield of existing hybrids. During spring, 2018 the 24 inbred lines Were crossed with four testers in Line x Tester design, Lovely Professional University, Punjab. Subsequently during spring 2018 along with a standard checks and parents (lines and testers) were evaluated, at Lovely Professional University.

Pedigree lines:

1. MUP 01009 00016 1 @ +
2. MUP 00122 00012 1 @ +
3. MUP 00122 00054 1 @ +
4. MUP 00122 00048 1 @ +
5. MUP 00121 00034 1 @ +
6. MUP 00121 00024 1 @ +
7. MUP 00120 00037 1 @ +
8. MUP 00120 00034 1 @ +
9. MUP 00120 00027 1 @ +
10. MUP 01027 00048 1 @ +
11. MUP 00103 00050 1 @ +
12. MUP 01056 00063 1 @ +
13. MUP 00105 00044 1 @ +
14. MUP 00102 00062 1 @ +
15. MUP 01028 00030 1 @ +
16. MUP 00102 00002 1 @ +
17. MUP 00105 00054 1 @ +
18. DECDT24013
19. #8218_Yr_2017
20. #8218_Yr_2017
21. DECDT24013
22. MUP 00102 00002 1 @ +
23. MUP 01028 00030 1 @ +
24. MUP 00105 00044 1 @ +

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