Journal Homepage: - www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
ISSN NO. 2320-5407
Article DOI: 10.21474/IJAR01/3098
DOI URL: http://dx.doi.org/10.21474/IJAR01/3098

RESEARCH ARTICLE

MAGAGNITUDES OF VARIABILITY IN EARLY INBREEDING GENERATIONS (S_1 AND S_2) FOR GRAIN YIELD AND ITS COMPONENTS IN MAIZE.

Prashanth. M And Kajjidoni S.T.
Department of Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad – 560 006.

……………………………………………………………………………………………………....

Manuscript Info

……………………….

Manuscript History

Received: 03 November 2016
Final Accepted: 28 December 2016
Published: January 2017

Key words:-
Heterosis, *Zea mays*, variability, morphological traits and yield

Abstract

…………………………………………………………………

Study was conducted to assess the magnitude of heterosis and combining ability in the line × tester cross material involved 100 hybrids generated by crossing 25 lines with four testers and 3 commercial hybrid check (900 M, DMH-2 and Prabha) in maize at Agricultural Research Station, Arabhavi. The analysis of variance indicated significant amount of variability among the genotypes for yield and yield contributing traits. Among the hybrids, ARYP-24 × CM-111 and ARYP-15 × CM-111 were found to be the best cross combinations for grain yield and its components.

……………………………………………………………………………………………………....

Introduction:-

Maize (*Zeamays* L.; 2n = 20) is an important cereal crop with high yield potential. The total production at world level has surpassed both sorghum and pearl millet gaining a third place after wheat and rice. The demand for maize grain is increasing every year due to its diversified use in poultry, piggery and industry. During the year 2005-06, the total area in the country under maize cultivation was 7.58 mha. and the total production was 14.70 mt. as compared to 14.17 mt. during 2004-05. The increased production from Andhra Pradesh, Gujarat, Karnataka, Maharastra, Orissa and Tamil Nadu was due to the availability and adaptation of recently released hybrids (Anon., 2005).

Maize is mainly grown in the warmer parts of temperate regions and in humid-subtropical climate. The highest production is in areas with the warmest month isotherms from 21^0 to 27^0C and a frost-free season of 120 to 180 days duration. Today, maize has become an all season crop in India.

Maize has more than 1000 industrial uses and mainly used for production of starch due to its high starch content (66.2 to 77%). Maize seed oil contains highest polyunsaturated fatty acid (PUFA), linoleic acid (61.9%) and it remains as liquid at fairly low temperatures which is helpful in combating heart diseases. Maize seed oil is also low in linolenic acid (0.7%) and contains a high level of natural flavour. Maize is used primarily as food for humans in Africa and Asian sub-continents. A number of genotypes *viz.*, single cross, three way cross, double top cross, double cross hybrids, composites, synthetic population are being cultivated by farmers.

Beal (1880) was the first to conduct experiment on various hybridizations in maize. The inbreeding experiments were first reported by Darwin (1877) which continued for only one generation with limited impact on the future of maize breeding. East (1908) and Shull (1908, 1909) were first to report the results of their experiments on

Corresponding Author:- Prashanth. M.
Address:- Department of Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad – 560 006.

inbreeding and restoration of vigour upon crossing. Shull (1909) published "A pure line method of corn breeding", which outlined the three essential steps a) large scale inbreeding to obtain many homozygous or near homozygous lines, (b) testing the selected pure lines in all possible crosses and (c) utilizing the best cross for practical corn production. In early days when relatively few lines were available, it was common to evaluate inbreds in all possible cross combinations.

The efficiency and success of hybrid maize breeding depends on the contribution of heterotic effects from the superior inbred lines. The superior cross combination may be exploited as commercial single cross. Usually, the hybrid development programme in maize involves development of inbred lines, evaluation of inbred lines, crossing of selected inbreds and production of hybrids. In this context, a programme on development of inbred lines was initiated by using inbreeding system utilizing yellow pool as the base population. Yellow pool is a blend of 50 elite lines received from Directorate of Maize Research (DMR), New Delhi and inter mated for four cycles at Agricultural Research Station, Arabhavi. The S_2 lines derived from this population were evaluated by line × tester analysis involving four diverse testers to know their performance, combining ability and nature of inheritance of different quantitative traits. The line × tester (L × T) design is basically an extension of top cross analysis involving more than one tester (Kempthorne, 1957). Thus, keeping these views in background, the proposed work was undertaken to develop hybrids suitable for *kharif* season in Karnataka.

***Part of the Ph.D thesis submitted to the University of Agricultural Sciences, Dharwad**

Meterial and Methods:-

Fifty elite breeding lines (Table 1) were received from Directorate of Maize Research (DMR), IARI, New Delhi for development of full season heterotic yellow pool. These lines were raised and allowed to open pollinate for four generations (intermating) without exercising any selection. In each generation, the plants were raised in half-sib family method and at the end of fourth generation, the seeds were collected and grown as base population at College of Agriculture, Dharwad in isolation and allowed to open pollinate. Sufficient care was taken to maintain more than 10 thousand plant population. Out of this population, 150 plants were tagged in each grid by dividing entire population into 10 grids of 150 sq. mt. at the time of tassel emergence, based on vigour, standing ability, silk and tassel traits and free from disease incidence, 800 cobs were selected based on grain yield (*per se*) performance and this material formed basis for further inbreeding and isolation of inbred lines.

The experiments were laid out at Agricultural Research Station, Arabhavi and the experimental details are mentioned below under.

After thorough land preparation, hand dibbling was done with two seeds per hill and thinned out to maintain single plant per hill during second week after sowing (10-15 days after sowing). The crop was applied with recommended dose of fertilizers as per the package of practices.

Observations on quantitative traits:-

In these investigations, data were collected in respect of quantitative traits. Observations on quantitatively inherited traits were recorded on five competitive randomly selected plants. The average was taken as the mean of the treatment. The way in which observations were recorded is described below.

Plant height at 60 days after sowing (cm):-

Plant height was expressed in centimetres by measuring the plant stalk from the ground level to the base of the last leaf sheath of the plant.

Ear height at 60 days after sowing (cm):-

This observation was recorded at the same time as plant height (at harvest), measured as the height of the plant from the ground level to the uppermost ear bearing node and expressed in centimetre.

Leaf area at 60 days after sowing (cm^2):-

The average of five leaves from five different plants at 60 days after sowing was calculated by using formula L × B × 0.75 and expressed in square centimetre (Montgomery, 1911).

Ear weight (g):-
Five ears were sun dried and weight in grams was recorded at stable moisture content.

Ear length (cm):-
Length of the ear was measured and recorded in centimetres at the time of harvest as its total length (from the base to the tip of the ear).

Ear circumference (cm):-
Ear circumference at one-third length from the base of the ear was measured and recorded in centimetre.

Number of kernel rows per cob:-
Number of kernel rows in each ear was counted for five cobs and mean was worked out.

Number of kernels per row:-
The number of kernels in any one of the row in each ear was counted and mean was worked out.

Number of kernels per ear:-
Total number of kernels in each ear of the selected plants was recorded.

Hundred grain weight (g):-
One hundred randomly selected grains per cob were weighed and weight was recorded in grams.

Shelling percentage:-
The ratio of grain weight to the ear weight was expressed in percentage.

$$\text{Shelling percentage} = \frac{\text{Grain weight}}{\text{Cob weight}} \times 100$$

Pith / shank / heart weight (g):-
The total pith / shank / heart weight from each ear was recorded and the average heart weight was expressed as heart weight per plant in grams.

Kernel yield per plant (g) :-
At the time of harvesting, fresh ear weight was recorded in grams per plant. Moisture determinations were made from shelled samples from five random ears of each plot with the help of electronic moisture meter. The fresh ear weight data was used to work out the dry weight at 15 per cent moisture grain yield in grams per plant.

Kernel yield per plot (kg/plot):-
At the time of harvest, fresh ear weight was recorded in kilograms for each plot. This fresh ear weight was adjusted to zero per cent grain moisture and recorded as grain yield per plot. Moisture percentage was determined on universal moisture tested in a grain sample obtained from two rows of each of five ears selected at random at the time of harvest were used for genetical analysis following Combstock (1948) and Robinson (1968).

$$\text{Yield per plot (kg/plot)} = \frac{\text{Fresh ear weight} \times (100 - \text{AVM})}{\text{Final stand}} \times \text{K}$$

Where,

$$K = \frac{\text{Average stand/plot of the trial} \times \text{plot area} \times 0.9412}{100 \times \text{plot area}}$$

AVM = Average moisture

Kernel / grain yield per hectare (q/ha):-

Fresh dehusked ear weight per plot was recorded at the time of harvest. Moisture content of 100 grams of fresh kernels was recorded by moisture meter of each entry and the moisture percentage was calculated by using moisture conversion charts. Kernel yield per hectare was calculated using the formula given below:

$$\text{Yield (q/ha)} = \frac{\text{Fresh ear weight} \times \text{100-AVM}}{\text{Final stand harvest}} \times K$$

Where,

$$K = \frac{\text{Average stand of the trial} \times \text{Area (ha)} \times 0.9412}{100 \times \text{plot area}}$$

AVM – Average moisture

Statistical analysis:-

Analysis of variance:-

The data were subjected to statistical analysis for randomised block design (RBD) as described by Panse and Sukhatme (1962). The mean values of the entries in each replication were used for analysis of variance (ANOVA). The significant difference among genotypes was tested by 'F' test at one per cent and five per cent levels of probability.

Results:-

Performance of yellow pool base population:-

Mean and range values for ten quantitative traits among selected:-

progenies in yellow pool base population:-

The yellow pool base population comprising of 10,000 plants was raised during *kharif* season. A total of 1500 plants were initially tagged based on plant morphological traits and finally 800 cobs were selected based on plant morphology and cob characters. The cobs harvested from such selected plants were assessed for following ten quantitative traits whose results are presented below.

Cob weight (g):-

The cob weight among 800 progenies ranged from 91.90 to 375.00 g. and the mean cob weight was 160.35g (Table 2). However, the median value (155.31g) was comparatively lower than mean value, while the mode value (170.00g) was relatively higher than the mean cob weight. The skewness of the results indicated the negative distribution in the base population. The kurtosis (1.57) and skewness (0.89) values supported the deviation from normal distribution. The cob weight trait recorded higher co-efficient of variance (23.49%) with coefficient range value of 0.61.

Cob length (cm):-

The cob length ranged from 9.00 to 23.00 cm (Table 2).The median (15.00 cm) and mode (15.00cm) values were comparable with the mean value (15.08 cm). The mode value (15.00cm) was equal to the mean value indicating a positively skewed distribution in the base population and a marginal deviation from the normal distribution. The cob length recorded higher coefficient of variance (13.89%) with a coefficient range of 0.44. As many as 312 progenies (39%) recorded cob length ranging from 15.08 to 17.17 cm (Table 2).

Cob girth (cm) :-

The cob girth in population ranged from 10.00 to 18.00 cm with a mean of 13.08cm (Table 2). The magnitude of median (13.00) and mode (13.00) were comparable with mean value. This indicated the positive skewness and narrow deviation from the normal distribution. The cob girth recorded relatively lower coefficient of variation (9.25) with a coefficient range of 0.29.

Number of kernel rows per cob:-

The number of kernel rows per cob ranged between 8.00 to 20.00 rows per cob (Table 2). The magnitude of median (14.00) and mode (14.00) were comparable with the mean number of kernel rows per cob (13.79). The magnitude of kurtosis indicated negative distribution (-0.19) while the skewness indicated positive distribution (+0.19). The data indicated negatively skewed distribution with narrow deviation from the normal distribution. The coefficient of variance with respect to number of kernel rows per cob was 14.69 with a coefficient range value of 0.43.

Number of kernels per row:-

The number of kernels per row ranged from 18.00 to 48.00 with a mean value of 30.90 (Table 2). The magnitude of median (31.00) was comparable with the mean value, while the mode value (28.00) was relatively lower than mean value. The skewness recorded positive distribution (0.30), while the kurtosis (-0.40) recorded negative distribution indicating the deviation from normal distribution. The coefficient of variation was 18.38 per cent with a co-efficient range of 0.45.

Number of kernels per cob:-

The number of grains per cob ranged from 200.00 to 774.00 with a mean of 428.09 (Table 2). The magnitude of median (420.00) and mode (336.00) were relatively lower than mean value. This indicated negatively skewed distribution from the normal distribution. The kurtosis was negative (-0.02) while skewness (0.58) had positive. The number of grains per cob recorded higher coefficient of variation value (25.64%) with a coefficient of range of 0.60.

Hundred seed weight (g):-

The range of 100-seed weight was between 16.53 to 46.53 g with a mean value of 29.55g (Table 2). The median value (29.21) and mode value (29.28) were relatively lower than the mean (29.55 g). This indicated negatively skewed distribution and deviation from the normal distribution in the base population. However, the kurtosis (0.42) and skewness (0.42) indicated relatively lesser deviation. The 100-seed weight recorded coefficient of variation of 16.88 per cent with a coefficient range of 0.48.

Shelling percentage (%):-

The shelling per cent in the base population ranged between 74.71 to 95.60 per cent (Table 2). The mean shelling percentage was 86.05. The magnitude of median (86.24) and mode (86.65) were comparable with the mean value (86.05) indicating negatively skewed distribution. The kurtosis value of 0.76 and skewness of -0.43 were recorded for the shelling percentage. The shelling percentage recorded minimum coefficient of variation (3.14) with a coefficient of range of 0.12.

Grain yield per plant (g):-

The grain yield per plant ranged between 72.73 to 318.18g, with a mean value of 138.15 g (Table 2). The median (133.93) was lesser than the mean value (138.15), while the mode value (151.91) was relatively higher than mean value. This indicated both negative and positive skewed distribution in the base population. The kurtosis (1.45) and skewness (0.90) were appreciably deviated from the normal distribution. The grain yield per plant recorded coefficient of variation of 24.27 per cent with a coefficient of range of 0.63.

Distribution of progenies for various qualitative traits in base population:-

The distribution for qualitative traits of the progenies in yellow pool base population were studied for grain colour, grain size, grain texture pith colour and tip filling and the same is presented here under.

Grain colour:-

Out of 800 progenies in the base population, 369 progenies were with yellow colour followed by 309 with orange yellow and 122 progenies had yellow orange grain colour (Table 3). The frequency of yellow population was relatively high (46.13%) followed by orange yellow (38.63%). The frequency of yellow orange progenies was minimum with per cent value of 15.25.

Grain size:-
Among the 800 progenies, 546 had medium grain size accounting for 68.25 per cent of the population followed by 219 progenies with bolder grain size (27.37%) (Table 3). Thirty four progenies recorded smaller grain size, while only one progeny recorded very bold grain size. Highest number of progenies (95.6%) recorded grain size which ranged between bold to medium grain size.

Grain texture:-
Out of the 800 progenies, 713 possessed flint grain texture accounting to 89.13 per cent of the population (Table 3). The other progenies exhibited grain texture such as dent (8 progenies), semident (26 progenies) and semi-flint (53 progenies) accounting to 10.87 per cent of the base population.

Tip filling:-
Moderate tip filling was recorded by 437 progenies accounting to 54.63 per cent, while 326 lines exhibited no tip filling accounting to 40.75 per cent of the base population (Table 3). Only 37 progenies recorded complete tip filling accounting for 4.63 per cent of the base population.

Discussions:-

Characterization of yellow pool base population based on Quantitative traits:-
The proportion of superior inbred lines is determined by the proportion of the superior genotypes in the base population and the effectiveness of selection during the inbreeding. Hence, selection of proper germplasm source is an essential part of breeding programme. The breeding methods, efficiency of selection and final success are highly dependent on the base population chosen. Tannar and Smith (1987) studied various maize population derived from synthetics using two methods of recurrent selection and population derived from open pollinated variety based on the changes in grain yield, grain moisture and lodging. The study indicated the importance of effective population size and selection during S_1 or S_2 was more effective in eliminating unfavourable allele in the population.

In an another attempt, made to establishing inbreeding tolerant base population, Choudhary and Choudhari (2001) using DH-8644 and Jogia local as a base population indicated the possibilities of establishing inbreeding tolerant base population by selecting crosses which showed non-significant inbreeding depression with better yield performance.

Out of ten quantitative characters recorded in 800 selected progenies on cob characters, the progenies exhibited very high coefficient of variation for cob weight, pith weight, number of kernels per cob and grain yield per plant coupled with relatively high estimates of coefficient of range values indicating the presence of high variability in the base population. Further the median and mode values indicated positive skewed distribution for pith weight with high mode value suggesting the greater scope for selection of progenies for lower pith weight there by shelling percentage can be improved. It is interesting to note that out of the traits which recorded high estimates of coefficient of variability, cob weight and the grain yield per plant revealed platykurtic distribution with a high mode value than their respective mean values indicating the presence of relatively high proportion of superior progenies with higher mean values for both the characters in base population. Carlone and Russell (1989) selected 247 progenies from BSSS population and advanced to S_2 generation. Similarly, Venkatesh *et al*. (2001) selected 500 progenies from CMIP2-7 population and selfed it for two generation to obtain S_2 generation. The results on the *per se* performance of line, crosses vis-à-vis revealed that high yielding sister line crosses (SLCs) recorded high values for various yield related traits.

Cob girth and shelling percentage exhibited lower coefficient of variability with a 0.29 and 0.12 coefficients of range values, respectively with a platykurtic distribution in both the cases. However, shelling percentage had the greater mode value than the mean indicating the presence of superior progenies with a high shelling percentage in the base population comparatively with cob girth. It is interesting to note that cob length, number of kernels per cob, number of kernels per row and 100-seed weight had more or less a similar coefficient of range value varying from 0.43 to o.48 revealing the presence of moderate variability for these traits in the selected progenies in base population. Wide range of cluster mean, for various traits were observed by Saxena and Sandhu (1989) in a divergence study involving 140 genotypes belonging to diverse geographic region.

Selected 800 progenies were grouped into different classes based on their superiority over the mean (Table 4). When superior progenies were scored based on greater values than mean + two standard deviation (>M + 2 SD) for ten quantitative traits, two traits namely number of kernels per cob and number of kernel rows per cob had high frequency of progenies *i.e.*, 6.25 per cent for number of kernels per cob and 5.50 per cent for number of kernel rows per cob followed by 100-seed weight and grain yield per plot. However, there were no superior progenies for shelling percentage under this class. Similar results were quoted by earlier workers. Marker and Joshi (2005) reported genetic gain for two traits *vis-à-vis* 100-grain weight and ear diameter through full sib family selection.

In a similar frequency classification made considering the class value of M + SD to M + 2 SD, high frequency of superior progenies were scored for number of kernels per cob (33.50%) and number of kernel rows per cob (20.88%). These two traits also had similar trend in the higher class value. However, as many as 49.00 per cent progenies had shelling percentage between M to M + 2 SD followed by cob length with 39.00 per cent of the progenies. Out of ten traits under study, the base population had maximum number of superior progenies in higher class values for number of kernel rows per cob and number of kernels per cob which are important components of a grain yield, revealing the importance of the Yellow pool population for isolation of productive inbred lines at later generations.

These were also scored for grain colour, grain size, grain texture, pith colour and tip filling characters. As many as 713 (89%) progenies were flint type, 546 (68.25%) with medium grain size and 437 (54.60%) with a medium tip filling traits. However, there were only 37 (4.60%) plants with a complete tip filling and 122 progenies with a yellow orange grain colour. Majority of the progenies (87.40%) had the white pith colour.

The grouping made on the basis of qualitative cob character clearly revealed the presence of desirable alleles for grain texture, grain size and tip filling in the Yellow pool population.

References:-

1. Anonymous, 2005, *XXXXVIII Annual Progress Report*, All India Co-ordinated Maize Improvement Project, Directorate of Maize Research Pusa Campus, New Delhi – 110012.
2. Beal, W. J., 1880, Indian corn, *Report Michigan State Board. Agric.*, 19 :279- 289 (Cf. Lonnquist and Gardner, 1961).
3. Carlone, M. R. Jr., and Rusell, W. A., 1989, Evaluation of S_2 maize lines reproduced for several Generations by random mating with lines. II.
4. Comparisons for test cross performance of original and Advanced S_2 and S_8 lines. *Crop Science,* 29 : 899-903.
5. 4. Choudhary, A. K. and Choudhari, L. B., 2001, An approach to establish inbreeding tolerant base population in maize (*Zea mays* L.). *Indian Journal of Genetics*, 61(1) : 31-33.
6. Comstock, R. E. and Robinson, H. F., 1948, The components of genetic variance in populations of biparental progenies and their use in estimating average degree of dominance. *Biometrics,* 4 : 254-266.
7. Darwin, C. 1877, The effect of crosses and self fertilization in the vegetable kingdom. D. Appleton and Co., New York, p. 482.
8. East, E. M., 1908, Hybridization methods in inbreeding. *Report of African Breeders Association*, 6 : 63-72.
9. Kempthorne, O., 1957, *An Introduction to Genetic Statistics*. John Willey and Sons, New York.
10. Marker, S. and Joshi, V. N., 2005, Estimation of genetic variance from full sib and half sib families in a maize (*Zea mays* L.) composite. *Indian Journal of Genetics,* 65(3) : 180-183.
11. *10.*Montgomery, E. G., 1911, Correlation studies in corn. Nebr. Agriculture Experimental Station, *Annual Report*, 24 : 108-159.
12. 11.Panse, V. G. and Sukhatme, P. V., 1962, *Statistical Methods for Agricultural Workers*, ICAR Publication, New Delhi, p. 145.
13. 12.Robinson, N. G., 1968, Genetic variance estimates from different mating systems in a variety of corn (*Zea mays* L) *Diss. Abstr.*, 28 : 2214B-2215B.
14. 13.Saxsena, V. K. and Sandhu, A. S., 1989, Divergence analysis in maize.*Crop Improvement*,16(2) : 154-158.
15. 14.Shull, G. H., 1908, The composition of a field maize. American Breeders Association Republic, 4 :296-301.
16. 15.Shull, G. H., 1909, A pure line method of corn breeding. *American Breeders Association Republic*, **5** :51-59.
17. 16.Tanner, A. H. AND SMITH, O. S., 1987, Comparison of half sib and S_1 recurrent selection in the krug yellow dent maize populations. *Crop Science,* 27 : 509-513.
18. 17.Venkatesh, S., Singh, N. N., and Gupta, N. P., 2001, Early generation identification and utilization of potential inbred lines in modified single cross hybrids of maize (*Zea mays* L.) *Indian Journal of Genetics*, 61(3) : 213- 217.