6. SUMMARY AND CONCLUSIONS

The present investigation entitled "Studies on heterosis and inbreeding depression in sorghum (Sorghum bicolor [L.] Moench)" was conducted during the kharif season 2000 at the Research Farm, Department of Agricultural Botany, J.V. (P.G.) College, Baraut (U.P.), to achieve the following objectives of estimating the magnitude of heterosis, identifying the type of cross which may result in higher heterosis, determining the degree of inbreeding depression, estimating divergence among various genotypes and also to find out major yield components.

To achieve these objectives, 26 parental lines, 24 different types of F$_1$ crosses using Kharif (K) and Rabi (R) based parental lines i.e. KxK, KxR, RxK, RxR and RxGS, three population bulks namely, M35-1 (Bulk 1-3) and seven corresponding F$_2$ hybrids namely, CSH 13, CSH 16, CSH 17, SPH 922, CSH 15R, CSH 19R and SPH 1026. All these crosses (F$_1$ and F$_2$) with their parents and checks were grown in R.B.D. with three replications. Data recorded for 14 characters were statistically analysed. The important findings of the studies are summarised below:

The mean performance of parents, F$_1$s, population bulks and F$_2$s showed that majority of the F$_1$ crosses and population bulks flowered and matured earlier than the parents and F$_2$s flowered and matured lately
compared to others. Among \( F_1 \) crosses like SPH 999, 104 A x RS 651 and cross combinations with SPSFR 94006A, SPSFR 94016A and 42 A flowered earlier than other \( F_1 \) crosses and among parents AKMS 14B, ICSV 93028, 42 B and SPV 839 flowered and matured earlier than other parents. Earliness is the desirable character since sorghum is grown mostly as rainfed crop wherein moisture stress is the limiting factor.

\( F_1 \) and \( F_2 \) crosses and population bulks possessed intermediate plant height compared to their parents which may be desirable. Among \( F_1 \) hybrids, \( R_xK \) and \( R_xR \) crosses were taller (244.8 cm) than other type of crosses. RS 615 (224 cm) in parents and 104 A x RS 651 (288 cm) in crosses had tallest plant height than others.

For panicle length \( F_1 \)'s hybrids recorded longer panicles than others. In \( K_xK \) crosses (\( F_1 \)'s) recorded higher number of primaries per panicle, high number of seeds per primaries, high number of grains per panicle, longer panicle length and grain yield per plant than other type of \( F_1 \) crosses, while \( F_2 \) generations had lowest values of these traits due to inbreeding. Among parents, 401 B (2112) and among the hybrid CSH 9 (2482) recorded highest number of grains per panicle.

Regarding grain yield, RS 680 (66gm) among parents and SPH 1102 (84.6 g) among \( F_1 \)'s recorded highest yield. Among \( F_2 \)'s SPH 1026 (52.8 g/plant) recorded higher grain yield. The \( F_1 \) hybrids yielding higher than the check, CSH 17 were SPH 1026, SPH 1102 and CSH 13. The other promising parents were RS 29, RS 647, CS 3541, 401 B and SPV 839.
F₁'s had higher 100-seed weight than compared to parents, bulks and F₂'s. Among F₁'s RxK and RxF crosses recorded high 100-seed weight than others. Among parents, RS 647 (3.97g) followed by 104 B and C 43 and among F₁'s, SPH 1077 (3.77g) followed by SPSFR 94006A x RS 585 and CSH 13 recorded high 100-seed weight while, seven corresponding F₁'s recorded lower test weight compared to F₁'s due to inbreeding depression.

For harvest index, F₁'s, recorded higher than F₂'s. Among F₁'s, KxK type crosses recorded high harvest index than others. RS 29 (49.30%) among parents, CSH 17 (49.10%) among F₁'s and among F₂'s (47.70%) recorded high harvest index.

Most of the F₁ crosses showed higher leaf area of 50 per cent flowering than parents. Among parents, RS 673 (23.37 sq.cm) followed by 116 B, among F₁'s SPH 1026 (2460 sq.cm) followed by CSH 9 and among F₂'s also SPH 1026 (2213 sq.cm) recorded higher leaf area. The KxK (1908 sq.cm) and RxK (1898 sq.cm) possessed higher leaf area than other type of F₁ crosses.

Fodder weight was highest in F₁'s than compared to parents, F₂'s and bulks. Among parents, RS654 (71.3g), among F₁'s SPH 1102 (120.4g) and among F₂'s, SPH1026 (90.2g) recorded higher fodder yield. The KxK types of crosses were on par with both checks, RxF and RxR were closer to check, CSH 19R.

Percentage of protein content ranged from 7.03-9.53 per cent in parents, 6.71-10.53 per cent in F₁'s and 7.13-7.93 per cent in F₂ crosses. AKMS 14B (9.53%) among parents and CSH 9 (10.53%) among F₁'s, recorded highest protein percentage. The KxK type of crosses had high protein percentage (9.64%) compared to different types of F₁ crosses.
Heterosis for days to 50 per cent flowering was negative and significant in most of the crosses over mid-parent and better parent suggesting the presence of over dominance in the negative direction. All SPSFR nos. cross combinations recorded highest negative heterosis and heterobeltiosis for days to 50 per cent flowering. Some of the crosses also revealed negative standard heterosis for this trait.

Heterotic effect for plant height was positive and significant in most of the crosses. Only one (SPH 733) and two (SPH 733 and SPH 999) crosses had negative values of heterosis and heterobeltiosis, respectively. These results indicated the presence of dominance in most of the crosses. The KxK crosses had high range of heterosis and heterobeltiosis for plant height.

Heterosis for number of leaves was negative in most of the crosses indicating reduction in number of leaves in hybrids. The average leaf area at 50% flowering increased in F1's than parental mean values. The KxK crosses recorded highest leaf area (1908 Sq.cm) than other type of crosses.

Heterosis for panicle length and width was positive and significant for few number of crosses over MP and BP. However, negative standard heterosis was recorded in most of the crosses indicating superiority of standard checks, CSH 17 and CSH 19R which had lengthy and more width panicles.

Among F1's four crosses recorded positive and significant heterosis for number of primaries per panicle but seven crosses showed positive heterobeltiosis for the same trait. The character number of seeds per primaries only two crosses (104A x ICSV 93028, CSH 19R) had positive and significant heterosis over MP and BP. However, negative standard heterosis for number of
primaries per panicle and seeds per primaries was recorded in most of the crosses indicating superiority of standard checks (CSH 17 and CSH 19R) which had more number of primaries per panicle and number of seeds per primaries.

For number of grains per panicle 33 per cent crosses recorded positive and significant heterosis. Highest heterosis of 76.44 per cent and heterobeltiosis of 63.90 per cent were observed in CSH 9 and CSH 16, respectively and 57.26 per cent standard heterosis over CSH 19R was recorded in CSH 13. The combinations of 296 A with different restorer lines had maximum heterotic effects. The KxK crosses had higher grain number (2372.6) than other types of crosses.

In respect of grain yield, CSH 15R and CSH 16 recorded high heterosis as well as moderate heterobeltiosis than other crosses. On the other hand, majority of the crosses revealed significant and positive heterosis and heterobeltiosis for grain yield. SPH 1102 had recorded highest standard heterosis over CSH 19R (43.63%) and over CSH 17 (29.02%) than other crosses.

Hybrids with more than 11 per cent heterosis and heterobeltiosis were CSH Nos. 9, 13, 15R, 16 and SPH Nos. 733, 922, 999, 1026, 1078 and crosses 104 A x ICSV 93028, 104 A x ICSV 95076 and SPSFR 94006 A x RS 585. More than 11 per cent standard heterosis was observed in CSH 13 and SPH 1102. KxK and RxK crosses had higher grain yield per plant while RxK crosses showed high heterosis range for grain yield per plant 17.97 to 52.89 per cent among different type of crosses.

In this view grain yield, heterosis, heterobeltiosis and standard heterosis (over CSH 19R) were positive and significant in the crosses viz., SPH
1102 (116 A × RS 680), SPH 733 (401 A × SPV 839), SPH 1026 (115 A × RS 647),
CSH 13 (296 A × RS 29) and CSH 16 (27 A × C 43). The CMS lines involved in
these combinations viz., 27 A, 116 A, 296 A and 401 A lines. Many of them are
also good general combiners. Their exploitation in commercial breeding
programme could be rewarding.

For 100-seed weight, eleven crosses had bolder seeds and recorded
heterosis and nine hybrids exhibited heterobeltiosis. Some of them had
standard heterosis indicating usefulness of these hybrids for bolder seeds. RxR
crosses had bolder seeds followed by RxK crosses than other crosses.

There was negative heterosis and heterobeltiosis for most of the
crosses for harvest index. Only one hybrid SPSFR 94006 A × RS 585 recorded
high positive heterosis (18.91%) and heterobeltiosis (9.50%). KxK crosses
showed high heterosis than other groups and 3.07 per cent higher than RxK
crosses.

Out of 24 hybrids, 16 hybrids recorded heterosis and 13 hybrids
exhibited heterobeltiosis for fodder yield, while most of them had standard
heterosis indicating usefulness of these hybrids for fodder purpose.

More than 60 per cent of crosses showed negative heterosis and
heterobeltiosis for percentage of protein content. Among different crosses CSH 9
and SPH 999 recorded high heterosis and heterobeltiosis for protein percentage.
KxK crosses showed high heterosis among different type of crosses.

Most of the characters showed positive and significant inbreeding
depression between different F1 crosses. CSH 15R recorded low inbreeding
depression (1.98%) for days to 50 per cent flowering, number of grains per
panicle (5.68%) and grain yield per plant (16.57%), CSH 13 recorded low inbreeding depression (-1.65%) for plant height and high heterosis (57.98%) and also exhibited low inbreeding depression for harvest index (-1.19%). Low inbreeding depression was recorded in SPH 922 for panicle length (9.67%) and protein percentage (7.41%). SPH 1026 revealed low inbreeding depression for panicle width (5.0%) and for 100-seed weight (7.36%). Low inbreeding depression (1.10%) and high heterosis (29.28%) was observed in CSH 19R for number of primaries per panicle and plant height (0.92%). The number of seeds per primaries in CSH 16 revealed low inbreeding depression. The hybrid CSH 15R showed low inbreeding depression (16.57%) and high heterosis (60.42%) for grain yield and number of grains per panicle (5.64%). The fodder weight per plant in CSH 17 revealed low inbreeding depression (2.25%).

The study of character association in the genotypes indicated that grain yield was significantly and positively correlated with leaf area at 50% flowering, panicle length, panicle width, number of seeds per primaries, number of grains per panicle, 100-seed weight, harvest index, fodder weight per plant and percentage of protein content.

Significant and positive correlation of grain yield with number of seeds per primaries and total number of grains per panicle and their combinations with panicle length indicated the progress in recombining these traits as the local varieties possess the short panicle and low seed number per panicle. The increase in the grain yield may be due to the increase in panicle length, which may have potential to more number of grains per panicle as well as high sink size resulting in high harvest index.
grouped into eleven clusters. In general, geographic diversity was not related to genetic diversity. However, some of the *kharif* parents possessed long panicle and small seed and some of them like AKMS 14 B and CS 3541 had shorter heads have grouped together in the same cluster. Highly divergent stocks isolated on the basis of this analysis can be successfully exploited in breeding programmes aimed at the evaluation of high yielding genotypes.


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* Original not seen.
DEPARTMENT OF AGRICULTURAL BOTANY
JANTA VEDIC (P.G.) COLLEGE, BARAUT,
BAGHPAT – 250611 (U.P.)

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"Studies on heterosis and inbreeding depression in sorghum [Sorghum bicolor (L.) Moench]"

Mukesh Tomar

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ABSTRACT

The present investigation was carried out to study heterosis, inbreeding depression, character association and genetic diversity in 60 genotypes (26 parental lines, 24 F1's, 7 F2's and 3 bulks) were grown and evaluated in RBD with three replications during kharif 2000 season. The parents represented kharif (K), rabi (R) and genetic stocks (GS) and hybrids were based on various combinations of them i.e., KxK, KxR, RxK, RxR and RxGS. The data were statistically analysed using RBD model. The estimates of heterosis over mid-parent, superior parent and standard heterosis were estimated.

Analysis of variance revealed highly significant differences (P<0.01) among parents, F1's and due to parents vs. F1's and F1's vs. F2's . For most of the characters, these studies suggested the presence of considerable amount of genetic variability and heterosis. Heterosis was positive and significant for plant height, panicle length and width, number of primaries/panicle, number of
seeds/primaries, number of grains/panicle, 100-seed weight, fodder and grain yield, while negative heterosis was recorded in respect of days to 50% flowering, number of leaves, harvest index and protein content in most of the crosses. For grain yield two hybrids viz., CSH 16 and CSH 15'R possessed consistently higher estimates of heterosis. SPH 1102 was superior than check, CSH 19'R. *Khurf* hybrid CSH 13 possessed high grain number and SPH 1102 possessed high grain yield. The KxK and RxK were much higher yielders than RxA and RxGS types of hybrids.

Out of seven *F*₂ crosses studied, five crosses (CSH 13, 15 R, 19 R and SPH 922, 1026) were found to be low in inbreeding depression for some of the characters. CSH 15'R found to be low in inbreeding depression for number of grain/panicle, grain yield and days to 50% flowering.

The correlation coefficient computed for fourteen characters revealed significant positive correlation between grain yield and important characters such as panicle length, panicle width, number of seeds/primaries, number of grains/panicle, 100-seed weight, harvest index, fodder yield and protein content. The regression analysis indicated that 100-seed weight contributed to a greater degree for the grain yield.

Out of six characters studied, number of seeds/primaries and protein content were relatively high. In contrast, panicle width had moderately high heritability.

Sixty genotypes were evaluated for certain genetic parameters. The estimates of GCV, PCV, heritability and genetic gain were of higher order for the character like plant height, panicle length, leaf area, number of grains/panicle, number of seeds/primaries and grain yield. Thus, there is substantial scope for improvement of these characters.

Considerable amount of genetic diversity was observed among the genotypes studied. All 60 genotypes were grouped into 11 clusters depending on their *D*² values. The *D*² statistics showed that there was adequate diversity among the genotypes ranging from 0.0 to 68.36. The clustering pattern of these genotypes did not necessarily follow the geographical distribution. On the basis of inter-cluster distance and cluster means, the CMS lines viz., 296 A, 27 A, 42 A, 104 A, AKMS 14 A and 401 A and the restorers, RS 647, RS 653, RS 654, R 354, RS 627, C 43, CS 3541 and RS 680 had been identified for hybridization programme and further genetic improvement.