LINE × TESTER ANALYSIS ACROSS ENVIRONMENTS FOR STALK SUGAR YIELD TRAITS IN SWEET SORGHUM [*Sorghum bicolor* (L.) Moench]

DEEPAK, G.C.

DEPARTMENT OF GENETICS AND PLANT BREEDING
COLLEGE OF AGRICULTURE, BIJAPUR
UNIVERSITY OF AGRICULTURAL SCIENCES,
DHARWAD - 580 005

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By

DEEPAK, G.C.

DEPARTMENT OF GENETICS AND PLANT BREEDING
COLLEGE OF AGRICULTURE, BIJAPUR
UNIVERSITY OF AGRICULTURAL SCIENCES, DHARWAD
JUNE, 2014

DEPARTMENT OF GENETICS AND PLANT BREEDING
COLLEGE OF AGRICULTURE, BIJAPUR
UNIVERSITY OF AGRICULTURAL SCIENCES, DHARWAD

CERTIFICATE

This is to certify that the thesis entitled "**LINE × TESTER ANALYSIS ACROSS ENVIRONMENTS FOR STALK SUGAR YIELD TRAITS IN SWEET SORGHUM [*Sorghum bicolor* (L.) Moench]**" *submitted by* **Mr. DEEPAK, G. C.,** *for the degree of* **MASTER OF SCIENCE (AGRICULTURE)** *in* **GENETICS AND PLANT BREEDING** *to the University of Agricultural Sciences, Dharwad, is a record of research work carried out by him during the period of his study in this university, under my guidance and supervision, and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.*

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(G. M. SAJJANAR)

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(B. D. BIRADAR)

2. ____________________________
(A. P. BIRADAR)

3. ____________________________
(A. K. GUGGARI)

Affectionately dedicated

to

My beloved

Grand Parents & Parents

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With regardful memories . . . . . .

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1. INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) *Moench*] is normally a self-pollinating but can cross pollinate, diploid (2n = 2x = 20) and belongs to the family Poaceae. It is a C4 plant with higher photosynthetic efficiency and higher abiotic stress tolerance (Nagy *et al.*, 1995 and Reddy *et al.*, 2009). It is one of the most important cereal crops in the world because of its adaptation to a wide range of ecological conditions, suitability for low input cultivation and diverse uses.

Sweet sorghum, which is similar to grain sorghum but with sugar rich stalks and juice recovery of 65%, is an alternative when compared to grain sorghum in crop diversification process. Sorghum with more than 8% Brix is called as sweet sorghum (www.fao.org). Sweet sorghum being a C_4 plant with very low photorespiration has a high biomass production capacity. It has characteristic juicy stalks with high sugar content (sucrose being the major form of carbohydrate accumulated in the stalk) (Reddy and Reddy, 2003). Thus, sweet sorghum can give a stiff competition to sugarcane as source of raw material for production of ethanol. The photoperiod and thermo insensitiveness is an important feature of sweet sorghum which enables to take up its sowing at different dates to ensure year round supply of sweet sorghum for ethanol production as well as grain (Reddy *et al*., 2005). Currently, sweet sorghum is grown for syrup, forage and silage in USA and other countries. Since, sweet sorghum is relatively a new crop to India, the statistical data on its area and production is hardly available.

At present, in India, sugarcane is the only crop utilized commercially for sugar production by sugar industries and the by-product (molasses) is used for ethanol production. The inclusion of sweet sorghum as an alternative source can be justified as it has short growing period (4 months) with lower water requirement (8000 m^3) as compared to sugarcane which has longer growing period (18 months) and higher water requirement (36,000 m^3) (Soltani and Almodares, 1994). Further, the cost of cultivation of sweet sorghum is lesser by three times than that of sugarcane. Sweet sorghum is seed propagated while sugarcane is vegetatively propagated. The juice from sweet sorghum is much cleaner (low in aldehydes) and can be fermented with 90% efficiency to produce clear and potable ethanol as compared to the juice from sugarcane. Moreover, the alcohol industry in the country is also quite eager to find out alternative source of raw material for ethanol production following the policy of Government of India to blend petrol with ethanol (initially 5% and increased up to 10%) (Ratnavathi *et al.*, 2005). Under utilization of the existing molasses based ethanol distilleries and the deficit in requirement of ethanol in future can be made good if sweet sorghum cultivation is promoted for ethanol production as it can meet food, feed, fodder and fuel. From the above facts, it is clear that, sweet sorghum can form a supplementary crop to sugarcane.

Sweet sorghum research in India is carried out by Directorate of Sorghum Research (DSR) (formerly NRCS), Hyderabad and its AICSIP centers, Rahuri, Parbhani, Akola, Surat, Coimbatore and Dharwad and this has lead to identification of promising varieties like SSV 84, SSV 74, SSV 119 etc. The wide variability available for Brix (8-18%), biomass (36-140 t/ha) and grain yield (2-6 t/ha) in sweet sorghum (Reddy *et al.*, 2005) can be used for the genetic improvement through exploitation of heterosis for development of hybrids. Cytoplasmic male sterility in sorghum was identified by Stephens and Holland (1954) made hybrid production feasible. In India, HYV/hybrids are predominant in *kharif* sorghum than *rabi* sorghum (Seetharama, 2006). Of the 6.5 m ha area under HYVs in India, 4 m ha is under *kharif* season, 1 m ha is under *rabi* and 1.5 m ha under summer season (www.icrisat.org). This statistical data also favours the objective of development of hybrids for *kharif* sorghum area. And hybrids of sweet sorghum can very well fit into this.

Heterosis in sorghum was demonstrated as early as 1927 (Corner and Karper, 1927), but its commercial exploitation was possible only after the discovery of a stable and heritable cytoplasmic-nuclear male-sterility (CMS) mechanism (Stephens and Holland, 1954). Breeding for heterosis in sweet sorghum can be accomplished by identification of stable cytoplasmic male sterile lines, maintainer and restorer lines having high general combining ability (GCA) for biomass, juice yield and sugar content and hybrid with desirable specific combining ability (SCA).

For the development of effective heterosis breeding programme in sweet sorghum, one needs to have information about genetic architecture and estimated prepotency of parents in hybrid combinations. Selection made on *per se* performance alone does not lead to expected success in hybrid breeding. Therefore, the selection of parents/inbreds with good combining ability is very important in producing superior hybrids. The estimation of general combining ability (*gca*) and specific combining ability (*sca*) effects helps in identifying the potential parents and crosses, respectively. The line × tester (Kempthorne, 1957) analysis is one of the simplest and efficient methods of evaluating large number of inbreds for combining ability and *per se* performance. This provides information on relative magnitude of fixable and non-fixable genetic variation available in the material. Analysis of *gca* and *sca* is also useful in understanding the type of gene action involved in controlling various characters and in formulating suitable breeding strategies.

Considering the importance of the crop and the above indicated facts, there is a need to generate information on general combining ability of parents, specific combining ability in cross combinations, the extent of heterosis to identify promising heterotic crosses etc., for sugar related traits, yield and yield components in sweet sorghum. The experiment was planned for evaluation of stalk sugar yield traits in crosses of B and R lines of sweet sorghum produced in line x tester (L × T) design across environments with the following objectives.

OBJECTIVES

1. To assess the extent of heterosis for stalk sugar yield traits and identification of heterotic cross combinations of B and R lines across environments.
2. To estimate general combining ability effects of parents and specific combining ability effects of crosses for stalk sugar yield traits.
3. To study the nature and magnitude of gene action in the inheritance of various traits.

2. REVIEW OF LITERATURE

Sweet sorghum is a new generation bioenergy crop with considerable tolerance to drought, salinity and water logging, is amenable for multiple uses. At present in India, sorghum production is restricted to grain and fodder use only. Therefore, if alternative uses of sorghum are exploited, then the crop can be grown on a wider area with higher returns to farmers.

Sweet sorghum is gaining importance as a raw material for ethanol production. Information on genetics of sugar content in stalk is required to facilitate the breeding of cultivars with high ethanol yield. The genetic improvement of both quantitative and qualitative characters is the main interest of plant breeders for which adequate knowledge on genetics of yield and its component characters is very much essential. The success of any crop improvement programme lies in the selection of the base material and its creative manipulation. Keeping in view of the objectives of the present investigation, the literature related to sweet sorghum has been reviewed. However, there has not been much research on heterosis and combining ability in sweet sorghum, although some information on characteristics valued in sweet sorghum production that can be extracted from grain sorghum hybrid research has been reviewed and presented under the following headings.

2.1 Heterosis

Heterosis is the increased vigour of F_1 generation of a cross in terms of size, duration or yield of economic product over the mean of the parents or better parent (Hayes *et al*., 1955). Corner and Karper (1927) were the first to notice hybrid vigour in sorghum. Karper and Quinby (1937) made a detailed study by attempting extensive crosses between *milo*, *kafir*, *hegari*, *kaoling*, *songo* and *broomcorn* and indicated that *milo* and *hegari* were the two groups whose hybrids invariably expressed extreme vigour in grain sorghum suggested the use of crossed sorghum seed for practical utilization of hybrid vigour for increasing production.

Heterosis has been fully exploited in sorghum only after the discovery of cytoplasmic genetic male sterility and fertility restoration system by Stephens and Holland in 1954. Heterosis of F_1 is expressed over mid parent, better parent or available standard check variety or hybrid. Significant heterosis over mid parent indicates partial dominance while, significant heterosis over better parent indicates over-dominance. The standard heterosis over best check variety or hybrid is the real heterosis in which breeders are interested for development of high yielding hybrids.

A survey of the literature showed extensive reports on heterosis for grain yield and its components but little information is available on stem sugar heterosis in sorghum.

In a set of 28 grain sorghum × sweet sorghum hybrids, 11 hybrids showed significant high-parent heterosis for green stalk yield, only two showed high-parent heterosis for per cent extractable juice, and none showed significant high parent heterosis for juice brix (Selvi and Palanisamy, 1987).

In a study of heterosis and heterobeltiosis in high energy sorghum involving 3 females and 8 lines and their 24 hybrids, Chaudhari (1992) observed reasonable amount of heterosis in respect of plant height, green stem weight at physiological maturity, juice yield and grain yield. Heterobeltiosis was observed only in one cross for brix.

Substantial magnitude of standard heterosis was observed for plant height (up to 46.9 %), total soluble solids (up to 7.4 %), millable stalk yield (up to 1.5 %) and juice yield (up to 122.6 %), in a study involving 3 CMS lines, 7 testers and 21 hybrids (Sankarapandian *et al.*, 1994b).

Significant positive heterosis was reported by Ganesh *et al*. (1996) for plant height, 100-grain weight and grain yield in a set of 42 cross combinations of sweet sorghum developed through 7 × 7 diallel cross.

In a study of heterosis in 60 sweet sorghum hybrids developed by crossing 10 male sterile lines with 6 testers, Senthil and Khan (1997) observed positive relative heterosis for days to 50 per cent flowering and plant height in all 60 hybrids, while only one cross recorded highest positive relative heterosis and heterobeltiosis for brix and grain yield per plant.

From a study of 40 hybrids developed by crossing 4 male sterile lines with 10 restorer lines in L × T mating design, Meshram *et al*. (2005) reported significant overall heterosis for plant height, green cane yield, grain yield and commercial cane sugar.

Agarwal and Shrotria (2005), in a study involving 50 hybrids derived from a cross between 5 CMS lines and 10 restorer lines in L × T fashion noticed the presence of significant mid-parent, better parent and standard heterosis for plant height and total soluble solids.

In a study involving 144 sweet sorghum hybrids developed by crossing 9 female lines and 16 male lines in a line × tester fashion, Rajashekhar (2007) noticed significantly higher standard heterosis for days to 50 per cent flowering, plant height, juice volume, juice weight, 100-grain weight and grain yield in three hybrids.

Corn (2008) reported better parent heterosis values ranging between -24% and 7% for stem brix, and -27% to 43% for stem biomass production. Therefore there is potential to exploit heterosis in new sweet sorghum cultivar development.

In a study comprising 61 hybrids, 16 parents and three check varieties were evaluated by Makanda *et al*. (2009) and it was reported that there was significant (P = 0.05) variation among genotypes for stem brix and associated traits. The top 20 stem brix performers were constituted by 17 hybrids (exhibiting heterosis of up to 112%) and three parents.

In a heterosis study of 18 hybrids developed by crossing 3 lines with 6 testers in L × T mating design, Sandeep *et al*. (2009) reported significant mid-parent heterosis and better parent heterosis for cane height, cane weight, juice volume and ethanol yield. Significant standard heterosis in respect of juice brix was observed in two hybrids and in respect of above mentioned four characters was observed in 5-13 hybrids in desirable direction.

In a L × T analysis involving 72 hybrids produced by crossing 4 CMS lines with 18 testers, Vinaykumar (2009) reported significant standard heterosis for ethanol yield and grain yield in six and one hybrids respectively.

In a heterosis study of 20 genotypes involving male-sterile hybrids and lines, Pfeiffer *et al*. (2010) reported positive heterosis for brix in six hybrids. The greater juice yield and higher sugar content of selected hybrids such as A3 N100 × Dale could produce more total syrup or ethanol than current pure-line sweet sorghum varieties.

Pothisoong and Jaisil (2011) studied 20 sweet sorghum hybrids and it was revealed that F1 hybrids showed %heterosis over better male parent for days to flowering, plant height, percent brix, stripped stalk yield, grain yield, and per cent cane juice extracted up to -7.83, 8.06, 7.60, 15.47, 66.33 and 34.89%, respectively. The magnitude of heterosis in these F1 hybrids was very high for grain yield as in grain sorghum but relatively low for per cent brix and stripped stalk yield which were important characters of sweet sorghum.

In a line × tester analysis involving 16 hybrids produced by crossing eight parents, Umakanth *et al*. (2012) reported that significant and positive mid-parental heterosis was recorded in 11 hybrids for total biomass and juice yields and 6 hybrids were shown significant and positive better parent heterosis ranging between 12 to 41 % for total biomass.

In a study of 24 grain sorghum hybrids with their parents, it was observed that 23 hybrids had higher grain yield; however, only 16 were taller, nine bloomed earlier, and just five had greater stalk diameter than the superior parent (Kirby and Atkins, 1968).

In a study when short grain sorghum types were crossed with three tall genetically diverse sorghum accessions, mid-parent heterosis for grain yield was 80% with a general combining ability : specific combining ability (GCA:SCA) ratio of 3.56:1. Mid-parent heterosis for height was 38% with a GCA:SCA ratio of 5.88:1 (Niehaus and Pickett, 1966). The high GCA:SCA ratios suggest the likelihood of most hybrids exhibiting heterosis for these traits.

Nandanwankar (1990) observed marked heterosis over better parent for grain yield from a study of 33 hybrids developed by crossing 3 male sterile lines with 11 restorers in L × T mating design, and the manifestation of heterosis for grain yield was attributed to increased number of seeds per earhead, earhead length and grain size.

In a study of 6 x 6 diallel cross involving five *rabi* and one *kharif* lines, Gururaja Rao *et al*. (1993) observed maximum mid parent and better parent heterosis for plant height and grain yield. The parents with high *per se* performance were reported to produce superior hybrids.

Sankarapandian *et al.* (1994a) observed significant positive heterosis over better parent for grain yield in 20 out of 42 hybrids produced by crossing 3 male sterile lines with 14 testers.

Significant mid parent heterosis and maximum heterobeltiosis in all hybrids was reported by Sankarapandian *et al.* (1994c) for plant height in a study involving 42 hybrids and their parents.

In a set of 81 cross combinations developed by crossing 9 male sterile lines with 9 tester lines of sorghum, Veerabadhiran *et al.* (1994b) noticed significant positive heterosis for plant height and grain yield.

In a study of 32 hybrids involving 4 male sterile lines and 8 restorers, Ghorade *et al*. (1997) observed profitable heterosis and heterobeltiosis for days to 50 per cent flowering, plant height and grain yield.

Badhe and Patil (1997b) reported significant positive heterosis for plant height, 100-grain weight and grain yield per plant in a study of 32 hybrids produced by crossing 4 male sterile lines with 8 testers.

In a study of heterosis involving 60 hybrids developed by mating 5 lines with 12 testers in L × T mating design, Salunke and Deore (1998) reported pronounced hybrid vigour for grain yield, 1000 grain weight and plant height, and low magnitude of heterosis towards earliness for days to 50 per cent flowering.

In another study of 60 hybrids obtained by crossing 5 male sterile lines with 12 restorers in L × T mating design, Salunke and Deore (2000) observed highly significant positive heterosis for plant height and moderate heterosis for 1000 grain weight, while low range of heterosis for days to 50 per cent flowering.

In a sorghum cross involving A_2 CMS line and A_1 restorer line, Laxman (2000) observed positive standard heterosis for plant height, grain yield per plant and 100-grain weight and negative heterosis for days to 50 per cent flowering.

Significant heterobeltiosis and standard heterosis for days to 50 per cent flowering, plant height and 100-grain weight was observed by Laxman (2001) in a study of 10 hybrids involving 5 male sterile lines and 2 restorer lines.

Prabhakar (2001) in a study of 18 hybrids developed through L × T mating design involving 3 lines and 6 restorers, reported significant heterobeltiosis and useful heterosis for days to 50 per cent flowering ranging from -11.53 to -1.41 per cent and significant heterosis over better parent to the extent of 102.9 per cent for grain yield per plant.

In a study of heterosis in 28 hybrids developed by mating four male sterile lines with seven restorers through L ×x T mating design, Chaudhary *et al*. (2003) reported negative heterobeltiosis for days to 50 per cent flowering (16 crosses), positive heterobeltiosis for plant height (10 crosses), 1000 grain weight (10 crosses) and grain yield per plant (15 crosses).

Hemalatha *et al*. (2003) observed significant positive heterosis, heterobeltiosis and highest magnitude of economic heterosis (45.85%) for grain yield in 74, 52 and 27 crosses, respectively out of 80 crosses produced by crossing 4 lines with 20 testers. The heterosis for 1000 grain weight was also observed in the study.

Umakanth *et al*. (2003), in a study of 32 hybrids developed from 12 parents through 4 x 8 (L × T) mating design, observed significant heterosis over mid parent for plant height in all 32 hybrids and significant heterosis over better parent in 20 and 14 hybrids for 1000 seed weight and grain yield, respectively.

Through L × T analysis involving three lines and five testers, Chaudhary *et al*. (2004) observed positive heterosis for plant height, days to 50 per cent flowering, 1000 grain weight and grain yield in nine hybrids, while all the hybrids showed heterosis over better parent and the check for days to 50 per cent flowering and grain yield.

Kulkarni and Patil (2004) observed a marked degree of significant desirable heterosis over better parent and checks for grain yield in 4 out of 33 hybrids produced by crossing 3 lines with 11 testers and also recorded maximum heterosis for days to 50 per cent flowering in two hybrids.

In a study of 28 sorghum hybrids derived by mating four lines with eight testers, Chaudhary and Narkhede (2004b) observed negative heterosis for days to 50 per cent flowering and positive heterosis for plant height, 1000 grain weight and grain yield in most of the hybrids.

Nirmala *et al*. (2004) observed highly significant positive mid parent heterosis to the tune of 121.5 per cent and better parent heterosis to the tune of 110.8 per cent for grain yield in a study of seven hybrids.

Kaul *et al*. (2005), in six generation mean analysis of 6 sorghum crosses, observed positive heterobeltiosis and positive heterosis for grain yield in five crosses and positive heterobeltiosis for test weight in three crosses.

In a study of 80 sorghum hybrids derived from crossing 4 lines with 20 testers, Hemalatha *et al*. (2005) reported significant positive heterosis, heterobeltiosis and economic heterosis for grain yield in 48, 25 and 25 hybrids, respectively.

Four *milo* hybrids out of 27 hybrids developed by crossing 3 male sterile lines possessing two different types of cytoplasm and 9 restorers, recorded higher *per se* performance and positive heterosis for grain yield (Pattanashetti *et al*., 2005).

Grain yield per plant exhibited heterobeltiosis to the tune of 63.10 per cent, while 500 seed weight exhibited mid-parent heterosis ranging from -19.23 to 45.09 per cent and better parent heterosis ranging from -36.18 to 2.98 per cent in a study of 12 hybrids developed by 4 × 4 diallel (Patil and Biradar, 2005).

Appreciable amount of heterosis for days to 50 per cent flowering, plant height, 1000 grain weight and grain yield was reported by Rajguru *et al.* (2005b) in a study of 30 hybrids involving 3 male sterile lines, 10 restorers and 2 check varieties.

In a study of 7 sorghum hybrids, Chaudhary *et al*. (2006) reported significant useful heterosis for grain yield in all seven hybrids.

Desai *et al*. (2006), in a study of 32 hybrids produced by crossing 4 male sterile lines with 8 restorers reported high magnitude of relative heterosis and heterobeltiosis for grain yield per plant and 100-grain weight. Further 26 and 21 hybrids exhibited significant positive heterosis for grain yield over mid parent and better parent, respectively.

Jayalakshmi *et al*. (2006) identified the presence of desirable heterobeltiosis for grain yield in three hybrids.

From a study of 36 hybrids sorghum derived through crossing 4 lines with 9 testers in L × T mating design, Premalatha*et al.* (2006) reported maximum heterosis for grain yield in four crosses with 90, 86.89 and 33.45 per cent heterosis over mid parent, better parent and standard check, respectively and these crosses were also found to be superior for days to 50 per cent flowering, plant height and grain yield per plant.

Reddy *et al*. (2007) in a study consisted of six pairs of iso-nuclear, allo-plasmic (A1 and A2) A-lines and 36 iso-nuclear hybrids produced by crossing these A-lines with three dual restorer (R-) lines, It was reported that cytoplasm had limited effect on mid-parent heterosis of iso-nuclear hybrids for days to 50% flowering, plant height and grain yield. The relative frequency of the occurrence of the A1- and A2-based hybrids with significant mid-parent heterosis indicated that A2 CMS system is as efficient as A1 with a slight edge over A1 for commercial exploitation.

Kulkarni *et al*. (2007) observed pronounced hybrid vigour for grain yield and 1000 seed weight in 27 out of 30 hybrids of sorghum, produced by crossing 3 lines with 10 testers, while 4 hybrids exhibited highest percentage increase over the standard control.

In another study involving 21 hybrids and their 10 parents, Wadikar*et al*. (2007) observed significant heterotic effects in positive direction for plant height and grain yield. Significantly high heterosis over better parent and controls for grain yield was observed in 5 hybrids.

Makanda *et al*. (2010) in a study consisting 8 cytoplasmic male-sterile (CMS) A-lines, 10 cytoplasmic male-fertile lines, 80 hybrids and two standard check varieties were evaluated in replicated row-column α-designs across six environments. They reported significantly high levels of average heterosis and standard heterosis, for grain yield potential and secondary traits.

2.2 Combining ability and Gene action

The combining ability is the ability of an inbred to transmit desirable performance to its offspring. The information on the nature and magnitude of combining ability of parents and hybrids facilitates selection of appropriate parents in breeding programmes. Sprague and Tatum (1942) proposed the concept of combining ability using single crosses of maize. They defined general combining ability (GCA) as the average performance of a line in a series of hybrid combinations, whereas specific combining ability (SCA) refers to the performance of two specific inbreds in a particular cross combination. The term SCA is used to designate those cases in which certain combination do relatively better or otherwise than would be expected on the basis of the average performance of the lines involved. From the genetic point of view, SCA measures the variance due to non-additive gene action including dominance and epistasis.

The study of combining ability is thus useful in getting information on the relative proportion of additive and non-additive types of gene action in the expression of the characters under consideration and overall genetic potential of lines and hybrids that helps in selection of desirable parents and appropriate methods for future crop improvement programme.

Schlehuber (1945) reported that genes with partial dominance action controlled sucrose content in hybrids. However, Baocheng *et al.* (1986) reported that genes with additive and dominance effects influenced stem sugar accumulation. Whereas Guiying *et al.* (2000) reported that recessive genes exhibiting additive effects controlled stem sugar accumulation in sorghum.

The line × tester analysis of combining ability revealed significance of both GCA and SCA variances for grain, fodder and quality characters. Larger variances due to SCA observed for grain yield, 250 grain weight and sugar content indicated predominance of non-additive gene action, where as additive component was predominant for grain weight (Nayeem and Bapat, 1984).

Sankarapandian *et al*. (1994b) reported predominant role of non-additive gene action for plant height, total soluble solids (TSS), millable sweet stalk yield and extractable juice yield in a study of 10 sweet sorghum lines and their 21 hybrids obtained by crossing 3 lines with 7 testers in L × T mating design.

In a combining ability analysis involving 21 sorghum diallel crosses and their 7 parents, Saxena *et al.* (1999) noticed significance of both GCA and SCA variances for juice percentage, sucrose percentage and grain yield.

Estimates of GCA and SCA variances revealed importance of non-additive gene action in genetic control of days to 50 per cent flowering, plant height, Brix, 100-grain weight and grain yield per plant in a study of 36 hybrids produced by crossing four lines with nine testers (Premalatha *et al.*, 2006).

Higher magnitude of SCA variances than GCA variances and predominance of non-additive gene action for biomass, juice yield and grain yield was noticed in a combining ability analysis involving 144 hybrids produced by crossing 9 lines with 16 testers in L × T fashion. Among parents, 2 lines and 3 testers were good general combiners for biomass, juice yield and grain yield (Rajashekhar, 2007).

Based on the ratio of GCA and SCA variance, predominance of non-additive gene action in the genetic control of days to 50 per cent flowering, cane weight, juice volume, Brix and grain yield was reported by Sandeep (2007) in a L × T analysis involving 9 parents and their 18 hybrids produced by crossing 3 lines with 6 testers.

Studies by Ritter *et al.* (2008) suggested involvement of major genes in addition to genes with minor effects for stem ^{o}brix. Moderate to high h^2 estimates, ranging between 40% and 96% (Baocheng *et al.*, 1986; Guiying *et al.,* 2000), and predominance of genes with additive effects suggest that ^{o}brix could be improved through selection.

In a study, 61 hybrids, 16 parents and three check varieties were evaluated by Makanda *et al*. (2009), it was reported that the general and specific combining ability effects were significant for stem brix and associated traits implying that both additive and non-additive gene action, respectively, were important for controlling the traits.

In a L × T analysis involving 72 hybrids produced by crossing 4 CMS lines with 18 testers, Vinaykumar (2009) reported higher SCA variance than GCA variance indicating predominance of non-additive gene action in the genetic control of plant height, cane height, juice weight, 100-grain weight, ethanol yield and grain yield per plant suggesting good scope for heterosis breeding.

In a study involving one elite male-sterile line, 27 B and two sweet sorghum lines, kellar and BJ 248, Audilakshmi *et al*. (2010), reported that both additive and dominant gene actions for traits, sucrose and brix in stalk juice were significant, however dominance gene action was more important.

In a generation mean analysis, Kumar *et al*. (2011) studied six basic generations, namely P1, P2, F1, F2, BC1P1, BC1P2 of four inter-varietal crosses involving eight diverse sweet sorghum parents, reported that high positive additive × additive interaction effects were found in all the crosses. The magnitude of dominance gene effects was substantially higher than that of additive gene effects in all the crosses for all characters studied, whereas dominance × dominance gene effects were positive for characters particular for Brix% and sugar yield in all the crosses.

In a study of 171 hybrids developed by crossing 19 female parents with nine male parents in line × tester design at two seasons Sanjana *et al.* (2011), reported that magnitude of SCA variance was higher suggesting the importance of non-additive gene action in inheritance of all the traits though both additive and dominant genes controlled overall sugar yield during both the seasons.

Estimates of GCA and SCA variance revealed non-additive control of genetic variation for total biomass, juice extraction and grain yield; the presence of additive gene action for fresh stalk yield, juice yield, brix content, total sugar yield and computed bioethanol yields. Also there was significant interaction of variance due to SCA with environment for all the characters studied except juice extraction (%) in a line × tester analysis involving 16 hybrids produced by crossing eight parents (Umakanth *et al*., 2012).

In a study of six sorghum genotypes of varying characteristics and three standard seed parents Godoy and Tesso (2013), reported that GCA for females, was significant ($P \leq 0.05$) only for juice yield, Brix, days to flowering, and plant height, whereas the effect of GCA for males was highly significant for all traits studied.

In a line × tester analysis of combining ability analysis by Nayakar *et al.*(1989) revealed the preponderance of additive gene effects for grain yield per plant.

The components of variance due to GCA and SCA indicated preponderance of non-additive gene action as reflected by higher SCA variance for grain yield in a study of 28 hybrids produced by crossing 7 lines with 4 testers by Selvi and Palanisamy (1990). The *gca* and *sca* effects for testers and hybrids ranged from -7.81 to 3.92 and -12.74 to 11.89, respectively. Two testers and eight cross combinations exhibited significant *gca* and *sca* effects, respectively.

In a study of combining ability involving a diallel set of 10 varieties of grain sorghum, Patel *et al.* (1990) indicated higher *sca* variance than *gca* variance for days to 50 per cent flowering and grain yield indicating predominance of non-additive gene action.

Jagadeshwar and Shinde (1992), in another study combining ability of 28 hybrids through 8 × 8 diallel analysis reported significance of both GCA and SCA variance for earliness, plan height and grain yield indicating importance of both additive and dominance gene action in the genetic control of above traits. Further, the study indicated that crosses involving good × good and good × poor combiners will throw productive lines in advanced generations.

The analysis of full diallel crosses involving six parents by Sheriff and Prasad (1994) indicated significant variances due to GCA and SCA and hence, operation of both additive and non-additive gene action in the inheritance of grain yield.

Sankarapandian and Subbaraman (1994) recorded predominance of non-additive gene action in the genetic control of 1000 seed weight and grain yield in a study of combining ability of 42 hybrids, produced by crossing 3 lines with 14 testers.

Naik *et al.* (1994) noticed higher magnitude of SCA variance in relation to

GCA variances in respect of days to 50 per cent flowering, plant height and grain yield indicating predominance of non-additive gene action in the genetic control of these traits.

Combining ability studies involving diverse cytosterile lines by Senthil and Palanisamy (1994) revealed importance of non-additive gene action in the genetic control of 100-grain weight and grain yield, and additive gene action for days to 50 per cent flowering and plant height.

In a set of 81 crosses produced by crossing nine male sterile lines with nine restorers, Veerabadhiran *et al.* (1994a) observed non-additive gene action for days to 50 per cent flowering and preponderance of non-additive gene action for grain yield as reflected by high SCA variance.

In L × T analysis involving 3 CMS lines and 14 testers, Manickam and Das (1995) noticed major role of non-additive gene action in the genetic control of plant height.

Pillai *et al.* (1995), in a study of 40 hybrids involving four male sterile lines and ten restorers, reported presence of non-additive gene action for grain yield per plant and additive gene action for 100 seed weight based on GCA and SCA variance.

Pooran Chand (1996) through combining ability analysis in 5 × 5 diallel set of crosses in grain sorghum, reported operation of both additive and non-additive gene action in inheritance of plant height and grain yield based on estimates of GCA and SCA variances.

Nguyen *et al*. (1997), in a study of 6 × 6 diallel analysis reported highly significant positive *gca* effect for grain yield and negative *gca* effect for days to 50 per cent flowering in some parents and significant *sca* effect for days to flowering and grain yield in hybrids.

In L × T analysis involving four male sterile lines and eight male parents, Badhe and Patil (1997a) observed predominance of additive gene action for plant height and non-additive gene action for grain yield per plant based on GCA and SCA variances.

In a study of combining ability analysis involving 18 hybrids produced by crossing 3 male sterile lines with 6 restorer lines, Biradar *et al*. (2000) reported significant GCA and SCA variances suggesting importance of both additive and non-additive gene action in the inheritance of days to flowering, plant height and grain yield.

In another study involving 40 hybrids developed by crossing 4 CMS lines with 10 restorers in L × T mating design, Hovny (2000) identified three and one restorers as good combiners for earliness and grain yield per plant, respectively. Further, one hybrid with high *sca* effect for grain yield per plant was also identified.

In a L × T analysis involving 80 hybrids produced by crossing 4 CMS lines with 20 restorers, Hovny *et al*. (2000a) observed positive and highly significant *gca* effects for grain yield in one line and five restorers. Further, positive and highly significant *sca* effects for grain yield were observed in 12 hybrids.

Hovny *et al*. (2000b) reported positive significant *gca* effects in some CMS lines for grain yield in a L × T analysis involving 32 parents and their 60 hybrids produced by crossing 30 CMS lines with 2 restorer lines and noticed the importance of non-additive genetic variance in inheritance of grain yield.

Kadam *et al*. (2000) reported higher magnitude of SCA variance than GCA variance for plant height, number of nodes per plant and grain yield indicating predominant role of dominance gene action in a study of 16 parents and their 39 hybrids obtained by crossing 3 male sterile lines with 13 testers. Further, the crosses showing good *sca* effect involved parents of either good × poor or poor × poor general combiners indicating prevalence of non-additive gene effects.

In a L × T analysis involving 30 crosses produced by crossing 3 CMS lines with 10 restorers, five parents and two hybrids showed highly significant positive *gca* and *sca* effects, respectively for grain yield (Hovny *et al*., 2001).

Iyanar *et al*. (2001) observed predominance of non-additive gene action in the genetic control of days to 50 per cent flowering, plant height and test weight, in a study involving 14 parents and their 40 hybrids obtained by crossing four lines with ten testers in L × T mating design.

In a study of 30 hybrids produced by crossing three male sterile lines with ten restorers in L × T fashion, Kanawade *et al.* (2001) observed preponderance of additive gene effects in the inheritance of 1000 grain weight and grain yield per plant, where as non-additive gene effects were predominant for plant height and days to 50 per cent flowering.

From combining ability analysis in a diallel set comprising of 10 parents and their 45 hybrids, Ravindrababu *et al.* (2001) noticed predominance of both additive and non-additive gene effects for days to 50 per cent flowering, plant height, 1000 grain weight and grain yield. Further, they reported additive and additive × additive gene effects in the genetic control of above characters.

In a study of line × tester analysis of 10 hybrids produced by 5 male sterile lines and 2 testers, Laxman (2001) observed higher *sca* effects for grain yield in many crosses and more *gca* effect for plant height and number of grains per panicle in one tester.

In a combining ability study of 108 cytosterile lines, Bhavsar and Borikar (2002) reported higher magnitude of SCA variance than GCA variance indicating importance of non-additive gene action for days to 50 per cent flowering, plant height, 1000 grain weight and grain yield per plant.

Gaikwad *et al.* (2002) observed non-additive gene effects in the genetic control of days to 50 per cent flowering, plant height and grain yield and additive gene effects for 1000 grain weight in a study of 40 hybrids obtained by crossing 4 male sterile lines with 10 restorers.

In another study involving 32 hybrids produced by crossing eight lines with four testers in L × T mating design, Umakanth *et al.* (2002) reported higher SCA variance than GCA variances indicating predominance of non-additive gene action in the inheritance of days to 50 per cent flowering, plant height, 100-grain weight and seed yield per plant.

Combining ability study involving 11 male sterile lines and 3 testers by Biradar *et al.* (2004) revealed higher estimates of GCA variances than SCA variances for plant height indicating additive gene effects, while higher sca effects than gca effects were observed for grain yield per plant and 1000 grain weight indicating non-additive gene action in genetic control of these traits.

The crosses exhibiting good *sca* effect involved parents of good × poor or poor × poor general combining ability for days to 50 per cent flowering, plant height, 1000 grain weight and grain yield indicating the prevalence of non-additive effects, in a study of 40 hybrids involving 4 ms lines and 10 testers (Chaudhary and Narkhede, 2004a).

In a study of hybrids produced through L × T mating design, Iyanar and Khan (2004) observed predominance of additive gene action for plant height and number of nodes per plant.

Kenga *et al*. (2004) in a study of 75 hybrids with 20 parental lines including 15 restorers and 5 male-sterile A-lines revealed that highly significant *gca* effects of males were found for all traits under study, where as significant *sca* effects were detected in all the traits except inflorescence length.

The SCA variance was reported to be higher than GCA variance for days to 50 per cent flowering, plant height, test weight and grain yield in a study involving 9 parents and their 14 hybrids obtained by crossing them in 5L × 4T mating design (Kaul *et al*., 2004).

In another study consisting of 40 hybrids produced by 10 lines and 4 testers, Patil *et al.* (2005) observed significant GCA variance for days to 50 per cent flowering, plant height and grain yield per plant and high SCA variance for grain yield in 9 crosses.

Rajguru *et al.* (2005a), in a study of 30 hybrids developed by crossing 3 male sterile lines with 10 restorers, reported predominance of additive gene action in genetic control of days to 50 per cent flowering and plant height but non-additive gene action in genetic control of 1000 grain weight and grain yield.

Reddy *et al*. (2007) in a study consisted of six pairs of iso-nuclear, allo-plasmic (A1 and A2) A-lines and 36 iso-nuclear hybrids, reported that cytoplasm had limited effect on *gca* effects of A-lines and on *sca* effects of iso-nuclear hybrids for days to 50% flowering, plant height and grain yield. The relative frequency of the occurrence of the A1- and A2-based hybrids with significant *sca* effects indicated that A2 CMS system is as efficient as A1 with a slight edge over A1 for commercial exploitation.

Makanda *et al*. (2010) in a study consisting 8 cytoplasmic male-sterile (CMS) A-lines, 10 cytoplasmic male-fertile lines, 80 hybrids and two standard check varieties were evaluated in replicated row-column α-designs across six environments. They reported that *gca* and *sca* effects were significant ($P \leq 0.05$) for all the traits, implying that both additive and non-additive gene effects were important.

2.3 G × E interaction

The phenotype of an individual is determined by the effects of its genotype and environment surrounding it. The phenotypic response to change in environment is not the same for all the genotypes leading to genotype-environment interaction.

Genotype × environment (G × E) interactions are of major consequence to the breeders in the process of evolution of improved varieties and also it poses problem in demonstrating the significant superiority of any variety in a set of entries as their rankings usually do not remain same from location to location.

Presence of G × E interaction in any study leads to over estimation of genetical and statistical parameters. In nut-shell it can be emphasized that G × E interaction underlines the very success of scientific crop improvement programme related to stability of genotypes and also it influences the post-breeding adaptive evaluation of improved strains before being released for commercial cultivation (Sharma, 1998). However, for some situations, high interactions are beneficial and can be exploited for better results under certain environments (Khanure, 1993).

Therefore, G × E interaction is considered as one of the important issues in crop breeding and its measurement has always remained an intriguing problem in the past, though many attempts were made to resolve it.

Allard and Bradshaw (1964) have discussed the significance of the genotype-environment interaction on the basis of the relative magnitude of different variances estimated from multi-location and year test. When genotype × environment variance is very large, the selection for average performance over the entire area from which the locations were drawn may not be considered. If a criterion was found for establishing sub areas or regions, this interaction variance can be reduced.

Srinivasa Rao *et al.* (2011) in a study of eleven improved sweet sorghum lines evaluated in both seasons for three years, reported that that there is significant interaction of genotypes with seasons and years for Brix%, sugar yield and grain yield in hybrids. Mean squares due to genotype × year × season interaction for the three traits showed differential behaviour of genotypes in different seasons and years except for sugar yield.

In a study of recombinant inbred (RI) population derived from a grain sorghum × sweet sorghum (Zou *et al.*, 2011) reported that significant differences among genotypes were observed for all measured traits. A large proportion of the phenotypic variance for plant height, harvested stem length, panicle length and sugar concentration was attributed by genotypic variance. Highest ratio of genotype × environment (G × E) interaction variance to phenotypic variance was observed for Stem diameter. Moderate proportion of phenotypic variances for heading date, number of nodes and Panicle neck length were explained by genotypic variances.

In a study involving eight parents and 16 hybrids evaluated at three semi-arid locations using the line × tester mating design (Umakanth *et al*., 2012), reported that significant differences among environments, testers, environments × testers and environments × line × tester effects were observed for all sugar related traits suggesting the environmental influence on testers and the interactions.

In a study of thirty genotypes evaluated across two locations, to obtain more information on their genetic and morphological diversity (Sami *et al.*, 2013). Reported significant mean squares were obtained for 10 traits (days to 50% flowering, plant height, stem thickness, number of nodes, number of leaves, panicle weight, 1000 grain weight, grain yield and sugar content) in the individual analysis and also for the combined analysis across locations, suggesting that this sweet sorghum population was highly variable for some of the characters and as such will respond to selection.

2.4 Character associations

In a study of seven sweet sorghum genotypes (Kachapur and Salimath, 2009), it was reported that positive and significant relationship was established between brix and pol percent but significant and negative relation between brix and panicle weight, and brix and grain yield .

In a study of recombinant inbred (RI) population derived from a grain sorghum × sweet sorghum, Zou *et al.* (2011) reported that plant height, harvested stem length and numbers of nodes had consistently positive and significant correlation with sugar concentration. Panicle neck length had no significant correlation with sugar concentration in all three trials. Heading date, stem diameter and panicle length had no consistently significant correlations with sugar concentration in three trials.

3. MATERIAL AND METHODS

The proposed research programme was carried out on Line × Tester analysis across environments for stalk sugar yield traits in crosses of B and R lines of sweet sorghum at two locations *viz.*, Regional Agricultural Research Station, Bijapur and International Crop Research Institute for Semi-Arid Tropics, Patenchure, Hyderabad during *kharif* season of 2013. The experimental material was evaluated for stalk sugar yield traits in both the locations. The details on material used and methods followed are given below.

3.1 Experimental Material

The material involved in the present study were consisted of 49 crosses derived from 14 hybrid parental lines (B and R). The crosses were made in L × T design (Kempthorne, 1957) at International Crop Research Institute for Semi-Arid Tropics (ICRISAT) during *kharif* 2013. The male parents (testers) were PMS 90 B, ICSB 323, ICSB 351, ICSB 374, ICSB 480, Parbhani Moti and NSSV 13 and the female parents (lines) were IS 13871, IS 22670, ICSV 25333, ICSV 93046, NTJ 2, Wray and SPSSV 30. The details on list of parents and their pedigree are given in Table 1 and list of cross combinations produced in L × T (7 × 7) design is given in Table 2. Panicle photos of parents given in Plate 1. The seed material of these crosses along with their parents and a standard check were received from ICRISAT for evaluation in two environments.

The parental lines, F_1 hybrids generated and a standard check (CSH22SS) were served as the experimental material for evaluation in replicated trial to get the information about heterosis and combining ability status of the lines for various quantitative characters.

3.2 Location

The experiment was conducted during *kharif* 2013 at two locations, Regional Agricultural Research Station, Bijapur and International Crop Research Institute for Semi-Arid Tropics (ICRISAT), Patenchure, Hyderabad. International Crop Research Institute for Semi-Arid Tropics is situated at $17^0 53'$ N latitude and $78^0 27'$ E longitude

Table 1. List and pedigree details of hybrid parental lines (B and R lines) and check hybrid of sweet sorghum used in the present study

SL. No.	Parents	Pedigree
Female parents (lines)		
1	**IS 13871**	IS 13871
2	**IS 22670**	IS 22670
3	**ICSV 25333**	ICSV 25333
4	**ICSV 93046**	(((IS 1082 × SC 108-3)-1-1-1-1-1) × (((IS 5622 × CS 3541)-20-1-1-1-1-1-1 × (UCh V2 × Bulk Y-35)-1-5-1)-5-2-5-1-1))-9-1-3-1-1-1
5	**NTJ 2**	NTJ 2
6	**Wray**	F_2 progeny of a cross of a selection from PI 152728 (Mer. 57-1) with ‘Brawley’ × ‘Rio’
7	**SPSSV 30**	Urja
Male parents (testers)		
1	**PMS 90 B**	PMS 28B × 1046B
2	**ICSB 323**	(IS 29016 × ICSB 26)2
3	**ICSB 351**	(ICSB 11 × IS 2815)2-1-1-2-2
4	**ICSB 374**	(ICSB 11 × IS 2815)42-2-1-1
5	**ICSB 480**	[(ICSB 70 × ICSV 700) × PS 19349B]5-4-1-4-2
6	**Parbhani moti**	IS 33844-1-1
7	**NSSV 13**	NSS 1005A 9 (SSV 84 9 401B)
Check hybrid		
1	**CSH22SS**	ICSA 38 × SSV 84

Table 2. List of cross combinations obtained in L × T (7 × 7) mating design

Sl. No.	Cross	Sl. No.	Cross
1	IS 13871 × PMS 90 B	26	ICSV 93046 × ICSB 480
2	IS 13871 × ICSB 323	27	ICSV 93046 × Parbhani Moti
3	IS 13871 × ICSB 351	28	ICSV 93046 × NSSV 13
4	IS 13871 × ICSB 374	29	NTJ 2 × PMS 90 B
5	IS 13871 × ICSB 480	30	NTJ 2 × ICSB 323
6	IS 13871 × Parbhani Moti	31	NTJ 2 × ICSB 351
7	IS 13871 × NSSV 13	32	NTJ 2 × ICSB 374
8	IS 22670 × PMS 90 B	33	NTJ 2 × ICSB 480
9	IS 22670 × ICSB 323	34	NTJ 2 × Parbhani Moti
10	IS 22670 × ICSB 351	35	NTJ 2 × NSSV 13
11	IS 22670 × ICSB 374	36	Wray × PMS 90 B
12	IS 22670 × ICSB 480	37	Wray × ICSB 323
13	IS 22670 × Parbhani Moti	38	Wray × ICSB 351
14	IS 22670 × NSSV 13	39	Wray × ICSB 374
15	ICSV 25333 × PMS 90 B	40	Wray × ICSB 480
16	ICSV 25333 × ICSB 323	41	Wray × Parbhani Moti
17	ICSV 25333 × ICSB 351	42	Wray × NSSV 13
18	ICSV 25333 × ICSB 374	43	SPSSV 30 × PMS 90 B
19	ICSV 25333 × ICSB 480	44	SPSSV 30 × ICSB 323
20	ICSV 25333 × Parbhani Moti	45	SPSSV 30 × ICSB 351
21	ICSV 25333 × NSSV 13	46	SPSSV 30 × ICSB 374
22	ICSV 93046 × PMS 90 B	47	SPSSV 30 × ICSB 480
23	ICSV 93046 × ICSB 323	48	SPSSV 30 × Parbhani Moti
24	ICSV 93046 × ICSB 351	49	SPSSV 30 × NSSV 13
25	ICSV 93046 × ICSB 374		

with an altitude of 545 m above mean sea level and having mean annual rainfall of 975 mm. Whereas, Bijapur is situated at 16^0 49' N latitude, 75^0 43' E longitude and 593 m above mean sea level. Bijapur comes under Northern Dry Zone of Karnataka (Zone 3) with an annual rainfall of 590 mm. The soil type and climatic conditions in both the locations are well suited for *kharif* sweet sorghum cultivation.

3.3 Weather conditions

In both the locations (Bijapur and Hyderabad), experiment was laid out in black cotton soil and plots were homogeneous with respect to nutrient status. The total rainfall for the year 2013-14 was 1074.25 mm which was optimum both in terms of total precipitation and distribution. April and May were the months of maximum air temperature ranging from 37.47^0C to 40.23^0C. December and January were the coldest months with a mean monthly minimum temperature varying from 11.4^0C to 15.38^0C (2013). All other agronomic managements were followed according to recommended package of practices for rainfed conditions of the zone. Whereas, in Bijapur, the rainfall was bi-modal in nature with the highest peak in July. September received maximum average rainfall of 194.8 mm followed by October (112.5mm). The total rainfall received during 2013-14 was 771.6 mm. April and May were the months of maximum air temperature ranging from 38.7^0C to 39.3^0C. December and January were the coldest months with a mean monthly minimum temperature varying from 11.6^0C to 15.0^0C (2013). Weather data of Hyderabad and Bijapur for the year 2013-14 are presented in Appendix Ia and Appendix Ib.

3.4 Sampling

From each entry/replication, ten random, competitive plants were tagged and numbered in the middle of the row for observing yield and other quantitative characters in International Crop Research Institute for Semi-Arid Tropics (ICRISAT), Hyderabad. Whereas, in Bijapur, from each entry/replication, three random, competitive plants were tagged and numbered in the middle of the row for observing yield and other quantitative characters. Mean of the plants was computed and taken for analysis. The method followed for recording observations on various characters is given below.

3.5 Observations recorded

Initially observations on the following quantitative characters were recorded at appropriate stages of plant growth leaving scope to take elaborate observations in the second experiment.

3.5.1 Days to 50 per cent flowering

The number of days from the day of sowing to first flowering in fifty per cent of plants were counted and recorded as days to fifty per cent flowering.

3.5.2 Plant height (m)

Plant height was recorded in meters (m) from base of the plant to the tip of matured panicle of the plant.

3.5.3 Stem thickness (mm)

Stem thickness was measured (mm) at the middle of a fixed internode (fourth from the bottom) by using vernier calipers.

3.5.4 Stalk yield (t ha^{-1})

Plants tagged for recording observation were cut at physiological maturity, destripped and weighed and averaged to get individual stalk yield. The data obtained was converted as tons per hectare.

3.5.5 Juice yield (t ha^{-1}) and volume (L ha^{-1})

Sampled plants were crushed in the electric motor crusher and juice recovered from it was weighed in grams and mean calculated to express as juice yield per cane. Similarly juice volume was measured in measuring cylinder and expressed as juice volume in litres (L) per cane. The data obtained on juice yield and juice volume were converted into tons per hectare and litres per hectare, respectively.

3.5.6 Brix (%)

Brix value was recorded by using hand refractrometer (HR) by placing a drop of extracted juice from sampled plants and recording the value in Brix.

3.5.7 Bagasse yield (t ha^{-1})

After complete crushing of the sampled plant, the bagasse of the sampled plants were collected, weighed and averaged to get individual plant bagasse yield. The data obtained was converted as tons per hectare.

3.5.8 Total soluble solids (%)

Were calculated by using formula given by Corleto and Cazzato (1997), as reported by Reddy *et al.*, 2005 and measured in percentage.

$$TSS = 0.1516 + (\text{Brix \%} \times 0.8746)$$

3.5.9 Total sugar index

Is calculated by using formula

$$TSI = \frac{\text{Sugar (\%)}}{100} \times \frac{\text{Juice yield (L ha}^{-1})}{1000}$$

3.5.10 Juice extraction (%)

Juice extraction per cent was calculated from weight of juice and weight of the stripped stem using the following formula.

$$\text{Juice extraction (\%)} = \frac{\text{Juice weight (kg)}}{\text{Fresh stalk yield (kg)}} \times 100$$

3.5.11 Ethanol yield (L ha^{-1})

The alcohol yield was estimated by using the following formula.

$$\text{Ethanol yield (L ha}^{-1}) = \text{Brix (\%)} \times \text{fresh biomass (t ha}^{-1}) \times 6.5 \times 0.85 \times 1.27$$

3.5.12 Panicle weight (t ha^{-1})

Fully dried panicles from the five sampled plants were weighed and weight was recorded and averaged to get weight per panicle. The data obtained was converted as tons per hectare.

3.5.13 Panicle length (cm)

Panicle length was recorded in centimeters from the base of the panicle to the tip of the panicle in three randomly selected plants and mean was calculated.

3.5.14 Panicle breadth (cm)

The spread of the primaries at the middle of panicle was recorded in centimeters as breadth of panicle.

3.5.15 Grain yield per plant (t ha^{-1})

The grains harvested from the three sampled plants were dried and weighed and averaged to obtain grain yield per plant. The data obtained was converted as tons per hectare.

3.5.16 Thousand seed weight (test weight) (g)

Weight of 1000 well developed grains from the bulk of five sampled plants was recorded in grams.

3.6 Statistical Analysis

The mean values of five randomly selected plants used for recording observations in each entry of three replications for all the characters were used for statistical analysis, using SAS 9.2 software. The sum of squares due to hybrids was partitioned into sum of squares due to females, males, and females x males, which was used to estimate the additive and dominance components of the variation.

The main effects of B lines and restorer lines were equivalent to general combining ability (GCA), and the effects of B line with a specific restorer were equivalent to specific combining ability (SCA) (Hallauer and Miranda, 1981).

3.6.1 General ANOVA for parents and hybrids

Variance is the measure of variability and is defined as the average of the squared deviation from mean. There are two main objectives of the analysis of variance. Firstly, it helps in sorting out the variance due to different sources and secondly it helps to provide the basis for test of significance (Singh and Choudhary, 1977). The data recorded on 7 B lines, 7 testers and 49 hybrids of sweet sorghum in respect of grain yield, stalk sugar yield and its attributing characters in each entry of three replications were first subjected to Analysis of Variance as per the methods outlined by Panse and Sukhatme (1967) using mean values of randomly selected plants. The model of ANOVA (parents and hybrids) is given below.

Sources of variation	**Df**	**MSS**	**F –value**
Replications	(r – 1)	M_r	M_r/M_e
Genotypes	(g – 1)	M_g	M_g/M_e
Parents	(p -1)	M_p	M_p/M_e
Hybrids	(lt -1)	M_h	M_h/M_e
Parents Vs Hybrids	L	M_{ph}	M_{ph}/M_e
Error	(g – 1) (r – 1)	M_e	
Total	(ltr – 1)		

Where,

r = Number of replications

g = Number of genotypes

p = Number of parents (l + t)

t = Number of testers and

l = Number of lines

All sources of variation were tested against error for significance by comparing calculated 'F' value with table 'F' value at 1 per cent and 5 per cent probability levels.

3.6.2 Estimation of heterosis

The treatments mean value for each trait was used for the estimation of heterosis. The per cent heterosis of all F_1 crosses over their better parent (BP) and standard check (SC) were computed by the method suggested by Turner (1953) and Hayes *et al* (1955).

$$\text{Per cent heterosis over mid parent (\%)} = \frac{\overline{F1} - \overline{MP}}{\overline{MP}} \times 100$$

$$\text{Per cent heterosis over better parent (\%)} = \frac{\overline{F1} - \overline{BP}}{\overline{BP}} \times 100$$

$$\text{Per cent heterosis over standard check (\%)} = \frac{\overline{F1} - \overline{SC}}{\overline{SC}} \times 100$$

To compute the standard error (SE) of estimates of heterosis, mean squares due to error (M_e) from ANOVA table was considered.

$$\text{SE for heterosis over mid parent (BP)} = \sqrt{3\ Me\ /2\ r}$$

$$\text{SE for heterosis over better parent (BP)} = \sqrt{2\ Me\ /\ r}$$

$$\text{SE for heterosis over standard check (SC)} = \sqrt{2\ Me\ /\ r}$$

Further, 't' value was calculated to test the significance of deviation of F_1 from BP and SC as given below.

$$\text{'t' value for better parent heterosis} = \frac{\overline{F1} - \overline{MP}}{SE\ (MP)}$$

$$\text{'t' value for better parent heterosis} = \frac{\overline{F1} - \overline{BP}}{SE\ (BP)}$$

$$\text{'t' value for standard heterosis} = \frac{\overline{F1} - \overline{SC}}{SE\ (SC)}$$

The calculated 't' value was compared with table 't' value at error degrees of freedom

Where,

M_e	=	Error MSS in general ANOVA table
r	=	Number of replications
F_1	=	Mean value of hybrid over replications
MP	=	Mean value of mid parent over replications
BP	=	Mean value of better parent over replications
SC	=	Mean value of standard check over replications

3.6.3 Combining ability analysis

3.6.3.1 ANOVA for line × tester analysis

The variation among the hybrids was further partitioned into genetic components attributable to general combining ability (GCA) and specific combining ability (SCA) following the method suggested by Kempthorne (1957). For this purpose, pooled data over replications for crosses were compiled in the form of a two-way table for each character. From this table, sum of squares due to lines, sum of squares due to testers and sum of squares due to line × tester were computed and the ANOVA for Line × Tester analysis was set up, a model of which is given below.

3.6.3.2.1 ANOVA structure for combining ability

Source	df	MSS	Expected MSS
Replication	$(r - 1)$		
Crosses / Hybrids	$(lt - 1)$		
Lines	$(l - 1)$	M_l	$\sigma^2 e + r\,\sigma^2\, sca + tr\,\sigma^2\, gca$
Testers	$(t - 1)$	M_t	$\sigma^2\, e + r\,\sigma^2\, sca + lr\,\sigma^2\, gca$
Line × Tester	$(l - 1)(t - 1)$	M_{lt}	$\sigma^2 e + r\,\sigma^2 sca$
Error	$(r - 1)(lt - 1)$	M_e	$\sigma^2 e$
Total	$(ltr - 1)$		

Where,

t	=	Number of testers
l	=	Number of lines

r = Number of replications

$\sigma^2\ gca$ = Co-variance of half sibs

$\sigma^2\ sca$ = [Cov (FS) – 2 Cov (HS)]

3.6.3.2.2 Pooled ANOVA for combining ability

Source	**df**	**MSS**	**Expected MSS**
Environment	$(e - 1)$		
Replication in environment	$e\ (r - 1)$		
Crosses / Hybrids	$(lt - 1)$		
Lines	$(l - 1)$	M_l	$\sigma^2 e + r\,\sigma^2 lte + r\,\sigma^2_{le} + re\,\sigma^2_{lt} + rte\,\sigma^2_{l}$
Testers	$(t - 1)$	M_t	$\sigma^2 e + r\,\sigma^2 lte + r\,\sigma^2_{te} + re\,\sigma^2_{lt} + rle\,\sigma^2_{t}$
Line × tester	$(l - 1)\ (t - 1)$	M_{lt}	$\sigma^2 e + r\,\sigma^2 lte + re\,\sigma^2_{lt}$
Line × environment	$(l - 1)\ (e - 1)$	M_{le}	$\sigma^2 e + r\,\sigma^2 lte + rte\,\sigma^2_{le}$
Tester × environment	$(t - 1)\ (e - 1)$	M_{te}	$\sigma^2 e + r\,\sigma^2 lte + rl\,\sigma^2_{te}$
Line × tester × environment	$(l - 1)\ (t - 1)\ (e - 1)$	M_{lte}	$\sigma^2 e + r\,\sigma^2 lte$
Error	$e\ (lt - 1)\ (r - 1)$	M_e	$\sigma^2 e$
Total	$(ltr - 1)$		

Where,

t = Number of testers

l = Number of lines

r = Number of replications

e = number of environment

σ^2_{l} = variance due to line

σ^2_{t} = variance due to tester

σ^2_{lt} = variance due to line × tester

σ^2_{le} = variance due to line × environment

σ^2_{te} = variance due to tester × environment

σ^2_{lte} = variance due to tester line × tester × environment

3.6.3.3 Estimation of components of genetic variances

From the expectations of mean sum of squares, the GCA variance of the lines and testers as well as SCA variance of hybrids were calculated using the following formula.

GCA variance for lines (Covariance of HS) $= \dfrac{M_l - M_{lt}}{tr} = \frac{1}{4}\,\sigma^2 A = \sigma^2 GCA$

GCA variance for testers (Covariance of HS) $= \dfrac{M_t - M_{lt}}{lr} = \frac{1}{4}\,\sigma^2 A = \sigma^2 GCA$

SCA variance for hybrids $= \dfrac{M_{lt} - M_e}{r} = \sigma^2 SCA = (\text{Cov FS} - 2\ \text{Cov HS})$

When both lines and tester mean sum of squares are significant, an average estimate of Cov (HS) was calculated as King *et al*. (1961).

$$\text{Average Cov (HS)} = \frac{M_l + M_t - 2M_{l\times t}}{r\,(l + t)}$$

Where,

M_l = Mean sum of squares due to lines

M_t = Mean sum of squares due to testers

M_{lt} = Mean sum of squares due to line x tester

M_e = Mean sum of squares due to error.

t = Number of testers

l = Number of lines

r = Number of replications

After estimating Cov (HS) and Cov (FS), the additive and dominance variance were computed as given below

σ^2_{GCA} = Cov (HS) = ¼ V_A

Hence, 4 σ^2_{GCA} = V_A = Additive genetic variance

σ^2_{SCA} = Cov (FS) – 2 Cov (HS) = ¼V_D

Hence, V_D = 4 σ^2_{SCA} = Dominance genetic variance

After estimating the GCA and SCA variances, the ratio of GCA/SCA variance was computed to predict the type of gene action involved.

3.6.3.4 Estimation of combining ability effects

The observation recorded on i × jth cross grown in kth replication can be expressed as per the linear model given below (Arunachalam, 1974).

$$Y_{ijk} = \mu + g_i + g_j + s_{ij} + e_{ijk}$$

Where,

Y_{ijk} = Mean value of the character measured on i × jth cross in kth replication

μ = Population mean

g_i = gca effect of ith female parent

g_j=gca effect of jth male parent

s_{ij}=sca effect of ijth cross

e_{ijk}=Environmental effect pertaining to ijkth individual

The estimates of general combining ability effects of lines and testers as well as specific combining ability effects of crosses are calculated from two way table as given below.

3.6.3.5 General combining ability effects

$$gca \text{ effects of lines } (g_i) = \frac{x_{i..}}{tr} - \frac{x_{...}}{ltr}$$

Where,

$x_{i..}$=Total of phenotypic values of the line over testers and *r* replication.

$x_{...}$ =Grand total of phenotypic values of all the hybrids in the l × t set over replivations.

g_i =General combining ability effect of i^{th} line.

Check: $\sum g_i = 0$

$$gca \text{ effects of testers: } g_j = \frac{x_{.j.}}{lr} - \frac{x_{...}}{ltr}$$

Where,

$x_{...}$= Gross total of phenotypic values of all the hybrids in the l × t set over replications.

$x_{.j.}$ = Total of all crosses involving j^{th} male parent and r replications.

g_j = General combining ability effect of j^{th} tester.

Check : $\sum g_j = 0$

3.6.3.6 Specific combining ability effects

$$s_{ij} = \frac{x_{ij.}}{r} - \frac{x_{i..}}{tr} - \frac{x_{.j.}}{lr} + \frac{x_{...}}{ltr}$$

Where,

s_{ij} = Specific combining ability effect of ij^{th} cross combination

$x_{ij.}$ = Total of ij^{th} cross combination over all the replications

$x_{i..}$ = Total of phenotypic values of the crosses of line 'i' with each of the testers over replications.

$x_{.j.}$ = Total of all crosses involving j^{th} male parent.

$x_{...}$ = Grand total of phenotypic values of all the hybrids in the l × t set.

Check : $\sum_i s_{ij} = \sum_j s_{ij} = \sum_i \sum_j s_{ij} = 0$

The standard error (SE) and critical difference (CD) pertaining to the *gca* effects of male and female parents and sca effects of different combinations were calculated as follows.

SE (gca for line) = $\sqrt{Me / rt}$

SE (gca for tester) = $\sqrt{Me / rl}$

SE (sca effect) = $\sqrt{Me / r}$

Where,

Me = Error variance (eMSS)

r = Replication

l = Lines

t = Testers

CD = $\sqrt{2 \text{ (SE) (table 't' for error d.f.}}$ (at 5% and 1%, respectively)

3.6.3.7 Proportional contribution of lines, testers and their interactions

a) Contribution of lines (%) = $\dfrac{\text{SS (lines)}}{\text{SS (crosses)}} \times 100$

b) Contribution of tester (%) = $\dfrac{\text{SS (tester)}}{} \times 100$

SS (crosses)

c) Contribution of L × T (%) = $\dfrac{\text{SS (line × tester)}}{\text{SS (crosses)}} \times 100$

Where,

SS (lines) = Sum of squares of lines

SS (testers) = Sum of squares of testers

SS (line × tester) = Sum of squares of line × tester interaction

SS (crosses) = Sum of squares of crosses from the ANOVA table of l × t analysis

3.6.4 Correlation analysis

The correlation coefficients were worked out to determine the degree of association of a character with shoot fly resistance and yield and also among shoot fly resistance and the yield components.

Phenotypic correlations were computed by using the formula given by Weber and Murthi (1952).

$$rp = \frac{\text{Cov } X_p\ Y_p}{\sqrt{X2p \times Y2p}}$$

Where,

rp = Phenotypic correlation

Cov X_p Y_p = Phenotypic covariance between the characters 'X' and 'Y',

$X^2{}_p$ and $Y^2{}_p$ = phenotypic variance of the characters 'X' and 'Y', respectively

Phenotypic correlation coefficients were compared against 'r' values given in Fisher and Yates (1963) table at (n – 2) degrees of freedom at the probability levels of 0.05 and 0.01 to test their significance.

4. EXPERIMENTAL RESULTS

In the present study, a total of 49 crosses derived as per L × T (7 × 7) design were evaluated along with 14 parental lines (B and R) and a standard check to estimate combining ability effects and variances, magnitude of heterosis and nature of gene action involved in controlling stalk sugar related traits, yield and yield components. The results obtained in the present investigation are presented separately for stalk sugar related traits, grain & fodder yield and yield components under the following sections.

1. Analysis of variance (ANOVA) for RCBD

2. *Per se* performance of parents and crosses

3. Magnitude of heterosis

4. Analysis of variance (ANOVA) for combining ability and its effects

5. Character associations

The genotypes were evaluated at two locations, Bijapur and ICRISAT. The observations on stalk sugar related traits, grain & fodder yield and yield components were recorded at both the locations. The results of evaluation of material at individual location and across environments are presented below.

4.1 Analysis of variance (ANOVA)

The analysis of variance indicated that, variances due to the genotypes, parents and crosses were significant for all the characters studied *viz,* days to 50% flowering, plant height, stem thickness, stalk yield, juice yield, juice volume, brix value, bagasse yield, total soluble solids content, total sugar index, juice extraction percentage, ethanol yield, panicle weight, panicle length, panicle breath, grain yield and 1000-seed weight in individual locations, Bijapur (Table 3a) and ICRISAT (Table 3b), and across environments (Table 3c) indicating substantial amount of variation among all the genotypes under study.

Variances due to parents were significant for all the characters studied in individual location as well as across environments. Variances due to line and tester were significant for all the characters except for plant height at Bijapur location and panicle length across environments.

Variances due to lines × testers were significant for all the characters in individual locations and across environments. Variances due to parents vs crosses were significant for all the characters in both the locations. Whereas across environments the environment × parents vs crosses were significant for all characters except for days to 50% flowering, plant height, stem thickness, brix (%), total soluble solids, panicle length, panicle breadth and 1000-seed weight.

4.1.1 Pooled analysis of variance

The genotypes will be stable in the absence of the environmental influence as well as genotype × environment interaction.

Pooled ANOVA for stability of genotypes for different characters is given in Table 3c. Variance due to genotype x environment, and variances due to environment x crosses were significant for all the characters studied *viz,* days to 50% flowering, plant height, stem thickness, stalk yield, juice yield, juice volume, brix (%), bagasse yield, total soluble solids, total sugar index, juice extraction (%), ethanol yield, panicle weight, panicle length, panicle breath, grain yield and 1000-seed weight. Variance due to environment × parents were significant for all the characters except, days to 50% flowering, stem thickness and panicle length. Variance due to environment × lines, and variances due to environment × Line × Tester were significant for all the characters except panicle length. Variance due to environment × testers were significant for all the characters except for plant height, stem thickness, brix (%), Total Soluble Solids, panicle length and 1000-seed weight. Variance due to environments was significant for all the characters except for panicle length and grain yield.

Table 3a. Analysis of variance of parents and crosses for stalk sugar related traits, yield and yield components in sweet sorghum evaluated at Bijapur

Source	df	DFL	Plant height (m)	Stem thickness (mm)	Stalk yield (t ha^{-1})	Juice yield (t ha^{-1})	Juice volume (L ha^{-1})	Brix (%)	Bagasse yield (t ha^{-1})	Total soluble solids (%)
Replication	2	47.05	0.07	3.15	106.43	3.18	4095827.76	7.40	70.06	6.02
Genotypes	62	1074.11**	0.68**	44.27**	2818.89**	193.32**	190958035.46**	19.32**	2031.82**	14.90**
Parents	13	624.33**	0.78**	15.53**	1288.30**	96.52**	104157751.36**	24.78**	828.18**	19.32**
Parents Vs. Crosses	1	765.28**	4.50**	149.50**	12220.57**	77.68**	50188634.43**	5.48*	10133.38**	7.11**
Crosses/Hybrids	48	1202.36**	0.57**	49.86**	3037.56**	221.95**	217399141.59**	18.12**	2189.02**	13.86**
Line	6	7154.61**	2.31**	139.26**	8925.91**	620.03**	604380280.23**	16.31**	7202.55**	12.48**
Tester	6	450.75**	0.26NS	37.57**	1484.97**	203.55**	199044099.51**	19.05**	1115.26**	14.57**
Line × Tester	36	335.59**	0.33**	37.01**	2314.93**	158.67**	155961458.83**	18.27**	1532.39**	13.98**
Error	124	25.33	0.14	4.08	75.99	3.28	3008904.01	1.16	60.59	0.89
Total	188	241.90	0.22	11.34	977.26	72.21	71189957.58	4.57	690.86	3.49

*Significance at 5% probability, **significance at 1% probability, DFL: days to 50% flowering

Table 3a (conti....)

Source	df	Total sugar index	Juice extraction (%)	Ethanol yield (L ha^{-1})	Panicle weight (t ha^{-1})	Panicle length (cm)	Panicle breadth (cm)	Grain yield (t ha^{-1})	1000-seed weight (g)
Replication	2	0.41	0.32	1807123.93	0.03	9.50	0.14	0.03	31.92
Genotypes	62	3.36**	155.43**	17703510.20**	27.88**	53.47**	2.05**	11.87**	77.02**
Parents	13	2.13**	89.62**	9581934.46**	15.62**	58.02**	1.59**	5.64**	100.81**
Parents Vs. Crosses	1	0.80**	525.78**	82180496.66**	223.20**	299.04**	5.25**	72.42**	70.07*
Crosses/Hybrids	48	3.75**	165.54**	18559833.08**	27.13**	47.13**	2.11**	12.30**	70.72**
Line	6	10.20**	558.96**	56779608.40**	22.30**	138.77**	2.17**	8.56**	234.80**
Tester	6	4.18**	118.19**	16414735.99**	59.40**	33.72*	4.48**	32.51**	115.25**
Line × Tester	36	2.60**	107.87**	12547386.71**	22.55**	34.09**	1.71**	9.55**	35.95**
Error	124	0.11	3.83	621588.06	0.72	14.59	0.20	0.19	12.56
Total	188	1.27	49.21	6014839.21	9.18	15.27	0.55	3.94	24.55

*Significance at 5% probability, **significance at 1% probability

Table 3b. Analysis of variance of parents and crosses for stalk sugar related traits, yield and yield components in sweet sorghum evaluated at ICRISAT

Source	df	DFL	Plant height (m)	Stem thickness (mm)	Stalk yield ($t\ ha^{-1}$)	Juice yield ($t\ ha^{-1}$)	Juice volume ($L\ ha^{-1}$)	Brix (%)	Bagasse yield ($t\ ha^{-1}$)	Total soluble solids (%)
Replication	2	12.78	0.11	1.25	129.26	23.74	24385710.62	4.36	19.98	3.34
Genotypes	62	1430.26**	1.73**	34.33**	5048.58**	620.18**	615378781.57**	12.51**	2557.07**	9.57**
Parents	13	1004.39**	2.64**	23.18**	2135.21**	342.95**	342134387.37**	23.27**	980.59**	17.80**
Parents Vs. Crosses	1	351.94**	9.92**	283.79**	46099.96**	4965.02**	4894665193.43**	20.36**	20748.65**	15.57**
Crosses/Hybrids	48	1568.07**	1.31**	32.15**	4982.38**	604.74**	600230671.42**	9.43**	2605.05**	7.21**
Line	6	11550.93**	7.36**	202.53**	23667.65**	2157.85**	2148738120.05**	34.43**	14535.08**	26.34**
Tester	6	465.03**	0.68**	18.73**	3677.04**	952.54**	943318457.97**	11.49**	1066.30**	8.79**
Line × Tester	36	88.10**	0.41**	5.99**	2085.72**	287.92**	284964798.90**	4.92**	873.17**	3.76**
Error	124	18.54	0.06	2.70	57.77	12.00	11823172.32	1.47	30.24	1.12
Total	188	362.26	0.43	4.88	1588.33	198.48	196945421.87	1.24	816.28	0.88

*Significance at 5% probability, **significance at 1% probability, DFL: days to 50% flowering

Table 3b (conti....)

Source	df	Total sugar index	Juice extraction (%)	Ethanol yield (L ha^{-1})	Panicle weight (t ha^{-1})	Panicle length (cm)	Panicle breadth (cm)	Grain yield (t ha^{-1})	1000-seed weight (g)
Replication	2	0.26	17.23	813002.22	0.10	24.35	0.15	0.14	41.37
Genotypes	62	20.54**	207.64**	31647171.94**	17.11**	65.32**	3.60**	11.21**	76.44**
Parents	13	12.15**	200.67**	15197477.01**	6.80**	48.44**	3.90**	4.30**	49.29**
Parents Vs. Crosses	1	157.14**	25.63*	257134133.73**	69.55**	387.10**	8.59**	26.94**	44.88*
Crosses/Hybrids	48	19.97**	213.32**	31404652.61**	18.80**	63.19**	3.42**	12.75**	84.45**
Line	6	64.58**	1175.72**	147209022.20**	52.20**	258.56**	10.02**	43.57**	475.83**
Tester	6	35.20**	214.30**	18247632.44**	17.00**	47.33**	3.13**	10.50**	61.83**
Line × Tester	36	9.99**	52.76**	14296761.05**	13.54**	33.28**	2.37**	7.99**	22.99**
Error	124	0.45	6.17	480491.53	0.61	8.08	0.22	0.15	9.57
Total	188	6.65	52.22	10192724.95	7.04	15.19	1.10	4.65	24.27

*Significance at 5% probability, **significance at 1% probability

Table 3c. Pooled analysis of variance of parents and crosses for stalk sugar related traits, yield and yield components in sweet sorghum evaluated across environments

Source	Df	DFL	Plant height (m)	Stem thickness (mm)	Stalk yield (t ha^{-1})	Juice yield (t ha^{-1})	Juice volume (L ha^{-1})
Environment	1	651.31**	65.88**	567.73**	15190.77**	25199.23**	25326190756**
Replication	4	26.26	0.07	1.57	126.06	15.11	16013011
Genotypes	62	2278.05**	2.39**	69.12**	7338.23**	855.93**	845203945**
Parents	13	1403.35**	3.10**	33.14**	2903.64**	346.15**	357065542 **
Crosses	48	2532.76**	1.90**	70.98**	7488.21**	929.23**	916602535**
Line	6	17851.92**	9.62**	344.12**	30995.53**	2808.87**	2776206439**
Tester	6	813.54**	1.80**	45.77**	3819.45**	1152.25**	1133372928**
Line × Tester	36	257.12**	0.64**	29.90**	4181.78**	578.79**	570540152**
Parents	1	1423.14**	16.40**	447.90**	57788.59**	3964.28**	3763870881**
Environment × Genotype	62	151.93**	0.32**	13.03**	1615.85**	277.71**	276289142**
Environment × Parent	13	47.06	0.35**	5.52	519.93**	93.28**	89227388**
Parent x Environment × Line	6	57.54	0.43**	6.96	356.08**	48.60**	48463057**
Parent x environment × Tester	6	16.58	0.16	3.04	647.59**	142.26**	130479019**
Environment × Crosses	48	182.69**	0.31**	15.15**	1862.97**	305.41**	303270081**
Environment × Line	6	418.09**	0.87**	16.45**	4335.41**	594.00**	590255590**
Environment × Tester	6	104.68**	0.28	7.49	3012.71**	647.81**	644372853**
Environment × (Line × Tester)	36	156.56**	0.22**	16.21**	1259.27**	200.25**	198588700**
Environment × (Parents Vs Crosses)	1	38.56	0.16	8.87	4001.04**	1345.66**	1413006887**
Error	248	17.37	0.07	3.09	66.30	7.55	7318372
Total		156971.60	250.82	6396.92	587290.13	97417.14	96737770410

*Significance at 5% probability, **significance at 1% probability, DFL: days to 50% flowering

Table 3c (conti....)

Source	df	Brix (%)	Bagasse yield (t ha^{-1})	Total soluble solids (%)	Total sugar index	Juice extraction (%)	Ethanol yield (L ha^{-1})
Environment	1	662.70**	1350.37**	558.52**	29934.79**	28483.94**	55649392**
Replication	4	5.85	44.20	4.82	14.97	8.62	1385042
Genotypes	62	24.19**	4013.39**	18.73**	1009.92**	305.99**	45824257**
Parents	13	40.53**	1566.37**	31.35**	424.92**	259.96**	22968653**
Crosses	48	19.78**	4116.48**	15.12**	1094.53**	320.07**	45695956**
Line	6	40.28**	20214.17**	30.81**	3250.42**	1606.02**	186187346**
Tester	6	27.27**	1143.88**	20.82**	1364.64**	323.64**	24710752**
Line × Tester	36	15.11**	1998.92**	11.56**	690.20**	105.15**	25778259**
Parents	1	23.73**	30876.35**	27.78**	4553.61**	228.44**	349105538**
Environment × Genotype	62	8.38**	754.63**	6.79**	333.19**	83.86**	7658138**
Environment × Parent	13	7.52**	242.44**	7.66**	98.88**	29.40**	1959390**
Parent x Environment × Line	6	8.24**	199.44**	6.30**	58.46**	21.18*	1635613
Parent x environment × Tester	6	6.67**	266.03**	10.28**	132.14**	42.14**	1823586
Environment × Crosses	48	8.73**	894.43**	6.69**	366.84**	98.44**	8980131**
Environment × Line	6	6.71**	1970.78**	5.13**	718.77**	139.16**	20826022**
Environment × Tester	6	3.23	1141.94**	2.48	753.66**	126.57**	13528505**
Environment × (Line × Tester)	36	9.99**	672.30**	7.65**	243.72**	86.96**	6247753**
Environment × (Parents Vs Crosses)	1	2.29	702.56**	0.59	1763.75**	92.35**	18286236**
Error	248	1.30	39.03	0.99	7.87	5.03	535886
Total		3026.69	307598.39	2406.50	115219.75	53937.07	3509997819

*Significance at 5% probability, **significance at 1% probability

Table 3c (conti....)

Source	df	Panicle weight (t ha^{-1})	Panicle length (cm)	Panicle breadth (cm)	Grain yield (t ha^{-1})	1000-seed weight (g)
Environment	1	139.34**	6.10	17.19**	1.89	276.47**
Replication	4	0.02	16.51	0.16	0.08	25.81
Genotypes	62	30.57**	102.97**	3.81**	15.89**	125.03**
Parents	13	15.65**	92.74**	3.92**	5.50**	92.17**
Crosses	48	29.95**	93.18**	3.57**	17.16**	134.52**
Line	6	52.38**	410.19**	10.12**	43.52**	706.24**
Tester	6	48.51**	39.06	4.97**	27.85**	127.53**
Line × Tester	36	23.11**	49.36**	2.25**	10.98**	40.08**
Parents	1	254.76**	706.28**	13.83**	90.35**	96.61
Environment × Genotype	62	15.05**	21.31*	1.86**	7.65**	33.60**
Environment × Parent	13	6.77**	13.83	1.53**	4.43**	57.93**
Parent x Environment × Line	6	9.83**	16.34	1.39**	5.75**	50.41**
Parent x environment × Tester	6	4.52**	5.32	1.92**	2.42**	18.81
Environment × Crosses	48	17.25**	23.74**	1.98**	8.58**	27.73**
Environment × Line	6	22.54**	26.64	2.14**	11.15**	51.47**
Environment × Tester	6	26.84**	40.37	2.96**	14.66**	20.08
Environment × (Line × Tester)	36	14.77**	20.49	1.79**	7.14**	25.07**
Environment × (Parents Vs Crosses)	1	17.38**	1.67	0.18	4.67**	0.82
Error	248	0.64	11.26	0.20	0.17	9.47
Total		3127.07	10570.03	419.45	1503.86	12556

*Significance at 5% probability, **significance at 1% probability

4.2 *Per se* performance of parents and crosses

Mean performance of parents and crosses evaluated at two locations (E1: Bijapur, E2: ICRISAT) during *kharif* 2013 and range of expression of the all quantitative characters is presented in Table 4 and Appendix II, respectively.

4.2.1 Days to 50 % flowering

At Bijapur location, the mean performance for days to 50% flowering was ranged from 67 (IS 13871) to 116 (ICSV 25333) among lines, 70 (ICSB 351) to 96 (ICSB 323) among the testers (Table 4), and 67 (IS 13871 × Parbhani Moti) to 136 (ICSV 25333 × NSSV 13) among the F_1 crosses (Appendix II).

Similarly, at ICRISAT location, the variation for days to 50% flowering was ranged from 64 (IS 13871) to 122 (ICSV 25333) among lines, 64 (ICSB 351) to 98 (ICSB 323) among the testers (Table 4), and 67 (IS 13871 × Parbhani Moti & Wray × ICSB 351) to 138 (ICSV 25333 × NSSV 13) among the F_1 crosses (Appendix II).

Across environments, the variation for days to 50% flowering was ranged from 65 (IS 13871) to 119 (ICSV 25333) among lines, 67 (ICSB 351) to 97 (ICSB 323) among the testers (Table 4), and 64 (IS 13871 × Parbhani Moti) to 137 (ICSV 25333 × NSSV 13) among the F_1 crosses (Appendix II).

4.2.2 Plant height (m)

At Bijapur location, the variation for plant height was ranged from 1.94 (IS 13871) to 2.99 (ICSV 25333) among lines, 1.42 (PMS 90 B) to 2.54 (Parbhani Moti) among the testers (Table 4), and 1.88 (SPSSV 30 × PMS 90B) to 3.78 (IS 22670 × NSSV 13) among the F_1 crosses (Appendix II).

At ICRISAT location, the variation for plant height was ranged from 2.43 (IS 13871) to 4.60 (IS 22670) among lines, 1.57 (ICSB 351) to 3.57 (Parbhani Moti) among the testers (Table 4), and 2.33 (IS 13871 × ICSB 323) to 4.97 (ICSV 25333 × ICSB 374) among the F_1 crosses (Appendix II).

Across environments, the variation for plant height was ranged from 2.18 (IS 13871) to 3.78 (ICSV 25333) among lines, 1.50 (ICSB 351) to 3.05 (Parbhani Moti) among the testers (Table 4), and 2.19 (IS 13871 × ICSB 480) to 4.15 (IS 22670 × NSSV 13) among the F_1 crosses (Appendix II).

4.2.3 Stem thickness (mm)

At Bijapur location, the variation for stem thickness was ranged from 13.00 (Wray) to 21.89 (NTJ 2) among lines, 16.22 (ICSB 480) to 20.67 (PMS 90 B) among the testers (Table 4), and 12.00 (SPSSV 30 × PMS 90B) to 30.39 (IS 22670 × ICSB 374) among the F_1 crosses (Appendix II).

At ICRISAT location, the variation for stem thickness was ranged from 17.78 (IS 13871) to 26.00 (IS 22670) among lines, 15.65 (ICSB 480) to 22.12 (NSSV 13) among the testers (Table 4), and 19.02 (IS 13871 × ICSB 374) to 30.47 (ICSV 25333 × NSSV 13) among the F_1 crosses (Appendix II).

Across environments, the variation for stem thickness was ranged from 15.53 (Wray) to 23.70 (IS 22670) among lines, 15.94 (ICSB 480) to 21.17 (NSSV 13) among the testers (Table 4), and 15.76 (IS 13871 × ICSB 374) to 29.68 (IS 22670 × ICSB 374) among the F_1 crosses (Appendix II).

4.2.4 Stalk yield (t ha^{-1})

At Bijapur location, the variation for stalk yield was ranged from 27.00 (Wray) to 92.19 (NTJ 2) among lines, 23.40 (ICSB 351) to 82.09 (NSSV 13) among the testers (Table 4), and 13.39 (SPSSV 30 × PMS 90B) to 141.85 (IS 22670 × NSSV 13) among the F_1 crosses (Appendix II).

At ICRISAT location, the variation for stalk yield was ranged from 24.25 (IS 13871) to 93.23 (ICSV 25333) among lines, 18.68 (ICSB 351) to 76.19 (Parbhani Moti) among the testers (Table 4), and 29.95 (IS 13871 × ICSB 351) to 177.93 (ICSV 25333 × PMS 90 B) among the F_1 crosses (Appendix II).

Across environments, the variation for stalk yield was ranged from 29.38 (IS 13871) to 86.55 (NTJ 2) among lines, 21.04 (ICSB 351) to 78.17 (NSSV 13) among the testers (Table 4), and 31.91 (IS 13871 × ICSB 351) to 149.45 (IS 22670 × ICSB 374) among the F_1 crosses (Appendix II).

4.2.5 Juice yield (t ha^{-1})

At Bijapur location, the variation for juice yield was ranged from 5.59 (IS 13871) to 25.19 (NTJ 2) among lines, 4.22 (ICSB 351) to 17.44 (NSSV 13) among the testers (Table 4), and 1.94 (SPSSV 30 × PMS 90B) to 38.35 (ICSV 93046 × PMS 90B) among the F_1 crosses (Appendix II).

At ICRISAT location, the variation for juice yield was ranged from 5.78 (IS 13871) to 36.27 (NTJ 2) among lines, 4.47 (ICSB 351) to 32.00 (NSSV 13) among the testers (Table 4), and 5.93 (IS 22670 × ICSB 480) to 75.78 (NTJ 2 × Parbhani Moti) among the F_1 crosses (Appendix II).

Across environments, the variation for juice yield was ranged from 5.69 (IS 13871) to 30.73 (NTJ 2) among lines, 4.35 (ICSB 351) to 24.72 (NSSV 13) among the testers (Table 4), and 6.02 (IS 13871 × ICSB 351) to 46.43 (NTJ 2 × Parbhani Moti) among the F_1 crosses (Appendix II).

4.2.6 Juice volume (L ha^{-1})

At Bijapur location, the variation for juice volume was ranged from 5556 (IS 13871) to 24877 (NTJ 2) among lines, 4136 (ICSB 351) to 20228 (NSSV 13) among the testers (Table 4), and 1944 (SPSSV 30 × PMS 90B) to 37963 (ICSV 93046 × PMS 90B) among the F_1 crosses (Appendix II).

At ICRISAT location, the variation for juice volume was ranged from 5733 (IS 13871) to 36207 (NTJ 2) among lines, 4415 (ICSB 351) to 31911 (NSSV 13) among the testers (Table 4), and 5827 (IS 22670 × ICSB 480) to 75111 (NTJ 2 × Parbhani Moti) among the F_1 crosses (Appendix II).

Across environments, the variation for juice volume was ranged from 5644 (IS 13871) to 30542 (NTJ 2) among lines, 4275 (ICSB 351) to 26070 (NSSV 13) among the testers (Table 4), and 5893 (IS 13871 × ICSB 351) to 45943 (NTJ 2 × Parbhani Moti) among the F_1 crosses (Appendix II).

4.2.7 Brix (%)

At Bijapur location, the variation for brix was ranged from 10 (IS 13871) to 16 (ICSV 25333 and SPSSV 30) among lines, 8 (ICSB 351 and ICSB 374) to 16 (ICSB 323) among the testers (Table 4), and 8 (ICSV 93046 × PMS 90B and IS 13871 × ICSB 351) to 19 (SPSSV 30 × PMS 90B) among the F_1 crosses (Appendix II).

At ICRISAT location, the variation for brix was ranged from 14 (ICSV 93046 and IS 13871) to 20 (Wray) among lines, 12 (ICSB 351 and ICSB 374) to 17 (NSSV 13) among the testers (Table 4), and 10 (ICSV 25333 × Parbhani Moti) to 20 (SPSSV 30 × ICSB 323) among the F_1 crosses (Appendix II).

Across environments, the variation for brix was ranged from 12 (IS 13871) to 18 (SPSSV 30) among lines, 10 (ICSB 351, ICSB 374 and PMS 90 B) to 16 (ICSB 323) among the testers (Table 4), and 11 (ICSV 93046 × PMS 90B and IS 13871 × ICSB 351) to 18 (ICSV 93046 × NSSV 13) among the F_1 crosses (Appendix II).

4.2.8 Bagasse yield (t ha^{-1})

At Bijapur location, the variation for brix was ranged from 19.72 (Wray) to 68.35 (IS 22670) among lines, 19.09 (ICSB 351) to 65.75 (NSSV 13) among the testers (Table 4), and 11.28 (SPSSV 30 × PMS 90B) to 128.61 (IS 22670 × NSSV 13) among the F_1 crosses (Appendix II).

At ICRISAT location, the variation for brix was ranged from 18.43 (IS 13871) to 68.27 (ICSV 25333) among lines, 14.16 (ICSB 351) to 46.47 (Parbhani Moti) among the testers (Table 4), and 22.39 (IS 13871 × ICSB 351) to 127.71 (ICSV 25333 × PMS 90 B) among the F_1 crosses (Appendix II).

Across environments, the variation for brix was ranged from 22.34 (Wray) to 68.21 (IS 22670) among lines, 16.62 (ICSB 351) to 54.66 (NSSV 13) among the testers (Table 4), and 23.06 (SPSSV 30 × PMS 90B) to 118.08 (IS 22670 × ICSB 374) among the F_1 crosses (Appendix II).

4.2.9 Total soluble solids (%)

At Bijapur location, the variation for total soluble solids was ranged from 8.90 (IS 13871) to 14.44 (SPSSV 30) among lines, 7.15 (ICSB 351) to (ICSB 323) among the testers (Table 4), and 6.71 (IS 13871 × ICSB 351) to 16.33 (SPSSV 30 × PMS 90B) among the F_1 crosses (Appendix II).

At ICRISAT location, the variation for total soluble solids was ranged from 12.40 (IS 13871) to 17.38 (Wray) among lines, 8.61 (PMS 90 B) to 14.73 (NSSV 13) among the testers (Table 4), and 8.90 (ICSV 25333 × Parbhani Moti) to 17.76 (SPSSV 30 × ICSB 323) among the F_1 crosses (Appendix II).

Across environments, the variation for total soluble solids was ranged from 10.65 (IS 13871) to 15.46 (SPSSV 30) among lines, 8.61 (PMS 90 B) to 13.85 (ICSB 323) among the testers (Table 4), and 9.79 (ICSV 93046 × PMS 90B) to 16.11 (ICSV 93046 × NSSV 13) among the F_1 crosses (Appendix II).

4.2.10 Total sugar index

At Bijapur location, the variation for total sugar index was ranged from 0.61 (IS 13871) to 2.93 (NTJ 2) among lines, 0.36 (ICSB 351) to 2.84 (NSSV 13) among the testers (Table 4), and 0.36 (IS 13871 × ICSB 351) to 4.98 (ICSV 93046 × ICSB 323) among the F_1 crosses (Appendix II).

At ICRISAT location, the variation for total sugar index was ranged from 0.88 (IS 13871) to 6.54 (NTJ 2) among lines, 0.59 (ICSB 351) to 5.85 (NSSV 13) among the testers (Table 4), and 0.85 (IS 22670 × ICSB 480) to 13.22 (NTJ 2 × Parbhani Moti) among the F_1 crosses (Appendix II).

Across environments, the variation for total sugar index was ranged from 0.75 (IS 13871) to 4.73 (NTJ 2) among lines, 0.47 (ICSB 351) to 4.35 (NSSV 13) among the testers (Table 4), and 0.81 (IS 13871 × ICSB 351) to 7.69 (NTJ 2 × Parbhani Moti) among the F_1 crosses (Appendix II).

4.2.11 Juice extraction (%)

At Bijapur location, the variation for juice extraction was ranged from 10.03 (ICSV 25333) to 27.95 (ICSV 93046) among lines, 18.56 (ICSB 351) to 26.19 (NSSV 13) among the testers (Table 4), and 6.65 (IS 22670 × ICSB 374) to 35.25 (SPSSV 30 × ICSB 323) among the F_1 crosses (Appendix II).

At ICRISAT location, the variation for juice extraction was ranged from 23.96 (IS 13871) to 46.26 (ICSV 93046) among lines, 23.94 (ICSB 351) to 43.24 (ICSB 323) among the testers (Table 4), and 11.83 (IS 22670 × ICSB 480) to 51.41 (ICSV 93046 × ICSB 374) among the F_1 crosses (Appendix II).

Across environments, the variation for juice extraction was ranged from 18.45 (ICSV 25333) to 37.10 (ICSV 93046) among lines, 21.25 (ICSB 351) to 34.69 (NSSV 13) among the testers (Table 4), and 11.85 (IS 22670 × ICSB 480) to 40.21 (SPSSV 30 × Parbhani Moti) among the F_1 crosses (Appendix II).

4.2.12 Ethanol yield (L ha^{-1})

At Bijapur location, the variation for ethanol yield was ranged from 1887 (Wray) to 7036 (IS 22670) among lines, 1057 (ICSB 351) to 5590 (NSSV 13) among the testers (Table 4), and 1458 (SPSSV 30 × PMS 90B) to 10427 (IS 22670 × NSSV 13) among the F_1 crosses (Appendix II).

At ICRISAT location, the variation for ethanol yield was ranged from 1801 (IS 13871) to 8047 (ICSV 25333) among lines, 1198 (ICSB 351) to 4763 (NSSV 13) among the testers (Table 4), and 2409 (IS 13871 × ICSB 351) to 13744 (ICSV 25333 × PMS 90 B) among the F_1 crosses (Appendix II).

Across environments, the variation for ethanol yield was ranged from 1912 (IS 13871) to 7492 (IS 22670) among lines, 1128 (ICSB 351) to 5176 (NSSV 13) among the testers (Table 4), and 1973 (IS 13871 × ICSB 351) to 11637 (IS 22670 × ICSB 374) among the F_1 crosses (Appendix II).

4.2.13 Panicle weight (t ha^{-1})

At Bijapur location, the variation for panicle weight was ranged from 1.88 (IS 13871) to 7.77 (NTJ 2) among lines, 1.97 (ICSB 323) to 8.57 (PMS 90 B) among the testers (Table 4), and 1.67 (SPSSV 30 × PMS 90B) to 14.01 (ICSV 25333 × ICSB 480) among the F_1 crosses (Appendix II).

At ICRISAT location, the variation for panicle weight was ranged from 1.90 (IS 22670) to 5.21 (ICSV 25333) among lines, 2.53 (ICSB 374) to 7.13 (PMS 90 B) among the testers (Table 4), and 1.87 (IS 22670 × ICSB 323) to 13.30 (NTJ 2 × PMS 90 B) among the F_1 crosses (Appendix II).

Across environments, the variation for panicle weight was ranged from 2.54 (ICSV 93046) to 5.83 (NTJ 2) among lines, 3.01 (ICSB 323) to 7.85 (PMS 90 B) among the testers (Table 4), and 2.68 (IS 22670 × NSSV 13) to 11.53 (NTJ 2 × PMS 90 B) and 14.76 (CSH22S) among the F_1 crosses (Appendix II).

4.2.14 Panicle length (cm)

At Bijapur location, the variation for panicle length was ranged from 17.4 (ICSV 93046) to 28.2 (ICSV 25333) among lines, 19.7 (ICSB 480) to 33.1 (PMS 90 B) among the testers (Table 4), and 20.1 (ICSV 93046 × ICSB 351) to 38.4 (ICSV 25333 × ICSB 374) among the F_1 crosses (Appendix II).

At ICRISAT location, the variation for panicle length was ranged from 17.4 (ICSV 93046) to 29.0 (IS 13871) among lines, 19.3 (Parbhani Moti) to 29.9 (PMS 90 B) among the testers (Table 4), and 18.9 (NTJ 2 × NSSV 13) to 43.1 (ICSV 25333 × ICSB 374) among the F_1 crosses (Appendix II).

Across environments, the variation for panicle length was ranged from 17.4 (ICSV 93046) to 28.3 (ICSV 25333) among lines, 19.5 (ICSB 480) to 31.5 (PMS 90 B) among the testers (Table 4), and 20.0 (NTJ 2 × NSSV 13) to 40.8 (ICSV 25333 × ICSB 374) among the F_1 crosses (Appendix II).

4.2.15 Panicle breadth (cm)

At Bijapur location, the variation for panicle breadth was ranged from 2.7 (IS 13871 and Wray) to 4.7 (NTJ 2) among lines, 3.4 (ICSB 323) to 4.8 (NSSV 13 and PMS 90 B) among the testers (Table 4), and 2.7 (IS 13871 × ICSB 374 and SPSSV 30 × PMS 90B) to 6.0 (ICSV 25333 × ICSB 480) among the F_1 crosses (Appendix II).

At ICRISAT location, the variation for panicle breadth was ranged from 2.5 (SPSSV 30) to 5.8 (ICSV 25333) among lines, 3.0 (ICSB 351) to 6.2 (NSSV 13) among the testers (Table 4), and 2.8 (IS 22670 × ICSB 374) to 7.6 (NTJ 2 × PMS 90 B) among the F_1 crosses (Appendix II).

Across environments, the variation for panicle breadth was ranged from 2.9 (IS 13871) to 5.0 (ICSV 25333) among lines, 3.5 (ICSB 351 and ICSB 374) to 5.5 (NSSV 13) among the testers (Table 4), and 3.2 (IS 22670 × NSSV 13) to 6.1 (NTJ 2 × PMS 90 B) and 6.4 (CSH22S) among the F_1 crosses (Appendix II).

4.2.16 Grain yield (t ha^{-1})

At Bijapur location, the variation for grain yield was ranged from 0.41 (IS 13871) to 4.73 (IS 22670) among lines, 0.24 (ICSB 323) to 3.15 (ICSB 351) among the testers (Table 4), and 0.38 (Wray × NSSV 13) to 8.28 (NTJ 2 × ICSB 351) among the F_1 crosses (Appendix II).

At ICRISAT location, the variation for grain yield was ranged from 0.55 (IS 22670) to 2.66 (NTJ 2) among lines, 1.61 (ICSB 374) to 4.85 (NSSV 13) among the testers (Table 4), and 0.18 (ICSV 25333 × Parbhani Moti) to 9.56 (NTJ 2 × PMS 90 B) among the F_1 crosses (Appendix II).

Across environments, the variation for grain yield was ranged from 1.09 (ICSV 93046) to 3.41 (NTJ 2) among lines, 1.14 (ICSB 323) to 3.90 (PMS 90 B) among the testers (Table 4), and 0.71 (IS 22670 × NSSV 13) to 8.06 (NTJ 2 × PMS 90 B) and 8.22 (CSH22SS) among the F_1 crosses (Appendix II).

4.2.17 1000-seed weight (g)

At Bijapur location, the variation for 1000-seed weight was ranged from 15.86 (Wray) to 35.51 (NTJ 2) among lines, 15.76 (ICSB 480) to 26.42 (Parbhani Moti) among the testers (Table 4), and 10.78 (ICSV 25333 × NSSV 13) to 35.93 (IS 13871 × PMS 90 B) among the F_1 crosses (Appendix II).

At ICRISAT location, the variation for 1000-seed weight was ranged from 14.25 (ICSV 25333) to 27.78 (NTJ 2) among lines, 22.19 (ICSB 323) to 27.60 (PMS 90 B) among the testers (Table 4), and 10.11 (ICSV 25333 × NSSV 13) to 35.59 (NTJ 2 × PMS 90 B) among the F_1 crosses (Appendix II).

Across environments, the variation for 1000-seed weight was ranged from 16.86 (Wray) to 31.64 (NTJ 2) among lines, 19.16 (ICSB 323) to 26.10 (PMS 90 B) among the testers (Table 4), and 10.44 (ICSV 25333 × NSSV 13) to 33.39 (IS 13871 × PMS 90 B) among the F_1 crosses (Appendix II).

4.3 Magnitude of heterosis

The magnitude of heterosis for stalk sugar yield and its related traits, yield and yield components at individual locations (Bijapur and ICRISAT) and across environments are detailed in Table 5a, Table 5b and Table 5c, respectively.

4.3.1 Day to 50% flowering.

The magnitude of heterosis for the trait days to 50% flowering at Bijapur was ranged from -16.83 (Wray × ICSB 323) to 63.28 (SPSSV 30 × PMS 90B) per cent over mid parent, -26.99 (IS 13871 × ICSB 323) to 59.49 (SPSSV 30 × PMS 90B) per cent over better parent, and -24.06 (IS 13871 × Parbhani Moti and Wray × ICSB 351) to 53.38 (ICSV 25333 × NSSV 13) per cent over standard check (CSH22 SS) (Table 5a).

Among the forty nine crosses studied, eight of them shown negatively significant heterosis and fifteen shown positively significant heterosis over mid

Table 4. Performance of hybrid parental lines (B and R lines) used in Line × Tester analysis for individual and across environments

Ety no.	Genotype	DFL			Plant height (m)			Stem thickness (mm)			Stalk yield (t ha^{-1})			Juice yield (t ha^{-1})		
		E1	**E2**	**E1E2**	**E1**	**E2**	**E1E2**	**E1**	**E2**	**E1E2**	**E1**	**E2**	**E1E2**	**E1**	**E2**	**E1E2**
LINES																
1	IS 13871	67	64	66	1.94	2.43	2.18	18.00	17.78	17.89	34.50	24.25	29.38	5.59	5.78	5.69
2	IS 22670	109	110	109	2.73	4.60	3.67	21.39	26.00	23.70	79.75	93.21	86.48	11.22	25.11	18.16
3	ICSV 25333	116	122	119	2.99	4.57	3.78	18.33	23.01	20.67	61.74	93.23	77.49	6.21	24.92	15.56
4	ICSV 93046	90	95	93	2.51	3.43	2.97	18.11	20.45	19.28	63.71	65.93	64.82	17.84	30.52	24.18
5	NTJ 2	87	94	91	2.36	2.83	2.6	21.89	23.75	22.82	92.19	80.92	86.55	25.19	36.27	30.73
6	Wray	76	73	74	2.62	3.27	2.95	13.00	18.06	15.53	27.00	44.33	35.66	7.12	19.35	13.23
7	SPSSV 30	75	70	73	2.31	3.20	2.76	18.39	18.79	18.59	49.41	51.45	50.43	13.28	21.96	17.62
Minimum		67	64	66	1.94	2.43	2.18	13.00	17.78	15.53	27.00	24.25	29.38	5.59	5.78	5.69
Maximum		116	122	119	2.99	4.60	3.78	21.89	26.00	23.70	92.19	93.23	86.55	25.19	36.27	30.73
TESTERS																
8	PMS 90 B	79	75	77	1.42	1.83	1.63	20.67	20.06	20.37	61.87	26.44	44.16	13.14	9.2	11.17
9	ICSB 323	96	98	97	1.62	2.33	1.98	18.56	21.43	19.99	46.69	67.96	57.32	9.68	29.41	19.54
10	ICSB 351	70	64	67	1.43	1.57	1.50	17.33	19.94	18.64	23.40	18.68	21.04	4.22	4.47	4.35
11	ICSB 374	71	64	68	1.72	1.97	1.85	16.89	17.48	17.18	35.48	24.95	30.21	8.43	9.94	9.19
12	ICSB 480	79	74	76	1.77	2.23	2.00	16.22	15.65	15.94	55.40	33.91	44.66	10.48	12.33	11.40
13	Parbhani Moti	90	90	90	2.54	3.57	3.05	18.00	19.49	18.75	55.40	76.19	65.79	12.28	30.67	21.48
14	NSSV 13	93	87	90	2.35	3.17	2.76	20.22	22.12	21.17	82.09	74.25	78.17	17.44	32.00	24.72
Minimum		70	64	67	1.42	1.57	1.50	16.22	15.65	15.94	23.40	18.68	21.04	4.22	4.47	4.35
Maximum		96	98	97	2.54	3.57	3.05	20.67	22.12	21.17	82.09	76.19	78.17	17.44	32.00	24.72

E1: Bijapur location**, E2:** ICRISAT, Patancheru, **E1E2:** across environments **E1 & E2**, DFL: days to 50% flowering

Table 4 (conti....)

Ety no.	Genotype	Juice volume (L ha^{-1})			Brix (%)			Bagasse yield (t ha^{-1})			Total soluble solids (%)			Total sugar index		
		E1	**E2**	**E1E2**	**E1**	**E2**	**E1E2**	**E1**	**E2**	**E1E2**	**E1**	**E2**	**E1E2**	**E1**	**E2**	**E1E2**
LINES																
1	IS 13871	5556	5733	5644	10	14	12	28.63	18.43	23.53	8.90	12.40	10.65	0.61	0.88	0.75
2	IS 22670	11111	25037	18074	15	17	16	68.35	68.07	68.21	12.98	14.73	13.85	1.79	4.57	3.18
3	ICSV 25333	6173	24815	15494	16	17	16	55.32	68.27	61.79	14.15	14.84	14.5	1.09	4.59	2.84
4	ICSV 93046	17531	30444	23988	14	14	14	45.69	35.36	40.52	12.69	12.69	12.69	2.78	4.8	3.79
5	NTJ 2	24877	36207	30542	11	16	14	66.75	44.62	55.69	9.48	14.50	11.99	2.93	6.54	4.73
6	Wray	7006	19289	13148	14	20	17	19.72	24.96	22.34	12.10	17.38	14.74	1.07	4.17	2.62
7	SPSSV 30	12994	21867	17430	16	19	18	35.80	29.46	32.63	14.44	16.48	15.46	2.35	4.49	3.42
Minimum		5556	5733	5644	10	14	12	19.72	18.43	22.34	8.9	12.40	10.65	0.61	0.88	0.75
Maximum		24877	36207	30542	16	20	18	68.35	68.27	68.21	14.44	17.38	15.46	2.93	6.54	4.73
TESTERS																
8	PMS 90 B	12901	9126	11014	10	10	10	48.59	17.19	32.89	8.61	8.61	8.61	1.38	0.99	1.18
9	ICSB 323	9568	29348	19458	16	15	16	36.80	38.52	37.66	14.44	13.27	13.85	1.71	4.87	3.29
10	ICSB 351	4136	4415	4275	8	12	10	19.09	14.16	16.62	7.15	10.65	8.90	0.36	0.59	0.47
11	ICSB 374	8086	9852	8969	8	12	10	26.85	14.95	20.9	7.44	10.38	8.91	0.74	1.26	1
12	ICSB 480	10309	12267	11288	12	13	13	44.79	21.55	33.17	10.36	11.81	11.08	1.34	1.82	1.58
13	Parbhani Moti	12407	30481	21444	13	14	13	43.53	46.47	45.00	11.58	11.99	11.78	1.78	4.54	3.16
14	NSSV 13	20228	31911	26070	13	17	15	65.75	43.57	54.66	9.77	14.73	12.25	2.84	5.85	4.35
Minimum		4136	4415	4275	8	10	10	19.09	14.16	16.62	7.15	8.61	8.61	0.36	0.59	0.47
Maximum		20228	31911	26070	16	17	16	65.75	46.47	54.66	14.44	14.73	13.85	2.84	5.85	4.35

E1: Bijapur location**, E2:** ICRISAT, Patancheru, **E1E2:** across environments **E1 & E2**

Table 4 (conti....)

Ety no.	Genotype	Juice extraction %			Ethanol yield (L ha^{-1})			Panicle weight (t ha^{-1})			Panicle length (cm)			Panicle breadth (cm)		
		E1	**E2**	**E1E2**	**E1**	**E2**	**E1E2**	**E1**	**E2**	**E1E2**	**E1**	**E2**	**E1E2**	**E1**	**E2**	**E1E2**
LINES																
1	IS 13871	16.30	23.96	20.13	2024	1801	1912	1.88	3.41	2.65	22.6	29.0	25.8	2.7	3.0	2.9
2	IS 22670	13.98	26.87	20.43	7036	7948	7492	6.74	1.90	4.32	27.5	27.1	27.3	4.0	3.6	3.8
3	ICSV 25333	10.03	26.87	18.45	6227	8047	7137	5.43	5.21	5.32	28.2	28.4	28.3	4.2	5.8	5.0
4	ICSV 93046	27.95	46.26	37.10	4589	3571	4080	2.07	3.02	2.54	17.4	17.4	17.4	3.1	3.9	3.5
5	NTJ 2	27.33	44.86	36.10	4998	5146	5072	7.77	3.89	5.83	24.3	21.2	22.8	4.7	4.3	4.5
6	Wray	26.28	43.57	34.93	1887	3448	2667	2.31	3.20	2.76	23.9	23.2	23.5	2.7	3.8	3.2
7	SPSSV 30	26.92	42.68	34.80	4129	3856	3992	2.29	2.84	2.57	23.2	27.9	25.6	3.6	2.5	3.1
Minimum		10.03	23.96	18.45	1887	1801	1912	1.88	1.90	2.54	17.4	17.4	17.4	2.7	2.5	2.9
Maximum		27.95	46.26	37.10	7036	8047	7492	7.77	5.21	5.83	28.2	29.0	28.3	4.7	5.8	5.0
TESTERS																
8	PMS 90 B	21.11	34.92	28.02	3298	1205	2252	8.57	7.13	7.85	33.1	29.9	31.5	4.8	5.0	4.9
9	ICSB 323	20.97	43.24	32.11	4149	4070	4109	1.97	4.06	3.01	25.7	22.7	24.2	3.4	4.7	4.0
10	ICSB 351	18.56	23.94	21.25	1057	1198	1128	5.53	3.33	4.43	30.1	26.6	28.3	4.1	3.0	3.5
11	ICSB 374	24.11	39.85	31.98	1540	1222	1381	3.87	2.53	3.20	30.3	26.4	28.4	3.9	3.0	3.5
12	ICSB 480	18.86	36.33	27.60	3703	2037	2870	4.89	4.13	4.51	19.7	19.4	19.5	4.7	4.6	4.7
13	Parbhani Moti	22.18	40.25	31.22	3991	4415	4203	2.81	4.63	3.72	21.1	19.3	20.2	3.7	5.6	4.6
14	NSSV 13	26.19	43.20	34.69	5590	4763	5176	5.65	6.73	6.19	23.0	24.2	23.6	4.8	6.2	5.5
Minimum		18.56	23.94	21.25	1057	1198	1128	1.97	2.53	3.01	19.7	19.3	19.5	3.4	3.0	3.5
Maximum		26.19	43.24	34.69	5590	4763	5176	8.57	7.13	7.85	33.1	29.9	31.5	4.8	6.2	5.5

E1: Bijapur location**, E2:** ICRISAT, Patancheru, **E1E2:** across environments **E1 & E2**

Table 4 (conti....)

Ety no.	Genotype	Grain weight (t ha^{-1})			1000-seed weight (g)		
		E1	E2	E1E2	E1	E2	E1E2
LINES							
1	IS 13871	0.41	2.11	1.26	27.43	23.77	25.60
2	IS 22670	4.73	0.55	2.64	27.23	18.05	22.64
3	ICSV 25333	1.80	1.42	1.61	29.13	14.25	21.69
4	ICSV 93046	0.75	1.42	1.09	26.31	18.86	22.58
5	NTJ 2	4.16	2.66	3.41	35.51	27.78	31.64
6	Wray	1.25	2.12	1.68	15.86	17.86	16.86
7	SPSSV 30	1.64	1.90	1.77	17.18	17.37	17.28
Minimum		0.41	0.55	1.09	15.86	14.25	16.86
Maximum		4.73	2.66	3.41	35.51	27.78	31.64
TESTERS							
8	PMS 90 B	3.10	4.70	3.90	24.61	27.60	26.10
9	ICSB 323	0.24	2.03	1.14	16.13	22.19	19.16
10	ICSB 351	3.15	1.83	2.49	23.13	23.72	23.42
11	ICSB 374	1.14	1.61	1.38	23.39	24.41	23.9
12	ICSB 480	2.52	2.45	2.48	15.76	23.33	19.55
13	Parbhani Moti	1.31	3.10	2.21	26.42	24.34	25.38
14	NSSV 13	2.70	4.85	3.78	25.07	24.36	24.72
Minimum		0.24	1.61	1.14	15.76	22.19	19.16
Maximum		3.15	4.85	3.90	26.42	27.60	26.10

E1: Bijapur location**, E2:** ICRISAT, Patancheru, **E1E2:** across environments **E1 & E2**

parent; twenty three crosses shown negatively significant heterosis and six shown positively significant heterosis over better parent; and twenty two hybrid shown negatively significant heterosis and sixteen shown positively significant heterosis over standard check (CSH22SS).

The magnitude of heterosis for the trait days to 50% flowering at ICRISAT was ranged from -22.57 (NTJ 2 × ICSB 323) to 46.95 (ICSV 25333 × ICSB 374) per cent over mid parent, -31.97 (IS 13871 × Parbhani Moti) to 15.15 (IS 22670 × NSSV 13) per cent over better parent, and -31.72 (IS 13871 × Parbhani Moti) to 54.48 (ICSV 25333 × NSSV 13) per cent over standard check (CSH22 SS) (Table 5b).

Among the forty nine crosses studied, sixteen of them shown negatively significant heterosis and seventeen shown positively significant heterosis over mid parent; twenty nine crosses shown negatively significant heterosis and six shown positively significant heterosis over better parent; and thirty hybrid shown negatively significant heterosis and sixteen shown positively significant heterosis over standard check (CSH22SS).

Across environments the magnitude of heterosis for the trait days to 50% flowering was ranged from -17.38 (IS 13871 × Parbhani Moti) to 43.70 (ICSV 25333 × ICSB 374) per cent over mid parent, -28.57 (IS 13871 × Parbhani Moti) to 26.90 (SPSSV 30 × PMS 90B) per cent over better parent, and -27.90 (IS 13871 × Parbhani Moti) to 53.93 (ICSV 25333 × NSSV 13) per cent over standard check (CSH22 SS) (Table 5c).

Among the forty nine crosses studied, ten of them shown negatively significant heterosis and fifteen shown positively significant heterosis over mid parent; twenty four crosses shown negatively significant heterosis and seven shown positively significant heterosis over better parent; and twenty five hybrid shown negatively significant heterosis and sixteen shown positively significant heterosis over standard check (CSH22SS).

4.3.2 Plant height (m)

The magnitude of heterosis for the trait plant height at Bijapur was ranged from -11.70 (IS 22670 × Parbhani Moti) to 74.68(IS 22670 × ICSB 351) per cent over mid parent, -23.76 (Wray × ICSB 480) to 38.11 (IS 22670 × NSSV 13) per cent over better parent, and -33.51 (SPSSV 30 × PMS 90 B) to 33.87 (IS 22670 × NSSV 13) per cent over standard check (CSH22SS) (Table 5a).

Among the forty nine crosses studied, sixteen shown positively significant heterosis and none shown negatively significant heterosis over mid parent, three shown positively significant heterosis and three shown negatively significant heterosis over better parent, and two shown positively significant heterosis and nineteen shown negatively significant heterosis over standard check (CSH22SS).

The magnitude of heterosis for the trait plant height at ICRISAT was ranged from -12.22 (IS 13871 × Parbhani Moti) to 53.26 (ICSV 25333 × ICSB 351) per cent over mid parent, -31.01 (IS 22670 × ICSB 480) to 26.17 (NTJ 2 × Parbhani Moti) per cent over better parent, and -33.33 (IS 13871 × ICSB 323) to 41.90 (ICSV 25333 × ICSB 374) per cent over standard check (CSH22SS) (Table 5b).

Among the forty nine crosses studied, thirty seven shown positively significant heterosis and two shown negatively significant heterosis over mid parent, ten shown positively significant heterosis and thirteen shown negatively significant heterosis over better parent, and twelve shown positively significant heterosis and eighteen shown negatively significant heterosis over standard check (CSH22SS).

Across environments the magnitude of heterosis for the trait plant height was ranged from -6.50 (Wray × Parbhani Moti) to 49.77 (IS 22670 × ICSB 351) per cent over mid parent, -18.95 (IS 13871 × Parbhani Moti) to 15.00 (Wray × NSSV 13) per cent over better parent, and -30.59 (IS 13871 × ICSB 480) to 31.46 (IS 22670 × NSSV 13) per cent over standard check (CSH22SS) (Table 5c).

Among the forty nine crosses studied, thirty shown positively significant heterosis and none shown negatively significant heterosis over mid parent, four shown positively significant heterosis and eight shown negatively significant heterosis over better parent, and nine shown positively significant heterosis and nineteen shown negatively significant heterosis over standard check (CSH22SS).

4.3.3 Stem thickness (mm)

The magnitude of heterosis for the trait stem thickness at Bijapur was ranged from -38.55 (SPSSV 30 × PMS 90B) to 58.78 (IS 22670 × ICSB 374) per cent over mid parent, -41.94 (SPSSV 30 × PMS 90B) to 42.08 (IS 22670 × ICSB 374) per cent over better parent, and -54.04 (SPSSV 30 × PMS 90B) to 16.38 (IS 22670 × ICSB 374) per cent over standard check (CSH22SS) (Table 5a).

Among the forty nine crosses studied, twenty one shown positively significant heterosis and four shown negatively significant heterosis over mid parent, seventeen shown positively significant heterosis and eight shown negatively significant heterosis over better parent, and one shown positively significant heterosis and thirty eight shown negatively significant heterosis over standard check (CSH22SS).

The magnitude of heterosis for the trait stem thickness at ICRISAT was ranged from -0.01 (IS 13871 × ICSB 323) to 43.16 (ICSV 25333 × ICSB 374) per cent over mid parent, -9.69 (NTJ 2 × ICSB 480) to 32.40 (ICSV 25333 × NSSV 13) per cent over better parent, and -12.38 (IS 13871 × ICSB 374) to 40.37 (ICSV 25333 × NSSV 13) per cent over standard check (CSH22SS) (Table 5b).

Among the forty nine crosses studied, thirty shown positively significant heterosis and none shown negatively significant heterosis over mid parent, fifteen shown positively significant heterosis and two shown negatively significant heterosis over better parent, and twenty shown positively significant heterosis and eight shown negatively significant heterosis over standard check (CSH22SS).

Across environments the magnitude of heterosis for the trait stem thickness was ranged from -14.54 (SPSSV 30 × PMS 90B) to 45.20 (IS 22670 × ICSB 374) per cent over mid parent, -18.27 (SPSSV 30 × PMS 90B) to 36.50 (ICSV 25333 × PMS 90 B) per cent over better parent, and -34.09 (IS 13871 × ICSB 374) to 24.14 (IS 22670 × ICSB 374) per cent over standard check (CSH22SS) (Table 5c).

Among the forty nine crosses studied, twenty one shown positively significant heterosis and one shown negatively significant heterosis over mid parent, fifteen shown positively significant heterosis and four shown negatively significant heterosis over better parent, and seven shown positively significant heterosis and twenty seven shown negatively significant heterosis over standard check (CSH22SS).

4.3.4 Stalk yield (t ha^{-1})

The magnitude of heterosis for the trait stalk yield at Bijapur was ranged from -75.94 (SPSSV 30 × PMS 90B) to 137.89 (IS 22670 × ICSB 351) per cent over mid parent, -78.36 (SPSSV 30 × PMS 90B) to 103.27 (ICSV 93046 × Parbhani Moti) per cent over better parent, and -90.47 (SPSSV 30 × PMS 90B) to 0.96 (IS 22670 × NSSV 13) per cent over standard check (CSH22SS) (Table 5a).

Among the forty nine crosses studied, twenty six shown positively significant heterosis and five shown negatively significant heterosis over mid parent, twenty two shown positively significant heterosis and sixteen shown negatively significant heterosis over better parent, and none shown positively significant heterosis and forty seven shown negatively significant heterosis over check (CSH22SS).

The magnitude of heterosis for the trait stalk yield at ICRISAT was ranged from -28.75 (ICSV 25333 × Parbhani Moti) to 198.85 (IS 22670 × ICSB 374) per cent over mid parent, -52.37 (IS 13871 × Parbhani Moti) to 119.70 (NTJ 2 × Parbhani Moti) per cent over better parent, and -65.60 (IS 13871 × ICSB 351) to 104.36 (ICSV 25333 × PMS 90 B) per cent over standard check (CSH22SS) (Table 5b).

Among the forty nine crosses studied, forty two shown positively significant heterosis and three shown negatively significant heterosis over mid parent, thirty three shown positively significant heterosis and five shown negatively significant heterosis over better parent, and twenty shown positively significant heterosis and nineteen shown negatively significant heterosis over check (CSH22SS).

Across environments the magnitude of heterosis for the trait stalk yield was ranged from -21.55 (SPSSV 30 × PMS 90B) to 156.14 (IS 22670 × ICSB 374) per cent over mid parent, -38.30 (IS 13871 × Parbhani Moti) to 86.99 (SPSSV 30 × ICSB 480) per cent over better parent, and -71.96 (IS 13871 × ICSB 351) to 31.35 (IS 22670 × ICSB 374) per cent over standard check (CSH22SS) (Table 5c).

Among the forty nine crosses studied, twenty nine shown positively significant heterosis and none shown negatively significant heterosis over mid parent, sixteen shown positively significant heterosis and three shown negatively significant heterosis over better parent, and three shown positively significant heterosis and twenty nine shown negatively significant heterosis over check (CSH22SS).

4.3.5 Juice yield (t ha^{-1})

The magnitude of heterosis for the trait juice yield at Bijapur was ranged from -85.28 (SPSSV 30 × PMS 90B) to 171.48 (ICSV 25333 × ICSB 351) per cent over mid parent, -85.36 (SPSSV 30 × PMS 90B) to 128.03 (ICSV 25333 × ICSB 351) per cent over better parent, and -94.71 (SPSSV 30 × PMS 90B) to 4.23 (ICSV 93046 × PMS 90B) per cent over standard check (CSH22SS) (Table 5a).

Among the forty nine crosses studied, twenty shown positively significant heterosis and fifteen shown negatively significant heterosis over mid parent, thirteen shown positively significant heterosis and twenty eight shown negatively significant heterosis over better parent, and none shown positively significant heterosis and thirty eight shown negatively significant heterosis over standard check (CSH22SS).

The magnitude of heterosis for the trait juice yield at ICRISAT was ranged from -68.34 (IS 22670 × ICSB 480) to 208.20 (IS 22670 × ICSB 374) per cent over mid parent, -76.40 (IS 22670 × ICSB 480) to 115.10 (IS 22670 × ICSB 374) per cent over better parent, and -84.45 (IS 22670 × ICSB 480) to 98.80 (NTJ 2 × Parbhani Moti) per cent over standard check (CSH22SS) (Table 5b).

Among the forty nine crosses studied, thirty nine shown positively significant heterosis and four shown negatively significant heterosis over mid parent, thirty three shown positively significant heterosis and seven shown negatively significant heterosis over better parent, and eleven shown positively significant heterosis and twenty four shown negatively significant heterosis over standard check (CSH22SS).

Across environments the magnitude of heterosis for the trait juice yield was ranged from -54.91 (IS 22670 × ICSB 480) to 152.36 (ICSV 25333 × ICSB 351) per cent over mid parent, -63.30 (IS 22670 × ICSB 480) to 92.55 (ICSV 25333 × PMS 90

B) per cent over better parent, and -83.94 (IS 13871 × ICSB 351) to 23.96 (NTJ 2 × Parbhani Moti) per cent over standard check (CSH22SS) (Table 5c).

Among the forty nine crosses studied, twenty one shown positively significant heterosis and one shown negatively significant heterosis over mid parent, thirteen shown positively significant heterosis and five shown negatively significant heterosis over better parent, and one shown positively significant heterosis and thirty eight shown negatively significant heterosis over standard check (CSH22SS).

4.3.6 Juice volume (L ha^{-1})

The magnitude of heterosis for the trait juice volume at Bijapur was ranged from -84.98 (SPSSV 30 × PMS 90B) to 170.66 (ICSV 25333 × ICSB 351) per cent over mid parent, -85.04 (SPSSV 30 × PMS 90B) to 126.72 (Wray × ICSB 374) per cent over better parent, and -94.66 (SPSSV 30 × PMS 90B) to 4.24 (ICSV 93046 × PMS 90B) per cent over standard check (CSH22SS) (Table 5a).

Among the forty nine crosses studied, nineteen shown positively significant heterosis and sixteen shown negatively significant heterosis over mid parent, thirteen shown positively significant heterosis and thirty shown negatively significant heterosis over better parent, and none shown positively significant heterosis and forty seven shown negatively significant heterosis over standard check (CSH22SS).

The magnitude of heterosis for the trait juice volume at ICRISAT was ranged from -68.76 (IS 22670 × ICSB 480) to 207.77 (IS 22670 × ICSB 374) per cent over mid parent, -76.73 (IS 22670 × ICSB 480) to 114.44 (IS 22670 × ICSB 374) per cent over better parent, and -84.67 (IS 22670 × ICSB 480) to 97.58 (NTJ 2 × Parbhani Moti) per cent over standard check (CSH22SS) (Table 5b).

Among the forty nine crosses studied, thirty nine shown positively significant heterosis and four shown negatively significant heterosis over mid parent, thirty two shown positively significant heterosis and eight shown negatively significant heterosis over better parent, and eleven shown positively significant heterosis and twenty four shown negatively significant heterosis over standard check (CSH22SS).

Across environments the magnitude of heterosis for the trait juice volume was ranged from -55.35 (IS 22670 × ICSB 480) to 152.29 (ICSV 25333 × ICSB 351) per cent over mid parent, -63.73 (IS 22670 × ICSB 480) to 92.87 (ICSV 25333 × PMS 90 B) per cent over better parent, and -84.17 (IS 13871 × ICSB 351) to 23.45 (NTJ 2 × Parbhani Moti) per cent over standard check (CSH22SS) (Table 5c).

Among the forty nine crosses studied, twenty one shown positively significant heterosis and one shown negatively significant heterosis over mid parent, thirteen shown positively significant heterosis and five shown negatively significant heterosis over better parent, and one shown positively significant heterosis and thirty eight shown negatively significant heterosis over standard check (CSH22SS).

4.3.7 Brix (%)

The magnitude of heterosis for the trait brix at Bijapur was ranged from -36.11 (ICSV 93046 × PMS 90B) to 63.64 (IS 13871 × ICSB 374) per cent over mid parent, -46.51 (ICSV 93046 × PMS 90B) to 50.00 (IS 13871 × ICSB 374) per cent over better parent, and -35.71 (IS 13871 × ICSB 351) to 58.57 (SPSSV 30 × PMS 90B) per cent over standard check (CSH22SS) (Table 5a).

Among the forty nine crosses studied, fifteen shown positively significant heterosis and fifteen shown negatively significant heterosis over mid parent, ten shown positively significant heterosis and twenty seven shown negatively significant heterosis over better parent, and twenty three shown positively significant heterosis and seven shown negatively significant heterosis over standard check (CSH22SS).

The magnitude of heterosis for the trait brix (%) at ICRISAT was ranged from -34.07 (ICSV 25333 × Parbhani Moti) to 19.72 (ICSV 93046 × PMS 90B) per cent over mid parent, -40.48 (ICSV 25333 × Parbhani Moti) to 12.00 (NTJ 2 × NSSV 13) per cent over better parent, and -38.02 (ICSV 25333 × Parbhani Moti) to 24.79 (SPSSV 30 × ICSB 323) per cent over standard check (CSH22SS) (Table 5b).

Among the forty nine crosses studied, eighteen shown positively significant heterosis and three shown negatively significant heterosis over mid parent, three shown positively significant heterosis and nineteen shown negatively significant heterosis over better parent, and eight shown positively significant heterosis and sixteen shown negatively significant heterosis over standard check (CSH22SS).

Across environments the magnitude of heterosis for the trait brix as ranged from -19.19 (ICSV 25333 × Parbhani Moti) to 32.40 (IS 13871 × ICSB 374) per cent over mid parent, -27.05 (SPSSV 30 × ICSB 374) to 24.15 (ICSV 93046 × NSSV 13) per cent over better parent, and -20.74 (ICSV 93046 × PMS 90B) to 31.29 (ICSV 93046 × NSSV 13) per cent over standard check (CSH22SS) (Table 5c).

Among the forty nine crosses studied, thirteen shown positively significant heterosis and three shown negatively significant heterosis over mid parent, three shown positively significant heterosis and seventeen shown negatively significant heterosis over better parent, and ten shown positively significant heterosis and five shown negatively significant heterosis over standard check (CSH22SS).

4.3.8 Bagasse yield (t ha^{-1})

The magnitude of heterosis for the trait bagasse yield at Bijapur was ranged from -73.27 (SPSSV 30 × PMS 90B) to 160.61 (IS 22670 × ICSB 351) per cent over mid parent, -76.79 (SPSSV 30 × PMS 90B) to 120.62 (ICSV 93046 × Parbhani Moti) per cent over better parent, and -89.10 (SPSSV 30 × PMS 90B) to 24.25 (IS 22670 × NSSV 13) per cent over standard check (CSH22SS) (Table 5a).

Among the forty nine crosses studied, twenty eight shown positively significant heterosis and five shown negatively significant heterosis over mid parent, twenty two shown positively significant heterosis and thirteen shown negatively significant heterosis over better parent, and three shown positively significant heterosis and forty two shown negatively significant heterosis over standard check (CSH22SS).

The magnitude of heterosis for the trait bagasse yield at ICRISAT was ranged from -20.61 (ICSV 25333 × Parbhani Moti) to 198.87 (ICSV 25333 × PMS 90 B) per cent over mid parent, -44.16 (IS 13871 × Parbhani Moti) to 118.82 (NTJ 2 × Parbhani Moti) per cent over better parent, and -54.20 (IS 13871 × ICSB 351) to 161.19 (ICSV 25333 × PMS 90 B) per cent over standard check (CSH22SS) (Table 5b).

Among the forty nine crosses studied, forty one shown positively significant heterosis and two shown negatively significant heterosis over mid parent, thirty shown positively significant heterosis and three shown negatively significant heterosis over better parent, and twenty two shown positively significant heterosis and eighteen shown negatively significant heterosis over standard check (CSH22SS).

Across environments the magnitude of heterosis for the trait bagasse yield was ranged from -29.60 (SPSSV 30 × PMS 90B) to 165.01(IS 22670 × ICSB 374) per cent over mid parent, -30.27 (IS 13871 × Parbhani Moti) to 109.05 (SPSSV 30 × ICSB 480) per cent over better parent, and -69.73 (SPSSV 30 × PMS 90B) to 54.96 (IS 22670 × ICSB 374) per cent over standard check (CSH22SS) (Table 5c).

Among the forty nine crosses studied, twenty nine shown positively significant heterosis and none shown negatively significant heterosis over mid parent, eighteen shown positively significant heterosis and one shown negatively significant heterosis over better parent, and eight shown positively significant heterosis and twenty eight shown negatively significant heterosis over standard check (CSH22SS).

4.3.9 Total soluble solids (%)

The magnitude of heterosis for the trait total soluble solids at Bijapur was ranged from -35.60 (ICSV 93046 × PMS 90B) to 62.46 (IS 13871 × ICSB 374) per cent over mid parent, -45.96 (ICSV 93046 × PMS 90B) to 49.15 (IS 13871 × ICSB 374) per cent over better parent, and -35.19 (IS 13871 × ICSB 351) to 57.71 (SPSSV 30 × PMS 90B) per cent over standard check (CSH22SS) (Table 5a).

Among the forty nine crosses studied, seventeen shown positively significant heterosis and thirteen shown negatively significant heterosis over mid parent, ten shown positively significant heterosis and twenty seven shown negatively significant heterosis over better parent, and twenty three shown positively significant heterosis and seven shown negatively significant heterosis over standard check (CSH22SS).

The magnitude of heterosis for the trait total soluble solids at ICRISAT was ranged from -33.68 (ICSV 25333 × Parbhani Moti) to 19.44 (ICSV 93046 × PMS 90B) per cent over mid parent, -40.06 (ICSV 25333 × Parbhani Moti) to 11.88 (NTJ 2

× NSSV 13) per cent over better parent, and -37.61 (ICSV 25333 × Parbhani Moti) to 24.53 (SPSSV 30 × ICSB 323) per cent over standard check (CSH22SS) (Table 5b).

Among the forty nine crosses studied, eighteen shown positively significant heterosis and three shown negatively significant heterosis over mid parent, three shown positively significant heterosis and nineteen shown negatively significant heterosis over better parent, and eight shown positively significant heterosis and sixteen shown negatively significant heterosis over standard check (CSH22SS).

Across environments the magnitude of heterosis for the trait total soluble solids was ranged from -18.97 (ICSV 25333 × Parbhani Moti) to 31.90 (IS 13871 × ICSB 374) per cent over mid parent, -26.78 (SPSSV 30 × ICSB 374) to 27.00 (ICSV 93046 × NSSV 13) per cent over better parent, and -20.49 (ICSV 93046 × PMS 90B) to 30.91 (ICSV 93046 × NSSV 13) per cent over standard check (CSH22SS) (Table 5c).

Among the forty nine crosses studied, fourteen shown positively significant heterosis and two shown negatively significant heterosis over mid parent, four shown positively significant heterosis and seventeen shown negatively significant heterosis over better parent, and ten shown positively significant heterosis and five shown negatively significant heterosis over standard check (CSH22SS).

4.3.10 Total sugar index

The magnitude of heterosis for the trait total sugar index at Bijapur was ranged from -78.83 (SPSSV 30 × PMS 90B) to 204.60 (ICSV 25333 × ICSB 351) per cent over mid parent, -83.22 (SPSSV 30 × PMS 90B) to 129.96 (Wray × ICSB 374) per cent over better parent, and -92.30 (IS 13871 × ICSB 351) to 6.62 (ICSV 93046 × ICSB 323) per cent over standard check (CSH22SS) (Table 5a).

Among the forty nine crosses studied, sixteen shown positively significant heterosis and fourteen shown negatively significant heterosis over mid parent, eleven shown positively significant heterosis and twenty four shown negatively significant heterosis over better parent, and none shown positively significant heterosis and forty seven shown negatively significant heterosis over standard check (CSH22SS).

The magnitude of heterosis for the trait total sugar index at ICRISAT was ranged from -73.35 (IS 22670 × ICSB 480) to 224.01 (IS 22670 × ICSB 374) per cent over mid parent, -81.38 (IS 22670 × ICSB 480) to 127.30 (IS 13871 × PMS 90 B) per cent over better parent, and -87.38 (IS 22670 × ICSB 480) to 95.90 (NTJ 2 × Parbhani Moti) per cent over standard check (CSH22SS) (Table 5b).

Among the forty nine crosses studied, forty shown positively significant heterosis and four shown negatively significant heterosis over mid parent, thirty three shown positively significant heterosis and eight shown negatively significant heterosis over better parent, and twelve shown positively significant heterosis and twenty six shown negatively significant heterosis over standard check (CSH22SS).

Across environments the magnitude of heterosis for the trait total sugar index was ranged from -59.22 (IS 22670 × ICSB 480) to 157.26 (ICSV 25333 × ICSB 351) per cent over mid parent, -69.50 (IS 22670 × ICSB 480) to 76.10 (ICSV 25333 × PMS 90 B) per cent over better parent, and -85.90 (IS 13871 × ICSB 351) to 34.63 (NTJ 2 × Parbhani Moti) per cent over standard check (CSH22SS) (Table 5c).

Among the forty nine crosses studied, twenty three shown positively significant heterosis and none shown negatively significant heterosis over mid parent, eight shown positively significant heterosis and five shown negatively significant heterosis over better parent, and one shown positively significant heterosis and twenty nine shown negatively significant heterosis over standard check (CSH22SS).

4.3.11 Juice extraction (%)

The magnitude of heterosis for the trait juice extraction per cent at Bijapur was ranged from -65.05 (IS 22670 × ICSB 374) to 47.22 (SPSSV 30 × ICSB 323) per cent over mid parent, -72.39 (IS 22670 × ICSB 374) to 30.94 (SPSSV 30 × ICSB 323) per cent over better parent, and -74.59 (IS 22670 × ICSB 374) to 34.61 (SPSSV 30 × ICSB 323) per cent over standard check (CSH22SS) (Table 5a).

Among the forty nine crosses studied, six shown positively significant heterosis and twenty nine shown negatively significant heterosis over mid parent, six shown positively significant heterosis and forty one shown negatively significant heterosis over better parent, and six shown positively significant heterosis and forty two shown negatively significant heterosis over standard check (CSH22SS).

The magnitude of heterosis for the trait juice extraction per cent at ICRISAT was ranged from -62.56 (IS 22670 × ICSB 480 to 19.40 (ICSV 93046 × ICSB 374) per cent over mid parent, -67.43 (IS 22670 × ICSB 480) to 11.14 (ICSV 93046 × ICSB 374) per cent over better parent, and -72.97 (IS 22670 × ICSB 480) to 17.43 (ICSV 93046 × ICSB 374) per cent over standard check (CSH22SS) (Table 5b).

Among the forty nine crosses studied, ten shown positively significant heterosis and thirteen shown negatively significant heterosis over mid parent, three shown positively significant heterosis and twenty six shown negatively significant heterosis over better parent, and two shown positively significant heterosis and twenty nine shown negatively significant heterosis over standard check (CSH22SS).

Across environments the magnitude of heterosis for the trait juice extraction per cent was ranged from -50.63 (IS 22670 × ICSB 480) to 21.82 (SPSSV 30 × Parbhani Moti) per cent over mid parent, -57.04 (IS 22670 × ICSB 480) to 15.55 (SPSSV 30 × Parbhani Moti) per cent over better parent, and -66.12 (IS 22670 × ICSB 480) to 14.94 (SPSSV 30 × Parbhani Moti) per cent over standard check (CSH22SS) (Table 5c).

Among the forty nine crosses studied, five shown positively significant heterosis and fourteen shown negatively significant heterosis over mid parent, two shown positively significant heterosis and thirty two shown negatively significant heterosis over better parent, and one shown positively significant heterosis and thirty four shown negatively significant heterosis over standard check (CSH22SS).

4.3.12 Ethanol yield (L ha^{-1})

The magnitude of heterosis for the trait ethanol yield at Bijapur was ranged from -60.73 (SPSSV 30 × PMS 90B) to 152.25 (ICSV 25333 × ICSB 374) per cent over mid parent, -64.68 (SPSSV 30 × PMS 90B) to 94.90 (ICSV 93046 × Parbhani Moti) per cent over better parent, and -82.80 (SPSSV 30 × PMS 90B) to 22.97 (IS 22670 × NSSV 13) per cent over standard check (CSH22SS) (Table 5a).

Among the forty nine crosses studied, twenty seven shown positively significant heterosis and four shown negatively significant heterosis over mid parent, twenty one shown positively significant heterosis and thirteen shown negatively significant heterosis over better parent, and four shown positively significant heterosis and thirty six shown negatively significant heterosis over standard check (CSH22SS).

The magnitude of heterosis for the trait ethanol yield at ICRISAT was ranged from -48.71 (ICSV 25333 × Parbhani Moti) to 199.33 (IS 22670 × ICSB 374) per cent over mid parent, -60.29 (ICSV 25333 × Parbhani Moti) to 121.83 (NTJ 2 × Parbhani Moti) per cent over better parent, and -56.49 (IS 13871 × ICSB 351) to 148.24 (ICSV 25333 × PMS 90 B) per cent over standard check (CSH22SS) (Table 5b).

Among the forty nine crosses studied, forty three shown positively significant heterosis and two shown negatively significant heterosis over mid parent, twenty nine shown positively significant heterosis and three shown negatively significant heterosis over better parent, and eighteen shown positively significant heterosis and nineteen shown negatively significant heterosis over standard check (CSH22SS).

Across environments the magnitude of heterosis for the trait ethanol yield was ranged from -14.65 (IS 13871 × Parbhani Moti) to 162.31 (IS 22670 × ICSB 374) per cent over mid parent, -37.91 (IS 13871 × Parbhani Moti) to 74.34 (SPSSV 30 × ICSB 480) per cent over better parent, and -71.84 (IS 13871 × ICSB 351) to 66.05 (IS 22670 × ICSB 374) per cent over standard check (CSH22SS) (Table 5c).

Among the forty nine crosses studied, twenty seven shown positively significant heterosis and none shown negatively significant heterosis over mid parent, seventeen shown positively significant heterosis and three shown negatively significant heterosis over better parent, and eight shown positively significant heterosis and twenty five shown negatively significant heterosis over standard check (CSH22SS).

4.3.13 Panicle weight (t ha^{-1})

The magnitude of heterosis for the trait panicle weight at Bijapur was ranged from -69.31 (SPSSV 30 × PMS 90B) to 452.94 (ICSV 93046 × ICSB 323) per cent over mid parent, -80.55 (SPSSV 30 × PMS 90B) to 439.40 (ICSV 93046 × ICSB 323) per cent over better parent, and -83.29 (SPSSV 30 × PMS 90B) to 40.44 (ICSV 25333 × ICSB 480) per cent over standard check (CSH22SS) (Table 5a).

Among the forty nine crosses studied, thirty five shown positively significant heterosis and nine shown negatively significant heterosis over mid parent, twenty six shown positively significant heterosis and fourteen shown negatively significant heterosis over better parent, and four shown positively significant heterosis and thirty four shown negatively significant heterosis over standard check (CSH22SS).

The magnitude of heterosis for the trait panicle weight at ICRISAT was ranged from -56.01 (IS 22670 × NSSV 13) to 173.74 (ICSV 93046 × ICSB 323) per cent over mid parent, -71.81 (IS 22670 × NSSV 13) to 138.69 (ICSV 93046 × ICSB 323) per cent over better parent, and -87.35 (IS 22670 × ICSB 323) to -9.84 (NTJ 2 × PMS 90 B) per cent over standard check (CSH22SS) (Table 5b).

Among the forty nine crosses studied, twenty six shown positively significant heterosis and seven shown negatively significant heterosis over mid parent, twenty shown positively significant heterosis and fourteen shown negatively significant heterosis over better parent, and none shown positively significant heterosis and all forty nine shown negatively significant heterosis over standard check (CSH22SS).

Across environments the magnitude of heterosis for the trait panicle weight was ranged from -54.76 (NTJ 2 × NSSV 13) to 275.09 (ICSV 93046 × ICSB 323) per cent over mid parent, -57.49 (SPSSV 30 × PMS 90B) to 245.89 (ICSV 93046 × ICSB 323) per cent over better parent, and -78.29 (IS 22670 × NSSV 13) to -6.79 (NTJ 2 × PMS 90 B) per cent over standard check (CSH22SS) (Table 5c).

Among the forty nine crosses studied, twenty eight shown positively significant heterosis and three shown negatively significant heterosis over mid parent, twenty two shown positively significant heterosis and eight shown negatively significant heterosis over better parent, and none shown positively significant heterosis and forty eight shown negatively significant heterosis over standard check (CSH22SS).

4.3.14 Panicle length (cm)

The magnitude of heterosis for the trait panicle length at Bijapur was ranged from -15.16 (ICSV 93046 × ICSB 351) to 52.03 (IS 13871 X Parbhani Moti) per cent over mid parent, -32.99 (ICSV 93046 × ICSB 351) to 47.04 (IS 13871 × Parbhani Moti) per cent over better parent, and -31.34 (ICSV 93046 × ICSB 351) to 31.06 (ICSV 25333 × ICSB 374) per cent over standard check (CSH22SS) (Table 5a).

Among the forty nine crosses studied, sixteen shown positively significant heterosis and none shown negatively significant heterosis over mid parent, nine shown positively significant heterosis and eight shown negatively significant heterosis over better parent, and four shown positively significant heterosis and eight shown negatively significant heterosis over standard check (CSH22SS).

The magnitude of heterosis for the trait panicle length at ICRISAT was ranged from -20.45 (SPSSV 30 × ICSB 374) to 56.88 (ICSV 25333 × ICSB 374) per cent over mid parent, -22.51 (SPSSV 30 × ICSB 374) to 51.37 (ICSV 25333 × ICSB 374) per cent over better parent, and -34.52 (NTJ 2 × NSSV 13) to 49.04 (ICSV 25333 × ICSB 374) per cent over standard check (CSH22SS) (Table 5b).

Among the forty nine crosses studied, twenty seven shown positively significant heterosis and three shown negatively significant heterosis over mid parent, twelve shown positively significant heterosis and five shown negatively significant heterosis over better parent, and six shown positively significant heterosis and fourteen shown negatively significant heterosis over standard check (CSH22SS).

Across environments the magnitude of heterosis for the trait panicle length was ranged from -13.92 (NTJ 2 × NSSV 13) to 43.82 (ICSV 25333 × ICSB 374) per cent over mid parent, -20.48 (ICSV 93046 × PMS 90B) to 43.68 (ICSV 25333 × ICSB 374) per cent over better parent, and -31.44 (NTJ 2 × NSSV 13) to 39.98 (ICSV 25333 × ICSB 374) per cent over standard check (CSH22SS) (Table 5c).

Among the forty nine crosses studied, twenty one shown positively significant heterosis and none shown negatively significant heterosis over mid parent, nine shown positively significant heterosis and three shown negatively significant heterosis over better parent, and five shown positively significant heterosis and thirteen shown negatively significant heterosis over standard check (CSH22SS).

4.3.15 Panicle breadth (cm)

The magnitude of heterosis for the trait panicle breadth at Bijapur was ranged from -36.68 (IS 22670 × NSSV 13) to 69.23 (ICSV 93046 × Parbhani Moti) per cent over mid parent, -43.45 (SPSSV 30 × PMS 90B) to 54.76 (ICSV 93046 × Parbhani Moti) per cent over better parent, and -50.15 (SPSSV 30 × PMS 90B) to 10.86 (ICSV 25333 × ICSB 480) per cent over standard check (CSH22SS) (Table 5a).

Among the forty nine crosses studied, twenty two shown positively significant heterosis and ten shown negatively significant heterosis over mid parent, fifteen shown positively significant heterosis and fourteen shown negatively significant heterosis over better parent, and one shown positively significant heterosis and thirty seven shown negatively significant heterosis over standard check (CSH22SS).

The magnitude of heterosis for the trait panicle breadth at ICRISAT was ranged from -31.75 (NTJ 2 × NSSV 13) to 62.60 (NTJ 2 × PMS 90 B) per cent over mid parent, -42.06 (IS 22670 × NSSV 13) to 51.32 (NTJ 2 × PMS 90 B) per cent over better parent, and -61.15 (IS 22670 × ICSB 374) to 4.25 (NTJ 2 × PMS 90 B) per cent over standard check (CSH22SS) (Table 5b).

Among the forty nine crosses studied, twenty one shown positively significant heterosis and eight shown negatively significant heterosis over mid parent, fifteen shown positively significant heterosis and twenty four shown negatively significant heterosis over better parent, and none shown positively significant heterosis and forty eight shown negatively significant heterosis over standard check (CSH22SS).

Across environments the magnitude of heterosis for the trait panicle breadth was ranged from -32.83 (NTJ 2 × NSSV 13) to 47.88 (ICSV 93046 × Parbhani Moti) per cent over mid parent, -41.95 (IS 22670 × NSSV 13) to 35.20 (ICSV 93046 × ICSB 323) per cent over better parent, and -50.07 (IS 22670 × NSSV 13) to -3.46 (NTJ 2 × PMS 90 B) per cent over standard check (CSH22SS) (Table 5c).

Among the forty nine crosses studied, eighteen shown positively significant heterosis and three shown negatively significant heterosis over mid parent, fourteen shown positively significant heterosis and twelve shown negatively significant heterosis over better parent, and none shown positively significant heterosis and forty two shown negatively significant heterosis over standard check (CSH22SS).

4.3.16 Grain yield (t ha^{-1})

The magnitude of heterosis for the trait grain yield at Bijapur was ranged from -80.77 (Wray × NSSV 13) to 1020.42 (ICSV 93046 × ICSB 323) per cent over mid parent, -85.95 (Wray × NSSV 13) to 639.39 (ICSV 93046 × ICSB 323) per cent over better parent, and -92.89 (Wray × NSSV 13) to 55.01 (NTJ 2 × ICSB 351) per cent over standard check (CSH22SS) (Table 5a).

Among the forty nine crosses studied, thirty three shown positively significant heterosis and nine shown negatively significant heterosis over mid parent, twenty four shown positively significant heterosis and fifteen shown negatively significant heterosis over better parent, and five shown positively significant heterosis and thirty four shown negatively significant heterosis over standard check (CSH22SS).

The magnitude of heterosis for the trait grain yield at ICRISAT was ranged from -92.14 (ICSV 25333 × Parbhani Moti) to 290.14 (ICSV 93046 × ICSB 323) per cent over mid parent, -94.27 (ICSV 25333 × Parbhani Moti) to 231.43 (ICSV 93046 × ICSB 323) per cent over better parent, and -98.40 (ICSV 25333 × Parbhani Moti) to -13.77 (NTJ 2 × PMS 90 B) per cent over standard check (CSH22SS) (Table 5b).

Among the forty nine crosses studied, twenty seven shown positively significant heterosis and fifteen shown negatively significant heterosis over mid parent, twenty three shown positively significant heterosis and eighteen shown negatively significant heterosis over better parent, and none shown positively significant heterosis and all forty nine shown negatively significant heterosis over standard check (CSH22SS).

Across environments the magnitude of heterosis for the trait grain yield was ranged from -77.94 (IS 22670 × NSSV 13) to 452.77 (ICSV 93046 × ICSB 323) per cent over mid parent, -81.26 (IS 22670 × NSSV 13) to 440.38 (ICSV 93046 × ICSB

323) per cent over better parent, and -91.39 (IS 22670 × NSSV 13) to -1.89 (NTJ 2 × PMS 90 B) per cent over standard check (CSH22SS) (Table 5c).

Among the forty nine crosses studied, twenty six shown positively significant heterosis and five shown negatively significant heterosis over mid parent, nineteen shown positively significant heterosis and nine shown negatively significant heterosis over better parent, and none shown positively significant heterosis and forty eight shown negatively significant heterosis over standard check (CSH22SS).

4.3.17 1000-seed weight (g)

The magnitude of heterosis for the trait 1000-seed weight at Bijapur was ranged from -60.22 (ICSV 25333 × NSSV 13) to 61.33 (Wray × ICSB 323) per cent over mid parent, -62.99 (ICSV 25333 × NSSV 13) to 59.98 (Wray × ICSB 323) per cent over better parent, and -65.85 (ICSV 25333 × NSSV 13) to 13.81 (IS 13871 × PMS 90 B) per cent over standard check (CSH22SS) (Table 5a).

Among the forty nine crosses studied, fourteen shown positively significant heterosis and five shown negatively significant heterosis over mid parent, eight shown positively significant heterosis and sixteen shown negatively significant heterosis over better parent, and none shown positively significant heterosis and thirty three shown negatively significant heterosis over standard check (CSH22SS).

The magnitude of heterosis for the trait 1000-seed weight at ICRISAT was ranged from -47.65 (ICSV 25333 × NSSV 13) to 31.39 (ICSV 93046 × ICSB 351) per cent over mid parent, -58.51 (ICSV 25333 × NSSV 13) to 28.13 (NTJ 2 × PMS 90 B) per cent over better parent, and -66.82 (ICSV 25333 × NSSV 13) to 16.85 (NTJ 2 × PMS 90 B) per cent over standard check (CSH22SS) (Table 5b).

Among the forty nine crosses studied, fifteen shown positively significant heterosis and five shown negatively significant heterosis over mid parent, nine shown positively significant heterosis and fourteen shown negatively significant heterosis over better parent, and one shown positively significant heterosis and thirty eight shown negatively significant heterosis over standard check (CSH22SS).

Across environments the magnitude of heterosis for the trait 1000-seed weight was ranged from -54.99 (ICSV 25333 × NSSV 13) to 33.76 (IS 13871 × ICSB 323) per cent over mid parent, -57.74 (ICSV 25333 × NSSV 13) to 27.90 (IS 13871 × PMS 90 B) per cent over better parent, and -66.33 (ICSV 25333 × NSSV 13) to 7.65 (IS 13871 × PMS 90 B) per cent over standard check (CSH22SS) (Table 5c).

Among the forty nine crosses studied, twelve shown positively significant heterosis and four shown negatively significant heterosis over mid parent, six shown positively significant heterosis and nine shown negatively significant heterosis over better parent, and none shown positively significant heterosis and thirty five shown negatively significant heterosis over standard check (CSH22SS).

4.4 Combining ability analysis

4.4.1 Analysis of variance (ANOVA) for combining ability

Analysis of variance for combining ability with respect to stalk sugar related traits, and yield and yield components comprising 17 characters are presented in the Table 6a, Table 6b and Table 6c for Bijapur, ICRISAT and across environments, respectively. The SCA variance was higher than GCA variance for all the traits studied in both the locations. Also the ratio of GCA variance to SCA variance was less than unity indicating the predominance of non-additive gene action for the inheritance of the 17 quantitative traits.

4.4.2 Combining ability effects

The *gca* and *sca* effects were estimated for stalk sugar related traits, yield and yield component traits in line x tester (7 x 7) mating design. The estimates on *gca* and *sca* effects for each of the 17 characters in Bijapur, ICRISAT and Across environment s are presented in Tables 7a, 7b and 7c (*gca* effects) and Tables 8a, 8b and 8c (*sca* effects), respectively and the results are given below.

4.4.2.1 General combining ability effects

4.4.2.1.1 Days to 50% flowering

At Bijapur, among the 14 parents studied, four lines (IS 13871, NTJ 2, Wray and SPSSV 30) and three testers (ICSB 323, ICSB 351 and Parbhani Moti) shown highly significant negative *gca* effects. Among the remaining two lines (IS 22670 and ICSV 25333) and two testers (NSSV 13 and PMS 90 B) showed significant positive *gca* effects (Table 7a).

Table 5a. Magnitude of heterosis (%) over mid parent, better parent and standard check for stalk sugar related traits, yield and yield components in sweet sorghum crosses evaluated at Bijapur

S.No.	Crosses	DFL			Plant height (m)			Stem thickness (mm)		
		Magnitude of heterosis (%)			Magnitude of heterosis (%)			Magnitude of heterosis (%)		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1	IS 13871 × PMS 90 B	-7.06	-13.92**	-23.31**	34.43*	16.54	-20.04*	1.78	-4.78	-24.64**
2	IS 13871 × ICSB 323	-14.05**	-26.99**	-20.68**	19.57	9.73	-24.70**	-9.73	-11.08	-36.81**
3	IS 13871 × ICSB 351	0.73	-1.42	-21.80**	21.67	5.68	-27.48**	-4.78	-6.54	-35.57**
4	IS 13871 × ICSB 374	8.65	5.61	-15.04**	5.24	-0.52	-31.74**	-28.34**	-30.56**	-52.13**
5	IS 13871 × ICSB 480	-2.74	-9.75*	-19.92**	1.94	-2.50	-33.10**	-1.95	-6.79	-35.74**
6	IS 13871 × Parbhani Moti	-14.41**	-25.19**	-24.06**	3.47	-8.80	-17.97*	-0.93	-0.93	-31.70**
7	IS 13871 × NSSV 13	-1.25	-14.75**	-10.90**	19.95	9.36	-8.87	32.21**	24.95**	-3.23
8	IS 22670 × PMS 90 B	5.15	-9.20**	11.28**	35.31**	2.80	-0.35	-22.06**	-23.38**	-37.23**
9	IS 22670 × ICSB 323	4.72	-1.23	21.05**	22.53	-2.50	-5.50	-2.36	-8.83	-25.32**
10	IS 22670 × ICSB 351	16.20**	-4.29	17.29**	74.68**	32.93**	28.84**	47.49**	33.51**	9.36
11	IS 22670 × ICSB 374	31.48**	8.90**	33.46**	48.09**	20.73*	17.02	58.78**	42.08**	16.38**
12	IS 22670 × ICSB 480	9.25**	-5.83	15.41**	41.04**	16.10	12.53	-3.16	-14.86*	-30.26**
13	IS 22670 × Parbhani Moti	-5.70	-13.80**	5.64	-11.70	-14.88	-17.49*	-5.22	-12.73*	-28.51**
14	IS 22670 × NSSV 13	11.59**	3.37	26.69**	48.52**	38.11**	33.87**	25.77**	22.34**	0.22
15	ICSV 25333 × PMS 90 B	20.89**	1.73	32.71**	33.08**	-1.89	4.14	34.19**	26.61**	0.21
16	ICSV 25333 × ICSB 323	12.58**	3.17	34.59**	42.44**	9.69	16.43	21.99**	21.26**	-13.83**
17	ICSV 25333 × ICSB 351	39.78**	12.39**	46.62**	23.83*	-8.57	-2.96	40.19**	36.36**	-4.26
18	ICSV 25333 × ICSB 374	40.46**	13.54**	48.12**	33.57**	5.23	11.70	45.74**	40.00**	-1.70
19	ICSV 25333 × ICSB 480	19.38**	0.29	30.83**	18.35	-5.90	-0.12	28.30**	20.91**	-15.11**
20	ICSV 25333 × Parbhani Moti	16.69**	3.75	35.34**	4.16	-3.79	2.13	23.65**	22.52**	-13.97**

Table 5a (conti....)

21	ICSV 25333 × NSSV 13	30.56**	17.58**	53.38**	-10.17	-19.82*	-14.89	29.68**	23.63**	-4.26
22	ICSV 93046 × PMS 90B	-3.15	-9.23*	-7.52*	16.27	-9.02	-18.91*	19.77**	12.37	-11.06*
23	ICSV 93046 × ICSB 323	-13.93**	-16.61**	-9.40*	18.00	-3.05	-13.59	27.27**	25.75**	-10.64*
24	ICSV 93046 × ICSB 351	13.69**	1.11	3.01	2.03	-20.03*	-28.72**	-17.87*	-19.63**	-44.26**
25	ICSV 93046 × ICSB 374	5.15	-5.90	-4.14	3.86	-12.47	-21.99*	18.57*	14.57*	-20.53**
26	ICSV 93046 × ICSB 480	-1.78	-8.12*	-6.39	7.94	-8.09	-18.09*	13.92	7.98	-25.11**
27	ICSV 93046 × Parbhani Moti	-7.21	-7.38*	-5.64	18.02	17.48	5.67	19.38**	19.02*	-17.45**
28	ICSV 93046 × NSSV 13	27.14**	25.54**	31.20**	-2.81	-5.97	-16.19	-12.18	-16.76*	-35.54**
29	NTJ 2 × PMS 90 B	2.20	-2.67	-4.14	33.45*	6.93	-10.64	11.23	8.12	-9.36
30	NTJ 2 × ICSB 323	-7.08	-11.42**	-3.76	16.44	-1.84	-17.97*	28.02**	18.27**	-0.85
31	NTJ 2 × ICSB 351	-4.02	-13.36**	-14.66**	12.60	-9.62	-24.47**	4.25	-6.60	-21.70**
32	NTJ 2 × ICSB 374	-0.84	-9.92**	-11.28**	20.10	3.96	-13.12	12.32	-0.51	-16.6**
33	NTJ 2 × ICSB 480	7.23	1.91	0.38	12.37	-1.70	-17.85*	13.12	-1.52	-17.45**
34	NTJ 2 × Parbhani Moti	7.14	5.56	7.14	-3.13	-6.57	-15.96	9.03	-0.65	-16.72**
35	NTJ 2 × NSSV 13	5.93	2.88	7.52*	-0.14	-0.28	-16.67	6.86	2.79	-13.83**
36	Wray × PMS 90 B	-4.09	-5.91	-16.17**	6.84	-17.66	-23.40**	-9.57	-26.34**	-41.70**
37	Wray × ICSB 323	-16.83**	-25.61**	-19.17**	0.63	-18.68	-24.35**	1.06	-14.07	-38.94**
38	Wray × ICSB 351	-7.97	-11.40**	-24.06**	27.24*	-1.78	-8.63	17.58*	2.88	-31.70**
39	Wray × ICSB 374	-7.24	-10.09*	-22.93**	22.39	1.40	-5.67	20.45*	6.58	-31.06**
40	Wray × ICSB 480	14.22**	12.29**	-0.38	-8.88	-23.76*	-29.08**	2.66	-7.53	-42.55**
41	Wray × Parbhani Moti	-10.44**	-17.41**	-16.17**	-9.30	-10.80	-17.02	5.02	-9.57	-37.66**
42	Wray × NSSV 13	1.19	-7.91*	-3.76	20.91*	14.61	6.62	50.50**	23.63**	-4.26
43	SPSSV 30 × PMS 90B	63.28**	59.49**	42.11**	0.54	-18.83	-33.51**	-38.55**	-41.94**	-54.04**
44	SPSSV 30 × ICSB 323	-8.74*	-18.69**	-11.65**	27.16*	8.08	-11.47	14.59*	14.07	-18.94**
45	SPSSV 30 × ICSB 351	-4.35	-7.52	-21.43**	48.97**	20.49	-1.30	11.98	8.76	-23.40**

Table 5a (conti....)

46	SPSSV 30 × ICSB 374	1.36	-1.33	-16.17**	27.19*	11.04	-9.04	23.77**	18.73*	-16.39**
47	SPSSV 30 × ICSB 480	-3.90	-5.93	-16.54**	13.33	0.00	-18.09*	5.30	-0.91	-30.21**
48	SPSSV 30 × Parbhani Moti	-9.27*	-16.67**	-15.41**	16.78	11.56	0.35	8.70	7.55	-24.26**
49	SPSSV 30 × NSSV 13	-12.30**	-20.50**	-16.92**	6.58	5.67	-11.94	-4.46	-8.79	-29.36**
	S.Em.±	4.02	4.65	4.65	0.30	0.35	0.35	1.62	1.87	1.87
	CD at 5%	11.27	13.01	13.01	0.85	0.98	0.98	4.52	5.23	5.23
	CD at 1%	14.89	17.19	17.19	1.12	1.30	1.30	5.98	6.91	6.91

MP: Mid Parent, BP: Better Parent, SC: Standard Check (CSH22SS), DFL: days to 50% flowering, *significant at 5% probability, **significant at 1% probability

Table 5a (conti....)

S.No.	Crosses	Stalk yield (t ha^{-1})			Juice yield (t ha^{-1})			Juice volume (L ha^{-1})		
		Magnitude of heterosis (%)			Magnitude of heterosis (%)			Magnitude of heterosis (%)		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1	IS 13871 × PMS 90 B	-4.46	-25.59**	-67.23**	-7.83	-34.30**	-76.54**	-7.68	-33.96**	-76.61**
2	IS 13871 × ICSB 323	-17.86	-28.58*	-76.27**	-46.64**	-57.91**	-88.93**	-46.94**	-58.06**	-88.98**
3	IS 13871 × ICSB 351	17.00	-1.83	-75.89**	-7.57	-18.89	-87.67**	-10.17	-21.64	-88.05**
4	IS 13871 × ICSB 374	4.00	2.58	-74.10**	-35.03*	-45.97**	-87.62**	-34.84*	-45.04**	-87.80**
5	IS 13871 × ICSB 480	-9.06	-26.22*	-70.91**	-21.20	-39.58**	-82.79**	-22.96	-40.72**	-83.22**
6	IS 13871 × Parbhani Moti	-0.10	-18.94	-68.04**	-11.19	-35.38**	-78.42**	-14.09	-37.81**	-78.81**
7	IS 13871 × NSSV 13	53.20**	8.79	-36.44**	-34.63**	-56.84**	-79.53**	-42.89**	-63.60**	-79.78**
8	IS 22670 × PMS 90 B	-34.45**	-41.80**	-66.96**	-62.13**	-64.90**	-87.47**	-63.24**	-65.79**	-87.88**
9	IS 22670 × ICSB 323	-6.85	-26.16**	-58.09**	-14.92	-20.75	-75.84**	-17.60	-23.32*	-76.61**
10	IS 22670 × ICSB 351	137.89**	53.84**	-12.68**	10.36	-24.05*	-76.85**	9.31	-25.00*	-77.12**
11	IS 22670 × ICSB 374	112.35**	53.41**	-12.92**	-17.19	-27.46*	-77.89**	-17.36	-28.61**	-78.22**
12	IS 22670 × ICSB 480	-7.43	-21.56**	-55.48**	-31.72**	-33.96**	-79.87**	-31.99**	-34.44**	-80.00**
13	IS 22670 × Parbhani Moti	1.96	-13.61	-50.96**	-42.53**	-45.03**	-81.64**	-44.36**	-47.26**	-82.03**
14	IS 22670 × NSSV 13	75.30**	72.80**	0.96	-8.64	-24.95**	-64.41**	-17.87*	-36.38**	-64.66**
15	ICSV 25333 × PMS 90 B	34.23**	34.09**	-40.95**	1.08	-25.56**	-73.42**	1.94	-24.64**	-73.31**
16	ICSV 25333 × ICSB 323	78.33**	56.60**	-31.18**	79.18**	47.07**	-61.31**	77.65**	46.13**	-61.61**
17	ICSV 25333 × ICSB 351	119.75**	51.51**	-33.42**	171.48**	128.03**	-61.51**	170.66**	126.00**	-61.69**
18	ICSV 25333 × ICSB 374	134.68**	84.76**	-18.81**	65.60**	43.78**	-67.05**	66.23**	46.56**	-67.46**
19	ICSV 25333 × ICSB 480	108.15**	97.46**	-13.23**	135.13**	87.22**	-46.66**	136.70**	89.22**	-46.44**
20	ICSV 25333 × Parbhani Moti	50.21**	42.49**	-37.38**	33.24*	0.30	-66.51**	30.75*	-2.10	-66.65**

Table 5a (conti….)

21	ICSV 25333 × NSSV 13	-9.69	-20.89**	-53.78**	-34.24**	-55.41**	-78.86**	-43.18**	-62.92**	-79.41**
22	ICSV 93046 × PMS 90B	84.82**	82.15**	-17.40**	147.59**	114.95**	4.23	149.49**	116.55**	4.24
23	ICSV 93046 × ICSB 323	117.81**	88.72**	-14.42**	167.56**	106.37**	0.07	168.79**	107.75**	0.00
24	ICSV 93046 × ICSB 351	-34.43**	-55.18**	-79.68**	-66.03**	-79.00**	-89.82**	-66.10**	-79.05**	-89.92**
25	ICSV 93046 × ICSB 374	78.45**	38.91**	-37.01**	30.26**	-4.08	-53.49**	27.95**	-6.51	-55.00**
26	ICSV 93046 × ICSB 480	39.84**	30.72**	-40.72**	28.60**	2.08	-50.50**	29.05**	2.46	-50.68**
27	ICSV 93046 × Parbhani Moti	117.46**	103.27**	-7.83	89.34**	59.86**	-22.48**	88.04**	60.56**	-22.71**
28	ICSV 93046 × NSSV 13	-32.89**	-40.40**	-65.18**	-71.55**	-71.87**	-86.36**	-74.50**	-76.20**	-86.78**
29	NTJ 2 × PMS 90 B	22.18**	2.09	-33.02**	14.29*	-13.06**	-40.47**	14.38*	-13.15**	-40.68**
30	NTJ 2 × ICSB 323	80.31**	35.82**	-10.89**	59.96**	10.71*	-24.19**	59.68**	10.55*	-24.49**
31	NTJ 2 × ICSB 351	3.51	-35.11**	-57.42**	-51.31**	-71.58**	-80.54**	-51.49**	-71.71**	-80.68**
32	NTJ 2 × ICSB 374	39.03**	-3.74	-36.84**	19.33**	-20.36**	-45.47**	18.35**	-21.59**	-46.44**
33	NTJ 2 × ICSB 480	-2.76	-22.16**	-48.93**	-39.61**	-57.24**	-70.72**	-40.00**	-57.57**	-71.02**
34	NTJ 2 × Parbhani Moti	13.22	-9.38	-40.54**	-8.84	-32.19**	-53.57**	-10.02	-32.57**	-53.94**
35	NTJ 2 × NSSV 13	-1.52	-6.91	-38.92**	-49.01**	-56.85**	-70.45**	-53.20**	-57.57**	-71.02**
36	Wray × PMS 90 B	-30.01*	-49.74**	-77.87**	-23.19*	-40.79**	-78.86**	-23.10*	-40.67**	-78.98**
37	Wray × ICSB 323	23.34	-2.67	-67.66**	-21.72	-32.08**	-82.13**	-22.91	-33.23**	-82.46**
38	Wray × ICSB 351	71.03**	59.61**	-69.33**	67.77**	33.65*	-74.14**	68.98**	34.36*	-74.15**
39	Wray × ICSB 374	86.90**	64.57**	-58.45**	142.32**	123.43**	-48.79**	142.94**	126.72**	-49.66**
40	Wray × ICSB 480	-25.51	-44.60**	-78.16**	-68.15**	-73.26**	-92.38**	-68.63**	-73.65**	-92.54**
41	Wray × Parbhani Moti	51.80**	12.89	-55.49**	0.29	-20.80*	-73.56**	-2.70	-23.88*	-74.07**
42	Wray × NSSV 13	3.51	-31.23**	-59.82**	-1.88	-30.93**	-67.25**	-12.51	-41.10**	-67.29**
43	SPSSV 30 × PMS 90B	-75.94**	-78.36**	-90.47**	-85.28**	-85.36**	-94.71**	-84.98**	-85.04**	-94.66**

Table 5a (conti….)

44	SPSSV 30 × ICSB 323	70.31**	65.63**	-41.76**	148.55**	114.82**	-22.43**	149.52**	116.63**	-22.71**
45	SPSSV 30 × ICSB 351	75.36**	29.20*	-54.57**	58.18**	4.23	-62.37**	57.48**	3.80	-62.97**
46	SPSSV 30 × ICSB 374	64.65**	41.44**	-50.26**	12.31	-8.20	-66.85**	12.45	-8.79	-67.46**
47	SPSSV 30 × ICSB 480	109.79**	98.44**	-21.75**	64.05**	46.75**	-47.01**	65.30**	48.22**	-47.12**
48	SPSSV 30 × Parbhani Moti	54.51**	46.16**	-42.38**	114.58**	106.51**	-25.44**	112.88**	108.08**	-25.76**
49	SPSSV 30 × NSSV 13	-15.08	-31.98**	-60.26**	15.59*	1.80	-51.73**	3.86	-14.71**	-52.63**
	S.Em.±	6.99	8.07	8.07	1.45	1.68	1.68	1387.57	1602.23	1602.23
	CD at 5%	19.56	22.59	22.59	4.07	4.69	4.69	3883.99	4484.85	4484.85
	CD at 1%	25.86	29.86	29.86	5.37	6.20	6.20	5133.56	5927.73	5927.73

MP: Mid Parent, BP: Better Parent, SC: Standard Check (CSH22SS), *significant at 5% probability, **significant at 1% probability

Table 5a (conti....)

S.No.	Crosses	Brix (%)			Bagasse yield (t ha^{-1})			Total soluble solids (%)		
		Magnitude of heterosis (%)			Magnitude of heterosis (%)			Magnitude of heterosis (%)		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1	IS 13871 × PMS 90 B	11.86	10.00	-5.71	-3.74	-23.51*	-64.09**	11.66	9.83	-5.63
2	IS 13871 × ICSB 323	-4.81	-23.27**	7.43	-11.38	-21.22	-71.99**	-4.75	-23.02**	7.32
3	IS 13871 × ICSB 351	-16.67*	-25.00**	-35.71**	22.25	1.88	-71.82**	-16.35*	-24.57**	-35.19**
4	IS 13871 × ICSB 374	63.64**	50.00**	28.57**	13.55	10.03	-69.57**	62.46**	49.15**	28.15**
5	IS 13871 × ICSB 480	-4.62	-11.43	-11.43	-6.37	-23.26*	-66.79**	-4.54	-11.26	-11.26
6	IS 13871 × Parbhani Moti	-11.85	-22.19**	-12.86*	2.04	-15.43	-64.43**	-11.67	-21.90**	-12.67*
7	IS 13871 × NSSV 13	43.70**	28.27**	40.00**	72.76**	23.99**	-21.23**	54.65**	47.73**	39.41**
8	IS 22670 × PMS 90 B	-7.95	-23.64**	-4.00	-29.08**	-39.33**	-59.94**	-7.83	-23.36**	-3.94
9	IS 22670 × ICSB 323	-19.35**	-23.47**	7.14	-5.78	-27.53**	-52.14**	-19.14**	-23.22**	7.04
10	IS 22670 × ICSB 351	2.94	-20.45**	0.00	160.61**	66.69**	10.08*	2.90	-20.22**	0.00
11	IS 22670 × ICSB 374	4.35	-18.18**	2.86	139.33**	66.68**	10.07*	4.28	-17.97**	2.82
12	IS 22670 × ICSB 480	3.80	-6.82	17.14**	-2.80	-19.55**	-46.87**	3.75	-6.74	16.89**
13	IS 22670 × Parbhani Moti	-3.85	-9.09	14.29*	10.85	-9.27	-40.09**	-3.80	-8.98	14.08*
14	IS 22670 × NSSV 13	-16.06**	-21.59**	-1.43	91.81**	88.16**	24.25**	-10.25	-21.34**	-1.41
15	ICSV 25333 × PMS 90 B	14.29**	-8.33	25.71**	40.53**	31.98**	-29.46**	14.10**	-8.24	25.34**
16	ICSV 25333 × ICSB 323	-11.34**	-12.24**	22.86**	78.53**	48.65**	-20.55**	-11.22**	-12.12**	22.52**
17	ICSV 25333 × ICSB 351	19.44**	-10.42*	22.86**	112.84**	43.14**	-23.5**	19.17**	-10.31*	22.52**
18	ICSV 25333 × ICSB 374	12.33*	-14.58**	17.14**	147.48**	83.8**	-1.77	12.16*	-14.43**	16.89**
19	ICSV 25333 × ICSB 480	3.61	-10.42*	22.86**	103.82**	84.42**	-1.43	3.57	-10.31*	22.52**
20	ICSV 25333 × Parbhani Moti	-3.67	-12.50**	20.00**	52.61**	36.35**	-27.13**	-3.63	-12.37**	19.71**

Table 5a (conti….)

21	ICSV 25333 × NSSV 13	-23.43**	-31.25**	-5.71	-5.93	-13.40	-44.98**	-18.28**	-30.92**	-5.63
22	ICSV 93046 × PMS 90B	-36.11**	-46.51**	-34.29**	64.28**	59.37**	-25.18**	-35.60**	-45.96**	-33.78**
23	ICSV 93046 × ICSB 323	-19.57**	-24.49**	5.71	101.83**	82.19**	-19.57**	-19.35**	-24.23**	5.63
24	ICSV 93046 × ICSB 351	46.27**	13.95**	40.00**	-23.92	-46.07**	-76.19**	45.56**	13.79**	39.41**
25	ICSV 93046 × ICSB 374	-16.18**	-33.72**	-18.57**	95.75**	55.39**	-31.41**	-15.93**	-33.32**	-18.30**
26	ICSV 93046 × ICSB 480	-5.13	-13.95**	5.71	43.40**	41.99**	-37.32**	-5.06	-13.79**	5.63
27	ICSV 93046 × Parbhani Moti	-7.54	-11.63*	8.57	125.96**	120.62**	-2.61	-7.45	-11.49*	8.45
28	ICSV 93046 × NSSV 13	33.00**	25.58**	54.29**	-21.54*	-33.51**	-57.76**	41.54**	25.28**	53.49**
29	NTJ 2 × PMS 90 B	24.59**	18.75**	8.57	24.80**	7.82	-30.46**	24.18**	18.45**	8.45
30	NTJ 2 × ICSB 323	-13.58**	-28.57**	0.00	87.43**	45.39**	-6.24	-13.41**	-28.27**	0.00
31	NTJ 2 × ICSB 351	3.57	-9.38	-17.14**	22.39	-21.31**	-49.25**	3.51	-9.23	-16.89**
32	NTJ 2 × ICSB 374	50.88**	34.38**	22.86**	46.06**	2.40	-33.96**	49.97**	33.83**	22.52**
33	NTJ 2 × ICSB 480	1.49	-2.86	-2.86	8.95	-8.97	-41.29**	1.47	-2.82	-2.82
34	NTJ 2 × Parbhani Moti	-1.40	-10.46	0.29	20.07*	-0.82	-36.03**	-1.38	-10.32	0.28
35	NTJ 2 × NSSV 13	23.93**	13.87*	24.29**	12.48	11.63	-28.01**	33.31**	31.32**	23.93**
36	Wray × PMS 90 B	20.00**	2.44	20.00**	-32.41*	-52.49**	-77.70**	19.71**	2.41	19.71**
37	Wray × ICSB 323	4.44	-4.08	34.29**	36.38*	4.73	-62.76**	4.39	-4.04	33.78**
38	Wray × ICSB 351	-20.00**	-36.59**	-25.71**	71.62**	68.86**	-67.83**	-19.69**	-36.13**	-25.34**
39	Wray × ICSB 374	10.61	-10.98*	4.29	68.27**	45.93*	-62.14**	10.44	-10.84*	4.22
40	Wray × ICSB 480	13.16*	4.88	22.86**	-14.08	-38.12**	-73.22**	12.98*	4.82	22.52**
41	Wray × Parbhani Moti	14.71**	12.20*	31.43**	66.19**	20.75	-49.22**	14.52**	12.04*	30.97**
42	Wray × NSSV 13	31.31**	26.83**	48.57**	2.69	-33.25**	-57.60**	39.98**	26.49**	47.86**
43	SPSSV 30 × PMS 90B	42.31**	13.27**	58.57**	-73.27**	-76.79**	-89.10**	41.75**	13.13**	57.71**
44	SPSSV 30 × ICSB 323	-16.33**	-16.33**	17.14**	46.31**	44.31**	-48.69**	-16.16**	-16.16**	16.89**

Table 5a (conti….)

45	SPSSV 30 × ICSB 351	20.55**	-10.20*	25.71**	81.28**	38.97**	-51.94**	20.26**	-10.10*	25.34**
46	SPSSV 30 × ICSB 374	-20.81**	-40.20**	-16.29**	83.56**	60.63**	-44.45**	-20.52**	-39.78**	-16.05**
47	SPSSV 30 × ICSB 480	-11.90*	-24.49**	5.71	123.85**	101.38**	-12.86*	-11.76*	-24.23**	5.63
48	SPSSV 30 × Parbhani Moti	-13.83**	-22.45**	8.57	34.28**	22.35	-48.54**	-13.67**	-22.21**	8.45
49	SPSSV 30 × NSSV 13	5.50	-6.12	31.43**	-25.50*	-42.47**	-63.45**	12.04*	-6.06	30.97**
	S.Em.±	0.85	0.98	0.98	6.24	7.21	7.21	0.75	0.86	0.86
	CD at 5%	2.39	2.76	2.76	17.48	20.18	20.18	2.09	2.41	2.41
	CD at 1%	3.15	3.64	3.64	23.10	26.67	26.67	2.76	3.19	3.19

MP: Mid Parent, BP: Better Parent, SC: Standard Check (CSH22SS), *significant at 5% probability, **significant at 1% probability

Table 5a (conti....)

S.No.	Crosses	Total sugar index			Juice extraction (%)			Ethanol yield (L ha^{-1})		
		Magnitude of heterosis (%)			Magnitude of heterosis (%)			Magnitude of heterosis (%)		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1	IS 13871 × PMS 90 B	4.38	-24.65	-77.80**	0.28	-11.15	-28.36**	8.57	-12.40	-65.92**
2	IS 13871 × ICSB 323	-52.21**	-67.56**	-88.13**	-34.16**	-41.48**	-53.15**	-17.62	-38.71**	-70.01**
3	IS 13871 × ICSB 351	-25.61	-41.07	-92.30**	-23.20**	-27.87**	-48.88**	-0.15	-24.00	-81.86**
4	IS 13871 × ICSB 374	8.27	-1.37	-84.31**	-37.77**	-47.85**	-51.99**	86.06**	63.81*	-60.90**
5	IS 13871 × ICSB 480	-28.53	-47.97**	-85.08**	-11.45	-17.45*	-40.56**	-12.50	-32.34*	-70.45**
6	IS 13871 × Parbhani Moti	-28.14	-51.76**	-81.60**	-7.74	-19.97**	-32.21**	-13.36	-34.71**	-69.27**
7	IS 13871 × NSSV 13	-23.52	-53.52**	-71.80**	-60.14**	-67.67**	-67.67**	143.47**	65.81**	9.32
8	IS 22670 × PMS 90 B	-65.82**	-69.80**	-88.40**	-42.61**	-52.31**	-61.55**	-36.56**	-53.41**	-61.34**
9	IS 22670 × ICSB 323	-33.00**	-34.58**	-74.88**	-13.71	-28.09**	-42.42**	-22.16*	-38.13**	-48.66**
10	IS 22670 × ICSB 351	-0.41	-40.30**	-77.08**	-56.98**	-62.29**	-73.27**	128.85**	31.62**	9.21
11	IS 22670 × ICSB 374	-17.60	-41.73**	-77.63**	-65.05**	-72.39**	-74.59**	122.73**	35.74**	12.63*
12	IS 22670 × ICSB 480	-30.43*	-39.24**	-76.67**	-27.67**	-37.02**	-54.65**	-2.30	-25.44**	-38.13**
13	IS 22670 × Parbhani Moti	-46.71**	-46.88**	-79.60**	-45.79**	-55.81**	-62.57**	4.91	-17.79*	-31.79**
14	IS 22670 × NSSV 13	-29.44**	-42.39**	-65.05**	-53.89**	-64.64**	-64.64**	65.17**	48.20**	22.97**
15	ICSV 25333 × PMS 90 B	27.18	13.88	-66.45**	-22.60**	-42.92**	-53.98**	59.01**	21.62**	-10.68
16	ICSV 25333 × ICSB 323	57.27**	28.72*	-52.91**	-4.65	-29.53**	-43.57**	58.85**	32.34**	-2.81
17	ICSV 25333 × ICSB 351	204.60**	102.24**	-52.88**	5.68	-18.61**	-42.32**	119.20**	28.20**	-5.85
18	ICSV 25333 × ICSB 374	91.77**	61.35**	-62.41**	-36.98**	-55.38**	-58.93**	152.25**	57.32**	15.53*
19	ICSV 25333 × ICSB 480	153.10**	129.38**	-34.22**	11.29	-14.77*	-38.63**	106.43**	64.59**	20.87**

Table 5a (conti….)

20	ICSV 25333 × Parbhani Moti	30.25*	4.90	-59.98**	-13.04	-36.86**	-46.52**	45.04**	19.00*	-12.61*
21	ICSV 25333 × NSSV 13	-53.76**	-68.00**	-80.59**	-33.86**	-54.27**	-54.27**	-25.61**	-29.41**	-48.16**
22	ICSV 93046 × PMS 90B	54.67**	15.63*	-31.20**	35.04**	18.53**	26.51**	5.15	-9.65	-51.09**
23	ICSV 93046 × ICSB 323	121.95**	79.20**	6.62	25.49**	9.82*	17.21**	64.79**	56.88**	-15.09*
24	ICSV 93046 × ICSB 351	-57.92**	-76.26**	-85.87**	-43.64**	-53.11**	-49.96**	-0.09	-38.54**	-66.73**
25	ICSV 93046 × ICSB 374	-3.69	-38.97**	-63.69**	-25.75**	-30.85**	-26.2**	54.66**	3.28	-44.10**
26	ICSV 93046 × ICSB 480	17.17	-13.18	-48.34**	-5.20	-20.62**	-15.28**	32.73**	19.91	-35.10**
27	ICSV 93046 × Parbhani Moti	72.15**	41.26**	-15.95**	-12.20*	-21.26**	-15.96**	108.50**	94.90**	5.49
28	ICSV 93046 × NSSV 13	-66.06**	-66.39**	-79.61**	-62.02**	-63.22**	-60.75**	8.50	-1.21	-34.87**
29	NTJ 2 × PMS 90 B	39.39**	2.51	-35.85**	-2.74	-13.80**	-10.04*	52.42**	26.51*	-25.43**
30	NTJ 2 × ICSB 323	53.29**	21.45**	-24.00**	-8.01	-18.72**	-15.17**	74.17**	59.38**	-6.06
31	NTJ 2 × ICSB 351	-54.41**	-74.42**	-83.99**	-47.41**	-55.85**	-53.92**	17.64	-28.74**	-58.00**
32	NTJ 2 × ICSB 374	68.57**	5.71	-33.85**	-12.07*	-17.26**	-13.65**	110.59**	37.73**	-18.82**
33	NTJ 2 × ICSB 480	-38.40**	-55.08**	-71.89**	-34.47**	-44.63**	-42.21**	9.68	-4.53	-43.73**
34	NTJ 2 × Parbhani Moti	-8.30	-26.20**	-53.81**	-17.41**	-25.19**	-21.92**	20.94	8.76	-35.89**
35	NTJ 2 × NSSV 13	-41.63**	-42.51**	-64.03**	-52.62**	-53.61**	-51.59**	42.94**	35.37**	-10.76
36	Wray × PMS 90 B	-3.26	-14.21	-74.72**	6.78	-3.72	-3.36	-11.72	-30.61*	-73.01**
37	Wray × ICSB 323	-20.79	-35.72**	-76.48**	-38.69**	-44.89**	-44.69**	39.58*	1.53	-50.32**
38	Wray × ICSB 351	26.97	-15.23	-80.68**	-1.35	-15.85**	-15.54**	38.55	8.08	-75.95**
39	Wray × ICSB 374	170.88**	129.96**	-47.59**	28.24**	22.93**	23.38**	94.38**	76.51**	-60.72**
40	Wray × ICSB 480	-64.52**	-68.16**	-90.87**	-59.66**	-65.36**	-65.23**	-0.65	-25.02	-67.25**
41	Wray × Parbhani Moti	11.27	-11.13	-66.10**	-34.87**	-39.95**	-39.73**	90.34**	40.16**	-34.03**
42	Wray × NSSV 13	15.63	-20.47**	-51.74**	-19.00**	-19.15**	-18.86**	42.21**	-4.90	-37.3**
43	SPSSV 30 × PMS 90B	-78.83**	-83.22**	-91.56**	-39.01**	-45.59**	-44.07**	-60.73**	-64.68**	-82.80**
44	SPSSV 30 × ICSB 323	109.74**	81.12**	-8.88	47.22**	30.94**	34.61**	25.11*	24.81*	-38.93**

Table 5a (conti….)

45	SPSSV 30 × ICSB 351	60.32**	-7.67	-53.54**	-4.78	-19.57**	-17.31**	96.80**	23.59	-39.82**
46	SPSSV 30 × ICSB 374	-17.56	-45.75**	-72.70**	-31.59**	-35.17**	-33.35**	39.28*	-4.39	-53.44**
47	SPSSV 30 × ICSB 480	41.54**	11.10	-44.10**	-21.79**	-33.50**	-31.64**	98.81**	88.55**	-8.18
48	SPSSV 30 × Parbhani Moti	82.01**	60.01**	-19.49**	37.98**	25.84**	29.36**	16.62	14.67	-44.16**
49	SPSSV 30 × NSSV 13	12.49	2.89	-37.57**	21.49**	19.84**	23.19**	-15.17	-26.26**	-51.38**
	S.Em.±	0.26	0.30	0.30	1.57	1.82	1.82	620.23	716.18	716.18
	CD at 5%	0.74	0.85	0.85	4.40	5.08	5.08	1736.09	2004.66	2004.66
	CD at 1%	0.97	1.12	1.12	5.82	6.72	6.72	2294.63	2649.61	2649.61

MP: Mid Parent, BP: Better Parent, SC: Standard Check (CSH22SS), *significant at 5% probability, **significant at 1% probability

Table 5a (conti....)

S.No.	Crosses	Panicle weight (t ha^{-1})			Panicle length (cm)			Panicle breadth (cm)		
		Magnitude of heterosis (%)			Magnitude of heterosis (%)			Magnitude of heterosis (%)		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1	IS 13871 × PMS 90 B	71.60**	4.63	-10.14	12.28	-5.54	6.59	29.18**	1.31	-10.71*
2	IS 13871 × ICSB 323	149.71**	144.19**	-51.86**	22.69*	15.23	1.04	30.94**	17.18*	-25.67**
3	IS 13871 × ICSB 351	78.96**	19.89*	-33.53**	27.68**	11.83	14.58	23.63**	2.77	-22.28**
4	IS 13871 × ICSB 374	-20.77	-41.15**	-77.17**	-11.11	-22.39**	-19.89*	-17.68*	-30.05**	-49.90**
5	IS 13871 × ICSB 480	106.47**	42.93**	-29.95**	35.93**	27.12*	-2.08	24.71**	-1.66	-14.61**
6	IS 13871 × Parbhani Moti	192.82**	144.40**	-31.19**	52.03**	47.04**	13.26	36.45**	18.27*	-19.22**
7	IS 13871 × NSSV 13	-32.16*	-54.80**	-74.38**	18.51	17.53	-7.95	-17.12*	-35.14**	-42.51**
8	IS 22670 × PMS 90 B	-25.60**	-33.54**	-42.91**	-10.38	-18.03*	-7.50	-13.17*	-20.00**	-29.49**
9	IS 22670 × ICSB 323	149.88**	61.39**	9.06	32.02**	27.87**	19.66*	5.42	-2.27	-27.41**
10	IS 22670 × ICSB 351	108.05**	89.38**	27.97**	9.32	4.58	7.16	11.56	10.57	-16.38**
11	IS 22670 × ICSB 374	42.70**	12.32	-24.10**	7.79	2.75	6.06	5.32	3.44	-23.17**
12	IS 22670 × ICSB 480	-28.18**	-38.05**	-58.14**	1.38	-12.99	-18.58*	-13.00	-19.28**	-29.91**
13	IS 22670 × Parbhani Moti	29.99*	-7.92	-37.78**	11.96	-0.97	-7.33	31.01**	25.74**	-6.60
14	IS 22670 × NSSV 13	-43.97**	-48.49**	-65.19**	18.67	8.99	1.99	-36.68**	-41.8**	-48.42**
15	ICSV 25333 × PMS 90 B	-50.24**	-59.37**	-65.10**	-1.89	-9.20	2.46	-28.70**	-33.01**	-40.96**
16	ICSV 25333 × ICSB 323	11.89	-23.78*	-58.54**	28.66**	23.08*	18.18*	-3.98	-12.68	-32.34**
17	ICSV 25333 × ICSB 351	53.52**	52.06**	-15.69**	-15.08	-17.74*	-15.72	12.62	11.26	-13.78*
18	ICSV 25333 × ICSB 374	-6.37	-19.80	-56.37**	31.56**	26.97**	31.06**	-24.41**	-27.27**	-43.64**
19	ICSV 25333 × ICSB 480	171.63**	158.19**	40.44**	31.36**	11.54	7.10	34.94**	27.68**	10.86*
20	ICSV 25333 × Parbhani Moti	44.81**	9.89	-40.23**	18.8	3.92	-0.21	-0.89	-6.77	-27.75**

Table 5a (conti….)

21	ICSV 25333 × NSSV 13	-31.31**	-32.70**	-61.85**	24.17*	12.72	8.24	-16.55*	-21.79**	-30.68**
22	ICSV 93046 × PMS 90B	110.21**	30.48**	12.07*	-0.95	-24.40**	-14.70	37.75**	13.12*	-0.30
23	ICSV 93046 × ICSB 323	452.94**	439.4**	11.82*	11.51	-6.48	-17.99*	48.78**	40.79**	-10.69*
24	ICSV 93046 × ICSB 351	-27.70	-50.33**	-72.46**	-15.16	-32.99**	-31.34**	-4.06	-16.12*	-36.57**
25	ICSV 93046 × ICSB 374	236.80**	158.37**	0.25	6.40	-16.19	-13.49	57.52**	41.02**	1.01
26	ICSV 93046 × ICSB 480	129.46**	63.26**	-19.99**	20.73	13.84	-23.67**	35.77**	12.15	-2.62
27	ICSV 93046 × Parbhani Moti	348.10**	289.01**	9.53	19.67	9.21	-21.40*	69.23**	54.76**	5.70
28	ICSV 93046 × NSSV 13	-19.19	-44.82**	-68.72**	40.53**	23.55*	-3.24	-15.44*	-30.71**	-38.59**
29	NTJ 2 × PMS 90 B	19.30**	13.76*	-2.29	-12.08	-23.73**	-13.94	-1.63	-2.35	-13.93*
30	NTJ 2 × ICSB 323	82.11**	14.10*	-11.11*	20.86*	17.58	3.11	44.54**	25.05**	8.62
31	NTJ 2 × ICSB 351	40.05**	19.86**	-6.62	-11.86	-20.26*	-18.30*	13.68*	6.32	-7.65
32	NTJ 2 × ICSB 374	26.41**	-5.32	-26.24**	-0.19	-10.00	-7.10	-12.43	-20.11**	-30.61**
33	NTJ 2 × ICSB 480	44.73**	17.88*	-8.16	13.65	2.76	-14.77	8.55	8.53	-5.73
34	NTJ 2 × Parbhani Moti	43.41**	-2.38	-23.95**	8.01	0.87	-16.34	9.21	-2.46	-15.27**
35	NTJ 2 × NSSV 13	-54.07**	-60.33**	-69.09**	-11.21	-13.68	-28.41**	-34.04**	-34.70**	-42.12**
36	Wray × PMS 90 B	36.11**	-13.58*	-25.77**	3.52	-10.94	0.49	22.13**	-4.83	-16.12**
37	Wray × ICSB 323	256.23**	229.64**	-23.61**	6.47	2.59	-10.04	11.04	-1.39	-37.45**
38	Wray × ICSB 351	64.90**	16.91	-35.18**	11.31	-0.18	2.27	39.02**	14.76*	-13.22*
39	Wray × ICSB 374	101.70**	61.08**	-37.50**	29.73**	15.96	19.70*	38.52**	16.86*	-16.30**
40	Wray × ICSB 480	68.54**	24.12*	-39.17**	14.64	4.59	-14.96	15.02	-9.89	-21.76**
41	Wray × Parbhani Moti	139.90**	118.68**	-38.43**	13.43	6.92	-13.07	26.23**	8.61	-25.82**
42	Wray × NSSV 13	-34.44*	-53.82**	-73.82**	23.64*	21.36*	-1.33	-6.83	-27.54**	-35.78**
43	SPSSV 30 × PMS 90B	-69.31**	-80.55**	-83.29**	-11.21	-24.47**	-14.77	-35.67**	-43.45**	-50.15**
44	SPSSV 30 × ICSB 323	342.98**	311.44**	-5.41	3.20	-1.84	-13.92	31.45**	28.11**	-14.38**

Table 5a (conti….)

45	SPSSV 30 × ICSB 351	179.53**	97.71**	9.62	22.76*	8.78	11.46	36.86**	28.90**	-2.52
46	SPSSV 30 × ICSB 374	225.39**	159.09**	0.53	4.23	-7.93	-4.97	33.34**	28.87**	-7.70
47	SPSSV 30 × ICSB 480	142.03**	77.78**	-12.87*	19.20	10.10	-12.88	9.95	-2.72	-15.53**
48	SPSSV 30 × Parbhani Moti	263.94**	230.55**	-6.93	31.11**	25.18*	-0.95	32.78**	31.35**	-10.29
49	SPSSV 30 × NSSV 13	38.17**	-2.89	-44.96**	23.37*	22.74*	-2.88	1.04	-11.39	-21.46**
	S.Em.±	0.67	0.78	0.78	3.05	3.52	3.52	0.35	0.41	0.41
	CD at 5%	1.88	2.18	2.18	8.54	9.87	9.87	0.99	1.15	1.15
	CD at 1%	2.49	2.87	2.87	11.29	13.04	13.04	1.31	1.52	1.52

MP: Mid Parent, BP: Better Parent, SC: Standard Check (CSH22SS), *significant at 5% probability, **significant at 1% probability

Table 5a (conti....)

S.No.	Crosses	Grain yield (t ha^{-1})			1000-seed weight (g)		
		Magnitude of heterosis (%)			Magnitude of heterosis (%)		
		MP	BP	SC	MP	BP	SC
1	IS 13871 × PMS 90 B	194.39**	66.74**	-3.15	38.08**	30.98**	13.81
2	IS 13871 × ICSB 323	747.30**	570.31**	-48.30**	48.19**	17.66*	2.24
3	IS 13871 × ICSB 351	107.77**	17.48	-30.78**	10.45	1.79	-11.55
4	IS 13871 × ICSB 374	24.03	-15.58	-81.97**	2.64	-4.91	-17.37*
5	IS 13871 × ICSB 480	124.18**	30.44**	-38.55**	17.40	-7.57	-19.68**
6	IS 13871 × Parbhani Moti	387.96**	220.77**	-21.39**	21.72*	19.48*	3.82
7	IS 13871 × NSSV 13	-60.28**	-77.11**	-88.42**	-11.64	-15.45	-26.53**
8	IS 22670 × PMS 90 B	-44.34**	-53.89**	-59.22**	7.16	2.01	-12.02
9	IS 22670 × ICSB 323	49.59**	-21.41**	-30.50**	24.62*	-0.78	-14.42*
10	IS 22670 × ICSB 351	98.38**	65.27**	46.15**	9.49	1.25	-12.67
11	IS 22670 × ICSB 374	45.41**	-9.74	-20.18**	1.22	-5.90	-18.84*
12	IS 22670 × ICSB 480	-64.32**	-72.65**	-75.82**	16.90	-7.71	-20.40**
13	IS 22670 × Parbhani Moti	-17.68	-47.44**	-53.52**	26.88**	25.00**	7.81
14	IS 22670 × NSSV 13	-79.45**	-83.85**	-85.72**	-42.06**	-44.36**	-52.01**
15	ICSV 25333 × PMS 90 B	-54.34**	-63.92**	-79.05**	-17.77*	-24.16**	-30.01**
16	ICSV 25333 × ICSB 323	6.60	-39.60*	-79.64**	-13.94	-33.15**	-38.31**
17	ICSV 25333 × ICSB 351	115.80**	69.65**	-0.05	-0.49	-10.74	-17.63*
18	ICSV 25333 × ICSB 374	-8.99	-25.68	-74.94**	-43.34**	-48.92**	-52.86**
19	ICSV 25333 × ICSB 480	220.99**	175.36**	29.72**	0.57	-22.51**	-28.49**
20	ICSV 25333 × Parbhani Moti	76.46**	52.37**	-48.63**	-25.20**	-28.68**	-34.19**

Table 5a (conti….)

21	ICSV 25333 × NSSV 13	-36.24**	-46.88**	-73.12**	-60.22**	-62.99**	-65.85**
22	ICSV 93046 × PMS 90B	158.33**	60.39**	-6.84	-3.42	-6.54	-22.11**
23	ICSV 93046 × ICSB 323	1020.42**	639.39**	3.82	31.03**	5.68	-11.93
24	ICSV 93046 × ICSB 351	-25.75	-54.03**	-72.91**	-12.80	-18.07*	-31.72**
25	ICSV 93046 × ICSB 374	394.75**	310.05**	-12.45*	7.40	1.46	-15.45*
26	ICSV 93046 × ICSB 480	66.08**	7.79	-49.22**	32.11**	5.63	-11.97
27	ICSV 93046 × Parbhani Moti	356.70**	259.18**	-11.97*	19.16*	18.90*	-0.49
28	ICSV 93046 × NSSV 13	-18.87	-48.18**	-73.78**	-2.84	-5.12	-20.93**
29	NTJ 2 × PMS 90 B	80.79**	57.92**	22.78**	-1.45	-16.58*	-6.17
30	NTJ 2 × ICSB 323	91.71**	1.39	-21.17**	15.53	-16.00*	-5.51
31	NTJ 2 × ICSB 351	126.85**	99.37**	55.01**	-9.18	-25.01**	-15.65*
32	NTJ 2 × ICSB 374	12.37	-28.39**	-44.32**	1.98	-15.41*	-4.86
33	NTJ 2 × ICSB 480	48.03**	18.86**	-7.59	2.47	-26.02**	-16.79*
34	NTJ 2 × Parbhani Moti	60.76**	5.72	-17.80**	-9.64	-21.20**	-11.37
35	NTJ 2 × NSSV 13	-72.27**	-77.11**	-82.21**	0.60	-14.19*	-3.47
36	Wray × PMS 90 B	129.81**	61.02**	-6.48	6.57	-12.38	-31.70**
37	Wray × ICSB 323	575.79**	302.99**	-6.06	61.33**	59.98**	-18.27*
38	Wray × ICSB 351	59.75**	11.48	-34.32**	22.29	3.07	-24.49**
39	Wray × ICSB 374	187.82**	175.73**	-35.73**	6.46	-10.69	-33.81**
40	Wray × ICSB 480	79.95**	34.50**	-36.64**	30.86*	30.46*	-34.47**
41	Wray × Parbhani Moti	163.90**	157.45**	-36.90**	29.62**	3.71	-13.20
42	Wray × NSSV 13	-80.77**	-85.95**	-92.89**	21.78	-0.60	-21.06**
43	SPSSV 30 × PMS 90B	-75.59**	-81.36**	-89.17**	20.23	2.09	-20.42**
44	SPSSV 30 × ICSB 323	482.91**	234.19**	2.34	27.70*	23.79	-32.63**

Table 5a (conti….)

45	SPSSV 30 × ICSB 351	169.73**	104.97**	20.76**	32.19**	15.19	-15.61*
46	SPSSV 30 × ICSB 374	53.52**	30.28	-60.10**	-12.59	-24.19*	-43.82**
47	SPSSV 30 × ICSB 480	179.04**	130.22**	8.45	57.90**	51.38**	-17.61*
48	SPSSV 30 × Parbhani Moti	274.10**	236.75**	3.13	20.58	-0.50	-16.73*
49	SPSSV 30 × NSSV 13	39.75**	12.16	-43.25**	2.31	-13.79	-31.53**
	S.Em.±	0.35	0.40	0.40	2.79	3.22	3.22
	CD at 5%	0.97	1.12	1.12	7.81	9.02	9.02
	CD at 1%	1.29	1.48	1.48	10.32	11.92	11.92

MP: Mid Parent, BP: Better Parent, SC: Standard Check (CSH22SS), *significant at 5% probability, **significant at 1% probability

Table 5b. Magnitude of heterosis (%) over mid parent, better parent and standard check for stalk sugar related traits, yield and yield components in sweet sorghum crosses evaluated at ICRISAT

S.No.	Crosses	DFL			Plant height (m)			Stem thickness (mm)		
		Magnitude of heterosis (%)			Magnitude of heterosis (%)			Magnitude of heterosis (%)		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1	IS 13871 × PMS 90 B	-7.47*	-14.29**	-28.36**	23.44**	8.22	-24.76**	12.01*	5.63	-2.35
2	IS 13871 × ICSB 323	-14.05**	-29.01**	-22.39**	-2.10	-4.11	-33.33**	-0.01	-8.53	-9.69*
3	IS 13871 × ICSB 351	-1.05	-1.05	-29.48**	18.33**	-2.74	-32.38**	2.44	-3.12	-11.00*
4	IS 13871 × ICSB 374	8.38*	8.38*	-22.76**	18.18**	6.85	-25.71**	7.88	6.98	-12.38**
5	IS 13871 × ICSB 480	-9.22*	-15.38**	-30.22**	7.14	2.74	-28.57**	16.75**	9.77	-10.10*
6	IS 13871 × Parbhani Moti	-20.43**	-31.97**	-31.72**	-12.22**	-26.17**	-24.76**	6.32	1.65	-8.72*
7	IS 13871 × NSSV 13	0.00	-13.41**	-15.67**	25.00**	10.53*	0.00	13.89**	2.70	4.68
8	IS 22670 × PMS 90 B	11.55**	-6.36**	15.30**	20.21**	-15.94**	10.48**	12.36**	-0.47	19.23**
9	IS 22670 × ICSB 323	0.48	-5.15*	16.79**	7.69	-18.84**	6.67	8.08*	-1.42	18.09**
10	IS 22670 × ICSB 351	25.14**	-1.21	21.64**	32.97**	-10.87**	17.14**	19.24**	5.34	26.19**
11	IS 22670 × ICSB 374	35.89**	7.27**	32.09**	30.96**	-6.52*	22.86**	33.24**	11.41**	33.46**
12	IS 22670 × ICSB 480	11.43**	-6.97**	14.55**	-7.12	-31.01**	-9.33*	24.31**	-0.43	19.28**
13	IS 22670 × Parbhani Moti	8.85**	-1.21	21.64**	12.65**	0.00	31.43**	5.56	-7.65*	10.63*
14	IS 22670 × NSSV 13	28.60**	15.15**	41.79**	16.74**	-1.45	29.52**	15.18**	6.59	27.69**
15	ICSV 25333 × PMS 90 B	24.53**	0.27	37.31**	38.54**	-2.92	26.67**	40.54**	31.54**	39.46**
16	ICSV 25333 × ICSB 323	14.55**	3.00	41.04**	39.13**	5.11	37.14**	33.52**	28.93**	36.69**
17	ICSV 25333 × ICSB 351	38.35**	5.18*	44.03**	53.26**	2.92	34.29**	31.10**	22.35**	29.71**
18	ICSV 25333 × ICSB 374	46.95**	11.72**	52.99**	52.04**	8.76**	41.90**	43.16**	25.95**	33.54**
19	ICSV 25333 × ICSB 480	29.25**	3.54	41.79**	35.29**	0.73	31.43**	37.19**	15.25**	22.19**
20	ICSV 25333 × Parbhani Moti	15.09**	-0.27	36.57**	-11.48**	-21.17**	2.86	11.95**	3.38	9.61*

Table 5b (conti….)

21	ICSV 25333 × NSSV 13	31.85**	12.81**	54.48**	3.45	-12.41**	14.29**	35.00**	32.40**	40.37**
22	ICSV 93046 × PMS 90B	-1.97	-12.32**	-7.09*	8.86	-16.50**	-18.10**	15.38**	14.28**	7.69
23	ICSV 93046 × ICSB 323	-19.93**	-21.16**	-13.81**	6.36	-10.68**	-12.38**	6.27	3.86	2.54
24	ICSV 93046 × ICSB 351	-9.05**	-23.94**	-19.40**	16.00**	-15.53**	-17.14**	9.44*	8.06	1.84
25	ICSV 93046 × ICSB 374	17.47**	-1.76	4.10	20.99**	-4.85	-6.67	7.66	-0.17	-5.92
26	ICSV 93046 × ICSB 480	-6.93*	-17.25**	-12.31**	10.59*	-8.74*	-10.48**	6.39	-6.11	-11.51**
27	ICSV 93046 × Parbhani Moti	-11.03**	-13.38**	-8.21**	-1.90	-3.74	-1.90	5.16	2.68	-3.23
28	ICSV 93046 × NSSV 13	-0.55	-4.58	1.12	3.03	-0.97	-2.86	13.04**	8.77*	10.88*
29	NTJ 2 × PMS 90 B	-0.59	-10.95**	-5.97*	34.29**	10.59*	-10.48**	11.37**	2.74	12.40**
30	NTJ 2 × ICSB 323	-22.57**	-23.89**	-16.79**	22.58**	11.76*	-9.52*	2.17	-2.82	6.32
31	NTJ 2 × ICSB 351	-5.49	-20.85**	-16.42**	46.97**	14.12**	-7.62	13.29**	4.21	14.01**
32	NTJ 2 × ICSB 374	-2.95	-18.73**	-14.18**	36.11**	15.29**	-6.67	18.00**	2.43	12.07**
33	NTJ 2 × ICSB 480	3.17	-8.13**	-2.99	35.53**	21.18**	-1.90	8.87	-9.69*	-1.19
34	NTJ 2 × Parbhani Moti	3.26	0.71	6.34*	40.63**	26.17**	28.57**	20.29**	9.52*	19.81**
35	NTJ 2 × NSSV 13	6.25*	2.12	7.84**	14.44**	8.42	-1.90	2.10	-1.39	7.88
36	Wray × PMS 90 B	-8.14*	-9.38**	-24.25**	26.80**	-1.02	-7.62	1.81	-3.28	-10.59*
37	Wray × ICSB 323	-13.89**	-24.91**	-17.91**	16.67**	0.00	-6.67	3.54	-4.60	-5.81
38	Wray × ICSB 351	-6.60	-12.39**	-28.73**	26.90**	-6.12	-12.38**	7.52	2.45	-5.88
39	Wray × ICSB 374	-5.13	-11.01**	-27.61**	21.02**	-3.06	-9.52*	11.46*	9.67	-8.75*
40	Wray × ICSB 480	-11.16**	-11.76**	-27.24**	10.30*	-7.14	-13.33**	21.92**	13.80**	-5.32
41	Wray × Parbhani Moti	-9.24**	-17.84**	-17.54**	-4.39	-8.41*	-6.67	14.51**	10.30*	-0.95
42	Wray × NSSV 13	-0.63	-8.81**	-11.19**	17.10**	15.31**	7.62	21.53**	10.36*	12.50**
43	SPSSV 30 × PMS 90B	-4.61	-7.59*	-22.76**	31.13**	3.12	-5.71	9.60	6.11	-1.91
44	SPSSV 30 × ICSB 323	-9.34**	-22.18**	-14.93**	15.66**	0.00	-8.57*	5.45	-1.06	-2.31
45	SPSSV 30 × ICSB 351	0.25	-4.29	-25.00**	35.66**	1.04	-7.62	4.14	1.13	-7.10

Table 5b (conti….)

46	SPSSV 30 × ICSB 374	8.23*	3.33	-19.03**	20.00**	-3.12	-11.43**	14.32**	10.34*	-4.49
47	SPSSV 30 × ICSB 480	-2.09	-4.52	-21.27**	19.02**	1.04	-7.62	21.30**	11.18*	-3.77
48	SPSSV 30 × Parbhani Moti	-11.06**	-20.82**	-20.52**	9.36*	3.74	5.71	11.04*	9.03	-2.09
49	SPSSV 30 × NSSV 13	-10.83**	-19.54**	-21.64**	17.28**	16.67**	6.67	7.81	-0.33	1.60
	S.Em.±	3.00	3.47	3.47	0.17	0.20	0.20	1.16	1.34	1.34
	CD at 5%	8.41	9.71	9.71	0.48	0.55	0.55	3.24	3.74	3.74
	CD at 1%	11.11	12.83	12.83	0.63	0.73	0.73	4.29	4.95	4.95

MP: Mid Parent, BP: Better Parent, SC: Standard Check (CSH22SS), DFL: days to 50% flowering, *significant at 5% probability, **significant at 1% probability

Table 5b (conti....)

S.No.	Crosses	Stalk yield (t ha^{-1}) Magnitude of heterosis (%)			Juice yield (t ha^{-1}) Magnitude of heterosis (%)			Juice volume (L ha^{-1}) Magnitude of heterosis (%)		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1	IS 13871 × PMS 90 B	100.41**	92.10**	-41.65**	108.66**	69.86**	-59.01**	109.17**	70.29**	-59.12**
2	IS 13871 × ICSB 323	5.24	-28.60**	-44.27**	-28.83*	-57.42**	-67.15**	-30.15**	-58.25**	-67.77**
3	IS 13871 × ICSB 351	39.51	23.49	-65.60**	46.24	29.74	-80.33**	46.50	29.65	-80.45**
4	IS 13871 × ICSB 374	50.56**	48.46**	-57.46**	49.86	18.48	-69.10**	47.35	16.55	-69.79**
5	IS 13871 × ICSB 480	21.34	4.06	-59.47**	16.20	-14.66	-72.41**	16.05	-14.86	-72.53**
6	IS 13871 × Parbhani Moti	-27.74**	-52.37**	-58.32**	-43.44**	-66.39**	-72.96**	-43.55**	-66.46**	-73.11**
7	IS 13871 × NSSV 13	72.21**	14.23*	-2.59	54.04**	-9.07	-23.67**	53.56**	-9.42	-23.97**
8	IS 22670 × PMS 90 B	156.08**	64.36**	75.97**	194.33**	101.08**	32.47**	194.16**	100.69**	32.18**
9	IS 22670 × ICSB 323	31.32**	13.53**	21.55**	20.65**	11.84	-13.72**	20.22**	11.39	-14.00**
10	IS 22670 × ICSB 351	137.32**	42.44**	52.50**	151.02**	47.87**	-2.59	151.10**	47.69**	-2.73
11	IS 22670 × ICSB 374	198.85**	89.42**	102.79**	208.20**	115.10**	41.70**	207.77**	114.44**	41.23**
12	IS 22670 × ICSB 480	-21.27**	-46.31**	-42.52**	-68.34**	-76.40**	-84.45**	-68.76**	-76.73**	-84.67**
13	IS 22670 × Parbhani Moti	60.62**	45.95**	56.26**	41.85**	28.98**	3.79	41.50**	28.86**	3.33
14	IS 22670 × NSSV 13	58.70**	42.56**	52.63**	53.57**	37.04**	15.04**	53.40**	36.88**	14.90**
15	ICSV 25333 × PMS 90 B	197.36**	90.85**	104.36**	194.03**	101.30**	31.58**	194.89**	101.67**	31.64**
16	ICSV 25333 × ICSB 323	83.35**	58.49**	69.71**	52.03**	40.42**	8.33	51.73**	40.01**	8.09
17	ICSV 25333 × ICSB 351	167.64**	60.64**	72.01**	145.57**	44.83**	-5.33	145.81**	44.77**	-5.50
18	ICSV 25333 × ICSB 374	163.01**	66.69**	78.49**	130.87**	61.49**	5.56	131.45**	61.67**	5.53
19	ICSV 25333 × ICSB 480	110.50**	43.53**	53.69**	80.87**	35.17**	-11.65*	81.12**	35.32**	-11.67*
20	ICSV 25333 × Parbhani Moti	-28.75**	-35.26**	-30.68**	-46.91**	-51.90**	-61.29**	-46.95**	-51.88**	-61.42**

Table 5b (conti….)

21	ICSV 25333 × NSSV 13	68.33**	51.20**	61.90**	50.45**	33.80**	12.32*	49.91**	33.24**	11.85*
22	ICSV 93046 × PMS 90B	119.25**	53.6**	16.3**	108.37**	35.59**	8.56	108.39**	35.43**	8.46
23	ICSV 93046 × ICSB 323	18.00**	16.24*	-9.27	23.81**	21.55**	-2.68	23.74**	21.51**	-2.69
24	ICSV 93046 × ICSB 351	25.02*	-19.78**	-39.25**	-8.30	-47.43**	-57.91**	-9.48	-48.18**	-58.5**
25	ICSV 93046 × ICSB 374	55.85**	7.42	-18.67**	89.31**	25.49**	0.47	88.24**	24.57**	-0.23
26	ICSV 93046 × ICSB 480	42.93**	8.22	-18.05**	49.79**	5.15	-15.82**	49.98**	5.21	-15.74**
27	ICSV 93046 × Parbhani Moti	18.59**	10.60	-3.22	18.10**	17.8**	-5.21	18.37**	18.30**	-5.14
28	ICSV 93046 × NSSV 13	77.87**	67.9**	43.19**	52.7**	49.17**	25.22**	51.82**	48.33**	24.51**
29	NTJ 2 × PMS 90 B	115.42**	42.91**	32.82**	118.1**	36.72**	30.07**	118.28**	36.65**	30.15**
30	NTJ 2 × ICSB 323	38.69**	27.58**	18.57**	36.55**	23.64**	17.63**	36.51**	23.58**	17.71**
31	NTJ 2 × ICSB 351	84.69**	13.66*	5.64	45.94**	-18.03**	-22.01**	45.72**	-18.26**	-22.14**
32	NTJ 2 × ICSB 374	103.47**	33.10**	23.7**	113.27**	35.87**	29.27**	113.32**	35.68**	29.23**
33	NTJ 2 × ICSB 480	52.99**	8.55	0.88	58.48**	6.17	1.01	58.50**	6.10	1.05
34	NTJ 2 × Parbhani Moti	126.31**	119.7**	104.19**	126.40**	108.95**	98.80**	125.26**	107.45**	97.58**
35	NTJ 2 × NSSV 13	36.04**	30.44**	21.23**	17.81**	10.88*	5.49	17.40**	10.43	5.18
36	Wray × PMS 90 B	100.8**	60.29**	-18.39**	126.31**	66.96**	-15.25**	126.38**	66.74**	-15.39**
37	Wray × ICSB 323	44.13**	19.07**	-7.07	38.68**	14.96*	-11.31*	38.39**	14.67*	-11.47*
38	Wray × ICSB 351	33.31*	-5.25	-51.76**	15.66	-28.8**	-63.86**	15.86	-28.81**	-63.88**
39	Wray × ICSB 374	87.02**	46.14**	-25.6**	95.74**	48.15**	-24.80**	95.85**	47.94**	-24.93**
40	Wray × ICSB 480	66.39**	46.84**	-25.24**	88.45**	54.25**	-21.71**	88.54**	54.22**	-21.75**
41	Wray × Parbhani Moti	43.60**	13.57*	-0.61	50.47**	22.69**	-1.27	50.70**	23.03**	-1.35
42	Wray × NSSV 13	91.49**	52.90**	30.39**	91.72**	53.82**	29.13**	91.75**	53.83**	29.13**
43	SPSSV 30 × PMS 90B	56.14**	18.20*	-30.15**	66.55**	18.17*	-31.94**	66.59**	18.06*	-32.09**
44	SPSSV 30 × ICSB 323	4.08	-8.55	-28.63**	2.12	-10.82	-31.2**	1.96	-11.04	-31.32**

Table 5b (conti….)

45	SPSSV 30 × ICSB 351	50.78**	2.76	-39.27**	36.42*	-17.89	-52.71**	36.41*	-18.02*	-52.84**
46	SPSSV 30 × ICSB 374	72.07**	27.75**	-24.50**	78.71**	29.81**	-25.23**	78.74**	29.64**	-25.43**
47	SPSSV 30 × ICSB 480	84.30**	52.89**	-9.65	74.94**	36.57**	-21.34**	74.4**	36.12**	-21.70**
48	SPSSV 30 × Parbhani Moti	27.51**	6.81	-6.53	43.62**	23.21**	-0.86	44.05**	23.69**	-0.82
49	SPSSV 30 × NSSV 13	27.61**	8.02	-7.88	37.67**	16.06*	-2.57	37.85**	16.16*	-2.49
	S.Em.±	5.34	6.16	6.16	2.43	2.81	2.81	2414.07	2787.53	2787.53
	CD at 5%	14.94	17.25	17.25	6.81	7.86	7.86	6757.29	7802.65	7802.65
	CD at 1%	19.75	22.80	22.80	9.00	10.39	10.39	8931.27	10312.94	10312.94

MP: Mid Parent, BP: Better Parent, SC: Standard Check (CSH22SS), *significant at 5% probability, **significant at 1% probability

Table 5b (conti....)

S.No.	Crosses	Brix (%)			Bagasse yield (t ha^{-1})			Total soluble solids (%)		
		Magnitude of heterosis (%)			Magnitude of heterosis (%)			Magnitude of heterosis (%)		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1	IS 13871 × PMS 90 B	10.70	-6.43	-18.80**	97.14**	90.55**	-28.19**	10.55	-6.35	-18.60**
2	IS 13871 × ICSB 323	-5.75	-8.89	-15.29**	25.71*	-7.08	-26.80**	-5.68	-8.79	-15.13**
3	IS 13871 × ICSB 351	17.95**	9.52	-4.96	37.43	21.52	-54.20**	17.71**	9.41	-4.91
4	IS 13871 × ICSB 374	10.12	1.07	-12.29**	49.70**	35.60*	-48.90**	9.98	1.06	-12.16**
5	IS 13871 × ICSB 480	2.93	0.48	-12.81**	23.71	14.74	-49.42**	2.89	0.47	-12.67**
6	IS 13871 × Parbhani Moti	4.84	3.10	-10.54*	-20.04*	-44.16**	-46.93**	4.78	3.06	-10.43*
7	IS 13871 × NSSV 13	7.17	-1.40	1.86	79.57**	27.76**	13.84*	7.09	-1.39	1.84
8	IS 22670 × PMS 90 B	13.92**	-10.00*	-7.02	140.58**	50.67**	109.77**	13.74**	-9.90*	-6.95
9	IS 22670 × ICSB 323	1.05	-4.00	-0.83	36.38**	6.77	48.65**	1.04	-3.96	-0.82
10	IS 22670 × ICSB 351	-0.70	-14.60**	-11.78**	132.43**	40.39**	95.45**	-0.69	-14.45**	-11.65**
11	IS 22670 × ICSB 374	12.81*	-4.00	-0.83	194.46**	79.58**	150.01**	12.65*	-3.96	-0.82
12	IS 22670 × ICSB 480	-11.11*	-20.00**	-17.36**	-1.83	-35.38**	-10.03	-10.98*	-19.79**	-17.17**
13	IS 22670 × Parbhani Moti	3.75	-6.00	-2.89	68.18**	41.49**	96.99**	3.71	-5.94	-2.86
14	IS 22670 × NSSV 13	-8.00	-8.00	-4.96	59.31**	30.64**	81.88**	-7.92	-7.92	-4.91
15	ICSV 25333 × PMS 90 B	15.87**	-8.73*	-4.96	198.87**	87.07**	161.19**	15.66**	-8.64*	-4.91
16	ICSV 25333 × ICSB 323	-3.56	-8.73*	-4.96	99.18**	55.78**	117.50**	-3.53	-8.64*	-4.91
17	ICSV 25333 × ICSB 351	11.11*	-4.76	-0.83	175.61**	66.39**	132.32**	10.98*	-4.71	-0.82
18	ICSV 25333 × ICSB 374	2.92	-12.70**	-9.09*	176.60**	68.59**	135.39**	2.89	-12.57**	-8.99*
19	ICSV 25333 × ICSB 480	0.88	-9.52*	-5.79	122.80**	46.57**	104.64**	0.87	-9.43*	-5.72
20	ICSV 25333 × Parbhani Moti	-34.07**	-40.48**	-38.02**	-20.61**	-33.28**	-6.85	-33.68**	-40.06**	-37.61**

Table 5b (conti….)

21	ICSV 25333 × NSSV 13	-10.36*	-10.71*	-7.02	74.99**	43.34**	100.13**	-10.25*	-10.60*	-6.95
22	ICSV 93046 × PMS 90B	19.72**	0.23	-10.95*	127.61**	69.15**	22.32**	19.44**	0.23	-10.83*
23	ICSV 93046 × ICSB 323	0.00	-2.22	-9.09*	13.28	8.63	-14.42*	0.00	-2.20	-8.99*
24	ICSV 93046 × ICSB 351	10.13	1.16	-10.12*	47.83**	3.52	-25.15**	10.00	1.15	-10.02*
25	ICSV 93046 × ICSB 374	16.01**	5.35	-6.40	67.84**	19.42*	-13.65*	15.79**	5.28	-6.34
26	ICSV 93046 × ICSB 480	6.02	2.33	-9.09*	37.88**	10.96	-19.76**	5.95	2.30	-8.99*
27	ICSV 93046 × Parbhani Moti	2.87	0.00	-11.16*	17.51*	3.46	-1.67	2.84	0.00	-11.04*
28	ICSV 93046 × NSSV 13	19.35**	11.00**	14.67**	94.22**	75.91**	56.75**	19.14**	10.89**	14.51**
29	NTJ 2 × PMS 90 B	12.28*	-10.77*	-9.30*	113.54**	47.91**	34.99**	12.12*	-10.66*	-9.20*
30	NTJ 2 × ICSB 323	-2.34	-6.50	-4.96	40.41**	30.81**	19.38**	-2.31	-6.44	-4.91
31	NTJ 2 × ICSB 351	0.94	-12.60**	-11.16*	111.53**	39.33**	27.15**	0.93	-12.47**	-11.04*
32	NTJ 2 × ICSB 374	7.24	-8.13	-6.61	95.99**	30.84**	19.40**	7.15	-8.05	-6.54
33	NTJ 2 × ICSB 480	9.87*	-0.41	1.24	48.92**	10.42	0.78	9.75*	-0.40	1.23
34	NTJ 2 × Parbhani Moti	6.90	-2.44	-0.83	123.26**	118.82**	107.97**	6.83	-2.41	-0.82
35	NTJ 2 × NSSV 13	12.9**	12.00**	15.70**	47.88**	46.14**	33.37**	12.77**	11.88**	15.54**
36	Wray × PMS 90 B	8.97	-18.78**	-0.83	83.46**	54.91**	-20.91**	8.86	-18.62**	-0.82
37	Wray × ICSB 323	-3.17	-14.72**	4.13	47.95**	21.91**	-3.96	-3.14	-14.59**	4.09
38	Wray × ICSB 351	9.36*	-12.01**	7.44	44.05**	12.88	-42.37**	9.26*	-11.91**	7.36
39	Wray × ICSB 374	1.91	-18.78**	-0.83	80.61**	44.41**	-26.27**	1.89	-18.62**	-0.82
40	Wray × ICSB 480	0.91	-15.40**	3.31	51.32**	40.98**	-28.02**	0.90	-15.26**	3.27
41	Wray × Parbhani Moti	10.53*	-6.77	13.84**	36.84**	5.17	-0.04	10.42*	-6.71	13.70**
42	Wray × NSSV 13	-4.67	-12.01**	7.44	87.50**	47.46**	31.40**	-4.63	-11.91**	7.36
43	SPSSV 30 × PMS 90B	14.35**	-13.21**	0.41	49.39**	18.29	-28.73**	14.18**	-13.09**	0.41
44	SPSSV 30 × ICSB 323	19.60**	7.86*	24.79**	5.50	-6.90	-26.66**	19.4**	7.78*	24.53**

Table 5b (conti….)

45	SPSSV 30 × ICSB 351	16.09**	-4.64	10.33*	59.47**	18.06	-28.87**	15.91**	-4.60	10.22*
46	SPSSV 30 × ICSB 374	3.84	-15.54**	-2.27	67.23**	26.06*	-24.05**	3.80	-15.39**	-2.25
47	SPSSV 30 × ICSB 480	12.71**	-3.39	11.78**	90.11**	64.59**	-0.83	12.57**	-3.36	11.65**
48	SPSSV 30 × Parbhani Moti	12.42**	-3.04	12.19**	14.68	-6.31	-10.95	12.29**	-3.01	12.06**
49	SPSSV 30 × NSSV 13	7.55	1.79	17.77**	17.83*	-1.25	-12.00	7.47	1.77	17.58**
	S.Em.±	0.86	0.99	0.99	3.88	4.48	4.48	0.75	0.87	0.87
	CD at 5%	2.40	2.77	2.77	10.85	12.53	12.53	2.10	2.42	2.42
	CD at 1%	3.17	3.66	3.66	14.34	16.56	16.56	2.77	3.20	3.20

MP: Mid Parent, BP: Better Parent, SC: Standard Check (CSH22SS), *significant at 5% probability, **significant at 1% probability

Table 5b (conti....)

S.No.	Crosses	Total sugar index			Juice extraction (%)			Ethanol yield (L ha^{-1})		
		Magnitude of heterosis (%)			Magnitude of heterosis (%)			Magnitude of heterosis (%)		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1	IS 13871 × PMS 90 B	140.87**	127.30**	-66.58**	5.83	-10.77**	-28.83**	114.33**	78.87**	-41.82**
2	IS 13871 × ICSB 323	-35.95**	-62.18**	-72.71**	-22.78**	-39.99**	-40.73**	17.04	-15.58	-37.94**
3	IS 13871 × ICSB 351	70.21	42.00	-81.47**	5.18	5.12	-42.46**	60.62*	33.75	-56.49**
4	IS 13871 × ICSB 374	65.60	40.64	-73.73**	-0.60	-20.41**	-27.55**	63.50*	37.20	-55.37**
5	IS 13871 × ICSB 480	19.22	-11.50	-76.17**	-0.97	-17.82**	-31.80**	26.38	19.06	-56.20**
6	IS 13871 × Parbhani Moti	-40.43**	-64.44**	-76.06**	-11.46*	-29.38**	-35.06**	-15.91	-40.80**	-52.80**
7	IS 13871 × NSSV 13	53.93**	-11.46	-23.19**	2.10	-20.63**	-21.68**	95.71**	34.86**	16.01*
8	IS 22670 × PMS 90 B	196.60**	80.48**	22.28**	6.69	-5.61	-24.71**	135.27**	35.47**	94.47**
9	IS 22670 × ICSB 323	21.87**	18.14*	-14.74*	-8.64*	-25.94**	-26.85**	35.79**	2.66	47.38**
10	IS 22670 × ICSB 351	123.14**	25.93**	-14.68*	9.98	3.98	-36.18**	108.71**	20.09**	72.39**
11	IS 22670 × ICSB 374	224.01**	106.67**	40.03**	-8.18	-23.14**	-30.03**	199.33**	72.67**	147.87**
12	IS 22670 × ICSB 480	-73.35**	-81.38**	-87.38**	-62.56**	-67.43**	-72.97**	-17.97*	-48.47**	-26.03**
13	IS 22670 × Parbhani Moti	48.20**	47.75**	0.10	-13.45**	-27.84**	-33.65**	71.33**	33.25**	91.28**
14	IS 22670 × NSSV 13	40.51**	25.12**	8.55	-5.90	-23.68**	-24.69**	49.86**	19.83**	72.02**
15	ICSV 25333 × PMS 90 B	202.15**	83.72**	25.04**	-8.78	-19.29**	-35.63**	197.09**	70.79**	148.24**
16	ICSV 25333 × ICSB 323	46.38**	42.21**	2.63	-20.32**	-35.40**	-36.19**	89.05**	42.33**	106.87**
17	ICSV 25333 × ICSB 351	144.05**	37.66**	-6.31	-5.24	-10.42	-45.02**	175.86**	58.47**	130.33**
18	ICSV 25333 × ICSB 374	120.92**	40.78**	-4.19	-22.51**	-35.13**	-40.95**	155.55**	47.17**	113.91**
19	ICSV 25333 × ICSB 480	73.94**	21.38*	-17.39**	-20.50**	-30.85**	-42.61**	111.67**	32.62**	92.76**
20	ICSV 25333 × Parbhani Moti	-64.69**	-64.87**	-76.09**	-27.16**	-39.27**	-44.16**	-48.71**	-60.29**	-42.28**

Table 5b (conti….)

21	ICSV 25333 × NSSV 13	34.30**	19.83**	3.96	-13.52**	-29.86**	-30.79**	60.80**	27.98**	86.01**
22	ICSV 93046 × PMS 90B	127.24**	37.09**	-2.44	0.71	-11.64**	-6.64*	150.92**	67.79**	8.23
23	ICSV 93046 × ICSB 323	23.30**	22.44**	-11.63*	4.92	1.51	7.25*	12.71	5.81	-22.22**
24	ICSV 93046 × ICSB 351	-5.55	-46.99**	-62.27**	-13.34**	-34.25**	-30.52**	57.80**	5.38	-32.03**
25	ICSV 93046 × ICSB 374	108.21**	31.43**	-6.47	19.40**	11.14**	17.43**	79.66**	20.56	-22.24**
26	ICSV 93046 × ICSB 480	55.98**	7.50	-23.50**	9.13**	-2.58	2.93	43.74**	12.86	-27.21**
27	ICSV 93046 × Parbhani Moti	21.81**	18.53*	-15.65**	-0.75	-7.19*	-1.94	21.43*	9.83	-12.43
28	ICSV 93046 × NSSV 13	80.82**	64.57**	42.77**	-14.27**	-17.10**	-12.41**	139.11**	109.20**	79.96**
29	NTJ 2 × PMS 90 B	112.80**	22.53**	18.83**	8.32*	-3.68	-1.30	112.51**	31.13**	21.89**
30	NTJ 2 × ICSB 323	32.17**	15.27*	11.78*	-0.66	-2.46	-0.05	36.20**	21.96**	13.36
31	NTJ 2 × ICSB 351	31.02**	-28.60**	-30.76**	-5.84	-27.80**	-26.01**	96.70**	21.25**	12.71
32	NTJ 2 × ICSB 374	108.53**	24.35**	20.59**	7.54*	1.54	4.05	93.78**	19.89*	11.44
33	NTJ 2 × ICSB 480	63.92**	4.72	1.55	7.77*	-2.47	-0.06	56.50**	9.22	1.52
34	NTJ 2 × Parbhani Moti	138.44**	102.00**	95.90**	0.16	-4.99	-2.64	138.81**	121.83**	106.20**
35	NTJ 2 × NSSV 13	31.78**	24.84**	21.07**	-13.20**	-14.80**	-12.70**	71.28**	64.90**	53.27**
36	Wray × PMS 90 B	118.48**	35.22**	-16.41**	15.48**	4.02	3.52	86.27**	25.68*	-21.73**
37	Wray × ICSB 323	37.94**	28.04**	-7.59	-4.19	-4.55	-5.01	47.33**	36.07**	0.03
38	Wray × ICSB 351	10.14	-37.16**	-61.15**	-2.75	-24.66**	-25.02**	47.57**	-0.57	-38.08**
39	Wray × ICSB 374	84.92**	20.40*	-25.57**	6.36	1.82	1.33	73.34**	17.38	-26.91**
40	Wray × ICSB 480	82.39**	30.92**	-19.07**	14.89**	5.35	4.84	50.36**	19.59	-25.53**
41	Wray × Parbhani Moti	73.69**	66.57**	12.16*	3.73	-0.21	-0.69	60.26**	42.71**	13.79
42	Wray × NSSV 13	86.66**	59.83**	38.66**	0.42	0.00	-0.48	90.62**	64.31**	41.34**
43	SPSSV 30 × PMS 90B	67.17**	2.07	-32.12**	9.85**	-0.13	-2.64	55.98**	2.37	-28.72**
44	SPSSV 30 × ICSB 323	23.00**	18.17*	-14.71*	-1.90	-2.54	-3.73	27.50**	24.14*	-8.74

Table 5b (conti….)

45	SPSSV 30 × ICSB 351	38.75*	-21.52*	-47.81**	2.61	-19.92**	-21.94**	71.49**	12.40	-21.73**
46	SPSSV 30 × ICSB 374	73.82**	11.32	-25.97**	4.62	1.15	-1.39	63.22**	7.47	-25.16**
47	SPSSV 30 × ICSB 480	86.19**	30.79**	-13.02*	-3.61	-10.77**	-13.02**	108.26**	59.13**	10.82
48	SPSSV 30 × Parbhani Moti	66.27**	65.24**	11.27	12.25**	9.06**	6.32	33.83**	25.36**	-0.04
49	SPSSV 30 × NSSV 13	49.29**	31.86**	14.40*	7.69*	7.04*	5.63	33.23**	20.55*	3.69
	S.Em.±	0.47	0.54	0.54	1.76	2.03	2.03	488.97	564.61	564.61
	CD at 5%	1.32	1.52	1.52	4.92	5.68	5.68	1368.68	1580.41	1580.41
	CD at 1%	1.75	2.02	2.02	6.50	7.50	7.50	1809.01	2088.87	2088.87

MP: Mid Parent, BP: Better Parent, SC: Standard Check (CSH22SS), *significant at 5% probability, **significant at 1% probability

Table 5b (conti....)

S.No.	Crosses	Panicle weight (t ha^{-1}) Magnitude of heterosis (%)			Panicle length (cm) Magnitude of heterosis (%)			Panicle breadth (cm) Magnitude of heterosis (%)		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1	IS 13871 × PMS 90 B	-28.26**	-46.95**	-74.36**	-8.95	-10.39	-7.12	1.10	-19.16**	-44.31**
2	IS 13871 × ICSB 323	-22.56	-28.71**	-80.39**	6.12	-5.36	-5.00	-6.20	-22.80**	-50.68**
3	IS 13871 × ICSB 351	-5.05	-6.29	-78.31**	9.29	4.79	5.19	11.97	11.76	-53.87**
4	IS 13871 × ICSB 374	31.62*	14.53	-73.49**	-1.64	-5.98	-5.62	40.69**	40.20**	-41.73**
5	IS 13871 × ICSB 480	36.96**	25.12*	-64.99**	15.04*	-4.02	-3.65	-7.27	-23.32**	-51.59**
6	IS 13871 × Parbhani Moti	37.78**	19.72*	-62.45**	21.38**	1.15	1.54	-13.21*	-33.00**	-49.17**
7	IS 13871 × NSSV 13	-2.80	-26.73**	-66.60**	9.81	0.77	1.15	6.54	-20.58**	-33.23**
8	IS 22670 × PMS 90 B	-30.20**	-55.82**	-78.65**	3.70	-1.30	2.31	-14.62*	-26.65**	-49.47**
9	IS 22670 × ICSB 323	-37.31*	-54.01**	-87.35**	-3.57	-11.29	-16.92**	-14.59*	-24.23**	-51.59**
10	IS 22670 × ICSB 351	132.25**	82.33**	-58.90**	10.14	9.24	2.31	52.43**	39.57**	-30.96**
11	IS 22670 × ICSB 374	-12.50	-23.44	-86.88**	-10.90	-11.91	-17.50**	-14.65	-21.47**	-61.15**
12	IS 22670 × ICSB 480	10.90	-19.08	-77.36**	2.85	-11.72	-17.33**	-8.28	-18.20**	-48.36**
13	IS 22670 × Parbhani Moti	14.75	-19.12*	-74.63**	15.21*	-1.23	-7.50	-6.30	-22.60**	-41.27**
14	IS 22670 × NSSV 13	-56.01**	-71.81**	-87.15**	11.59	5.75	-0.96	-27.05**	-42.06**	-51.29**
15	ICSV 25333 × PMS 90 B	3.20	-10.66	-56.83**	28.83**	25.60**	30.19**	-1.44	-7.69	-27.16**
16	ICSV 25333 × ICSB 323	-3.73	-14.39	-69.75**	32.79**	19.43**	17.60**	-23.49**	-30.77**	-45.37**
17	ICSV 25333 × ICSB 351	32.18**	8.24	-61.75**	8.38	4.88	3.27	13.65*	-13.56**	-31.79**
18	ICSV 25333 × ICSB 374	67.60**	24.43**	-56.02**	56.88**	51.37**	49.04**	22.43**	-6.54	-26.25**
19	ICSV 25333 × ICSB 480	18.60*	6.25	-62.45**	22.42**	2.93	1.35	8.01	-2.79	-23.29**
20	ICSV 25333 × Parbhani Moti	-51.23**	-53.98**	-83.73**	54.88**	30.08**	28.08**	-25.33**	-26.77**	-42.22**

Table 5b (conti….)

21	ICSV 25333 × NSSV 13	-55.33**	-60.35**	-81.93**	21.52**	12.50*	10.77	-23.85**	-26.19**	-37.95**
22	ICSV 93046 × PMS 90B	68.13**	19.67**	-42.17**	5.98	-16.14**	-13.08*	48.69**	31.50**	-9.41*
23	ICSV 93046 × ICSB 323	173.74**	138.69**	-34.34**	27.80**	12.96	-11.15	43.38**	31.12**	-16.24**
24	ICSV 93046 × ICSB 351	143.27**	132.07**	-47.69**	24.08**	2.71	-5.39	55.32**	37.97**	-26.93**
25	ICSV 93046 × ICSB 374	21.05	11.20	-77.24**	-5.82	-21.85**	-28.46**	-6.24	-16.33*	-55.69**
26	ICSV 93046 × ICSB 480	146.77**	113.64**	-40.23**	16.14	10.32	-25.96**	51.63**	39.42**	-11.99**
27	ICSV 93046 × Parbhani Moti	141.76**	99.75**	-37.35**	23.87**	17.82*	-21.15**	32.63**	12.60**	-14.57**
28	ICSV 93046 × NSSV 13	9.45	-20.70**	-63.86**	5.01	-9.68	-24.27**	-3.79	-21.59**	-34.08**
29	NTJ 2 × PMS 90 B	141.40**	86.57**	-9.84**	22.48**	4.64	8.46	62.60**	51.32**	4.25
30	NTJ 2 × ICSB 323	82.86**	79.08**	-50.74**	28.95**	24.69**	-1.92	36.21**	31.35**	-16.08**
31	NTJ 2 × ICSB 351	45.88**	35.28**	-64.32**	16.84*	5.01	-3.27	11.78	-5.37	-43.85**
32	NTJ 2 × ICSB 374	166.46**	119.80**	-42.03**	15.62*	4.20	-4.62	59.12**	35.29**	-19.73**
33	NTJ 2 × ICSB 480	136.21**	129.43**	-35.81**	20.38*	15.18	-15.38**	50.19**	45.67**	-8.04*
34	NTJ 2 × Parbhani Moti	-15.13	-21.89*	-75.50**	6.86	2.10	-24.99**	-1.64	-12.36*	-33.51**
35	NTJ 2 × NSSV 13	-55.63**	-64.98**	-84.04**	-16.75*	-21.90**	-34.52**	-31.75**	-41.79**	-51.06**
36	Wray × PMS 90 B	46.37**	6.02	-48.76**	23.30**	9.46	13.46*	18.26**	3.41	-28.76**
37	Wray × ICSB 323	17.28	4.87	-71.15**	17.53*	16.27*	-6.54	2.23	-7.60	-40.97**
38	Wray × ICSB 351	72.83**	69.56**	-61.78**	22.63**	14.82*	5.77	-3.76	-13.53	-55.39**
39	Wray × ICSB 374	78.97**	60.19**	-65.26**	26.85**	19.12**	9.04	37.16**	23.82**	-36.12**
40	Wray × ICSB 480	112.40**	88.52**	-47.26**	39.50**	27.99**	2.88	17.72**	6.97	-32.47**
41	Wray × Parbhani Moti	37.02**	15.88	-63.65**	20.10*	10.05	-11.54*	5.95	-11.00*	-32.47**
42	Wray × NSSV 13	46.47**	8.08	-50.74**	19.44**	16.97*	-1.92	7.38	-13.36**	-27.16**
43	SPSSV 30 × PMS 90B	0.39	-29.78**	-66.06**	11.27*	7.45	11.38*	12.97	-15.40**	-41.71**
44	SPSSV 30 × ICSB 323	-17.02	-29.44**	-80.59**	-13.72*	-21.71**	-24.42**	6.46	-18.19**	-47.74**

Table 5b (conti….)

45	SPSSV 30 × ICSB 351	28.05	18.78	-73.23**	0.71	-1.59	-5.00	54.53**	41.70**	-41.73**
46	SPSSV 30 × ICSB 374	8.46	2.43	-80.25**	-20.45**	-22.51**	-25.19**	44.03**	31.43**	-45.37**
47	SPSSV 30 × ICSB 480	64.02**	38.52**	-61.24**	31.61**	11.55	7.69	51.09**	16.59**	-26.40**
48	SPSSV 30 × Parbhani Moti	120.99**	78.41**	-44.04**	27.29**	7.77	4.04	37.19**	-0.40	-24.43**
49	SPSSV 30 × NSSV 13	73.37**	23.35**	-43.78**	3.84	-2.99	-6.35	28.21**	-9.75*	-24.13**
	S.Em.±	0.54	0.62	0.62	2.01	2.32	2.32	0.33	0.38	0.38
	CD at 5%	1.50	1.74	1.74	5.62	6.49	6.49	0.91	1.05	1.05
	CD at 1%	1.99	2.30	2.30	7.43	8.58	8.58	1.21	1.39	1.39

MP: Mid Parent, BP: Better Parent, SC: Standard Check (CSH22SS), *significant at 5% probability, **significant at 1% probability

Table 5b (conti....)

S.No.	Crosses	Grain yield (t ha^{-1}) Magnitude of heterosis (%)			1000-seed weight (g) Magnitude of heterosis (%)		
		MP	BP	SC	MP	BP	SC
1	IS 13871 × PMS 90 B	-28.62**	-48.32**	-78.09**	20.09**	11.75	1.26
2	IS 13871 × ICSB 323	-36.60**	-37.68**	-88.16**	20.08*	16.10*	-9.41
3	IS 13871 × ICSB 351	5.96	-1.06	-81.20**	12.73	12.61	-12.14*
4	IS 13871 × ICSB 374	10.46	-2.56	-81.49**	17.52*	15.96*	-7.06
5	IS 13871 × ICSB 480	67.37**	55.65**	-65.62**	6.72	5.75	-17.49**
6	IS 13871 × Parbhani Moti	47.18**	23.57**	-65.44**	18.14*	16.75*	-6.71
7	IS 13871 × NSSV 13	-13.10*	-37.68**	-72.74**	18.77*	17.32*	-6.17
8	IS 22670 × PMS 90 B	-41.73**	-67.44**	-86.19**	-8.85	-24.63**	-31.70**
9	IS 22670 × ICSB 323	-41.22*	-62.62**	-93.14**	-6.88	-15.58	-38.49**
10	IS 22670 × ICSB 351	231.95**	116.22**	-64.37**	-14.28	-24.53**	-41.23**
11	IS 22670 × ICSB 374	-50.68*	-66.87**	-95.19**	-9.84	-21.60**	-37.16**
12	IS 22670 × ICSB 480	-31.13*	-57.79**	-90.68**	21.44*	7.69	-17.51**
13	IS 22670 × Parbhani Moti	7.03	-36.94**	-82.36**	15.65	0.70	-19.53**
14	IS 22670 × NSSV 13	-75.87**	-86.56**	-94.12**	-26.60**	-36.11**	-48.91**
15	ICSV 25333 × PMS 90 B	-23.87**	-50.42**	-78.98**	-11.53	-32.92**	-39.22**
16	ICSV 25333 × ICSB 323	-70.86**	-75.24**	-95.46**	17.34	-3.65	-29.80**
17	ICSV 25333 × ICSB 351	-3.34	-14.05	-85.84**	-34.19**	-47.32**	-58.98**
18	ICSV 25333 × ICSB 374	53.75**	44.79**	-78.98**	-30.78**	-45.18**	-56.06**
19	ICSV 25333 × ICSB 480	-15.31	-33.06**	-85.21**	-8.14	-26.01**	-43.32**
20	ICSV 25333 × Parbhani Moti	-92.14**	-94.27**	-98.40**	-30.82**	-45.15**	-56.17**

Table 5b (conti….)

21	ICSV 25333 × NSSV 13	-73.07**	-82.59**	-92.38**	-47.65**	-58.51**	-66.82**
22	ICSV 93046 × PMS 90B	81.94**	18.49**	-49.76**	19.04*	0.19	-9.21
23	ICSV 93046 × ICSB 323	290.14**	231.43**	-39.18**	30.24**	20.46*	-12.23*
24	ICSV 93046 × ICSB 351	190.65**	158.45**	-57.41**	31.39**	17.93*	-8.17
25	ICSV 93046 × ICSB 374	38.11*	30.06*	-81.12**	-3.39	-14.38	-31.37**
26	ICSV 93046 × ICSB 480	215.69**	149.50**	-44.88**	18.90*	7.50	-17.65**
27	ICSV 93046 × Parbhani Moti	180.79**	104.78**	-42.72**	23.04**	9.19	-12.75*
28	ICSV 93046 × NSSV 13	-16.38*	-45.93**	-76.35**	1.51	-9.95	-27.98**
29	NTJ 2 × PMS 90 B	159.87**	103.36**	-13.77**	28.54**	28.13**	16.85**
30	NTJ 2 × ICSB 323	119.68**	93.96**	-53.52**	25.51**	12.89*	2.95
31	NTJ 2 × ICSB 351	30.84**	10.41	-73.54**	22.80**	13.82*	3.81
32	NTJ 2 × ICSB 374	132.99**	87.08**	-55.17**	10.78	4.07	-5.09
33	NTJ 2 × ICSB 480	138.73**	129.41**	-45.03**	-8.50	-15.83*	-23.23**
34	NTJ 2 × Parbhani Moti	-37.23**	-41.73**	-83.70**	1.11	-5.15	-13.49*
35	NTJ 2 × NSSV 13	-72.89**	-79.02**	-90.83**	0.58	-5.62	-13.92*
36	Wray × PMS 90 B	37.77**	0.00	-57.60**	15.42	-4.94	-13.87*
37	Wray × ICSB 323	23.99*	21.40*	-76.75**	7.56	-2.93	-29.27**
38	Wray × ICSB 351	108.50**	93.95**	-62.85**	8.27	-5.09	-26.10**
39	Wray × ICSB 374	79.89**	58.14**	-69.71**	9.14	-5.50	-24.26**
40	Wray × ICSB 480	155.72**	138.71**	-47.27**	8.13	-4.54	-26.88**
41	Wray × Parbhani Moti	34.22**	13.06	-68.38**	-2.08	-15.11*	-32.16**
42	Wray × NSSV 13	54.67**	11.20*	-51.36**	4.21	-9.69	-27.77**
43	SPSSV 30 × PMS 90B	14.86*	-19.41**	-65.83**	12.16	-8.62	-17.20**
44	SPSSV 30 × ICSB 323	-8.54	-11.65	-83.79**	-4.76	-15.11	-38.15**

Table 5b (conti….)

45	SPSSV 30 × ICSB 351	38.99**	36.46**	-76.66**	-1.80	-14.94*	-33.77**
46	SPSSV 30 × ICSB 374	-7.61	-14.58	-85.39**	-10.92	-23.77**	-38.90**
47	SPSSV 30 × ICSB 480	80.00**	59.68**	-64.73**	5.63	-7.87	-29.43**
48	SPSSV 30 × Parbhani Moti	147.33**	99.28**	-44.26**	20.67*	3.40	-17.38**
49	SPSSV 30 × NSSV 13	67.17**	16.27**	-49.15**	10.54	-5.32	-24.28**
	S.Em.±	0.27	0.32	0.32	2.18	2.51	2.51
	CD at 5%	0.76	0.88	0.88	6.09	7.03	7.03
	CD at 1%	1.01	1.17	1.17	8.05	9.29	9.29

MP: Mid Parent, BP: Better Parent, SC: Standard Check (CSH22SS), *significant at 5% probability, **significant at 1% probability

Table 5c. Magnitude of heterosis (%) over mid parent, better parent and standard check for stalk sugar related traits, yield and yield components in sweet sorghum crosses evaluated across environments

S.No.	Crosses	DFL			Plant height (m)			Stem thickness (mm)		
		Magnitude of heterosis (%)			Magnitude of heterosis (%)			Magnitude of heterosis (%)		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1	IS 13871 × PMS 90 B	-7.26	-14.10**	-25.84**	28.27**	11.90	-22.65**	6.84	0.34	-14.52**
2	IS 13871 × ICSB 323	-14.05**	-28.01**	-21.54**	7.15	2.02	-29.48**	-4.70	-9.71	-24.50**
3	IS 13871 × ICSB 351	-0.13	-1.24	-25.66**	19.86*	0.99	-30.20**	-1.05	-3.04	-24.42**
4	IS 13871 × ICSB 374	8.52	6.91	-18.91**	12.31	3.59	-28.40**	-10.14	-11.91	-34.09**
5	IS 13871 × ICSB 480	-5.88	-12.47**	-25.09**	4.84	0.42	-30.59**	7.29	1.44	-24.10**
6	IS 13871 × Parbhani Moti	-17.38**	-28.57**	-27.90**	-5.52	-18.95**	-21.73**	2.76	0.41	-21.27**
7	IS 13871 × NSSV 13	-0.64	-14.10**	-13.30**	22.81**	10.03	-3.96	22.85**	13.32*	0.36
8	IS 22670 × PMS 90 B	8.33*	-7.77*	13.30**	26.13**	-8.95	5.64	-4.07	-10.81*	-11.60*
9	IS 22670 × ICSB 323	2.58	-3.20	18.91**	13.41*	-12.75**	1.24	3.31	-4.77	-5.61
10	IS 22670 × ICSB 351	20.60**	-2.74	19.48**	49.77**	5.45	22.36**	32.16**	18.05**	17.00**
11	IS 22670 × ICSB 374	33.65**	8.08*	32.77**	37.89**	3.64	20.25**	45.20**	25.25**	24.14**
12	IS 22670 × ICSB 480	10.33**	-6.40*	14.98**	12.00	-13.45**	0.42	11.27	-6.94	-7.77
13	IS 22670 × Parbhani Moti	1.59	-7.47*	13.67**	19.97**	9.91*	27.53**	0.56	-9.94*	-10.74*
14	IS 22670 × NSSV 13	20.00**	9.30**	34.27**	29.31**	13.30**	31.46**	20.09**	13.70**	12.69*
15	ICSV 25333 × PMS 90 B	22.72**	0.98	35.02**	36.31**	-2.51	16.61**	37.52**	36.50**	18.03**
16	ICSV 25333 × ICSB 323	13.58**	3.08	37.83**	40.46**	6.92	27.90**	28.29**	26.18**	9.10
17	ICSV 25333 × ICSB 351	39.07**	8.68**	45.32**	40.93**	-1.63	17.67**	35.22**	28.56**	11.16*
18	ICSV 25333 × ICSB 374	43.70**	12.61**	50.56**	44.30**	7.36	28.43**	44.36**	32.18**	14.29**
19	ICSV 25333 × ICSB 480	24.34**	1.96	36.33**	28.32**	-1.90	17.35**	32.99**	17.76**	1.82
20	ICSV 25333 × Parbhani Moti	15.88**	1.68	35.96**	-5.15	-14.29**	2.53	17.34**	11.87*	-3.27

Table 5c (conti....)

21	ICSV 25333 × NSSV 13	31.21**	15.13**	53.93**	-2.12	-15.34**	1.27	32.55**	30.98**	16.00**
22	ICSV 93046 × PMS 90B	-2.56	-10.81**	-7.30	12.03	-13.34*	-18.46**	17.52**	14.40*	-2.55
23	ICSV 93046 × ICSB 323	-16.97**	-18.90**	-11.61**	11.22	-7.46	-12.92*	16.08**	14.02*	-4.66
24	ICSV 93046 × ICSB 351	2.40	-11.71**	-8.24*	9.84	-17.43**	-22.31**	-3.32	-4.94	-23.33**
25	ICSV 93046 × ICSB 374	11.25*	-3.78	0.00	13.46	-8.07	-13.50*	12.90*	6.75	-13.90**
26	ICSV 93046 × ICSB 480	-4.35	-12.79**	-9.36*	9.45	-8.46	-13.87*	10.06	0.51	-18.94**
27	ICSV 93046 × Parbhani Moti	-9.14*	-10.45**	-6.93	6.45	5.08	1.48	11.92	10.35	-10.99*
28	ICSV 93046 × NSSV 13	13.35**	11.71**	16.10**	0.55	-3.08	-8.81	1.09	-3.42	-14.47**
29	NTJ 2 × PMS 90 B	0.80	-6.97	-5.06	33.91**	8.93	-10.55	11.30*	5.32	0.52
30	NTJ 2 × ICSB 323	-15.00**	-17.70**	-10.30*	19.91*	5.59	-13.29*	14.38**	7.30	2.41
31	NTJ 2 × ICSB 351	-4.75	-17.25**	-15.54**	31.08**	3.34	-15.14**	9.01	-0.97	-5.49
32	NTJ 2 × ICSB 374	-1.89	-14.50**	-12.73**	28.75**	10.15	-9.55	15.25*	1.02	-3.59
33	NTJ 2 × ICSB 480	5.19	-3.30	-1.31	25.14**	10.79	-9.02	10.96	-5.77	-10.07*
34	NTJ 2 × Parbhani Moti	5.17	4.59	6.74	21.66**	12.56*	8.70	14.89**	4.64	-0.13
35	NTJ 2 × NSSV 13	6.09	5.50	7.68	8.03	4.83	-8.49	4.38	0.62	-3.97
36	Wray × PMS 90 B	-6.06	-7.59	-20.22**	17.97*	-8.43	-14.66*	-3.53	-14.98*	-27.58**
37	Wray × ICSB 323	-15.37**	-25.26**	-18.54**	9.76	-8.32	-14.56*	2.44	-9.00	-23.90**
38	Wray × ICSB 351	-7.31	-11.88*	-26.40**	27.05**	-4.19	-10.71	11.99	2.65	-19.98**
39	Wray × ICSB 374	-6.23	-10.54*	-25.28**	21.64**	-1.08	-7.81	15.56*	10.00	-20.94**
40	Wray × ICSB 480	1.88	0.66	-13.86**	1.79	-14.54*	-20.36**	12.98	11.53	-25.65**
41	Wray × Parbhani Moti	-9.85*	-17.63**	-16.85**	-6.50	-8.14	-11.29*	10.22	0.76	-21.00**
42	Wray × NSSV 13	0.30	-8.35*	-7.49	18.76**	15.00*	7.17	34.64**	16.70**	3.35
43	SPSSV 30 × PMS 90B	30.43**	26.90**	9.55*	18.11*	-6.08	-18.12**	-14.54*	-18.27**	-30.38**
44	SPSSV 30 × ICSB 323	-9.04*	-20.45**	-13.30**	20.44**	3.39	-9.86	9.82	5.96	-11.39*
45	SPSSV 30 × ICSB 351	-2.15	-5.96	-23.22**	41.51**	9.20	-4.80	7.90	7.76	-16.00**

Table 5c (conti....)

46	SPSSV 30 × ICSB 374	4.64	0.92	-17.60**	23.15**	2.81	-10.36	18.98**	14.49*	-10.99*
47	SPSSV 30 × ICSB 480	-3.02	-5.25	-18.91**	16.58*	0.60	-12.29*	13.28	5.20	-18.21**
48	SPSSV 30 × Parbhani Moti	-10.15*	-18.74**	-17.98**	12.46*	6.99	3.32	9.90	9.44	-14.2**
49	SPSSV 30 × NSSV 13	-11.59**	-20.04**	-19.29**	12.76	12.69	-1.64	1.85	-4.37	-15.31**
	S.Em.±	2.08	2.41	2.41	0.13	0.15	0.15	0.88	1.01	1.01
	CD at 5%	5.81	6.70	6.70	0.36	0.42	0.42	2.45	2.83	2.83
	CD at 1%	7.65	8.83	8.83	0.48	0.55	0.55	3.23	3.72	3.72

MP: Mid Parent, BP: Better Parent, SC: Standard Check (CSH22SS), DFL: days to 50% flowering, *significant at 5% probability, **significant at 1% probability

Table 5c (conti....)

S.No.	Crosses	Stalk yield (t ha^{-1}) Magnitude of heterosis (%)			Juice yield (t ha^{-1}) Magnitude of heterosis (%)			Juice volume (L ha^{-1}) Magnitude of heterosis (%)		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1	IS 13871 × PMS 90 B	31.69	9.65	-57.45**	43.94	8.60	-67.62**	44.44	9.23	-67.68**
2	IS 13871 × ICSB 323	-5.58	-28.59	-64.03**	-34.22	-57.54**	-77.85**	-35.21	-58.21**	-78.15**
3	IS 13871 × ICSB 351	26.59	8.62	-71.96**	19.92	5.82	-83.94**	18.82	4.41	-84.17**
4	IS 13871 × ICSB 374	23.22	21.52	-67.73**	9.83	-11.10	-78.20**	8.99	-11.21	-78.60**
5	IS 13871 × ICSB 480	2.88	-14.72	-66.53**	-1.39	-26.11	-77.50**	-2.22	-26.67	-77.76**
6	IS 13871 × Parbhani Moti	-14.68	-38.30*	-64.32**	-32.83	-57.52**	-75.64**	-33.78	-58.18**	-75.90**
7	IS 13871 × NSSV 13	61.90**	11.37	-23.49*	20.45	-25.93	-51.11**	14.35	-30.44	-51.28**
8	IS 22670 × PMS 90 B	52.81**	15.41	-12.28	87.87**	51.69*	-26.44*	87.92**	51.21*	-26.57*
9	IS 22670 × ICSB 323	14.54	-4.77	-27.62**	10.80	6.89	-44.23**	9.80	5.90	-44.63**
10	IS 22670 × ICSB 351	137.59**	47.70**	12.26	102.79**	25.67	-39.06**	102.74**	25.35	-39.13**
11	IS 22670 × ICSB 374	156.14**	72.81**	31.35**	127.24**	71.09**	-17.03	127.86**	70.47**	-17.21
12	IS 22670 × ICSB 480	-14.14	-34.90**	-50.52**	-54.91*	-63.30**	-82.20**	-55.35*	-63.73**	-82.39**
13	IS 22670 × Parbhani Moti	34.59*	18.49	-9.94	16.84	7.82	-38.17**	15.95	6.84	-38.44**
14	IS 22670 × NSSV 13	66.86**	58.84**	20.73*	32.78	15.17	-23.98*	28.10	8.46	-24.03*
15	ICSV 25333 × PMS 90 B	114.48**	68.35**	14.65	124.21**	92.55**	-19.99	125.47**	92.87**	-19.71
16	ICSV 25333 × ICSB 323	81.33**	57.74**	7.42	58.17*	42.07*	-25.87*	57.57*	41.52*	-26.01*
17	ICSV 25333 × ICSB 351	146.95**	57.00**	6.91	152.36**	61.43*	-32.92**	152.29**	60.95*	-32.99**
18	ICSV 25333 × ICSB 374	150.22**	73.89**	18.42*	111.56**	68.22*	-30.10**	112.45**	67.71*	-30.18**
19	ICSV 25333 × ICSB 480	109.37**	65.02**	12.38	97.66**	71.25**	-28.84**	98.22**	71.31**	-28.68**
20	ICSV 25333 × Parbhani Moti	3.53	-4.28	-34.82**	-26.90	-36.97	-63.85**	-27.41	-37.48	-63.98**

Table 5c (conti....)

21	ICSV 25333 × NSSV 13	32.28*	31.70*	-9.52	25.59	2.32	-32.46**	20.34	-4.07	-32.80**
22	ICSV 93046 × PMS 90B	99.41**	67.63**	-4.51	125.55**	64.87**	6.43	126.26**	65.07**	6.39
23	ICSV 93046 × ICSB 323	63.11**	53.68**	-12.45	69.05**	52.84**	-1.33	68.98**	53.02**	-1.37
24	ICSV 93046 × ICSB 351	-5.14	-37.17*	-64.21**	-30.62	-59.07**	-73.58**	-31.18	-59.46**	-73.87**
25	ICSV 93046 × ICSB 374	67.65**	22.89	-29.99**	66.06**	14.58	-26.03*	64.81**	13.21	-27.03*
26	ICSV 93046 × ICSB 480	41.25*	19.28	-32.05**	41.36	4.01	-32.85**	41.72	4.20	-32.84**
27	ICSV 93046 × Parbhani Moti	63.67**	62.45**	-6.06	41.60*	33.69*	-13.69	41.33*	33.83*	-13.74
28	ICSV 93046 × NSSV 13	21.40	11.03	-23.72**	7.87	6.69	-29.58**	4.18	0.02	-29.94**
29	NTJ 2 × PMS 90 B	60.47**	21.17	-7.83	70.62**	16.31	-4.57	71.05**	16.37	-4.51
30	NTJ 2 × ICSB 323	58.78**	31.97**	0.38	44.67**	18.34	-2.91	44.49**	18.27	-2.94
31	NTJ 2 × ICSB 351	41.09*	-12.31	-33.30**	5.16	-39.98**	-50.75**	5.22	-40.03**	-50.78**
32	NTJ 2 × ICSB 374	68.24**	13.48	-13.68	73.71**	12.82	-7.44	73.70**	12.36	-7.80
33	NTJ 2 × ICSB 480	21.63	-7.81	-29.87**	16.95	-19.82	-34.22**	17.07	-19.83	-34.21**
34	NTJ 2 × Parbhani Moti	71.53**	50.96**	14.83	77.86**	51.09**	23.96*	76.75**	50.43**	23.45*
35	NTJ 2 × NSSV 13	16.17	10.55	-15.91	-7.88	-16.88	-31.81**	-10.72	-17.26	-32.10**
36	Wray × PMS 90 B	27.98	15.67	-55.11**	64.26	51.45	-46.49**	64.80	51.42	-46.51**
37	Wray × ICSB 323	35.89	10.21	-44.47**	23.20	3.31	-46.09**	22.81	2.90	-46.20**
38	Wray × ICSB 351	50.07	19.30	-62.61**	32.46	-12.00	-68.91**	32.84	-11.98	-68.91**
39	Wray × ICSB 374	86.96**	72.67*	-45.88**	111.89**	79.50*	-36.58**	111.92**	78.25*	-37.03**
40	Wray × ICSB 480	19.25	7.24	-57.91**	32.51	23.36	-56.42**	32.86	23.46	-56.39**
41	Wray × Parbhani Moti	46.93*	13.29	-34.49**	36.44	10.25	-36.77**	35.72	9.46	-36.93**
42	Wray × NSSV 13	49.33**	8.73	-25.30**	61.44**	23.92	-18.20	55.55**	17.00	-18.05
43	SPSSV 30 × PMS 90B	-21.55	-26.43	-67.39**	-3.12	-20.86	-62.77**	-2.41	-20.37	-62.71**
44	SPSSV 30 × ICSB 323	33.62	25.58	-36.73**	47.36*	40.10	-26.90*	47.08*	39.42	-27.11*

Table 5c (conti....)

45	SPSSV 30 × ICSB 351	63.30*	15.71	-48.72**	45.09	-9.55	-57.45**	44.73	-9.89	-57.80**
46	SPSSV 30 × ICSB 374	68.17**	34.46	-40.41**	51.81	15.48	-45.67**	52.27	15.31	-45.99**
47	SPSSV 30 × ICSB 480	98.35**	86.99**	-17.12	70.48*	40.41	-33.95**	70.71*	40.63	-34.14**
48	SPSSV 30 × Parbhani Moti	39.68*	23.37	-28.66**	66.82**	51.83**	-12.93	66.54**	50.95**	-13.02
49	SPSSV 30 × NSSV 13	5.79	-12.98	-40.22**	29.66	11.03	-26.71*	24.87	4.18	-27.02*
	S.Em.±	4.07	4.70	4.70	1.37	1.59	1.59	1352.62	1561.88	1561.88
	CD at 5%	11.34	13.09	13.09	3.83	4.42	4.42	3767.60	4350.45	4350.45
	CD at 1%	14.95	17.26	17.26	5.04	5.82	5.82	4965.50	5733.67	5733.67

MP: Mid Parent, BP: Better Parent, SC: Standard Check (CSH22SS), *significant at 5% probability, **significant at 1% probability

Table 5c (conti....)

S.No.	Crosses	Brix (%)			Bagasse yield (t ha^{-1})			Total soluble solids (%)		
		Magnitude of heterosis (%)			Magnitude of heterosis (%)			Magnitude of heterosis (%)		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1	IS 13871 × PMS 90 B	11.23	0.42	-13.31*	28.10	9.87	-52.57**	11.05	0.41	-13.15*
2	IS 13871 × ICSB 323	-5.30	-16.38**	-5.76	5.88	-13.99	-57.49**	-5.24	-16.20**	-5.68
3	IS 13871 × ICSB 351	3.79	-4.86	-17.87**	28.41	9.57	-66.17**	3.73	-4.79	-17.65**
4	IS 13871 × ICSB 374	32.40**	21.46**	4.86	27.13	20.04	-62.94**	31.90**	21.15**	4.80
5	IS 13871 × ICSB 480	-0.41	-2.40	-12.23	4.23	-10.92	-61.22**	-0.40	-2.37	-12.08
6	IS 13871 × Parbhani Moti	-2.77	-7.52	-11.51	-8.42	-30.27	-58.82**	-2.73	-7.42	-11.37
7	IS 13871 × NSSV 13	22.72**	11.45	17.87**	75.46**	25.49	-9.98	26.48**	18.21**	17.65**
8	IS 22670 × PMS 90 B	3.42	-16.38**	-5.76	42.46**	5.58	-5.49	3.37	-16.20**	-5.68
9	IS 22670 × ICSB 323	-9.04	-9.04	2.52	15.44	-10.41	-19.81*	-8.94	-8.94	2.49
10	IS 22670 × ICSB 351	0.91	-17.34**	-6.83	146.96**	53.57**	37.47**	0.90	-17.15**	-6.75
11	IS 22670 × ICSB 374	9.02	-10.64	0.72	165.01**	73.11**	54.96**	8.90	-10.52	0.71
12	IS 22670 × ICSB 480	-4.14	-13.83*	-2.88	-2.37	-27.45*	-35.05**	-4.09	-13.68*	-2.84
13	IS 22670 × Parbhani Moti	0.12	-7.45	4.32	39.85**	16.06	3.89	0.11	-7.37	4.26
14	IS 22670 × NSSV 13	-11.64*	-14.36*	-3.48	77.04**	59.46**	42.74**	-8.93	-14.20*	-3.43
15	ICSV 25333 × PMS 90 B	15.09*	-8.54	7.91	111.98**	62.41**	31.70**	14.89*	-8.45	7.82
16	ICSV 25333 × ICSB 323	-7.48	-9.55	6.71	89.62**	52.59**	23.74*	-7.40	-9.45	6.63
17	ICSV 25333 × ICSB 351	14.90*	-7.52	9.11	145.83**	55.98**	26.49**	14.71*	-7.44	9.00
18	ICSV 25333 × ICSB 374	7.26	-13.62*	1.92	162.13**	75.40**	42.24**	7.16	-13.48*	1.89
19	ICSV 25333 × ICSB 480	2.19	-9.96	6.24	112.80**	63.51**	32.60**	2.17	-9.86	6.16
20	ICSV 25333 × Parbhani Moti	-19.19**	-26.83**	-13.67*	13.28	-2.11	-20.62*	-18.97**	-26.55**	-13.50*

Table 5c (conti....)

21	ICSV 25333 × NSSV 13	-16.40**	-20.73**	-6.47	32.92**	25.25*	1.57	-13.84*	-20.51**	-6.40
22	ICSV 93046 × PMS 90B	-8.19	-23.14**	-20.74**	86.95**	69.35**	-9.94	-8.08	-22.86**	-20.49**
23	ICSV 93046 × ICSB 323	-10.00	-13.83*	-2.88	59.99**	54.34**	-17.92	-9.89	-13.68*	-2.84
24	ICSV 93046 × ICSB 351	26.71**	7.56	10.91	7.16	-24.44	-59.82**	26.34**	7.47	10.78
25	ICSV 93046 × ICSB 374	1.03	-14.19*	-11.51	84.32**	39.70*	-25.71**	1.01	-14.02*	-11.37
26	ICSV 93046 × ICSB 480	0.62	-5.81	-2.88	41.27*	28.45	-31.69**	0.61	-5.74	-2.84
27	ICSV 93046 × Parbhani Moti	-2.29	-5.81	-2.88	74.08**	65.42**	-2.31	-2.26	-5.74	-2.84
28	ICSV 93046 × NSSV 13	25.72**	24.15**	31.29**	26.45	10.10	-21.02*	29.23**	27.00**	30.91**
29	NTJ 2 × PMS 90 B	17.67*	0.86	-1.80	55.76**	23.88	-9.46	17.41*	0.85	-1.78
30	NTJ 2 × ICSB 323	-7.53	-13.83*	-2.88	66.49**	39.54**	1.98	-7.45	-13.68*	-2.84
31	NTJ 2 × ICSB 351	1.98	-11.33	-13.67*	58.62**	2.99	-24.74*	1.95	-11.19	-13.50*
32	NTJ 2 × ICSB 374	24.84**	8.62	5.76	65.48**	13.80	-16.84	24.48**	8.51	5.68
33	NTJ 2 × ICSB 480	6.27	2.22	-0.48	23.84	-1.20	-27.80**	6.19	2.19	-0.47
34	NTJ 2 × Parbhani Moti	3.23	2.34	-0.36	66.75**	50.75**	10.17	3.19	2.31	-0.36
35	NTJ 2 × NSSV 13	17.47**	12.81*	19.30**	26.62*	25.46	-8.32	20.93**	19.63**	19.07**
36	Wray × PMS 90 B	13.85*	-10.09	7.91	11.81	-6.12	-59.48**	13.67*	-9.99	7.82
37	Wray × ICSB 323	0.36	-2.70	16.79**	42.50	13.52	-43.90**	0.36	-2.67	16.58**
38	Wray × ICSB 351	-2.56	-22.08**	-6.47	57.78	37.59	-59.66**	-2.53	-21.85**	-6.40
39	Wray × ICSB 374	5.49	-15.58**	1.32	73.97*	68.36*	-50.63**	5.42	-15.42**	1.30
40	Wray × ICSB 480	6.23	-7.09	11.51	13.32	-5.18	-58.72**	6.15	-7.02	11.37
41	Wray × Parbhani Moti	12.40*	1.00	21.22**	50.62*	12.70	-33.44**	12.25*	0.99	20.96**
42	Wray × NSSV 13	10.46	3.90	24.70**	40.43*	-1.08	-29.04**	13.45*	3.86	24.40**
43	SPSSV 30 × PMS 90B	27.73**	-0.86	24.82**	-29.60	-29.89	-69.73**	27.38**	-0.85	24.51**
44	SPSSV 30 × ICSB 323	1.91	-3.43	21.58**	26.58	18.12	-41.62**	1.89	-3.39	21.32**

Table 5c (conti....)

45	SPSSV 30 × ICSB 351	18.06**	-7.24	16.79**	71.62*	29.53	-44.54**	17.84**	-7.17	16.58**
46	SPSSV 30 × ICSB 374	-7.21	-27.05**	-8.15	76.79**	45.02*	-37.90**	-7.12	-26.78**	-8.05
47	SPSSV 30 × ICSB 480	1.22	-13.24**	9.23	110.77**	109.05**	-9.00	1.21	-13.11**	9.12
48	SPSSV 30 × Parbhani Moti	-0.11	-12.10*	10.67	24.69	7.55	-36.48**	-0.11	-11.98*	10.54
49	SPSSV 30 × NSSV 13	6.63	-1.90	23.50**	-7.38	-26.04	-46.95**	9.47	-1.89	23.21**
	S.Em.±	0.57	0.66	0.66	3.12	3.61	3.61	0.50	0.58	0.58
	CD at 5%	1.59	1.83	1.83	8.70	10.05	10.05	1.39	1.60	1.60
	CD at 1%	2.09	2.41	2.41	11.47	13.24	13.24	1.83	2.11	2.11

MP: Mid Parent, BP: Better Parent, SC: Standard Check (CSH22SS), *significant at 5% probability, **significant at 1% probability

Table 5c (conti....)

S.No.	Crosses	Total sugar index			Juice extraction (%)			Ethanol yield (L ha^{-1})		
		Magnitude of heterosis (%)			Magnitude of heterosis (%)			Magnitude of heterosis (%)		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1	IS 13871 × PMS 90 B	70.58	38.98	-71.17**	3.67	-10.91	-28.65**	46.74	35.69	-56.40**
2	IS 13871 × ICSB 323	-40.62	-63.58**	-79.02**	-26.84**	-40.48**	-45.38**	-0.72	-27.26	-57.35**
3	IS 13871 × ICSB 351	32.14	7.96	-85.90**	-6.77	-9.22	-44.86**	29.83	3.19	-71.84**
4	IS 13871 × ICSB 374	43.39	25.05	-78.06**	-15.01	-30.75**	-36.70**	75.71	51.28	-58.71**
5	IS 13871 × ICSB 480	-0.82	-26.99	-79.82**	-4.83	-17.70*	-35.08**	3.10	-14.10	-64.82**
6	IS 13871 × Parbhani Moti	-36.67	-60.87**	-78.32**	-10.07	-26.03**	-34.00**	-14.65	-37.91*	-62.76**
7	IS 13871 × NSSV 13	27.71	-25.19	-43.08**	-22.01**	-38.38**	-38.89**	121.36**	51.57**	11.96
8	IS 22670 × PMS 90 B	101.32**	38.12	-23.01	-11.17	-23.21**	-38.50**	44.15**	-6.27	0.21
9	IS 22670 × ICSB 323	7.02	5.28	-39.35**	-10.33	-26.64**	-32.68**	7.86	-16.49	-10.72
10	IS 22670 × ICSB 351	86.78*	7.26	-40.21**	-16.16	-17.78	-50.06**	118.17**	25.50*	34.17**
11	IS 22670 × ICSB 374	150.75**	64.84**	-8.12	-28.85**	-41.70**	-46.71**	162.31**	55.33**	66.05**
12	IS 22670 × ICSB 480	-59.22	-69.50**	-83.00**	-50.63**	-57.04**	-66.12**	-9.85	-37.66**	-33.35**
13	IS 22670 × Parbhani Moti	21.45	21.08	-32.52*	-24.77**	-37.78**	-44.47**	40.02**	9.28	16.83
14	IS 22670 × NSSV 13	19.00	3.09	-21.56	-23.38**	-39.14**	-39.64**	57.49**	33.15**	42.35**
15	ICSV 25333 × PMS 90 B	148.56**	76.10**	-12.40	-13.41	-28.20**	-42.50**	127.05**	49.34**	52.10**
16	ICSV 25333 × ICSB 323	48.86*	38.70	-20.10	-15.51	-33.48**	-38.96**	75.12**	37.97**	40.52**
17	ICSV 25333 × ICSB 351	157.26**	50.04	-25.36*	-1.31	-7.81	-44.01**	150.89**	45.27**	47.95**
18	ICSV 25333 × ICSB 374	113.97**	44.72	-28.01*	-27.41**	-42.77**	-47.68**	154.05**	51.60**	54.40**
19	ICSV 25333 × ICSB 480	95.70**	52.22*	-24.28	-10.53	-25.35**	-41.12**	109.07**	46.57**	49.27**
20	ICSV 25333 × Parbhani Moti	-41.98	-44.94	-69.50**	-22.58*	-38.41**	-45.04**	-6.47	-25.70*	-24.33*

Table 5c (conti....)

21	ICSV 25333 × NSSV 13	10.25	-8.83	-30.64*	-20.45*	-39.07**	-39.58**	19.34	2.94	4.84
22	ICSV 93046 × PMS 90B	96.92**	29.22	-14.21	13.64*	-0.27	5.77	60.12*	24.24	-27.66*
23	ICSV 93046 × ICSB 323	54.58**	44.35*	-4.16	12.19	4.64	10.98	40.50*	40.00*	-17.90
24	ICSV 93046 × ICSB 351	-24.82	-57.72**	-71.93**	-25.41**	-41.35**	-37.80**	26.42	-19.32	-53.02**
25	ICSV 93046 × ICSB 374	67.07*	5.61	-29.88*	2.39	-4.68	1.10	65.63*	10.84	-35.46**
26	ICSV 93046 × ICSB 480	41.09	-0.09	-33.67**	3.95	-9.37	-3.88	37.17	16.82	-31.98**
27	ICSV 93046 × Parbhani Moti	38.33	26.87	-15.77	-4.95	-12.49*	-7.18	66.53**	64.10**	-1.59
28	ICSV 93046 × NSSV 13	30.12	21.83	-7.31	-32.27**	-34.47**	-30.50**	67.30**	49.58**	10.49
29	NTJ 2 × PMS 90 B	86.12**	16.35	-3.55	4.14	-7.51	-4.57	78.48**	28.85	-6.74
30	NTJ 2 × ICSB 323	38.27*	17.18	-2.86	-3.27	-8.61	-5.71	55.11**	40.39**	1.61
31	NTJ 2 × ICSB 351	4.10	-42.75**	-52.54**	-22.47**	-38.42**	-36.46**	58.09*	-3.38	-30.07**
32	NTJ 2 × ICSB 374	95.75**	18.59	-1.69	0.13	-5.58	-2.58	102.30**	28.68	-6.86
33	NTJ 2 × ICSB 480	29.36	-13.76	-28.50*	-7.55	-18.43**	-15.84*	30.86	2.45	-25.85*
34	NTJ 2 × Parbhani Moti	94.71**	62.40**	34.63**	-6.30	-12.63*	-9.85	81.70**	66.12**	20.24
35	NTJ 2 × NSSV 13	8.49	4.03	-13.75	-28.10**	-29.50**	-27.25**	56.64**	55.06**	14.54
36	Wray × PMS 90 B	79.39*	30.27	-40.27**	12.21	1.11	0.94	34.62	24.13	-52.75**
37	Wray × ICSB 323	24.15	11.48	-35.78**	-16.35*	-19.73**	-19.86**	43.88	18.64	-30.43**
38	Wray × ICSB 351	14.01	-32.70	-69.14**	-2.19	-21.34**	-21.47**	44.07	2.49	-60.99**
39	Wray × ICSB 374	106.39**	42.69	-34.58**	14.60*	9.76	9.59	82.24*	38.29	-47.36**
40	Wray × ICSB 480	40.29	12.44	-48.45**	-12.02	-21.26**	-21.39**	24.61	20.22	-50.77**
41	Wray × Parbhani Moti	58.31*	44.67	-19.86	-10.41	-15.17*	-15.30*	73.13**	41.50*	-15.14
42	Wray × NSSV 13	66.76**	33.62*	1.67	-6.90	-7.21	-7.36	67.55**	26.94	-6.24
43	SPSSV 30 × PMS 90B	8.05	-27.26	-56.44**	-8.83	-17.71**	-18.15**	-13.43	-32.30	-61.43**
44	SPSSV 30 × ICSB 323	49.26*	46.43*	-12.32	15.68*	11.20	10.62	26.28	24.48	-27.01*

Table 5c (conti....)

45	SPSSV 30 × ICSB 351	46.26	-16.76	-50.16**	-0.39	-19.79**	-20.21**	84.31**	18.18	-32.67**
46	SPSSV 30 × ICSB 374	41.84	-8.30	-45.09**	-9.22	-12.90*	-13.36*	50.59	1.34	-42.27**
47	SPSSV 30 × ICSB 480	69.70*	24.02	-25.74*	-10.28	-19.56**	-19.99**	102.86**	74.34**	-0.68
48	SPSSV 30 × Parbhani Moti	71.22**	64.80**	-1.32	21.82**	15.55*	14.94*	25.31	22.17	-26.73*
49	SPSSV 30 × NSSV 13	37.00*	22.40	-6.87	12.96*	12.79*	12.20	7.58	-4.73	-29.63**
	S.Em.±	1.40	1.62	1.62	1.12	1.30	1.30	366.02	422.64	422.64
	CD at 5%	3.91	4.51	4.51	3.12	3.61	3.61	1019.52	1177.24	1177.24
	CD at 1%	5.15	5.95	5.95	4.12	4.75	4.75	1343.67	1551.53	1551.53

MP: Mid Parent, BP: Better Parent, SC: Standard Check (CSH22SS), *significant at 5% probability, **significant at 1% probability

Table 5c (conti....)

S.No.	Crosses	Panicle weight (t ha^{-1})			Panicle length (cm)			Panicle breadth (cm)		
		Magnitude of heterosis (%)			Magnitude of heterosis (%)			Magnitude of heterosis (%)		
		MP	BP	SC	MP	BP	SC	MP	BP	SC
1	IS 13871 × PMS 90 B	21.44	-18.80	-48.46**	1.36	-7.84	-0.21	14.59	-9.23	-30.06**
2	IS 13871 × ICSB 323	35.97	27.72	-68.88**	14.12	10.64	-1.96	10.25	-5.91	-40.07**
3	IS 13871 × ICSB 351	38.94	11.00	-60.25**	18.23*	12.94	9.92	18.14	6.77	-40.47**
4	IS 13871 × ICSB 374	5.85	-3.28	-74.98**	-6.26	-10.50	-12.81	10.34	0.90	-45.19**
5	IS 13871 × ICSB 480	69.83*	34.78	-50.86**	24.78**	9.62	-2.86	8.45	-12.42	-35.91**
6	IS 13871 × Parbhani Moti	94.87**	66.81*	-49.84**	35.93**	21.24**	7.44	7.98	-12.56	-36.46**
7	IS 13871 × NSSV 13	-15.32	-39.55*	-69.74**	13.82	8.97	-3.44	-4.09	-26.94**	-37.17**
8	IS 22670 × PMS 90 B	-27.31	-43.66**	-64.23**	-3.55	-10.08	-2.63	-13.89	-23.42**	-40.99**
9	IS 22670 × ICSB 323	73.85**	47.57*	-48.46**	14.81*	8.43	1.51	-5.14	-7.89	-41.33**
10	IS 22670 × ICSB 351	115.27**	112.60**	-23.86**	9.72	7.63	4.75	29.98**	25.39*	-24.77**
11	IS 22670 × ICSB 374	26.46	10.07	-61.56**	-1.20	-3.13	-5.63	-3.84	-8.39	-45.04**
12	IS 22670 × ICSB 480	-14.85	-16.64	-69.61**	2.11	-12.36	-17.96**	-10.70	-18.75*	-40.54**
13	IS 22670 × Parbhani Moti	23.80	15.20	-59.77**	13.55	-1.10	-7.41	10.72	1.07	-26.56**
14	IS 22670 × NSSV 13	-48.91**	-56.64**	-78.29**	15.10*	7.38	0.53	-31.60**	-41.95**	-50.07**
15	ICSV 25333 × PMS 90 B	-25.19	-37.24**	-60.16**	13.10*	7.33	16.22*	-13.77	-14.46	-33.01**
16	ICSV 25333 × ICSB 323	3.20	-19.18	-65.23**	30.67**	21.25**	17.89**	-15.27	-23.18**	-39.84**
17	ICSV 25333 × ICSB 351	44.17*	32.09	-43.17**	-3.68	-3.73	-6.30	13.15	-3.14	-24.15**
18	ICSV 25333 × ICSB 374	27.24	1.88	-56.17**	43.82**	43.68**	39.98**	0.09	-15.24*	-33.63**
19	ICSV 25333 × ICSB 480	98.90**	83.73**	-20.95**	26.89**	7.21	4.25	20.40**	16.46*	-8.80
20	ICSV 25333 × Parbhani Moti	-7.48	-21.41	-66.19**	36.56**	17.06*	13.82*	-15.32	-18.37*	-36.08**

Table 5c (conti....)

21	ICSV 25333 × NSSV 13	-43.77*	-47.72**	-73.83**	22.83**	12.61	9.49	-20.72**	-24.27**	-34.87**
22	ICSV 93046 × PMS 90B	89.67**	25.57*	-20.29*	2.41	-20.48**	-13.89*	43.58**	22.58**	-5.54
23	ICSV 93046 × ICSB 323	275.09**	245.89**	-15.72*	19.37*	2.64	-14.60*	45.71**	35.20**	-13.88*
24	ICSV 93046 × ICSB 351	50.10	18.16	-57.68**	3.72	-16.23*	-18.47**	25.11*	23.71*	-31.02**
25	ICSV 93046 × ICSB 374	132.59**	108.76**	-45.99**	0.54	-18.83**	-20.92**	25.63*	25.41*	-31.64**
26	ICSV 93046 × ICSB 480	138.23**	86.32**	-32.06**	18.44	12.09	-24.81**	44.07**	25.70**	-8.01
27	ICSV 93046 × Parbhani Moti	222.10**	171.23**	-18.44*	21.72*	13.32	-21.28**	47.88**	29.41**	-5.97
28	ICSV 93046 × NSSV 13	-3.21	-31.72*	-65.82**	22.49*	6.49	-13.68*	-8.90	-25.58**	-35.99**
29	NTJ 2 × PMS 90 B	68.49**	46.83**	-6.79	4.20	-10.26	-2.82	30.40**	25.28**	-3.46
30	NTJ 2 × ICSB 323	82.45**	38.36*	-34.75**	24.64**	20.92**	0.61	40.15**	32.93**	-5.61
31	NTJ 2 × ICSB 351	42.10*	25.00	-41.05**	1.57	-8.39	-10.84	12.81	0.70	-28.50**
32	NTJ 2 × ICSB 374	76.19**	36.42*	-35.66**	7.18	-3.38	-5.87	20.74*	6.54	-24.34**
33	NTJ 2 × ICSB 480	80.20**	59.76**	-24.66**	16.88	8.55	-15.08*	28.91**	27.00**	-7.06
34	NTJ 2 × Parbhani Moti	17.30	-3.96	-54.71**	7.47	1.45	-20.63**	3.33	2.16	-25.77**
35	NTJ 2 × NSSV 13	-54.76**	-56.07**	-78.01**	-13.92	-15.42	-31.44**	-32.83**	-38.69**	-47.27**
36	Wray × PMS 90 B	41.11*	-4.68	-39.49**	13.07	-1.25	6.93	20.03*	-0.59	-23.40**
37	Wray × ICSB 323	105.89**	97.10**	-51.97**	11.79	10.21	-8.30	5.92	-4.98	-39.48**
38	Wray × ICSB 351	68.50*	36.68	-51.05**	16.75*	6.86	4.01	17.54	12.09	-37.50**
39	Wray × ICSB 374	90.76**	77.54*	-54.06**	28.35**	17.43*	14.41*	37.82**	33.09**	-27.71**
40	Wray × ICSB 480	90.66**	53.60*	-43.99**	26.94**	16.13*	-6.11	16.46	-1.51	-27.93**
41	Wray × Parbhani Moti	77.70*	54.71*	-53.48**	16.68	8.46	-12.31	14.16	-3.18	-29.65**
42	Wray × NSSV 13	10.44	-20.19	-60.05**	21.52**	21.37**	-1.62	1.30	-19.56**	-30.82**
43	SPSSV 30 × PMS 90B	-35.94	-57.49**	-73.01**	0.18	-9.31	-1.80	-12.58	-29.01**	-45.30**
44	SPSSV 30 × ICSB 323	120.35**	104.11**	-50.27**	-5.40	-7.86	-19.13**	18.81	4.27	-33.59**

Table 5c (conti....)

45	SPSSV 30 × ICSB 351	112.74**	68.07**	-39.81**	11.61	6.13	3.29	44.25**	34.33**	-25.1**
46	SPSSV 30 × ICSB 374	124.36**	102.25**	-47.67**	-8.20	-12.75	-15.00*	37.90**	30.00**	-29.39**
47	SPSSV 30 × ICSB 480	103.60**	59.80**	-41.73**	25.71**	10.89	-2.67	28.98**	6.87	-21.79**
48	SPSSV 30 × Parbhani Moti	178.99**	135.87**	-29.07**	29.14**	15.68*	1.53	35.10**	12.26	-18.43**
49	SPSSV 30 × NSSV 13	57.41*	11.36	-44.25**	13.02	8.70	-4.60	14.85	-10.46	-23.00**
	S.Em.±	0.40	0.46	0.46	1.68	1.94	1.94	0.23	0.26	0.26
	CD at 5%	1.11	1.29	1.29	4.67	5.40	5.40	0.63	0.72	0.72
	CD at 1%	1.47	1.70	1.70	6.16	7.11	7.11	0.83	0.95	0.95

MP: Mid Parent, BP: Better Parent, SC: Standard Check (CSH22SS), *significant at 5% probability, **significant at 1% probability

Table 5c (conti....)

S.No.	Crosses	Grain yield (t ha^{-1})			1000-seed weight (g)		
		Magnitude of heterosis (%)			Magnitude of heterosis (%)		
		MP	BP	SC	MP	BP	SC
1	IS 13871 × PMS 90 B	47.34	-2.56	-53.72**	29.14**	27.90**	7.65
2	IS 13871 × ICSB 323	70.07	61.84	-75.20**	33.76**	16.93*	-3.48
3	IS 13871 × ICSB 351	54.33	16.22	-64.81**	11.55	6.81	-11.84
4	IS 13871 × ICSB 374	14.46	9.62	-81.65**	9.88	6.24	-12.31
5	IS 13871 × ICSB 480	89.61*	42.87	-56.81**	11.83	-1.39	-18.60**
6	IS 13871 × Parbhani Moti	131.86**	82.12**	-51.11**	20.03*	19.52*	-1.35
7	IS 13871 × NSSV 13	-27.70	-51.80**	-77.84**	2.90	1.13	-16.53*
8	IS 22670 × PMS 90 B	-43.29*	-52.47**	-77.42**	-0.34	-6.95	-21.68**
9	IS 22670 × ICSB 323	18.48	-15.24	-72.77**	9.46	1.05	-26.24**
10	IS 22670 × ICSB 351	129.38**	122.79**	-28.42**	-1.28	-2.94	-26.70**
11	IS 22670 × ICSB 374	19.53	-9.09	-70.79**	-3.82	-6.37	-27.84**
12	IS 22670 × ICSB 480	-54.59*	-55.93*	-85.84**	19.13*	11.00	-18.98**
13	IS 22670 × Parbhani Moti	-8.37	-15.90	-72.98**	21.92*	15.33	-5.62
14	IS 22670 × NSSV 13	-77.94**	-81.26**	-91.39**	-35.14**	-37.86**	-50.48**
15	ICSV 25333 × PMS 90 B	-37.43	-55.79**	-79.00**	-15.04	-22.22**	-34.53**
16	ICSV 25333 × ICSB 323	-42.10	-50.62	-90.31**	0.01	-5.82	-34.13**
17	ICSV 25333 × ICSB 351	68.59*	38.91	-57.94**	-14.67	-17.83*	-37.94**
18	ICSV 25333 × ICSB 374	22.84	13.83	-77.67**	-38.01**	-40.88**	-54.43**
19	ICSV 25333 × ICSB 480	109.30**	72.58**	-47.83**	-3.40	-8.18	-35.77**
20	ICSV 25333 × Parbhani Moti	-23.43	-33.73	-82.21**	-27.50**	-32.77**	-44.98**

Table 5c (conti....)

21	ICSV 25333 × NSSV 13	-57.67*	-69.80**	-86.12**	-54.99**	-57.74**	-66.33**
22	ICSV 93046 × PMS 90B	111.45**	35.15*	-35.80**	7.30	0.06	-15.78*
23	ICSV 93046 × ICSB 323	452.77**	440.38**	-25.20**	30.64**	20.74*	-12.08
24	ICSV 93046 × ICSB 351	72.62	24.00	-62.45**	7.65	5.72	-20.16**
25	ICSV 93046 × ICSB 374	175.12**	146.2**	-58.78**	2.38	-0.45	-23.27**
26	ICSV 93046 × ICSB 480	147.21**	77.67**	-46.29**	25.49**	17.06	-14.76*
27	ICSV 93046 × Parbhani Moti	235.83**	150.62**	-32.72**	20.90*	14.24	-6.51
28	ICSV 93046 × NSSV 13	-17.26	-46.73**	-75.51**	-0.85	-5.13	-24.39**
29	NTJ 2 × PMS 90 B	120.59**	106.56**	-1.89	12.93	3.04	5.14
30	NTJ 2 × ICSB 323	106.15**	37.49	-43.00**	20.44*	-3.32	-1.35
31	NTJ 2 × ICSB 351	90.33**	64.67**	-31.73**	5.78	-7.96	-6.09
32	NTJ 2 × ICSB 374	66.18*	16.65	-51.64**	6.11	-6.86	-4.97
33	NTJ 2 × ICSB 480	87.35**	61.98**	-32.85**	-3.01	-21.55**	-19.95**
34	NTJ 2 × Parbhani Moti	10.49	-8.98	-62.27**	-4.73	-14.16*	-12.41
35	NTJ 2 × NSSV 13	-72.60**	-73.94**	-88.02**	0.59	-10.42	-8.60
36	Wray × PMS 90 B	73.60**	24.27	-40.97**	11.25	-8.45	-22.94**
37	Wray × ICSB 323	169.25**	125.51**	-53.76**	31.44**	23.55*	-23.67**
38	Wray × ICSB 351	82.83*	53.31*	-53.58**	15.06	-1.06	-25.28**
39	Wray × ICSB 374	121.99**	101.62*	-58.66**	7.85	-8.04	-29.12**
40	Wray × ICSB 480	121.52**	85.89**	-43.81**	18.00	9.89	-30.74**
41	Wray × Parbhani Moti	76.81*	55.93	-58.14**	13.79	-5.31	-22.51**
42	Wray × NSSV 13	5.70	-23.58	-64.87**	12.86	-5.08	-24.36**
43	SPSSV 30 × PMS 90B	-22.96	-44.04*	-73.42**	16.05	-3.58	-18.84**
44	SPSSV 30 × ICSB 323	150.26**	105.69**	-55.78**	10.08	4.66	-35.34**

Table 5c (conti....)

45	SPSSV 30 × ICSB 351	112.52**	81.71**	-44.98**	15.03	-0.06	-24.53**
46	SPSSV 30 × ICSB 374	19.42	6.20	-77.17**	-11.74	-23.98**	-41.41**
47	SPSSV 30 × ICSB 480	128.41**	95.43**	-40.92**	29.01**	21.51*	-23.41**
48	SPSSV 30 × Parbhani Moti	194.35**	165.05**	-28.85**	20.63*	1.37	-17.05*
49	SPSSV 30 × NSSV 13	56.43*	14.80	-47.23**	6.40	-9.62	-27.97**
	S.Em.±	0.21	0.24	0.24	1.54	1.78	1.78
	CD at 5%	0.57	0.66	0.66	4.29	4.95	4.95
	CD at 1%	0.76	0.87	0.87	5.65	6.52	6.52

MP: Mid Parent, BP: Better Parent, SC: Standard Check (CSH22SS), *significant at 5% probability, **significant at 1% probability

At ICRISAT, among the 14 parents, five lines (ICSV 93046, IS 13871, NTJ 2, SPSSV 30 and Wray) and three testers (ICSB 351, ICSB 480 and PMS 90 B) showed highly significant negative *gca* effects. Among the remaining two lines (IS 22670 and ICSV 25333) and two testers two (ICSB 374 and NSSV 13) showed significant positive *gca* effects (Table 7b).

Across environments among the 14 parents, five lines (ICSV 93046, IS 13871, NTJ 2, SPSSV 30 and Wray) and three testers (ICSB 323, ICSB 351 and ICSB 480) shown significant negative *gca* effects. Among the remaining, two lines (IS 22670 and ICSV 25333) and only one tester (NSSV 13) showed highly significant positive *gca* effects (Table 7c).

4.4.2.1.2 Plant height (m)

At Bijapur, out of 14 parents evaluated, two lines (ICSV 25333 and IS 22670) and one tester (NSSV 13) exhibited significant positive *gca* effects. Whereas, three lines (IS 13871, NTJ 2 and ICSV 93046) and none of testers exhibited highly significant negative *gca* effects (Table 7a).

At ICRISAT, out of 14 parents evaluated, two lines (ICSV 25333 and IS 22670) and two testers (NSSV 13 and Parbhani Moti) exhibited significant positive *gca* effects. Whereas, four lines (ICSV 93046, IS 13871, SPSSV 30 and Wray) and four testers (ICSB 323, ICSB 480, ICSB 351 and PMS 90 B) exhibited highly significant negative *gca* effects (Table 7b).

Across environments out of 14 parents evaluated, two lines (IS 22670 and ICSV 25333) and two testers (NSSV 13 and Parbhani Moti) exhibited highly significant positive *gca* effects. Whereas, four lines (ICSV 93046, IS 13871, SPSSV 30 and Wray) and four testers (ICSB 323, ICSB 351, ICSB 480 and PMS 90 B) exhibited highly significant negative *gca* effects (Table 7c).

4.4.2.1.3 Stem thickness (mm)

At Bijapur, out of 14 parents evaluated three lines (NTJ 2, IS 22670 and ICSV 25333) and two testers (ICSB 374 and NSSV 13) exhibited significant positive *gca* effects. Whereas, three lines (Wray, IS 13871 and SPSSV 30) and two testers (ICSB 480 and PMS 90 B) exhibited highly significant negative *gca* effects (Table 7a).

At ICRISAT, out of 14 parents evaluated two lines (IS 22670 and ICSV 25333) and only one tester (NSSV 13) exhibited significant positive *gca* effects. Whereas, four lines (ICSV 93046, IS 13871, SPSSV 30 and Wray) and two testers (ICSB 480 and Parbhani Moti) exhibited highly significant negative *gca* effects (Table 7b).

Across environments out of 14 parents evaluated three lines (IS 22670, ICSV 25333 and NTJ 2) and only one tester (NSSV 13) exhibited significant positive *gca* effects and four lines (ICSV 93046, IS 13871, SPSSV 30 and Wray) and only one tester (ICSB 480) exhibited highly significant negative *gca* effects (Table 7c).

4.4.2.1.4 Stalk yield (t ha^{-1})

At Bijapur, out of 14 parents evaluated four lines (NTJ 2, ICSV 93046, IS 22670 and ICSV 25333) and three testers (Parbhani Moti, ICSB 323 and ICSB 374) exhibited highly significant positive *gca* and whereas two line (IS 13871 and Wray) and two testers (PMS 90 B and ICSB 351) exhibited significant negative *gca* effects (Table 7a).

At ICRISAT, out of 14 parents evaluated three lines (IS 22670, ICSV 25333 and NTJ 2) and three testers (ICSB 374, NSSV 13 and PMS 90 B) exhibited highly significant positive *gca* and where as other four line (ICSV 93046, IS 13871, SPSSV 30 and Wray) and three testers (ICSB 323, ICSB 480 and ICSB 351) exhibited significant negative *gca* effects (Table 7b).

Across environments out of 14 parents evaluated three lines (IS 22670, ICSV 25333 and NTJ 2) and three testers (ICSB 374, NSSV 13 and Parbhani Moti) exhibited highly significant positive *gca* and other three line (IS 13871, SPSSV 30 and Wray) and two testers (ICSB 351 and ICSB 480) exhibited significant negative *gca* effects (Table 7c).

4.4.2.1.5 Juice yield (t ha^{-1})

At Bijapur, out of 14 parents studied, three lines (NTJ 2, SPSSV 30 and ICSV 93046) and two testers (Parbhani Moti and ICSB 323) exhibited highly significant positive *gca* effects, whereas three lines (IS 13871, IS 22670 and Wray) and three tester (ICSB 351, NSSV 13 and ICSB 480) exhibited significant negative *gca* effects (Table 7a).

At ICRISAT, out of 14 parents studied, four lines (ICSV 93046, IS 22670, ICSV 25333 and NTJ 2) and four testers (ICSB 374, NSSV 13, PMS 90 B and Parbhani Moti) exhibited highly significant positive *gca* effects, whereas two lines (IS 13871 and SPSSV 30) and two tester (ICSB 351 and ICSB 480) exhibited significant negative *gca* effects (Table 7b).

Across environments out of 14 parents studied, three lines (ICSV 93046, ICSV 25333 and NTJ 2) and four testers (ICSB 323, NSSV 13, PMS 90 B and Parbhani Moti) exhibited highly significant positive *gca* effects, whereas three lines (IS 13871, IS22670 and Wray) and two tester (ICSB 351 and ICSB 480) exhibited significant negative *gca* effects (Table 7c).

4.4.2.1.6 Juice volume (L ha^{-1})

At Bijapur, out of 14 parents evaluated three lines (ICSV 93046, NTJ 2 and SPSSV 30) and two testers (ICSB 323 and Parbhani Moti) showed highly significant positive *gca* effects. Whereas three line (IS 13871, IS 22670 and Wray) and three testers (ICSB 351, ICSB 480 and NSSV 13) showed highly significant negative *gca* effects (Table 7a).

At ICRISAT, out of 14 parents evaluated four lines (ICSV 93046, IS 22670, ICSV 25333 and NTJ 2) and four testers (ICSB 374, NSSV 13, PMS 90 B and Parbhani Moti) showed highly significant positive *gca* effects. Whereas two line (IS 13871 and SPSSV 30) and two testers (ICSB 351 and ICSB 480) showed highly significant negative *gca* effects (Table 7b).

Across environments out of 14 parents evaluated three lines (ICSV 93046, ICSV 25333 and NTJ 2) and four testers (ICSB 323, NSSV 13, PMS 90 B and

Parbhani Moti) showed highly significant positive *gca* effects. Whereas three lines (IS 13871, IS22670 and Wray) and two testers (ICSB 351 and ICSB 480) showed highly significant negative *gca* effects (Table 7c).

4.4.2.1.7 Brix (%)

At Bijapur, out of 14 parents evaluated three lines (ICSV 25333, SPSSV 30 and Wray) and only one testers (NSSV 13) exhibited highly significant positive *gca* effects, whereas three line (IS 13871, IS 22670 and NTJ 2) and two tester (ICSB 351 and ICSB 374) exhibited negative significant *gca* effects (Table 7a).

At ICRISAT, out of 14 parents evaluated two lines (SPSSV 30 and Wray) and only one tester (NSSV 13) exhibited highly significant positive *gca* effects, whereas three line (IS 13871, IS 22670 and ICSV 25333) and only one tester (PMS 90 B) exhibited negative significant *gca* effects (Table 7b).

Across environments out of 14 parents evaluated two lines (SPSSV 30 and Wray) and only one testers (NSSV 13) exhibited highly significant positive *gca* effects, whereas four lines (ICSV 93046, IS 13871,IS 22670 and ICSV 25333) and three tester (ICSB 351, ICSB 374 and PMS 90 B) exhibited negative significant *gca* effects (Table 7c).

4.4.2.1.8 Bagasse yield (t ha^{-1})

At Bijapur, out of 14 parents evaluated, four lines (ICSV 93046, IS 22670, ICSV 25333 and NTJ 2) and two testers (ICSB 374 and NSSV 13) exhibited highly significantly positive *gca* effects and three line (IS 13871, SPSSV 30 and Wray) and two tester (ICSB 351 and PMS 90 B) exhibited significant negative *gca* effects (Table 7a).

At ICRISAT, out of 14 parents evaluated, three lines (IS 22670, ICSV 25333 and NTJ 2) and three testers (ICSB 374, NSSV 13 and PMS 90 B) exhibited highly significantly positive *gca* effects and four line (ICSV 93046, IS 13871, SPSSV 30 and Wray) and three tester (ICSB 323, ICSB 480 and ICSB 351) exhibited significant negative *gca* effects (Table 7b).

Across environments out of 14 parents evaluated, three lines (IS 22670, ICSV 25333 and NTJ 2) and three testers (ICSB 374, NSSV 13 and Parbhani Moti) exhibited highly significantly positive *gca* effects and four lines (ICSV 93046, IS 13871, SPSSV 30 and Wray) and three tester (ICSB 351, ICSB 480 and PMS 90 B) exhibited significant negative *gca* effects (Table 7c).

4.4.2.1.9 Total soluble solids (%)

At Bijapur, out of 14 parents studied three lines *viz.*, ICSV 25333, SPSSV 30 and Wray and only one tester NSSV 13 shown highly significant positive *gca* effects and three lines (IS 13871, IS 22670 and NTJ 2) and two testers (ICSB 351 and ICSB 374) shown highly significant negative *gca* effects (Table 7a).

At ICRISAT, out of 14 parents studied two lines (SPSSV 30 and Wray) and only one tester (NSSV 13) shown highly significant positive *gca* effects and three lines (IS 13871, IS 22670 and IS 22670) and only one tester (PMS 90 B) shown highly significant negative *gca* effects (Table 7b).

Across environments out of 14 parents studied two lines (SPSSV 30 and Wray) and only one tester (NSSV 13) shown highly significant positive *gca* effects and four lines (ICSV 93046, IS 13871, IS22670 and IS27206) and three tester (ICSB 351, ICSB 374 and PMS 90 B) shown highly significant negative *gca* effects (Table 7c).

4.4.2.1.10 Total sugar index

At Bijapur, out of 14 parents, four lines *viz.*, ICSV 93046, ICSV 25333, NTJ 2 and SPSSV 30 and two testers *viz.*, ICSB 323 and Parbhani Moti were exhibited significant positive *gca* effects and three lines (IS 13871, IS 22670 and Wray) and two testers (ICSB 351 and PMS 90 B) exhibited significant negative *gca* effects (Table 7a).

At ICRISAT, out of 14 parents, two lines *viz.*, IS 22670 and NTJ 2 and three testers *viz.*, NSSV 13, PMS 90 B and Parbhani Moti were exhibited significant positive *gca* effects and only one lines (IS 13871) and two testers (ICSB 351 and ICSB 480) exhibited significant negative *gca* effects (Table 7b).

Across environments out of 14 parents evaluated, four lines (ICSV 93046, NTJ 2, SPSSV 30 and Wray) and four testers (ICSB 323, ICSB 374, PMS 90 B and Parbhani Moti) exhibited highly significant positive *gca* effects. Whereas, three lines (IS 13871, IS 22670 and ICSV 25333) and two testers (ICSB 351 and ICSB 480) exhibited highly significant negative *gca* effects (Table 7c).

4.4.2.1.11 Juice extraction (%)

At Bijapur, out of 14 parents evaluated, four lines (ICSV 93046, NTJ 2, SPSSV 30 and Wray) and three testers (ICSB 323, PMS 90 B and Parbhani Moti) exhibited highly significant positive *gca* effects. Whereas, three lines (IS 13871, IS 22670 and ICSV 25333) and three testers (ICSB 351, ICSB 480 and NSSV 13) exhibited highly significant negative *gca* effects (Table 7a).

At ICRISAT, out of 14 parents evaluated, four lines (ICSV 93046, NTJ 2, SPSSV 30 and Wray) and four testers (ICSB 323, ICSB 374, NSSV 13 and PMS 90 B) exhibited significant positive *gca* effects. Whereas, three lines (IS 13871, IS 22670 and ICSV 25333) and two testers (ICSB 351 and ICSB 480) exhibited highly significant negative *gca* effects (Table 7b).

Across environments out of 14 parents evaluated, four lines (ICSV 93046, NTJ 2, SPSSV 30 and Wray) and four testers (ICSB 323, ICSB 374, PMS 90 B and Parbhani Moti) exhibited highly significant positive *gca* effects. Whereas, three lines (IS 13871, IS 22670 and ICSV 25333) and two testers (ICSB 351 and ICSB 480) exhibited highly significant negative *gca* effects (Table 7c).

4.4.2.1.12 Ethanol yield (L ha^{-1})

At Bijapur, out of 14 parents evaluated three lines (IS 22670, ICSV 25333 and NTJ 2) and two testers (ICSB 374 and NSSV 13) exhibited highly significant positive *gca* effects, whereas three line (IS 13871, SPSSV 30 and Wray) and two tester (ICSB 351 and PMS 90B) exhibited negative significant *gca* effects (Table 7a).

At ICRISAT, out of 14 parents evaluated three lines (IS 22670, ICSV 25333 and NTJ 2) and two testers (PMS 90 B and NSSV 13) exhibited significant positive *gca* effects, whereas four line (ICSV 93046, IS 13871, SPSSV 30 and Wray) and two tester (ICSB 480 and ICSB 351) exhibited negative significant *gca* effects (Table 7b).

Across environments out of 14 parents evaluated three lines (IS 22670, ICSV 25333 and NTJ 2) and two testers (NSSV 13and Parbhani Moti) exhibited significant positive *gca* effects, whereas four lineS (ICSV 93046, IS 13871, SPSSV 30 and Wray) and three testers (ICSB 351, ICSB 480 and PMS 90 B) exhibited negative significant *gca* effects (Table 7c).

4.4.2.1.13 Panicle weight (t ha^{-1})

At Bijapur, out of 14 parents evaluated, three lines (ICSV 93046, NTJ 2 and SPSSV 30) and four testers (ICSB 323, ICSB 351, ICSB 480 and Parbhani Moti) exhibited highly significantly positive *gca* effects and three line (IS 13871, ICSV 25333 and Wray) and only one tester (NSSV 13) exhibited significant negative *gca* effects (Table 7a)

At ICRISAT, out of 14 parents evaluated, three lines (ICSV 93046, NTJ 2 and Wray) and two testers (ICSB 480 and PMS 90 B) exhibited highly significantly positive *gca* effects and three line (IS 13871, IS 22670 and ICSV 25333) and three tester (ICSB 323, ICSB 374 and NSSV 13) exhibited significant negative *gca* effects (Table 7b).

Across environments out of 14 parents evaluated, three lines (ICSV 93046, NTJ 2 and SPSSV 30) and four testers (ICSB 323, ICSB 351, ICSB 480 and PMS 90 B) exhibited highly significantly positive *gca* effects and three lines (IS 13871, IS 22670 and ICSV 25333) and two tester (ICSB 374 and NSSV 13) exhibited significant negative *gca* effects (Table 7c).

4.4.2.1.14 Panicle length (cm)

At Bijapur, out of 14 parents studied only one line ICSV 25333 and only one tester ICSB 374 shown highly significant positive *gca* effects and two lines (ICSV 93046 and NTJ 2) and only one testers ICSB 480 shown highly significant negative *gca* effects (Table 7a).

At ICRISAT, out of 14 parents studied two lines (ICSV 25333 and Wray) and only one tester PMS 90 B shown highly significant positive *gca* effects and two lines (ICSV 93046 and NTJ 2) and only one testers NSSV 13 shown highly significant negative *gca* effects (Table 7b).

Across environments out of 14 parents studied only one lines (ICSV 25333) and one tester PMS 90 B shown significant positive *gca* effects and two lines (ICSV 93046 and NTJ 2) and one tester (ICSB 480) shown significant negative *gca* effects (Table 7c).

4.4.2.1.15 Panicle breadth (cm)

At Bijapur, out of 14 parents, two lines *viz.,* ICSV 93046 and NTJ 2 and three testers *viz.,* ICSB 351, ICSB 480 and Parbhani Moti were exhibited highly significant positive *gca* effects and three lines (IS 13871, IS 22670 and ICSV 25333) and only one testers (NSSV 13) exhibited significant negative *gca* effects (Table 7a).

At ICRISAT, out of 14 parents, two lines *viz.,* ICSV 93046 and NTJ 2 and two testers *viz.,* ICSB 480 and PMS 90B were exhibited highly significant positive *gca* effects and two lines (IS 13871 and IS 22670) and three testers (ICSB 323, ICSB 351 and ICSB 374) exhibited significant negative *gca* effects (Table 7b).

Across environments out of 14 parents, two lines *viz.,* ICSV 93046 and NTJ 2 and three testers *viz.,* ICSB 480, PMS 30B and Parbhani Moti were exhibited highly significant positive *gca* effects and two lines (IS 13871 and IS 22670) and two testers (ICSB 374 and NSSV 13) exhibited highly significant negative *gca* effects (Table 7c).

4.4.2.1.16 Grain yield (t ha^{-1})

At Bijapur, out of 14 parents evaluated, two lines (NTJ 2 and SPSSV 30) and four testers (ICSB 323, ICSB 351, ICSB 480 and Parbhani Moti) exhibited highly significantly positive *gca* effects and three line (IS 13871, IS 22670 and ICSV 25333) and two tester (ICSB 374 and NSSV 13) exhibited highly significant negative *gca* effects (Table 7a).

At ICRISAT, out of 14 parents evaluated, four lines (ICSV 93046, NTJ 2, SPSSV 30 and Wray) and two testers (ICSB 480 and PMS 90 B) exhibited highly significantly positive *gca* effects and three line (IS 13871, IS 22670 and ICSV 25333) and three tester (ICSB 323, ICSB 374 and NSSV 13) exhibited highly significant negative *gca* effects (Table 7b).

Across environments out of 14 parents evaluated, four lines (ICSV 93046, NTJ 2, SPSSV 30 and Wray) and four testers (ICSB 351, ICSB 480, PMS 90 B and Parbhani Moti) exhibited significantly positive *gca* effects and three line (IS 13871, IS 22670 and ICSV 25333) and two tester (ICSB 374 and NSSV 13) exhibited highly significant negative *gca* effects (Table 7c).

4.4.2.1.17 1000-seed weight (g)

At Bijapur, out of 14 parents studied two lines (IS 13871 and NTJ 2) and only one tester Parbhani Moti shown highly significant positive *gca* effects and three lines (ICSV 25333, SPSSV 30 and Wray) and two testers ICSB 374 and NSSV 13 shown significant negative *gca* effects (Table 7a).

At ICRISAT, out of 14 parents studied three lines (ICSV 93046, IS 13871 and NTJ 2) and only one tester PMS 90 B shown highly significant positive *gca* effects and three lines (IS 22670, ICSV 25333 and SPSSV 30) and two testers ICSB 374 and NSSV 13 shown significant negative *gca* effects (Table 7b).

Across environments out of 14 parents studied three lines (ICSV 93046, IS 13871 and NTJ 2) and two testers (PMS 90 B and Parbhani Moti) shown significant positive *gca* effects and four lines (ICSV 25333, IS 22670, SPSSV 30 and Wray) and two testers ICSB 374 and NSSV 13 shown significant negative *gca* effects (Table 7c).

4.4.2.2 Specific combining ability effects

4.4.2.2.1 Days to 50% flowering

At Bijapur, out of 49 crosses evaluated, thirteen crosses ranged from -17.14 (SPSSV 30 × NSSV 13) to -6.09 (IS 13871 × PMS 90 B) exhibited significant negative *sca* effects, whereas eight crosses ranged from 6.24 (ICSV 93046 × ICSB 351) to 41.82 (SPSSV 30 × PMS 90B) exhibited significant positive *sca* effects (Table 8a).

At ICRISAT, out of 49 crosses evaluated, eight crosses ranged from -5.03 (IS 22670 × ICSB 480) to -9.98 (SPSSV 30 × NSSV 13) exhibited significant negative

Table 6a. Analysis of variance for combining ability with respect to stalk sugar related traits, yield and yield components in sweet sorghum genotypes evaluated at Bijapur

Source	df	DFL	Plant height (m)	Stem thickness (mm)	Stalk yield (t ha^{-1})	Juice yield (t ha^{-1})	Brix (%)	Bagasse yield (t ha^{-1})	Juice volume (L ha^{-1})	Total soluble solids (%)
Replication	2	41.34	0.06	2.52	109.47	3.30	7.37	72.26	4395789.98	5.94
Crosses/hybrids	48	1202.36**	0.57**	49.86**	3037.56**	221.95**	18.12**	2189.02**	217399141.59**	13.86**
Line	6	7154.61**	2.31**	139.26**	8925.91**	620.03**	16.31**	7202.55**	604380280.23**	12.48**
Tester	6	450.75**	0.26	37.57**	1484.97**	203.55**	19.05**	1115.26**	199044099.51**	14.57**
L × T	36	335.59**	0.33*	37.01**	2314.93**	158.67**	18.27**	1532.39**	155961458.83**	13.98**
Error	96	32.40	0.18	5.23	97.69	4.22	1.45	77.97	3850721.25	1.11
Contribution of line %		74.38	50.66	34.91	36.73	34.92	11.25	41.13	34.75	11.25
Contribution of tester %		4.69	5.61	9.42	6.11	11.46	13.14	6.37	11.44	13.14
Contribution of L × T %		20.93	43.73	55.67	57.16	53.62	75.61	52.50	53.80	75.61
GCA variance		12.38	0.00	0.18	10.32	0.90	0.00	9.38	877681.18	0.00
SCA variance		101.06	0.05	10.59	739.08	51.48	5.61	484.81	50703579.19	4.29
GCA/SCA		0.12	0.07	0.02	0.01	0.02	0.00	0.02	0.02	0.00

*Significance at 5% probability, **significance at 1% probability, DFL: days to 50% flowering

Table 6a (conti....)

Source	df	Total sugar index	Juice extraction (%)	Ethanol yield ($L\ ha^{-1}$)	Panicle weight ($t\ ha^{-1}$)	Panicle length (cm)	Panicle breadth (cm)	Grain yield ($t\ ha^{-1}$)	1000-seed weight (g)
Replication	2	0.47	0.34	2008632.31	0.01	10.17	0.18	0.05	23.81
Crosses/hybrids	48	3.75**	165.54**	18559833.08**	27.13**	47.13**	2.11**	12.30**	70.72**
Line	6	10.20**	558.96**	56779608.40**	22.30**	138.77**	2.17**	8.56**	234.80**
Tester	6	4.18**	118.19**	16414735.99**	59.40**	33.72	4.48**	32.51**	115.25**
L × T	36	2.60**	107.87**	12547386.71**	22.55**	34.09*	1.71**	9.55**	35.95**
Error	96	0.14	4.94	769361.20	0.91	18.64	0.25	0.24	15.56
Contribution of line %		34.03	42.21	38.24	10.27	36.81	12.85	8.70	41.50
Contribution of tester %		13.94	8.92	11.06	27.37	8.94	26.52	33.04	20.37
Contribution of L × T %		52.03	48.87	50.70	62.35	54.25	60.63	58.26	38.13
GCA variance		0.02	0.82	85892.09	0.07	0.19	0.01	0.04	0.50
SCA variance		0.82	34.31	3926008.50	7.21	5.15	0.48	3.10	6.80
GCA/SCA		0.02	0.02	0.02	0.01	0.04	0.01	0.01	0.07

*Significance at 5% probability, **significance at 1% probability

Table 6b. Analysis of variance for combining ability with respect to stalk sugar related traits, yield and yield components in sweet sorghum genotypes evaluated at ICRISAT

Source	df	DFL	Plant height (m)	Stem thickness (mm)	Stalk yield (t ha^{-1})	Juice yield (t ha^{-1})	Brix (%)	Bagasse yield (t ha^{-1})	Juice volume (L ha^{-1})	Total soluble solids (%)
Replication	2	13.62	0.12	1.25	142.56	26.93	4.34	20.89	27628645.74	3.32
Crosses/hybrids	48	1568.07**	1.31**	32.15**	4982.38**	604.74**	9.43**	2605.05**	600230671.42**	7.21**
Line	6	11550.93**	7.36**	202.53**	23667.65**	2157.85**	34.43**	14535.08**	2148738120.05**	26.34**
Tester	6	465.03**	0.68**	18.73**	3677.04**	952.54**	11.49**	1066.30**	943318457.97**	8.79**
L × T	36	88.10**	0.41**	5.99**	2085.72**	287.92**	4.92**	873.17**	284964798.90**	3.76**
Error	124	18.03	0.06	2.68	56.97	11.83	1.47	30.04	11655492.13	1.12
Contribution of line %		92.08	70.23	78.73	59.38	44.60	45.64	69.74	44.75	45.64
Contribution of tester %		3.71	6.53	7.28	9.23	19.69	15.23	5.12	19.64	15.23
Contribution of L × T %		4.21	23.24	13.98	31.40	35.71	39.13	25.14	35.61	39.13
GCA variance		21.14	0.01	0.37	41.38	4.53	0.06	24.74	4503798.18	0.05
SCA variance		23.36	0.12	1.10	676.25	92.03	1.15	281.04	91103102.25	0.88
GCA/SCA		0.91	0.11	0.34	0.06	0.05	0.06	0.09	0.05	0.06

*Significance at 5% probability, **significance at 1% probability, DFL: days to 50% flowering

Table 6b (conti....)

Source	df	Total sugar index	Juice extraction (%)	Ethanol yield (L ha^{-1})	Panicle weight (t ha^{-1})	Panicle length (cm)	Panicle breadth (cm)	Grain yield (t ha^{-1})	1000-seed weight (g)
Replication	2	0.31	17.29	783465.15	0.03	22.90	0.17	0.10	44.28
Crosses/hybrids	48	19.97**	213.32**	31404652.61**	18.80**	63.19**	3.42**	12.75**	84.45**
Line	6	64.58**	1175.72**	147209022.20**	52.20**	258.56**	10.02**	43.57**	475.83**
Tester	6	35.20**	214.30**	18247632.44**	17.00**	47.33**	3.13**	10.50**	61.83**
L × T	36	9.99**	52.76**	14296761.05**	13.54**	33.28**	2.37**	7.99**	22.99**
Error	124	0.45	6.17	478174.91	0.58	8.07	0.21	0.15	9.46
Contribution of line %		40.43	68.89	58.59	34.70	51.14	36.64	42.70	70.43
Contribution of tester %		22.04	12.56	7.26	11.30	9.36	11.46	10.29	9.15
Contribution of L × T %		37.53	18.55	34.14	54.00	39.49	51.91	47.01	20.42
GCA variance		0.14	2.29	244398.45	0.08	0.43	0.02	0.07	0.88
SCA variance		3.18	15.53	4606195.38	4.32	8.40	0.72	2.61	4.51
GCA/SCA		0.04	0.15	0.05	0.02	0.05	0.02	0.03	0.19

*Significance at 5% probability, **significance at 1% probability

Table 6c. Analysis of variance for combining ability with respect to stalk sugar related traits, yield and yield components in sweet sorghum genotypes evaluated across environments

Source	df	DFL	Plant height (m)	Stem thickness (mm)	Stalk yield (t ha^{-1})	Juice yield (t ha^{-1})	Juice volume (L ha^{-1})	Brix (%)	Bagasse yield (t ha^{-1})	Total soluble solids (%)
Environment	1	691.52**	54.02**	498.24**	19186.45**	24740.30**	24986181956**	548.31**	430.42	419.39**
Replication	4	16.25	0.08	5.21	164.55	14.56	13786496	5.97	74.90	4.57
Crosses	48	2532.76**	1.90**	70.98**	7488.21**	929.23**	916602535**	19.78**	4116.48**	15.12**
Line	6	17851.92**	9.62**	344.12**	30995.53**	2808.87**	2776206439**	40.28**	20214.17**	30.81**
Tester	6	813.54**	1.80**	45.77**	3819.45**	1152.25**	1133372928**	27.27**	1143.88**	20.82**
Line × tester	36	257.12**	0.64**	29.90**	4181.78**	578.79**	570540152**	15.11**	1998.92**	11.56**
Environment × crosses	48	182.69**	0.31**	15.15**	1862.97**	305.41**	303270081**	8.73**	894.43**	6.69**
Environment × line	6	418.09**	0.87**	16.45**	4335.41**	594.00**	590255590**	6.71**	1970.78**	5.13**
Environment × tester	6	104.68**	0.28	7.49	3012.71**	647.81**	644372853**	3.23	1141.94**	2.48
Environment × line × tester	36	156.56**	0.22**	16.21**	1259.27**	200.25**	198588700**	9.99**	672.30**	7.65**
Error	192	20.12	0.07	3.09	72.34	8.29	8049678	1.20	44.50	0.92
Contribution of line %		88.11	63.10	60.60	51.74	37.78	38.00	25.46	61.38	25.47
Contribution of tester %		4.02	11.84	8.06	6.38	15.50	15.00	17.24	3.47	17.22
Contribution of L × T %		7.61	25.05	31.59	41.88	46.72	47.00	57.30	36.42	57.32
GCA variance		58.90	0.03	0.93	56.41	3.95	3866303.47	0.03	43.89	0.02
SCA variance		67.05	0.28	9.12	1948.34	252.36	247967634.67	3.41	884.42	2.61
GCA/SCA		0.88	0.11	0.10	0.03	0.02	0.02	0.01	0.05	0.01

*Significance at 5% probability, **significance at 1% probability, DFL: days to 50% flowering

Table 6c (conti....)

Source	df	Total sugar index	Juice extraction (%)	Ethanol yield (L ha^{-1})	Panicle weight (t ha^{-1})	Panicle length (cm)	Panicle breadth (cm)	Grain yield (t ha^{-1})	1000-seed weight (g)
environment	1	29716.25**	23523.29**	73870766**	153.16**	2.46	14.86**	4.98**	207.60**
replication	4	11.55	10.64	1745208	0.18	22.54	0.44	0.06	16.36
crosses	48	1094.53**	320.07**	45695956**	29.95**	93.18**	3.57**	17.16**	134.52**
line	6	3250.42**	1606.02**	186187346**	52.38**	410.19**	10.12**	43.52**	706.24**
tester	6	1364.64**	323.64**	24710752**	48.51**	39.06	4.97**	27.85**	127.53**
line × tester	36	690.2**	105.15**	25778259**	23.11**	49.36**	2.25**	10.98**	40.08**
environment × crosses	48	366.84**	98.44**	8980131**	17.25**	23.74	1.98**	8.58**	27.73**
environment × line	6	718.77**	139.16**	20826022**	22.54**	26.64	2.14**	11.15**	51.47**
environment × tester	6	753.66**	126.57**	13528505**	26.84**	40.37*	2.96**	14.66**	20.08
environment × line × tester	36	243.72**	86.96**	6247753**	14.77**	20.49	1.79**	7.14**	25.07**
error	192	8.46	4.85	605434	0.72	12.19	0.21	0.16	10.22
contribution of line %		37.12	62.72	51.00	21.87	55.03	35.43	31.71	65.63
contribution of tester %		15.58	12.64	7.00	20.25	5.24	17.39	20.29	11.85
contribution of L × T %		47.29	24.64	42.00	57.88	39.73	47.18	48.00	22.34
GCA variance		4.34	4.35	382624.31	-0.08	0.83	0.01	0.07	0.03
SCA variance		297.66	12.13	13020337.33	5.56	19.25	0.31	3.04	2.56
GCA/SCA		0.01	0.36	0.03	-0.01	0.04	0.02	0.02	0.01

*Significance at 5% probability, **significance at 1% probability

Table 7a. Estimates of general combining ability effects of parents evaluated at Bijapur for stalk sugar related traits, yield and yield components

S.No.	Parents	DFL	Plant height (m)	Stem thickness (mm)	Stalk yield (t ha^{-1})	Juice yield (t ha^{-1})	Juice volume (L ha^{-1})	Brix (%)	Bagasse yield (t ha^{-1})	Total soluble solids (%)
Lines										
1	IS 13871	-19.01**	-0.38**	-2.59**	-27.85**	-6.89**	-6799.74**	-1.10**	-20.94**	-0.97**
2	IS 22670	14.76**	0.56**	2.06**	14.85**	-4.92**	-4888.82**	-0.68**	19.77**	-0.59**
3	ICSV 25333	33.85**	0.35**	3.64**	20.34**	-0.26	-208.33	0.82**	20.63**	0.72**
4	ICSV 93046	-1.67	-0.17*	-0.52	13.62**	7.99**	7893.19**	-0.25	5.66**	-0.22
5	NTJ 2	-4.20**	-0.19*	2.01**	12.76**	3.41**	3345.14**	-0.68**	9.33**	-0.59**
6	Wray	-14.82**	-0.12	-2.89**	-27.43**	-3.51**	-3464.82**	0.99**	-23.98**	0.86**
7	SPSSV 30	-8.91**	-0.06	-1.72**	-6.29**	4.19**	4123.38**	0.9**	-10.46**	0.79**
Testers										
8	PMS 90 B	2.61*	-0.13	-1.02*	-12.80**	0.16	243.47	-0.13	-12.96**	-0.11
9	ICSB 323	-2.96**	-0.04	0.19	5.99**	5.02**	4978.92**	0.30	0.94	0.26
10	ICSB 351	-3.72**	0.02	-0.04	-10.61**	-4.34**	-4267.11**	-1.11**	-6.23**	-0.97**
11	ICSB 374	-0.29	0.07	1.06*	8.37**	0.17	27.26	-0.60*	8.15**	-0.52*
12	ICSB 480	-1.39	-0.13	-1.71**	0.19	-1.03*	-960.41*	-0.28	1.26	-0.24
13	Parbhani Moti	-3.48**	0.04	-0.74	5.52**	2.56**	2527.56**	-0.10	2.99	-0.09
14	NSSV 13	9.23**	0.17*	2.25**	3.35	-2.54**	-2549.69**	1.91**	5.85**	1.67**
	S.Em.±	2.89	0.22	1.16	5.02	1.04	996.86	0.61	4.49	0.54
	CD at 5%	8.09	0.61	3.25	14.05	2.92	2790.34	1.71	12.56	1.50
	CD at 1%	10.70	0.81	4.30	18.58	3.86	3688.06	2.27	16.60	1.98
	CV (%)	5.60	15.41	10.05	12.43	14.14	13.70	8.25	13.64	8.17

*Significance at 5% probability, **significance at 1% probability, DFL: days to 50% flowering

Table 7a (conti....)

S.No.	Parents	Total sugar index	Juice extraction (%)	Ethanol yield (L ha^{-1})	Panicle weight (t ha^{-1})	Panicle length (cm)	Panicle breadth (cm)	Grain yield (t ha^{-1})	1000-seed weight (g)
Lines									
1	IS 13871	-0.99**	-3.36**	-1935.08**	-1.44**	1.55	-0.30**	-0.59**	3.81**
2	IS 22670	-0.71**	-7.51**	1383.65**	0.23	1.37	-0.27**	-0.34**	0.78
3	ICSV 25333	0.16*	-3.94**	2490.80**	-0.72**	3.45**	-0.25*	-0.70**	-5.75**
4	ICSV 93046	0.77**	4.06**	95.15	1.13**	-3.96**	0.49**	0.09	1.14
5	NTJ 2	0.44**	0.92*	613.58**	0.85**	-2.70**	0.30**	1.06**	3.43**
6	Wray	-0.37**	2.58**	-1807.74**	-0.95**	0.60	-0.16	-0.11	-1.68*
7	SPSSV 30	0.70**	7.25**	-840.35**	0.91**	-0.32	0.18	0.59**	-1.74*
Testers									
8	PMS 90 B	-0.22**	2.17**	-1464.94**	-0.15	-0.42	-0.12	0.10	1.41
9	ICSB 323	0.76**	3.21**	211.46	1.10**	1.31	0.05	0.42**	0.95
10	ICSB 351	-0.62**	-2.55**	-843.69**	1.15**	0.06	0.26**	1.67**	0.47
11	ICSB 374	-0.06	-0.09	478.79**	-0.20	1.79*	-0.19	-0.73**	-2.13**
12	ICSB 480	-0.12	-2.07**	89.26	1.13**	-2.03*	0.51**	0.50**	-0.43
13	Parbhani Moti	0.38**	1.62**	328.08	0.54**	-0.62	0.36**	0.36**	3.41**
14	NSSV 13	-0.12	-2.30**	1201.04**	-3.58**	-0.09	-0.88**	-2.33**	-3.68**
	S.Em.±	0.19	1.13	445.58	0.48	2.19	0.25	0.25	2.00
	CD at 5%	0.53	3.16	1247.24	1.35	6.14	0.71	0.70	5.61
	CD at 1%	0.70	4.18	1648.51	1.79	8.11	0.94	0.92	7.41
	CV (%)	18.72	10.65	15.11	12.99	13.89	10.56	13.42	13.92

*Significance at 5% probability, **significance at 1% probability

Table 7b. Estimates of general combining ability effects of parents in evaluated at ICRISAT for stalk sugar related traits, yield and yield components

S.No.	Parents	DFL	Plant height (m)	Stem thickness (mm)	Stalk yield (t ha^{-1})	Juice yield (t ha^{-1})	Juice volume (L ha^{-1})	Brix (%)	Bagasse yield (t ha^{-1})	Total soluble solids (%)
Lines										
1	IS 13871	-21.12**	-0.83**	-3.07**	-46.87**	-19.27**	-19257.56**	-1.23**	-27.80**	-1.07**
2	IS 22670	22.84**	0.56**	3.26**	33.79**	4.52**	4472.67**	-0.60*	29.01**	-0.52*
3	ICSV 25333	41.27**	0.96**	5.03**	45.03**	3.82**	3837.44**	-1.18**	41.00**	-1.03**
4	ICSV 93046	-5.16**	-0.33**	-1.46**	-9.51**	2.36**	2323.76**	-0.52	-10.68**	-0.45
5	NTJ 2	-3.45**	-0.03	0.68	19.84**	13.67**	13624.76**	0.09	5.98**	0.08
6	Wray	-17.78**	-0.22**	-2.30**	-18.13**	-1.00	-951.09	1.25**	-17.29**	1.09**
7	SPSSV 30	-16.59**	-0.12*	-2.15**	-24.14**	-4.09**	-4049.97**	2.18**	-20.22**	1.91**
Testers										
8	PMS 90 B	-2.64**	-0.13*	0.45	11.41**	4.75**	4776.22**	-0.73**	6.50**	-0.64**
9	ICSB 323	-1.64	-0.11*	-0.11	-3.35*	-0.51	-506.58	0.31	-3.05*	0.27
10	ICSB 351	-4.88**	-0.11*	-0.05	-14.09**	-10.57**	-10530.67**	-0.03	-3.70**	-0.03
11	ICSB 374	2.65**	0.04	-0.06	3.89*	2.64**	2591.94**	-0.43	2.41*	-0.38
12	ICSB 480	-2.88**	-0.18**	-1.23**	-18.39**	-7.39**	-7324.61**	-0.21	-11.18**	-0.18
13	Parbhani Moti	0.22	0.20**	-0.75*	1.69	2.82**	2780.51**	-0.41	-1.32	-0.36
14	NSSV 13	9.17**	0.29**	1.74**	18.83**	8.26**	8213.18**	1.50**	10.34**	1.31**
	S.Em.±	2.45	0.14	0.95	4.36	1.99	1971.08	0.70	3.16	0.61
	CD at 5%	6.86	0.39	2.65	12.20	5.56	5517.30	1.96	8.86	1.71
	CD at 1%	9.07	0.51	3.50	16.12	7.35	7292.35	2.59	11.71	2.26
	CV (%)	4.90	7.18	7.26	8.92	11.30	11.27	7.81	10.10	7.73

*Significance at 5% probability, **significance at 1% probability, DFL: days to 50% flowering

Table 7b (conti....)

S.No.	Parents	Total sugar index	Juice extraction (%)	Ethanol yield (L ha^{-1})	Panicle weight (t ha^{-1})	Panicle length (cm)	Panicle breadth (cm)	Grain yield (t ha^{-1})	1000-seed weight (g)
	Lines								
1	IS 13871	-3.54**	-6.52**	-3286.36**	-1.26**	0.39	-0.80**	-0.60**	4.78**
2	IS 22670	0.54**	-7.83**	2914.75**	-2.32**	-1.34*	-0.90**	-1.76**	-2.91**
3	ICSV 25333	0.29	-9.47**	3994.14**	-0.66**	6.74**	0.14	-1.91**	-7.95**
4	ICSV 93046	0.22	6.26**	-1256.12**	2.07**	-4.39**	0.83**	1.64**	2.10**
5	NTJ 2	2.32**	5.33**	708.10**	1.66**	-2.20**	0.83**	1.26**	5.90**
6	Wray	0.22	6.40**	-1486.66**	0.68**	1.41*	-0.06	0.97**	-0.55
7	SPSSV 30	-0.06	5.83**	-1587.85**	-0.17	-0.61	-0.04	0.40**	-1.37*
	Testers								
8	PMS 90 B	0.49**	1.73**	392.99*	1.36**	2.83**	0.54**	1.03**	3.24**
9	ICSB 323	-0.05	1.16*	-254.19	-0.70**	-1.05	-0.22*	-0.56**	0.58
10	ICSB 351	-1.95**	-6.46**	-504.41**	-0.11	1.07	-0.38**	-0.11	-0.39
11	ICSB 374	0.26	2.93**	100.22	-0.85**	-0.01	-0.40**	-0.83**	-1.40*
12	ICSB 480	-1.28**	-1.80**	-1271.35**	1.09**	-1.13	0.48**	0.82**	-0.34
13	Parbhani Moti	0.52**	0.76	-214.73	-0.01	-0.35	0.11	0.15	0.41
14	NSSV 13	2.01**	1.68**	1751.47**	-0.78**	-1.36*	-0.12	-0.51**	-2.10**
	S.Em.±	0.39	1.43	399.24	0.44	1.64	0.27	0.22	1.78
	CD at 5%	1.08	4.01	1117.52	1.23	4.59	0.75	0.62	4.97
	CD at 1%	1.43	5.31	1477.05	1.62	6.07	0.99	0.83	6.57
	CV (%)	12.65	6.86	11.63	14.81	10.46	10.00	12.69	13.43

*Significance at 5% probability, **significance at 1% probability

Table 7c. Estimates of general combining ability effects of parents evaluated across two environments for stalk sugar related traits, yield and yield components

S.No.	Parents	DFL	Plant height (m)	Stem thickness (mm)	Stalk yield (t ha^{-1})	Juice yield (t ha^{-1})	Juice volume (L ha^{-1})	Brix (%)	Bagasse yield (t ha^{-1})	Total soluble solids (%)
	Lines									
1	IS 13871	-20.06**	-0.61**	-2.83**	-37.36**	-13.08**	-13028.65**	-1.16**	-24.37**	-1.02**
2	IS 22670	18.80**	0.63**	2.66**	24.32**	-0.20	-208.08	-0.64	24.39**	-0.56
3	ICSV 25333	37.56**	0.65**	4.34**	32.68**	1.78	1814.55	-0.18	30.81**	-0.16
4	ICSV 93046	-3.42*	-0.26**	-0.99*	2.06	5.17**	5108.47**	-0.39	-2.51	-0.34
5	NTJ 2	-3.82**	-0.12	1.35**	16.30**	8.54**	8484.95**	-0.29	7.65**	-0.26
6	Wray	-16.30**	-0.19**	-2.59**	-22.78**	-2.26	-2207.95	1.12**	-20.63**	0.98**
7	SPSSV 30	-12.75**	-0.10	-1.94**	-15.22**	0.05	36.71	1.54**	-15.34**	1.35**
	Testers									
8	PMS 90 B	-0.03	-0.28**	-0.57	-1.39	4.91**	5019.69**	-0.86*	-6.46*	-0.75*
9	ICSB 323	-4.60**	-0.18**	0.09	2.64	4.51**	4472.34**	0.61	-2.11	0.53
10	ICSB 351	-8.60**	-0.11	-0.09	-24.70**	-14.91**	-14797.78**	-1.14**	-9.93**	-1.00**
11	ICSB 374	2.35	0.09	1.01*	12.26**	2.81	2619.20	-1.03**	10.56**	-0.90**
12	ICSB 480	-4.27**	-0.34**	-2.94**	-18.20**	-8.42**	-8285.02**	-0.48	-9.92**	-0.42
13	Parbhani Moti	-3.27*	0.38**	-1.49**	7.21	5.37**	5308.07**	-0.51	1.68	-0.45
14	NSSV 13	18.40**	0.43**	3.99**	22.18**	5.72**	5663.49**	3.42**	16.18**	2.99**
	S.Em.±	1.70	0.11	0.72	3.32	1.12	1104.41	0.46	2.55	0.41
	CD at 5%	4.74	0.3	2.00	9.26	3.12	3076.23	1.29	7.10	1.13
	CD at 1%	6.25	0.39	2.63	12.20	4.12	4054.32	1.71	9.36	1.49
	CV (%)	4.75	8.90	8.23	10.40	12.33	12.24	8.03	11.19	7.96

*Significance at 5% probability, **significance at 1% probability, DFL: days to 50% flowering

Table 7c (conti....)

S.No.	Parents	Total sugar index	Juice extraction (%)	Ethanol yield (L ha^{-1})	Panicle weight (t ha^{-1})	Panicle length (cm)	Panicle breadth (cm)	Grain yield (t ha^{-1})	1000-seed weight (g)
Lines									
1	IS 13871	-2.27**	-4.94**	-2610.72**	-1.35**	0.97	-0.55**	-0.60*	4.30**
2	IS 22670	-0.08	-7.67**	2149.20**	-1.05**	0.02	-0.59**	-1.05**	-1.07
3	ICSV 25333	0.22	-6.70**	3242.47**	-0.69	5.10**	-0.05	-1.30**	-6.85**
4	ICSV 93046	0.49	5.16**	-580.48*	1.60**	-4.18**	0.66**	0.86**	1.62*
5	NTJ 2	1.38**	3.12**	660.84*	1.25**	-2.45**	0.57**	1.16**	4.66**
6	Wray	-0.07	4.49**	-1647.20**	-0.13	1.01	-0.11	0.43	-1.11
7	SPSSV 30	0.32	6.54**	-1214.10**	0.37	-0.46	0.07	0.49	-1.55*
Testers									
8	PMS 90 B	0.27	3.91**	-1071.95**	1.21**	2.41**	0.41**	1.13**	4.65**
9	ICSB 323	0.72**	4.37**	-42.73	0.40	0.27	-0.17	-0.13	1.52*
10	ICSB 351	-2.57**	-9.01**	-1348.10**	1.05**	1.13	-0.13	1.56**	0.09
11	ICSB 374	0.20	2.84**	579.01*	-1.04**	1.78*	-0.59**	-1.55**	-3.53**
12	ICSB 480	-1.40**	-3.86**	-1182.09**	2.22**	-3.16**	0.99**	1.31**	-0.77
13	Parbhani Moti	0.9**	2.38**	113.35	0.53	-0.97	0.47**	0.52*	3.82**
14	NSSV 13	1.89**	-0.63	2952.51**	-4.36**	-1.46*	-0.99**	-2.83**	-5.77**
	S.Em.±	1.15	0.92	298.86	0.33	1.37	0.18	0.17	1.26
	CD at 5%	3.19	2.55	832.43	0.91	3.82	0.51	0.47	3.50
	CD at 1%	4.20	3.36	1097.10	1.20	5.03	0.68	0.62	4.61
	CV (%)	11.51	8.16	13.17	13.93	12.29	10.23	13.21	12.90

*Significance at 5% probability, **significance at 1% probability

At ICRISAT, out of 49 crosses evaluated, eight crosses ranged from -5.03 (IS 22670 × ICSB 480) to -9.98 (SPSSV 30 × NSSV 13) exhibited significant negative *sca* effects, whereas nine crosses ranged from 4.88 (ICSV 25333 × ICSB 351) to 10.83 (NTJ 2 × Parbhani Moti) exhibited significant positive *sca* effects (Table 8b).

Across environments, out of 49 crosses evaluated, nine crosses ranged from -13.7 (SPSSV 30 × NSSV 13) to -3.70 (SPSSV 30 × ICSB 351) exhibited significant negative *sca* effects, whereas twelve crosses ranged from 3.67 (IS 22670 × ICSB 351) to 21.18 (SPSSV 30 × PMS 90B) exhibited significant positive *sca* effects (Table 8c).

4.4.2.2.2 Plant height (m)

At Bijapur, out of 49 crosses evaluated, four crosses ranged from 0.44 to 0.57 (ICSV 25333 × ICSB 323, IS 22670 × NSSV 13, IS 22670 × ICSB 351 and ICSV 93046 × Parbhani Moti) exhibited significantly positive *sca* effects. Whereas, three crosses ranged from -0.81 to -0.47 (IS 22670 × Parbhani Moti, ICSV 25333 × NSSV 13 and SPSSV 30 × PMS 90B) exhibited negatively significant *sca* effects (Table 8a).

At ICRISAT, out of 49 crosses evaluated, seven crosses ranged from 0.34 (ICSV 25333 × ICSB 480) to 0.85 (NTJ 2 × Parbhani Moti) exhibited significantly positive *sca* effects. Whereas, five crosses ranged from -1.04 (ICSV 25333 × Parbhani Moti) to -0.30 (SPSSV 30 × ICSB 374) exhibited negatively significant *sca* effects (Table 8b).

Across environments, out of 49 crosses evaluated, seven crosses ranged from 0.30 (IS 22670 × ICSB 351) to 1.08 (NTJ 2 × Parbhani Moti) exhibited significantly positive *sca* effects. Whereas, eight crosses ranged from -0.71 (ICSV 25333 × NSSV 13) to -0.28 (IS 22670 × ICSB 480) exhibited negatively significant *sca* effects (Table 8c).

4.4.2.2.3 Stem thickness (mm)

At Bijapur, out of 49 crosses evaluated, ten crosses ranged from 2.32 (ICSV 93046 × Parbhani Moti) to 6.77 (IS 22670 × ICSB 374) exhibited significantly positive *sca* effects. Whereas, nine crosses ranged from -6.47 (IS 13871 × ICSB 374) to -2.58 (SPSSV 30 × NSSV 13) exhibited negatively significant *sca* effects (Table 8a).

At ICRISAT, out of 49 crosses evaluated, two crosses NTJ 2 × Parbhani Moti (2.84) and IS 22670 × ICSB 374 (2.53) exhibited significantly positive *sca* effects. Whereas, three crosses ranged from -3.72 to -1.98 (ICSV 25333 × Parbhani Moti, NTJ 2 × NSSV 13 and Wray × PMS 90 B) exhibited negatively significant *sca* effects (Table 8b).

Across environments, out of 49 crosses evaluated, nine crosses ranged from 1.59 (IS 13871 × PMS 90 B) to 4.74 (IS 22670 × ICSB 374) exhibited significantly positive *sca* effects. Whereas, eleven crosses ranged from -3.71 (IS 13871 × ICSB 374) to -1.61 (SPSSV 30 × NSSV 13) exhibited negatively significant *sca* effects (Table 8c).

4.4.2.2.4 Stalk yield (t ha^{-1})

At Bijapur, out of 49 crosses evaluated, fourteen hybrid ranged from 10.20 (Wray × Parbhani Moti) to 49.41 (IS 22670 × NSSV 13) exhibited significantly positive *sca* effects while fifteen hybrid ranged from -48.70 (ICSV 93046 × ICSB 351) to -12.13 (ICSV 25333 × Parbhani Moti) exhibited significantly positive *sca* effects (Table 8a).

At ICRISAT, out of 49 crosses evaluated, seventeen hybrid ranged from 8.64 (Wray × ICSB 480) to 63.27 (NTJ 2 × Parbhani Moti) exhibited significantly positive *sca* effects while fifteen hybrid ranged from -79.33 (ICSV 25333 × Parbhani Moti) to -9.00 (NTJ 2 × ICSB 374) exhibited significantly positive *sca* effects (Table 8b).

Across environments, out of 49 crosses evaluated, fourteen hybrid ranged from 9.89 (ICSV 93046 × Parbhani Moti) to 78.86 NTJ 20 × Parbhani Moti) exhibited significantly positive *sca* effects while seventeen hybrid ranged from -58.82 (ICSV 25333 × Parbhani Moti) to -7.77 (Wray × PMS 90 B) exhibited significantly negative *sca* effects (Table 8c).

4.4.2.2.5 Juice yield (t ha^{-1})

At Bijapur, out of 49 crosses, twenty crosses ranged from 2.24 (IS 13871 × PMS 90 B) to 17.07 (ICSV 93046 × PMS 90B) exhibited significantly positive *sca* effects and nineteen hybrid ranged from -15.53 (SPSSV 30 × PMS 90B) to -2.44 (Wray × Parbhani Moti) exhibited significantly negative *sca* effects (Table 8a).

At ICRISAT, out of 49 crosses, seventeen crosses ranged from 3.94 (ICSV 93046 × NSSV 13) to 26.12 (NTJ 2 × Parbhani Moti) exhibited significantly positive *sca* effects and twelve hybrid ranged from -25.06 (ICSV 25333 × Parbhani Moti) to -4.30 (IS 22670 × ICSB 323) exhibited significantly negative *sca* effects (Table 8b).

Across environments, out of 49 crosses, seventeen crosses ranged from 2.31 (Wray × ICSB 374) to 40.20 (NTJ 2 × Parbhani Moti) exhibited significantly positive *sca* effects and nineteen hybrid ranged from -16.58 (ICSV 25333 × Parbhani Moti) to -2.45 (IS 13871 × ICSB 374) exhibited significantly negative *sca* effects (Table 8c).

4.4.2.2.6 Juice volume (L ha^{-1})

At Bijapur, out of 49 crosses, twenty hybrid ranged from 2202.03 (IS 13871 × PMS 90 B) to 16952.31 (ICSV 93046 × PMS 90B) exhibited significant positive *sca* effects and twenty crosses ranged from -15296.40 (SPSSV 30 × PMS 90B) to -1998.32 (Wray × PMS 90 B) exhibited significantly negative *sca* effects (Table 8a).

At ICRISAT, out of 49 crosses, sixteen hybrid ranged from 4014.95 (IS 13871 × ICSB 480) to 25694.10 (NTJ 2 × Parbhani Moti) exhibited significant positive *sca* effects and twelve crosses ranged from -24962.96 (ICSV 25333 × Parbhani Moti) to -4286.42 (IS 22670 × ICSB 323) exhibited significantly negative *sca* effects (Table 8b).

Across environments, out of 49 crosses, sixteen hybrid ranged from 2762.67 (SPSSV 30 × ICSB 323) to 39809.98 (NTJ 2 × Parbhani Moti) exhibited significant positive *sca* effects and nineteen crosses ranged from -16453.33 (ICSV 25333 × Parbhani Moti) to -2410.48 (IS 13871 × ICSB 374) exhibited significantly negative *sca* effects (Table 8c).

4.4.2.2.7 Brix (%)

At Bijapur, out of 49 crosses, twelve crosses ranged from 1.44 (Wray × ICSB 323) to 4.78 (SPSSV 30 × PMS 90B) exhibited significant positive *sca* effects, and eleven crosses ranged from -4.90 (ICSV 93046 × PMS 90B) to -1.23 (IS 13871 × ICSB 480) exhibited negatively significant *sca* effects (Table 8a).

At ICRISAT, out of 49 crosses, six crosses ranged from 1.40 (NTJ 2 × NSSV 13) to 1.96 (SPSSV 30 × ICSB 323) exhibited significant positive *sca* effects, and four crosses ranged from -4.10 (ICSV 25333 × Parbhani Moti) to -1.40 (NTJ 2 × ICSB 351) exhibited negatively significant *sca* effects (Table 8b).

Across environments, out of 49 crosses, thirteen crosses ranged from 0.89 (NTJ 2 × ICSB 374) to 2.62 (ICSV 93046 × NSSV 13) exhibited significant positive *sca* effects, and ten crosses ranged from -3.61 (ICSV 25333 × Parbhani Moti) to -1.11 (ICSV 93046 × ICSB 374) exhibited negatively significant *sca* effects (Table 8c).

4.4.2.2.8 Bagasse yield (t ha^{-1})

At Bijapur, out of 49 crosses, fourteen crosses ranged from 10.19 (IS 13871 × PMS 90 B) to 42.13 (IS 22670 × NSSV 13) exhibited significant positive *sca* effects, and sixteen crosses ranged from -35.66 (ICSV 93046 × ICSB 351) to -9.07 (ICSV 25333 × Parbhani Moti) exhibited negatively significant *sca* effects (Table 8a).

At ICRISAT, out of 49 crosses, seventeen crosses ranged from 6.76 (IS 13871 × ICSB 323) to 37.14 (NTJ 2 × Parbhani Moti) exhibited significant positive *sca* effects, and sixteen crosses ranged from -54.02 (ICSV 25333 × Parbhani Moti) to -6.37(NTJ 2 × PMS 90 B) exhibited negatively significant *sca* effects (Table 8b).

Across environments, out of 49 crosses, sixteen crosses ranged from 5.83 (ICSV 93046 x ICSB 323) to 38.49 (NTJ 2 × Parbhani Moti) exhibited significant positive *sca* effects, and eighteen crosses ranged from -43.05(ICSV 25333 × Parbhani Moti) to -5.39 (Wray × PMS 90 B) exhibited negatively significant *sca* effects (Table 8c).

4.4.2.2.9 Total soluble sugar (%)

At Bijapur, out of 49 crosses studied the *sca* effects were significant for twenty crosses out of that twelve crosses ranged from 1.26 (Wray × ICSB 323) to 4.18 (SPSSV 30 × PMS 90B) showed significant positive *sca* effects. Whereas eleven crosses ranged from -4.28 (ICSV 93046 × PMS 90B) to -1.07 (IS 13871 × ICSB 480) exhibited significant negative *sca* effects (Table 8a).

At ICRISAT, out of 49 crosses studied the *sca* effects were significant for ten crosses out of that six crosses ranged from 1.22 (NTJ 2 × NSSV 13) to 1.71 (SPSSV 30 × ICSB 323) showed significant positive *sca* effects. Whereas four crosses ranged from -3.58 (ICSV 25333 × Parbhani Moti) to -1.23 (NTJ 2 × ICSB 351) exhibited significant negative *sca* effects (Table 8b).

Across environments, out of 49 crosses studied the *sca* effects were significant for twenty three crosses out of that thirteen crosses ranged from 0.78 (NTJ 2 × ICSB 374) to 2.29 (ICSV 93046 × NSSV 13) showed significant positive *sca* effects. Whereas ten crosses ranged from -3.16 (ICSV 25333 × SPB 1411) to -0.97 (ICSV 93046 × ICSB 374) exhibited significant negative *sca* effects (Table 8c).

4.4.2.2.10 Total sugar index

At Bijapur, out of 49 crosses, seventeen crosses ranged from 0.46 (IS 13871 × PMS 90 B) to 1.67 (ICSV 93046 × ICSB 323) exhibited significant positive *sca* effects, and seventeen crosses ranged from -1.87 (SPSSV 30 × PMS 90B) to -0.42 (NTJ 2 × NSSV 13) exhibited negatively significant *sca* effects (Table 8a).

At ICRISAT, out of 49 crosses, fifteen crosses ranged from 0.80 (ICSV 25333 × ICSB 480) to 4.61 (NTJ 2 × Parbhani Moti) exhibited significant positive *sca* effects, and fourteen crosses ranged from -4.96 (ICSV 25333 × Parbhani Moti) to -0.81 (ICSV 93046 × Parbhani Moti) exhibited negatively significant *sca* effects (Table 8b).

Across environments, out of 49 crosses, seventeen crosses ranged from 2.83 (Wray × ICSB 374) to 44.19 (NTJ 2 × Parbhani Moti) exhibited significant positive *sca* effects, and twenty crosses ranged from -18.24 (ICSV 25333 × Parbhani Moti) to -2.40 (Wray × ICSB 323) exhibited negatively significant *sca* effects (Table 8c).

4.4.2.2.11 Juice extraction (%)

At Bijapur, out of 49 crosses evaluated, seventeen crosses ranged from 2.47 (IS 13871 × PMS 90 B) to 12.35 (Wray × ICSB 374) exhibited significant positive *sca* effects, and fifteen crosses ranged from -12.25 (SPSSV 30 × PMS 90B) to -2.69 (ICSV 25333 × ICSB 374) exhibited negatively significant *sca* effects (Table 8a).

At ICRISAT, out of 49 crosses evaluated, eleven crosses ranged from 3.03 (IS 22670 × PMS 90 B) to 6.20 (ICSV 93046 × ICSB 374) exhibited significant positive *sca* effects, and nine crosses ranged from -14.57 (IS 22670 × ICSB 480) to -2.87 (ICSV 25333 × Parbhani Moti) exhibited negatively significant *sca* effects (Table 8b).

Across environments, out of 49 crosses evaluated, eighteen crosses ranged from 1.81 (Wray × NSSV 13) to 7.96 (NTJ 2 × Parbhani Moti) exhibited significant positive *sca* effects, and sixteen crosses ranged from -6.95 (ICSV 93046 × NSSV 13) to -1.92 (IS 13871 × Parbhani Moti) exhibited negatively significant *sca* effects (Table 8c).

4.4.2.2.12 Ethanol yield (L ha^{-1})

At Bijapur, out of 49 crosses, fourteen crosses ranged from 1088.55 (ICSV 25333 × PMS 90 B) to 4544.58 (IS 13871 × NSSV 13) exhibited significant positive *sca* effects, and nineteen crosses ranged from -4755.28 (ICSV 25333 × NSSV 13) to -963.71 (Wray × ICSB 480) exhibited negatively significant *sca* effects (Table 8a).

At ICRISAT, out of 49 crosses, fourteen crosses ranged from 887.64 (IS 22670 × PMS 90 B) to 4351.23 (NTJ 2 × Parbhani Moti) exhibited significant positive *sca* effects, and sixteen crosses ranged from -7155.31 (ICSV 25333 × Parbhani Moti) to -914.75 (IS 13871 × ICSB 374) exhibited negatively significant *sca* effects (Table 8b).

Across environments, out of 49 crosses, fifteen crosses ranged from 646.45 (SPSSV 30 × ICSB 351) to 5147.77 (NTJ 2 × Parbhani Moti) exhibited significant positive *sca* effects, and eighteen crosses ranged from -5806.91 (ICSV 25333 ×

Parbhani Moti) to -701.54 (NTJ 2 × NSSV13) exhibited negatively significant *sca* effects (Table 8c).

4.4.2.2.13 Panicle weight (t ha^{-1})

At Bijapur, out of 49 crosses, fourteen crosses ranged from 1.08 (ICSV 25333 × NSSV 13) to 6.57 (ICSV 25333 × ICSB 480) exhibited significant positive *sca* effects, and fourteen crosses ranged from -6.57 (ICSV 93046 × ICSB 351) to -1.14 (Wray × ICSB 480) exhibited negatively significant *sca* effects (Table 8a).

At ICRISAT, out of 49 crosses, thirteen crosses ranged from 0.95 (ICSV 25333 × ICSB 351) to 4.83 (NTJ 2 × PMS 90 B) exhibited significant positive *sca* effects, and sixteen crosses ranged from -3.98 (NTJ 2 × NSSV 13) to -0.89 (IS 22670 × ICSB 480) exhibited negatively significant *sca* effects (Table 8b).

Across environments, out of 49 crosses, seventeen crosses ranged from 0.71 (Wray × PMS 90 B) to 3.63 (IS 22670 × ICSB 351) exhibited significant positive *sca* effects, and fourteen crosses ranged from -3.94 (SPSSV 30 × PMS 90B) to -0.70 (ICSV 93046× ICSB 374) exhibited negatively significant *sca* effects (Table 8c).

4.4.2.2.14 Panicle length (cm)

At Bijapur, out of 49 crosses studied the *sca* effects were significant for seven crosses out of that five crosses ranged from 4.39 (IS 22670 × ICSB 323) to 5.18 (ICSV 25333 × ICSB 374) showed significant positive *sca* effects. Whereas two crosses IS 13871 × ICSB 374 (-7.86) and ICSV 25333 × ICSB 351 (-6.81) exhibited highly significant negative *sca* effects (Table 8a).

At ICRISAT, out of 49 crosses studied the *sca* effects were significant for twelve crosses out of that four crosses ranged from 3.38 (IS 22670 × NSSV 13) to 8.39 (ICSV 25333 × ICSB 374) showed significant positive *sca* effects. Whereas eight crosses ranged from -5.91 (ICSV 25333 × ICSB 351) to -3.44 (Wray × Parbhani Moti) exhibited significant negative *sca* effects (Table 8b).

Across environments, out of 49 crosses studied the *sca* effects were significant for eleven crosses out of that four crosses ranged from 3.46 (Wray × ICSB 374) to 6.27 (ICSV 25333 × ICSB 374) showed significant positive *sca* effects. Whereas seven crosses ranged from -6.85 (ICSV 25333 × ICSB 351) to -3.27 (Wray × Parbhani Moti) exhibited significant negative *sca* effects (Table 8c).

4.4.2.2.15 Panicle breadth (cm)

At Bijapur, out of 49 crosses, thirteen crosses ranged from 0.53 (Wray × PMS 90 B) to 1.45 (ICSV 25333 × ICSB 480) exhibited significant positive *sca* effects, and ten crosses ranged from -1.64 (SPSSV 30 × PMS 90B) to -0.57 (ICSV 93046 × NSSV 13) exhibited negatively significant *sca* effects (Table 8a).

At ICRISAT, out of 49 crosses, fourteen crosses ranged from 0.54 (ICSV 93046 × PMS 90B) to 1.61 (IS 22670 × ICSB 351) exhibited significant positive *sca* effects, and thirteen crosses ranged from -1.91 (ICSV 93046 × ICSB 374) to -0.58 (IS 22670 × ICSB 374) exhibited negatively significant *sca* effects (Table 8b).

Across environments, out of 49 crosses, thirteen crosses ranged from 0.42 (ICSV 93046 × ICSB 323) to 1.00 (NTJ 2 × ICSB 323) exhibited significant positive *sca* effects, and twelve crosses ranged from -1.28 (SPSSV 30 × PMS 90B) to -0.41 (ICSV 25333 × PMS 90 B) exhibited negatively significant *sca* effects (Table 8c).

4.4.2.2.16 Grain yield (t ha^{-1})

At Bijapur, out of 49 crosses, twenty one crosses ranged from 0.65 (SPSSV 30 × ICSB 351) to 3.58 (ICSV 25333 × ICSB 480) exhibited significant positive *sca* effects, and twenty crosses ranged from -3.86 (ICSV 93046 × ICSB 351) to -0.55 (Wray × ICSB 480) exhibited negatively significant *sca* effects (Table 8a).

At ICRISAT, out of 49 crosses, fourteen crosses ranged from 0.77 (NTJ 2 × ICSB 480) to 4.03 (NTJ 2 × PMS 90 B) exhibited significant positive *sca* effects, and twenty crosses ranged from -2.98 (NTJ 2 × NSSV 13) to -0.46 (IS 13871 × ICSB 351) exhibited negatively significant *sca* effects (Table 8b).

Across environments, out of 49 crosses, eighteen crosses ranged from .32 (Wray × ICSB 374) to 2.89 (NTJ 2 × PMS 90 B) exhibited significant positive *sca* effects, and seventeen crosses ranged from -2.29 (SPSSV 30 × PMS 90B) to -0.51 (Wray × Parbhani Moti) exhibited negatively significant *sca* effects (Table 8c).

4.4.2.2.17 1000-seed weight (g)

At Bijapur, out of 49 crosses studied the *sca* effects were significant for nine crosses out of that five crosses ranged from 4.59 (IS 22670 × Parbhani Moti) to 6.01 (ICSV 25333 × ICSB 351) showed significant positive *sca* effects. Whereas four crosses ranged from -7.21(IS 22670 × NSSV 13) to -4.12 (NTJ 2 × Parbhani Moti) exhibited highly significant negative *sca* effects (Table 8a).

At ICRISAT, out of 49 crosses studied the *sca* effects were significant for five crosses out of that three crosses ICSV 25333 × ICSB 323 (5.59), IS 22670 × ICSB 480 (5.21) and IS 22670 × Parbhani Moti (3.84) showed significant positive *sca* effects. Whereas two crosses SPSSV 30 × ICSB 323 (-3.53) and NTJ 2 × ICSB 480 (-5.34) exhibited highly significant negative *sca* effects (Table 8b).

Across environments, out of 49 crosses studied the *sca* effects were significant for eighteen crosses out of that nine crosses ranged from 4.61 (ICSV 25333 × ICSB 323) to 8.43 (IS 22670 × Parbhani Moti) showed significant positive *sca* effects. Whereas nine crosses ranged from -9.81 (IS 22670 × NSSV 13) to -4.08 (ICSV 93046 × PMS 90B) exhibited highly significant negative *sca* effects (Table 8c).

4.5 Character associations

The correlation coefficients between stalk sugar yield in terms of brix and various sugar related component traits were estimated in order to determine the extent of association with each component. The results of across environments are presented in Table 9. The magnitude of correlation was highest for the traits between brix and the total soluble solids, Juice yield and juice volume i.e. (r = 1.00) and positive fallowed by bagasse yield and stalk yield (r = 0.98), the total sugar index with juice yield and volume and ethanol yield with bagasse yield (r = 0.97).

Days to 50% flowering was significant positively correlated to most of the characters except for brix, total soluble solids, juice extraction, panicle weight, circumference, grain yield and 1000-seed weight. The highest correlation was observed with ethanol yield (r = 0.85).

Table 8a. Estimates of specific combining ability effects for stalk sugar related traits, yield and yield components in the crosses evaluated at Bijapur

S.NO.	Crosses	DFL	Plant height (m)	Stem thickness (mm)	Stalk yield (t ha^{-1})	Juice yield (t ha^{-1})	Juice volume (L ha^{-1})	Brix (%)	Bagasse yield (t ha^{-1})	Total soluble solids (%)
1	IS 13871 × PMS 90 B	-6.09*	0.23	2.79*	12.45*	2.24*	2202.03*	-0.71	10.19*	-0.62
2	IS 13871 × ICSB 323	1.82	0.01	-1.61	-19.03**	-7.18**	-7040.82**	0.40	-11.88**	0.35
3	IS 13871 × ICSB 351	1.58	-0.14	-1.05	-1.91	2.65*	2545.95*	-3.23**	-4.54	-2.82**
4	IS 13871 × ICSB 374	4.15	-0.31	-6.47**	-18.37**	-1.84	-1657.07	3.76**	-16.58**	3.29**
5	IS 13871 × ICSB 480	0.91	-0.14	0.58	-5.70	1.14	997.27	-1.23*	-6.82	-1.07*
6	IS 13871 × Parbhani Moti	-0.66	0.11	0.66	-7.01	-0.85	-885.76	-1.57*	-6.11	-1.37*
7	IS 13871 × NSSV 13	-1.71	0.24	5.11**	39.57**	3.84**	3838.4**	2.58**	35.75**	2.26**
8	IS 22670 × PMS 90 B	-9.18**	-0.16	-5.15**	-29.87**	-3.75**	-3815.06**	-0.94	-26.21**	-0.82
9	IS 22670 × ICSB 323	5.05	-0.39	-3.25**	-36.2**	-4.33**	-4444.33**	-0.07	-32.05**	-0.06
10	IS 22670 × ICSB 351	2.48	0.51*	6.04**	44.21**	4.66**	4615.28**	0.51	39.53**	0.45
11	IS 22670 × ICSB 374	13.39**	0.13	6.77**	24.88**	-0.23	-80.33	0.33	25.14**	0.29
12	IS 22670 × ICSB 480	-1.52	0.21	-2.63*	-26.73**	0.24	259.19	1.68**	-26.91**	1.47**
13	IS 22670 × Parbhani Moti	-8.09**	-0.81**	-3.15**	-25.71**	-4.01**	-3969.52**	1.17	-21.62**	1.02
14	IS 22670 × NSSV 13	-2.14	0.51*	1.37	49.41**	7.43**	7434.77**	-2.68**	42.13**	-2.34**
15	ICSV 25333 × PMS 90 B	-9.28**	0.18	3.05**	1.18	-3.24**	-3186.91**	1.03	4.47	0.90
16	ICSV 25333 × ICSB 323	-2.04	0.44*	-1.83	-3.89	-3.65**	-3663.1**	0.27	-0.21	0.24
17	ICSV 25333 × ICSB 351	9.39**	-0.17	0.90	9.57	5.64**	5552.07**	1.68**	3.91	1.47**
18	ICSV 25333 × ICSB 374	7.29*	0.19	0.47	11.12*	-0.9	-841.07	0.5	12.03**	0.44
19	ICSV 25333 × ICSB 480	-6.95*	0.06	-0.26	27.14**	7.79**	7800.92**	0.85	19.26**	0.74
20	ICSV 25333 × Parbhani Moti	-0.85	-0.05	-0.94	-12.13*	-3.1**	-3045.95**	0.34	-9.07*	0.30

Table 8a (conti....)

21	ICSV 25333 × NSSV 13	2.44	-0.66**	-1.39	-32.99**	-2.54*	-2615.97**	-4.68**	-30.4**	-4.09**
22	ICSV 93046 × PMS 90B	-9.42**	0.05	4.27**	40.99**	17.07**	16952.31**	-4.9**	23.87**	-4.28**
23	ICSV 93046 × ICSB 323	-5.52	0.11	3.17**	26.38**	10.68**	10673.65**	-0.66	15.77**	-0.57
24	ICSV 93046 × ICSB 351	6.24*	-0.38	-5.38**	-48.7**	-13.02**	-12827.23**	4.75**	-35.66**	4.16**
25	ICSV 93046 × ICSB 374	-3.52	-0.24	-0.29	-7.74	-4.16**	-4405.55**	-2.6**	-3.68	-2.27**
26	ICSV 93046 × ICSB 480	-4.42	0.07	1.30	-4.77	-1.87	-1843.8	-0.08	-2.92	-0.07
27	ICSV 93046 × Parbhani Moti	-1.66	0.57*	2.32*	36.12**	4.85**	4853.41**	0.08	31.27**	0.07
28	ICSV 93046 × NSSV 13	18.29**	-0.18	-5.39**	-42.29**	-13.55**	-13402.8**	3.4**	-28.66**	2.97**
29	NTJ 2 × PMS 90 B	-3.9	0.3	2.17	19.92**	5.21**	5142.33**	0.53	14.73**	0.46
30	NTJ 2 × ICSB 323	2.01	0.01	3.18**	32.21**	6.33**	6301.94**	-0.9	25.91**	-0.79
31	NTJ 2 × ICSB 351	-6.9*	-0.24	-2.03	-16.56**	-5.03**	-4914.99**	-1.49*	-11.44*	-1.3*
32	NTJ 2 × ICSB 374	-7.33*	0.03	-1.8	-6.63	3.36**	3259.78**	2.66**	-9.99*	2.33**
33	NTJ 2 × ICSB 480	4.1	0.1	0.76	-15.43**	-4.73**	-4703.17**	-0.66	-10.69*	-0.57
34	NTJ 2 × Parbhani Moti	12.2**	-0.02	-0.03	-8.97	-2.01	-1972	-0.46	-6.99	-0.4
35	NTJ 2 × NSSV 13	-0.18	-0.17	-2.26	-4.53	-3.13**	-3113.89**	0.32	-1.53	0.28
36	Wray × PMS 90 B	-3.95	-0.12	-1.37	-2.91	-2	-1998.32*	0.2	-0.86	0.17
37	Wray × ICSB 323	-1.04	-0.23	-1.86	-7.36	-8.06**	-7999.2**	1.44*	0.7	1.26*
38	Wray × ICSB 351	-4.61	0.14	0.26	6.89	4.24**	4271.52**	-4.15**	2.64	-3.63**
39	Wray × ICSB 374	-7.04*	0.18	-0.67	3.19	9.06**	8896.9**	-1.17	-5.86	-1.02
40	Wray × ICSB 480	14.05**	-0.28	-0.9	-16.31**	-5.78**	-5732.71**	0.68	-10.44*	0.6
41	Wray × Parbhani Moti	2.15	-0.11	-0.6	10.2*	-2.44*	-2492.29*	1.51*	12.67**	1.32*
42	Wray × NSSV 13	0.44	0.42	5.14**	6.29	4.97**	5054.1**	1.49*	1.15	1.3*
43	SPSSV 30 × PMS 90B	41.82**	-0.47*	-5.76**	-41.76**	-15.53**	-15296.4**	4.78**	-26.18**	4.18**
44	SPSSV 30 × ICSB 323	-0.28	0.06	2.19	7.89	6.2**	6171.86**	-0.48	1.75	-0.42
45	SPSSV 30 × ICSB 351	-8.18**	0.28	1.26	6.49	0.87	757.39	1.93**	5.56	1.69**

Table 8a (conti....)

46	SPSSV 30 × ICSB 374	-6.95*	0.02	1.99	-6.45	-5.29**	-5172.66**	-3.49**	-1.06	-3.05**
47	SPSSV 30 × ICSB 480	-6.18*	-0.03	1.16	41.8**	3.21**	3222.3**	-1.24*	38.52**	-1.08*
48	SPSSV 30 × Parbhani Moti	-3.09	0.31	1.74	7.49	7.56**	7512.11**	-1.08	-0.15	-0.94
49	SPSSV 30 × NSSV 13	-17.14**	-0.17	-2.58*	-15.47**	2.98**	2805.4**	-0.43	-18.44**	-0.37
	S.Em.±	2.89	0.22	1.16	5.02	1.04	996.86	0.61	4.49	0.54
	CD at 5%	8.09	0.61	3.25	14.05	2.92	2790.34	1.71	12.56	1.5
	CD at 1%	10.7	0.81	4.3	18.58	3.86	3688.06	2.27	16.6	1.98
	CV	5.6	15.41	10.05	12.43	14.14	13.7	8.25	13.64	8.17

*Significance at 5% probability, **significance at 1% probability, DFL: days to 50% flowering

Table 8a (conti....)

S.NO.	Crosses	Total sugar index	Juice extraction (%)	Ethanol yield (L ha^{-1})	Panicle weight (t ha^{-1})	Panicle length (cm)	Panicle breadth (cm)	Grain yield (t ha^{-1})	1000-seed weight (g)
1	IS 13871 × PMS 90 B	0.46*	2.47*	830.57	3.53**	2.12	0.97**	2.11**	5.44**
2	IS 13871 × ICSB 323	-1.00**	-5.05**	-1192.55**	-1.88**	-1.24	-0.01	-0.62*	2.25
3	IS 13871 × ICSB 351	0.19	1.83	-1141.74*	-0.11	3.98	-0.04	-0.93**	-1.63
4	IS 13871 × ICSB 374	0.00	-1.45	-686.97	-3.11**	-7.86**	-1.08**	-1.27**	-0.86
5	IS 13871 × ICSB 480	0.02	3.52**	-1107.52*	0.28	1.19	0.12	-0.17	-3.29
6	IS 13871 × Parbhani Moti	-0.31	2.02	-1245.98**	0.74	4.27	0.03	0.88**	0.29
7	IS 13871 × NSSV 13	0.64**	-3.34**	4544.19**	0.55	-2.47	0.01	-0.01	-2.2
8	IS 22670 × PMS 90 B	-0.31	-2.07	-2099.74**	-1.41**	-1.84	-0.07	-1.14**	0.32
9	IS 22670 × ICSB 323	-0.66**	1.91	-2700.92**	2.53**	4.39*	-0.13	0.08	0.03
10	IS 22670 × ICSB 351	0.62**	-0.41	3261.31**	4.36**	1.98	0.26	2.93**	1.05
11	IS 22670 × ICSB 374	0.03	-3.22**	2228.69**	0.51	-0.07	0.34	1.78**	1.71
12	IS 22670 × ICSB 480	0.14	3.98**	-1685.99**	-4.2**	-3.48	-0.73**	-2.42**	-0.48
13	IS 22670 × Parbhani Moti	-0.5**	-1.79	-1386.69**	-1.59**	-1.59	0.68**	-1.09**	4.59*
14	IS 22670 × NSSV 13	0.68**	1.6	2383.34**	-0.2	0.62	-0.34	-0.13	-7.21**
15	ICSV 25333 × PMS 90 B	-0.15	-3.66**	1088.55*	-2.68**	-1	-0.71**	-1.84**	1.17
16	ICSV 25333 × ICSB 323	-0.5**	-1.97	79.78	-3.27**	1.88	-0.42	-2.19**	-0.98
17	ICSV 25333 × ICSB 351	0.89**	4.12**	877.21	0.95	-6.81**	0.37	0.82**	6.01**
18	ICSV 25333 × ICSB 374	-0.12	-2.69*	1367.48**	-1.76**	5.18*	-0.79**	-0.79**	-2.5
19	ICSV 25333 × ICSB 480	1.26**	4.6**	2210.07**	6.57**	1.97	1.45**	3.58**	3.49
20	ICSV 25333 × Parbhani Moti	-0.45*	-1.15	-867.8	-0.89	-1.59	-0.48	-0.48	-2.14

Table 8a (conti....)

21	ICSV 25333 × NSSV 13	-0.92**	0.75	-4755.28**	1.08*	0.37	0.59*	0.91**	-5.05*
22	ICSV 93046 × PMS 90B	0.89**	9.42**	57.86	3.17**	1.38	0.74**	1.24**	-3.22
23	ICSV 93046 × ICSB 323	1.67**	5.95**	1434.43**	1.89**	-1.32	0	1.49**	0.45
24	ICSV 93046 × ICSB 351	-1.27**	-5.88**	-1889.44**	-6.57**	-3.98	-1.6**	-3.86**	-5.32**
25	ICSV 93046 × ICSB 374	-0.79**	-2.12	-1292.79**	2.04**	-0.47	0.87**	1.77**	2.42
26	ICSV 93046 × ICSB 480	-0.01	2.72*	-140.12	-1.3**	0.36	-0.02	-1.42**	1.82
27	ICSV 93046 × Parbhani Moti	1.00**	-1.15	3062.73**	2.23**	-0.39	0.58*	0.7**	1.61
28	ICSV 93046 × NSSV 13	-1.48**	-8.95**	-1232.67**	-1.46**	4.42*	-0.57*	0.09	2.24
29	NTJ 2 × PMS 90 B	1**	3**	1715.05**	2.02**	0.34	0.19	1.84**	-0.48
30	NTJ 2 × ICSB 323	0.57**	0.62	1681.35**	-0.11	3.61	1.24**	-0.82**	0.19
31	NTJ 2 × ICSB 351	-0.85**	-3.77**	-1667.42**	0.29	-1.41	0.15	2**	-2.54
32	NTJ 2 × ICSB 374	0.93**	4.31**	332.48	-0.32	0.14	-0.64*	-0.92**	3.47
33	NTJ 2 × ICSB 480	-0.79**	-1.19	-1390.11**	0.16	1.71	0.00	-0.17	-1.99
34	NTJ 2 × Parbhani Moti	-0.44*	0.43	-964.92*	-0.83	-0.16	-0.36	-0.59*	-4.12*
35	NTJ 2 × NSSV 13	-0.42*	-3.41**	293.56	-1.21*	-4.23	-0.57*	-1.34**	5.46**
36	Wray × PMS 90 B	-0.01	3.08**	102.7	1.48**	1.27	0.53*	1.45**	-3.43
37	Wray × ICSB 323	-1.08**	-8.78**	349.84	0.44	-3.55	-0.79**	1.16**	1.27
38	Wray × ICSB 351	0.11	4.62**	-768.04	-0.77	1.32	0.31	-1.6**	-0.22
39	Wray × ICSB 374	1.1**	12.35**	-799.49	0.35	4.7*	0.59*	0.72**	-0.56
40	Wray × ICSB 480	-0.87**	-8.88**	-963.71*	-1.14*	-1.65	-0.4	-0.55*	-2.47
41	Wray × Parbhani Moti	-0.21	-5.89**	1614.56**	-0.48	-2.51	-0.47	-0.43	0.41
42	Wray × NSSV 13	0.96**	3.5**	464.14	0.11	0.41	0.23	-0.74**	5.01*
43	SPSSV 30 × PMS 90B	-1.87**	-12.25**	-1694.99**	-6.12**	-2.28	-1.64**	-3.66**	0.19
44	SPSSV 30 × ICSB 323	1.01**	7.32**	348.07	0.4	-3.77	0.11	0.91**	-3.2
45	SPSSV 30 × ICSB 351	0.31	-0.51	1328.11**	1.85**	4.93*	0.55*	0.65*	2.64

Table 8a (conti....)

46	SPSSV 30 × ICSB 374	-1.15**	-7.18**	-1149.4*	2.29**	-1.62	0.71**	-1.28**	-3.66
47	SPSSV 30 × ICSB 480	0.25	-4.75**	3077.38**	-0.37	-0.11	-0.41	1.16**	2.91
48	SPSSV 30 × Parbhani Moti	0.9**	7.53**	-211.9	0.81	1.97	0.03	1.01**	-0.64
49	SPSSV 30 × NSSV 13	0.55**	9.84**	-1697.27**	1.14*	0.88	0.66*	1.22**	1.77
	S.Em.±	0.19	1.13	445.58	0.48	2.19	0.25	0.25	2
	CD at 5%	0.53	3.16	1247.24	1.35	6.14	0.71	0.7	5.61
	CD at 1%	0.70	4.18	1648.51	1.79	8.11	0.94	0.92	7.41
	CV	18.72	10.65	15.11	12.99	13.89	10.56	13.42	13.92

*Significance at 5% probability, **significance at 1% probability

Table 8b. Estimates of specific combining ability effects for stalk sugar related traits, yield and yield components in the crosses evaluated at ICRISAT

S.NO.	Crosses	DFL	Plant height (m)	Stem thickness (mm)	Stalk yield (t ha^{-1})	Juice yield (t ha^{-1})	Juice volume (L ha^{-1})	Brix (%)	Bagasse yield (t ha^{-1})	Total soluble solids (%)
1	IS 13871 × PMS 90 B	0.35	0.11	0.57	-6.71	-3.03	-2989.59	-0.62	-3.48	-0.54
2	IS 13871 × ICSB 323	4.69	-0.21	-0.46	5.76	-0.87	-995.68	-1.1	6.76*	-0.96
3	IS 13871 × ICSB 351	1.59	-0.18	-0.8	-2.07	4.16*	4209.9*	0.91	-5.99	0.8
4	IS 13871 × ICSB 374	0.07	-0.1	-1.09	-12.95**	-4.77*	-4863.58*	0.13	-9.52**	0.11
5	IS 13871 × ICSB 480	-1.07	0.03	0.58	7.58	4*	4014.95*	-0.18	3.82	-0.16
6	IS 13871 × Parbhani Moti	-5.5*	-0.22	0.4	-11.5**	-6.41**	-6312.4**	0.39	-4.82	0.34
7	IS 13871 × NSSV 13	-0.12	0.56**	0.81	19.89**	6.93**	6936.4**	0.48	13.24**	0.42
8	IS 22670 × PMS 90 B	-4.6	-0.05	-1.07	15.03**	8.05**	7986.31**	0.65	7.17*	0.57
9	IS 22670 × ICSB 323	-4.27	-0.2	-0.76	-17.59**	-4.3*	-4286.42*	0.61	-13.17**	0.53
10	IS 22670 × ICSB 351	3.31	0.16	0.94	20.09**	10**	10023.67**	-0.82	10.37**	-0.71
11	IS 22670 × ICSB 374	5.12*	0.21	2.53**	45.91**	13.67**	13612.57**	1.35	30.93**	1.18
12	IS 22670 × ICSB 480	-5.03*	-0.69**	0.62	-58.33**	-24.38**	-24332.56**	-1.54*	-33.73**	-1.35*
13	IS 22670 × Parbhani Moti	-1.79	0.36*	-1.73	7.59	-0.95	-985.04	0.99	8.74**	0.87
14	IS 22670 × NSSV 13	7.26**	0.2	-0.53	-12.71**	-2.1	-2018.54	-1.25	-10.31**	-1.09
15	ICSV 25333 × PMS 90 B	-3.36	0.12	1.55	28.52**	8.41**	8419.07**	1.56*	20.32**	1.37*
16	ICSV 25333 × ICSB 323	-1.03	0.47**	1.51	13.11**	4.8*	4748.8*	0.52	8.51**	0.45
17	ICSV 25333 × ICSB 351	4.88*	0.37**	-0.06	25.85**	9.65**	9605.82**	1.53*	16.41**	1.34*
18	ICSV 25333 × ICSB 374	5.35*	0.48**	0.77	13.52**	0.59	677.44	0.59	11.79**	0.52
19	ICSV 25333 × ICSB 480	0.88	0.34*	-0.51	14.21**	4.06*	4055.73*	0.9	10.35**	0.79
20	ICSV 25333 × Parbhani Moti	-6.88**	-1.04**	-3.72**	-79.33**	-25.06**	-24962.96**	-4.1**	-54.02**	-3.58**

Table 8b (conti....)

21	ICSV 25333 × NSSV 13	0.16	-0.73**	0.46	-15.87**	-2.45	-2543.9	-1.01	-13.37**	-0.88
22	ICSV 93046 × PMS 90B	3.4	-0.16	1.15	6.39	1.09	1117.95	-0.06	4.1	-0.06
23	ICSV 93046 × ICSB 323	-3.6	0.03	0.59	-1.12	2.07	2163.72	-0.81	-4.31	-0.7
24	ICSV 93046 × ICSB 351	-5.36*	-0.14	0.38	-16.49**	-8.93**	-9026.98**	-0.63	-8.9**	-0.55
25	ICSV 93046 × ICSB 374	8.12**	0.07	-1.3	-16.54**	0.11	-1.47	0.37	-9.4**	0.32
26	ICSV 93046 × ICSB 480	-1.03	0.16	-1.34	6.28	3.94*	4018.79*	-0.29	1.21	-0.25
27	ICSV 93046 × Parbhani Moti	-0.46	0.08	-0.02	-0.89	-2.22	-2056.7	-0.42	0.19	-0.37
28	ICSV 93046 × NSSV 13	-1.07	-0.04	0.54	22.37**	3.94*	3784.69	1.84**	17.1**	1.61**
29	NTJ 2 × PMS 90 B	2.69	-0.19	0.03	-8.59	-2.01	-1936.86	-0.4	-6.37*	-0.35
30	NTJ 2 × ICSB 323	-7.98**	-0.17	-0.73	-6.24	-1.49	-1384.21	-0.74	-4.45	-0.65
31	NTJ 2 × ICSB 351	-4.41	-0.11	0.88	-6.76	-6.55**	-6509.07**	-1.4*	0	-1.23*
32	NTJ 2 × ICSB 374	-9.93**	-0.23	0.46	-9*	-0.22	-102.48	-0.27	-9.9**	-0.24
33	NTJ 2 × ICSB 480	5.59*	0.16	-1.24	-6.59	-0.95	-897.03	0.78	-5.42	0.68
34	NTJ 2 × Parbhani Moti	10.83**	0.85**	2.84**	63.27**	26.12**	25694.1**	0.64	37.14**	0.56
35	NTJ 2 × NSSV 13	3.21	-0.31*	-2.24*	-26.1**	-14.89**	-14864.45**	1.4*	-11**	1.22*
36	Wray × PMS 90 B	0.69	0.1	-1.98*	-15.2**	-4.62*	-4673.86*	-0.2	-10.43**	-0.17
37	Wray × ICSB 323	5.35*	0.12	-0.38	9.42*	2.14	2100.29	-0.44	7.41*	-0.38
38	Wray × ICSB 351	-1.07	-0.08	-0.46	-18.76**	-7.84**	-7798.23**	0.44	-10.71**	0.38
39	Wray × ICSB 374	-7.6**	-0.13	-1.07	-13.95**	-6.16**	-6115.91**	-0.5	-8.96**	-0.44
40	Wray × ICSB 480	-1.74	-0.05	0.85	8.64*	5.05*	5012.16*	-0.05	3.77	-0.05
41	Wray × Parbhani Moti	3.83	-0.19	1.32	10*	2.64	2661.53	1.85**	7.59*	1.62**
42	Wray × NSSV 13	0.54	0.22	1.74	19.86**	8.78**	8814.03**	-1.1	11.32**	-0.96
43	SPSSV 30 × PMS 90B	0.83	0.07	-0.24	-19.43**	-7.89**	-7923.02**	-0.93	-11.32**	-0.81
44	SPSSV 30 × ICSB 323	6.83**	-0.04	0.23	-3.34	-2.35	-2346.5	1.96**	-0.76	1.71**
45	SPSSV 30 × ICSB 351	1.07	-0.02	-0.87	-1.87	-0.49	-505.11	-0.03	-1.18	-0.03

Table 8b (conti....)

46	SPSSV 30 × ICSB 374	-1.12	-0.3*	-0.3	-6.99	-3.23	-3206.57	-1.67*	-4.95	-1.46*
47	SPSSV 30 × ICSB 480	2.4	0.05	1.04	28.22**	8.28**	8127.97**	0.38	20**	0.33
48	SPSSV 30 × Parbhani Moti	-0.03	0.15	0.92	10.86*	5.89**	5961.47**	0.65	5.19	0.57
49	SPSSV 30 × NSSV 13	-9.98**	0.09	-0.77	-7.45	-0.21	-108.24	-0.36	-6.98*	-0.32
	S.Em.±	2.45	0.14	0.95	4.36	1.99	1971.08	0.7	3.16	0.61
	CD at 5%	6.86	0.39	2.65	12.2	5.56	5517.3	1.96	8.86	1.71
	CD at 1%	9.07	0.51	3.5	16.12	7.35	7292.35	2.59	11.71	2.26
	CV	4.9	7.18	7.26	8.92	11.3	11.27	7.81	10.1	7.73

*Significance at 5% probability, **significance at 1% probability, DFL: days to 50% flowering

Table 8b (conti....)

S.NO.	Crosses	Total sugar index	Juice extraction (%)	Ethanol yield (L ha^{-1})	Panicle weight (t ha^{-1})	Panicle length (cm)	Panicle breadth (cm)	Grain yield (t ha^{-1})	1000-seed weight (g)
1	IS 13871 × PMS 90 B	-0.45	-0.09	-457.2	-1.78**	-4.33**	-0.38	-1.25**	-0.35
2	IS 13871 × ICSB 323	-0.33	-4.73**	404.56	-0.61	0.16	-0.1	-0.78**	-0.93
3	IS 13871 × ICSB 351	0.98*	2.13	-372.25	-0.9*	0.99	-0.16	-0.46*	-0.8
4	IS 13871 × ICSB 374	-0.7	-0.72	-914.75*	0.56	-1.05	0.74**	0.23	1.77
5	IS 13871 × ICSB 480	0.67	2.14	410.82	-0.13	0.63	-0.86**	0.35	-2.47
6	IS 13871 × Parbhani Moti	-1.12**	-1.84	-457.25	1.35**	1.35	-0.31	1.03**	0.06
7	IS 13871 × NSSV 13	0.96*	3.1*	1386.06**	1.51**	2.26	1.08**	0.88**	2.73
8	IS 22670 × PMS 90 B	1.46**	3.03*	887.64*	-1.35**	0.13	-0.66*	-0.98**	-2.7
9	IS 22670 × ICSB 323	-0.51	2.66	-1072.56**	-0.57	-1.55	-0.06	-0.17	-2.09
10	IS 22670 × ICSB 351	1.4**	6.19**	562.8	3.03**	1.89	1.61**	2.57**	-1.97
11	IS 22670 × ICSB 374	2.88**	-0.5	4136.86**	-0.36	-2.75	-0.58*	-0.13	0.29
12	IS 22670 × ICSB 480	-4.17**	-14.57**	-4119.85**	-0.89*	-1.58	-0.52	-1.27**	5.21**
13	IS 22670 × Parbhani Moti	-0.07	0.09	1318.93**	0.61	0.48	0.37	0.31	3.84*
14	IS 22670 × NSSV 13	-0.99*	3.09*	-1713.82**	-0.46	3.38*	-0.14	-0.33	-2.59
15	ICSV 25333 × PMS 90 B	1.9**	-0.11	2785.09**	0.22	0.1	-0.08	-0.04	0.06
16	ICSV 25333 × ICSB 323	0.92*	0.21	1142.07**	0.37	0.34	-0.66*	-0.28	5.59**
17	ICSV 25333 × ICSB 351	2.22**	3.97**	2691**	0.95*	-5.91**	0.5	0.34	-2.33
18	ICSV 25333 × ICSB 374	0.16	-3.64*	1177.44**	2.54**	8.39**	0.93**	1.81**	-0.43
19	ICSV 25333 × ICSB 480	0.8*	0.37	1378.11**	-0.34	-4.27*	0.27	-0.52*	2.39
20	ICSV 25333 × Parbhani Moti	-4.96**	-2.87*	-7155.31**	-2.39**	2.67	-0.75**	-1.32**	-2.27

Table 8b (conti....)

21	ICSV 25333 × NSSV 13	-1.04**	2.07	-2018.4**	-1.35**	-1.31	-0.21	0.01	-3.01
22	ICSV 93046 × PMS 90B	0.11	-3.14*	283.49	-0.35	-1.27	0.54*	-0.34	-0.86
23	ICSV 93046 × ICSB 323	0.02	3.5*	-755.09	2.86**	3.17	0.8**	2.41**	0.89
24	ICSV 93046 × ICSB 351	-1.49**	-5.41**	-1048.03**	0.3	2.72	0.18	-0.06	3.09
25	ICSV 93046 × ICSB 374	0.07	6.2**	-1110.54**	-3.32**	-2.87	-1.91**	-1.97**	-2.96
26	ICSV 93046 × ICSB 480	0.46	4.58**	-14.02	0.2	-1.03	0.41	0.41	0.16
27	ICSV 93046 × Parbhani Moti	-0.81*	-0.11	-252.35	1.72**	-0.42	0.59*	1.31**	0.9
28	ICSV 93046 × NSSV 13	1.64**	-5.62**	2896.55**	-1.41**	-0.3	-0.61*	-1.76**	-1.23
29	NTJ 2 × PMS 90 B	-0.56	0.12	-924.12*	4.83**	2.76	1.53**	4.03**	3.29
30	NTJ 2 × ICSB 323	-0.5	1.24	-749.14	0.85	3.64*	0.8**	1.2**	1.72
31	NTJ 2 × ICSB 351	-1.47**	-2.51	-535.26	-1.75**	1.13	-1.07**	-1.46**	2.95
32	NTJ 2 × ICSB 374	-0.21	1.27	-1209.99**	2.28**	1.82	0.71**	1.29**	1.25
33	NTJ 2 × ICSB 480	0.05	4.19**	-387.57	1.26**	-0.17	0.69*	0.77**	-5.34**
34	NTJ 2 × Parbhani Moti	4.61**	0.51	4351.23**	-3.5**	-3.72*	-0.8**	-2.85**	-3.12
35	NTJ 2 × NSSV 13	-1.93**	-4.81**	-545.13	-3.98**	-5.46**	-1.86**	-2.98**	-0.74
36	Wray × PMS 90 B	-0.84*	1.15	-1144.78**	0.06	0.6	0.01	-0.54*	0.38
37	Wray × ICSB 323	0.3	-2.01	707.29	-1.18**	-1.3	-0.13	-1.08**	-1.65
38	Wray × ICSB 351	-1.42**	-3.15*	-1152.42**	-0.4	0.14	-1.02**	0.01	0.29
39	Wray × ICSB 374	-1.22**	-1	-1138.32**	-0.17	2.16	0.41	-0.03	1.86
40	Wray × ICSB 480	0.75	5.26**	309.55	0.55	1.5	-0.21	0.82**	0
41	Wray × Parbhani Moti	1.06**	0.28	1429.74**	-0.77	-3.44*	0.17	-0.86**	-2.36
42	Wray × NSSV 13	1.36**	-0.54	988.94*	1.91**	0.35	0.78**	1.68**	1.48
43	SPSSV 30 × PMS 90B	-1.62**	-0.96	-1430.11**	-1.64**	2.02	-0.96**	-0.88**	0.18
44	SPSSV 30 × ICSB 323	0.09	-0.87	322.88	-1.72**	-4.45**	-0.65*	-1.29**	-3.53*
45	SPSSV 30 × ICSB 351	-0.24	-1.22	-145.83	-1.23**	-0.95	-0.04	-0.95**	-1.23

Table 8b (conti....)

46	SPSSV 30 × ICSB 374	-0.97*	-1.61	-940.7*	-1.53**	-5.7**	-0.29	-1.2**	-1.78
47	SPSSV 30 × ICSB 480	1.44**	-1.97	2422.95**	-0.66	4.91**	0.22	-0.55*	0.04
48	SPSSV 30 × Parbhani Moti	1.28**	3.93**	765.02	2.98**	3.08	0.74**	2.38**	2.96
49	SPSSV 30 × NSSV 13	0	2.71	-994.2*	3.79**	1.09	0.98**	2.5**	3.37
	S.Em.±	0.39	1.43	399.24	0.44	1.64	0.27	0.22	1.78
	CD at 5%	1.08	4.01	1117.52	1.23	4.59	0.75	0.62	4.97
	CD at 1%	1.43	5.31	1477.05	1.62	6.07	0.99	0.83	6.57
	CV	12.65	6.86	11.63	14.81	10.46	10	12.69	13.43

*Significance at 5% probability, **significance at 1% probability

Table 8c. Estimates of specific combining ability effects for stalk sugar related traits, yield and yield components in the crosses evaluated across environments

S.NO.	Crosses	DFL	Plant height (m)	Stem thickness (mm)	Stalk yield (t ha^{-1})	Juice yield (t ha^{-1})	Juice volume (L ha^{-1})	Brix (%)	Bagasse yield (t ha^{-1})	Total soluble solids (%)
1	IS 13871 × PMS 90 B	-3.01	0.21	1.59*	4.16	0.46	456.31	-0.66	3.6	-0.58
2	IS 13871 × ICSB 323	3.9*	-0.05	-0.95	-5.35	-3.17**	-3168.21**	-0.35	-2.22	-0.3
3	IS 13871 × ICSB 351	1.45	-0.12	-0.83	-0.7	4.26**	4228.02**	-1.16**	-4.92	-1.01**
4	IS 13871 × ICSB 374	2.64	-0.16	-3.71**	-14.37**	-2.45*	-2410.48*	1.95**	-12.71**	1.7**
5	IS 13871 × ICSB 480	-0.48	-0.02	0.65	2.23	3.42**	3356.12**	-0.7	-1.34	-0.61
6	IS 13871 × Parbhani Moti	-3.36	-0.3**	0.21	-16.97**	-8.76**	-8699.14**	-0.61	-8.16**	-0.54
7	IS 13871 × NSSV 13	-1.05	0.44**	3.05**	31.02**	6.24**	6237.38**	1.53**	25.79**	1.34**
8	IS 22670 × PMS 90 B	-6.12**	-0.14	-3.18**	-6.13	3.01*	2935.62*	-0.14	-8.71**	-0.12
9	IS 22670 × ICSB 323	-0.68	-0.34**	-1.92**	-25.6**	-3.46**	-3515.4**	0.27	-21.7**	0.24
10	IS 22670 × ICSB 351	3.67*	0.3**	3.55**	33.44**	8.18**	8169.5**	-0.15	25.85**	-0.13
11	IS 22670 × ICSB 374	7.73**	0.12	4.74**	36.68**	7.58**	7616.33**	0.84	28.93**	0.74
12	IS 22670 × ICSB 480	-2.76	-0.28**	-0.91	-41.24**	-11.22**	-11186.74**	0.07	-29.6**	0.06
13	IS 22670 × Parbhani Moti	-4.31*	0.01	-2.76**	-16.78**	-7.61**	-7577.33**	1.06*	-8.57**	0.93*
14	IS 22670 × NSSV 13	3.34	0.32**	0.5	19.64**	3.52**	3558.02**	-1.96**	17.97**	-1.71**
15	ICSV 25333 × PMS 90 B	-6.6**	0.13	2.13**	17.03**	3*	3024.29**	1.59**	22.47**	1.39**
16	ICSV 25333 × ICSB 323	-1.03	0.45**	-0.17	6.79	1	951.1	0.68	4.93	0.6
17	ICSV 25333 × ICSB 351	6.85**	0.08	0.39	19.89**	8.06**	7987**	1.89**	10.93**	1.66**
18	ICSV 25333 × ICSB 374	6.71**	0.33**	0.61	14.5**	0.26	326.33	0.83	12.68**	0.73
19	ICSV 25333 × ICSB 480	-3.58	0.2	-0.4	22.86**	6.35**	6336.43**	1.16**	15.4**	1.02**

Table 8c (conti....)

20	ICSV 25333 × Parbhani Moti	-3.29	-0.48**	-2.07**	-58.82**	-16.58**	-16453.33**	-3.61**	-43.05**	-3.16**
21	ICSV 25333 × NSSV 13	1.02	-0.71**	-0.48	-22.25**	-2.08	-2171.81	-2.55**	-20.16**	-2.23**
22	ICSV 93046 × PMS 90B	-3.43	-0.02	3.69**	24.98**	9.94**	9885.1**	-2.48**	13.99**	-2.16**
23	ICSV 93046 × ICSB 323	-4.19*	0.12	1.87**	13.91**	7.23**	7268.57**	-0.73	5.83*	-0.64
24	ICSV 93046 × ICSB 351	0.02	-0.21	-2.5**	-31.3**	-10.12**	-10077.02**	2.06**	-22.18**	1.81**
25	ICSV 93046 × ICSB 374	5.55**	-0.05	-0.78	-10.85**	-1.17	-1353.36	-1.11*	-6.44*	-0.97*
26	ICSV 93046 × ICSB 480	-3.41	0.15	-0.03	2.04	1.89	1937.57	-0.18	-0.12	-0.16
27	ICSV 93046 × Parbhani Moti	-1.62	0.09	0.77	9.89**	-3.81**	-3701.69**	-0.19	12.8**	-0.16
28	ICSV 93046 × NSSV 13	8.19**	-0.07	-2.42**	-8.67*	-3.96**	-3959.17**	2.62**	-4.72	2.29**
29	NTJ 2 × PMS 90 B	-0.74	-0.06	0.75	-2.95	-3.09**	-3055.4**	-0.24	0.08	-0.21
30	NTJ 2 × ICSB 323	-2.34	-0.2	1.01	4.37	-2.27	-2199.26	-1.13*	6.72*	-0.99*
31	NTJ 2 × ICSB 351	-5.79**	-0.29**	-0.8	-20.28**	-10.48**	-10370.19**	-1.75**	-9.73**	-1.53**
32	NTJ 2 × ICSB 374	-8.1**	-0.21	-0.9	-16.44**	-3.12**	-3079.52**	0.89*	-13.95**	0.78*
33	NTJ 2 × ICSB 480	4.44*	0.03	-0.46	-19.63**	-7.53**	-7458.26**	-0.24	-12.25**	-0.22
34	NTJ 2 × Parbhani Moti	11.23**	1.08**	2.9**	78.86**	40.2**	39809.98**	1.91**	38.49**	1.68**
35	NTJ 2 × NSSV 13	1.37	-0.35**	-2.49**	-23.93**	-13.7**	-13647.33**	0.56	-9.31**	0.49
36	Wray × PMS 90 B	-1.69	0.03	-2.19**	-7.77*	-2.46*	-2486.1*	0.01	-5.39*	0
37	Wray × ICSB 323	2.89	-0.02	-1.04	2.31	-2.1	-2099.45	0.5	4.4	0.44
38	Wray × ICSB 351	-2.9	0.07	0	-4.64	-0.94	-913.38	-1.85**	-3.7	-1.62**
39	Wray × ICSB 374	-6.71**	0.06	-0.78	-4.09	2.31*	2240.45	-0.83	-7.07**	-0.73
40	Wray × ICSB 480	5.97**	-0.12	0.05	-2.55	0.49	489.71	0.32	-3.18	0.28
41	Wray × Parbhani Moti	2.79	-0.38**	0.03	2.38	-5.03**	-5015.21**	1.66**	7.44**	1.45**
42	Wray × NSSV 13	0.43	0.36**	3.54**	14.36**	7.73**	7783.98**	0.2	7.53**	0.17
43	SPSSV 30 × PMS 90B	21.18**	-0.15	-3.07**	-29.31**	-10.86**	-10759.81**	1.93**	-18.5**	1.69**
44	SPSSV 30 × ICSB 323	3.93*	0.03	1.29	3.56	2.78*	2762.67*	0.74	0.84	0.65

Table 8c (conti....)

45	SPSSV 30 × ICSB 351	-3.7*	0.17	0.28	3.6	1.04	976.07	0.95*	2.53	0.83*
46	SPSSV 30 × ICSB 374	-3.5	-0.09	0.92	-5.43	-3.41**	-3339.76**	-2.57**	-2.66	-2.25**
47	SPSSV 30 × ICSB 480	-2.29	0.05	1.19	36.3**	6.6**	6525.17**	-0.43	29.42**	-0.37
48	SPSSV 30 × Parbhani Moti	-1.84	-0.02	1.02	1.45	1.6	1636.74	-0.23	-0.17	-0.21
49	SPSSV 30 × NSSV 13	-13.7**	0.01	-1.61*	-10.17**	2.24	2198.93	-0.39	-11.41**	-0.34
	S.Em.±	1.7	0.11	0.72	3.32	1.12	1104.41	0.46	2.55	0.41
	CD at 5%	4.74	0.3	2	9.26	3.12	3076.23	1.29	7.1	1.13
	CD at 1%	6.25	0.39	2.63	12.2	4.12	4054.32	1.71	9.36	1.49
	CV	4.75	8.9	8.23	10.4	12.33	12.24	8.03	11.19	7.96

*Significance at 5% probability, **significance at 1% probability, DFL: days to 50% flowering

Table 8c (conti....)

S.NO.	Crosses	Total sugar index	Juice extraction (%)	Ethanol yield (L ha^{-1})	Panicle weight (t ha^{-1})	Panicle length (cm)	Panicle breadth (cm)	Grain yield (t ha^{-1})	1000-seed weight (g)
1	IS 13871 × PMS 90 B	0.63	1.53	241.98	0.82*	-1.05	0.3	0.41*	2.46
2	IS 13871 × ICSB 323	-3.59**	-4.54**	-338.68	-1.31**	-0.48	-0.05	-0.72**	0.57
3	IS 13871 × ICSB 351	4.54**	2.31*	-701.67*	-0.56	2.54	-0.09	-0.71**	-1.3
4	IS 13871 × ICSB 374	-2.26	-0.76	-745.55*	-1.34**	-4.4**	-0.17	-0.54**	0.04
5	IS 13871 × ICSB 480	3.58**	3.18**	-293.05	0.02	0.95	-0.36	0.07	-2.62*
6	IS 13871 × Parbhani Moti	-9.68**	-1.92*	-1183.47**	1.41**	2.5	-0.17	1.09**	0.73
7	IS 13871 × NSSV 13	6.78**	0.2	3020.44**	0.97**	-0.06	0.55**	0.41*	0.17
8	IS 22670 × PMS 90 B	3.36**	0.81	-550.74	-1.44**	-0.81	-0.36	-1.09**	-1.28
9	IS 22670 × ICSB 323	-3.97**	2.63**	-1831.45**	0.91**	1.47	-0.09	-0.07	-1.13
10	IS 22670 × ICSB 351	8.88**	3.23**	1967.36**	3.63**	1.98	0.95**	2.72**	-0.55
11	IS 22670 × ICSB 374	8.76**	-1.54	3238.09**	0.02	-1.35	-0.13	0.8**	0.59
12	IS 22670 × ICSB 480	-12.41**	-4.98**	-2847.6**	-2.61**	-2.47	-0.61**	-1.87**	2.63*
13	IS 22670 × Parbhani Moti	-8.43**	-2.83**	-365.74	-0.12	-0.85	0.48*	-0.25	4.77**
14	IS 22670 × NSSV 13	3.79**	2.67**	390.07	-0.4	2.03	-0.25	-0.25	-4.99**
15	ICSV 25333 × PMS 90 B	3.48**	-2.29*	2236.06**	-1.08**	-0.94	-0.41*	-0.78**	1.05
16	ICSV 25333 × ICSB 323	0.95	-1.3	910.16**	-1.3**	0.61	-0.56**	-1.08**	2.74*
17	ICSV 25333 × ICSB 351	8.7**	3.64**	2083.34**	1.1**	-6.85**	0.43*	0.73**	2.28
18	ICSV 25333 × ICSB 374	0.74	-3.56**	1571.66**	0.54	6.27**	0.06	0.67**	-1.34
19	ICSV 25333 × ICSB 480	6.88**	2.08*	2093.31**	3.26**	-1.65	0.84**	1.69**	3.74**
20	ICSV 25333 × Parbhani Moti	-18.24**	0.43	-5806.91**	-2.54**	3.54*	-0.53**	-1.84**	-4.83**

Table 8c (conti....)

21	ICSV 25333 × NSSV 13	-2.52*	1.00	-3087.62**	0.02	-0.97	0.17	0.62**	-3.59**
22	ICSV 93046 × PMS 90B	9.56**	3.46**	225.97	1.35**	0.09	0.64**	0.42**	-2.22
23	ICSV 93046 × ICSB 323	8.12**	5.07**	394.98	2.32**	0.97	0.42*	1.93**	0.49
24	ICSV 93046 × ICSB 351	-10.93**	-5.31**	-1413.44**	-3.2**	-0.57	-0.7**	-1.98**	-1.3
25	ICSV 93046 × ICSB 374	-0.89	2.36**	-1146.34**	-0.7*	-1.61	-0.51**	-0.12	2.11
26	ICSV 93046 × ICSB 480	2.26	3.97**	-21.77	-0.61	-0.3	0.18	-0.53**	-1.25
27	ICSV 93046 × Parbhani Moti	-3.94**	-2.61**	1073.34**	2.34**	-0.69	0.55**	1.14**	1.72
28	ICSV 93046 × NSSV 13	-4.19**	-6.95**	887.26**	-1.5**	2.11	-0.59**	-0.86**	0.32
29	NTJ 2 × PMS 90 B	-2.75*	0.31	-180.31	3.58**	1.82	0.84**	2.89**	1.43
30	NTJ 2 × ICSB 323	-2.06	-0.31	-109.68	0.53	3.87**	1**	0.14	0.98
31	NTJ 2 × ICSB 351	-11.05**	-4.39**	-1677.11**	-0.57	0.09	-0.48*	0.22	0.23
32	NTJ 2 × ICSB 374	-5.86**	1.54	-1014.52**	1.14**	1.25	0.01	0.14	2.07
33	NTJ 2 × ICSB 480	-7.83**	0.25	-1464.61**	0.87*	1.03	0.33	0.25	-3.28*
34	NTJ 2 × Parbhani Moti	44.19**	7.96**	5147.77**	-3.11**	-3.45*	-0.46*	-1.45**	-3.76**
35	NTJ 2 × NSSV 13	-14.63**	-5.35**	-701.54*	-2.44**	-4.59**	-1.23**	-2.21**	2.38
36	Wray × PMS 90 B	-2.6*	2.45**	-465.73	0.71*	1	0.28	0.43**	-1.62
37	Wray × ICSB 323	-2.4*	-5.09**	583.87	-0.43	-2.37	-0.45*	0.02	-0.28
38	Wray × ICSB 351	-1.13	1.07	-904.92**	-0.64	0.77	-0.36	-0.82**	-0.06
39	Wray × ICSB 374	2.83*	6**	-913.58**	0.03	3.46*	0.51**	0.32*	0.24
40	Wray × ICSB 480	0.44	-1.46	-271.78	-0.35	-0.02	-0.28	0.11	-0.97
41	Wray × Parbhani Moti	-5.6**	-4.79**	1190.3**	-0.26	-3.27*	-0.2	-0.51**	-0.42
42	Wray × NSSV 13	8.46**	1.81*	781.82*	0.95**	0.44	0.51**	0.45**	3.16*
43	SPSSV 30 × PMS 90B	-11.68**	-6.27**	-1507.24**	-3.94**	-0.09	-1.28**	-2.29**	0.09
44	SPSSV 30 × ICSB 323	2.94*	3.54**	390.8	-0.72*	-4.06**	-0.27	-0.21	-3.46**

Table 8c (conti....)

45	SPSSV 30 × ICSB 351	0.98	-0.54	646.45*	0.24	2.05	0.26	-0.17	0.61
46	SPSSV 30 × ICSB 374	-3.33**	-4.05**	-989.76**	0.32	-3.61*	0.22	-1.26**	-3.13*
47	SPSSV 30 × ICSB 480	7.07**	-3.05**	2805.49**	-0.57	2.45	-0.11	0.28	1.75
48	SPSSV 30 × Parbhani Moti	1.7	3.75**	-55.3	2.26**	2.22	0.33	1.83**	1.71
49	SPSSV 30 × NSSV 13	2.31	6.62**	-1290.43**	2.4**	1.05	0.84**	1.84**	2.47
	S.Em.±	1.15	0.92	298.86	0.33	1.37	0.18	0.17	1.26
	CD at 5%	3.19	2.55	832.43	0.91	3.82	0.51	0.47	3.50
	CD at 1%	4.20	3.36	1097.1	1.20	5.03	0.68	0.62	4.61
	CV	11.51	8.16	13.17	13.93	12.29	10.23	13.21	12.9

*Significance at 5% probability, **significance at 1% probability

Plant height was significantly positively correlated with most of the traits studied except for juice extraction, panicle weight, panicle breadth, grain yield and 1000-seed weight. The highest correlation was observed with ethanol yield (r = 0.85).

Stem thickness was significantly positively correlated with the traits days to 50% flowering, plant height, stem thickness, stalk yield, juice yield, juice volume, bagasse yield, total sugar index, ethanol yield and panicle length. The highest correlation was observed with bagasse yield (r = 0.90).

Stalk yield was significantly positively correlated with most of the traits studied except for brix, total soluble solids, juice extraction, panicle length, grain yield and 1000-seed weight. With highest correlation with bagasse yield (r = 0.98).

Juice yield and juice volume were significantly positively correlated with most of the traits studied except for brix, total soluble solids, juice extraction, panicle length and 1000-seed weight. Both had highest correlation with each other (r = 1.00) followed by total sugar index (r = 0.97).

Brix was significantly positively correlated with traits plant height, total soluble solids, total sugar index and ethanol yield. The highest correlation was observed with total soluble solids (r = 1.00).

Bagasse yield was significantly positively correlated with most of the traits studied except for brix, total soluble solids, juice extraction, panicle weight, panicle breadth, grain yield and 1000-seed weight. The highest correlation was observed with ethanol yield (r = 0.97).

Total soluble solids was significantly positively correlated with traits plant height, brix, total sugar index and ethanol yield. The highest correlation was observed with brix (r = 1.00).

Total sugar index was significant positively associated with days to 50% flowering, plant height, stem thickness, stalk yield, juice yield, juice volume, brix, bagasse yield and total soluble sugars. The highest correlation was observed with juice yield and juice volume (r = 0.97).

Juice extraction was significant positively associated with juice yield, juice volume, total sugars index, panicle weight, panicle breadth and grain yield. The highest correlation was observed with juice yield and juice volume (r = 0.45).

Ethanol yield was significant positively associated with all sugar related traits and negatively correlated with yield traits. The highest correlation was observed with bagasse yield (r = 0.97).

Panicle weight was significant positively associated with stalk yield, juice yield, juice volume, total sugars index, juice extraction, panicle breadth, grain yield and 1000-seed weight. The highest correlation was observed with grain yield (r = 0.92).

Panicle length was significant positively associated with days to 50% flowering, plant height, stem thickness and bagasse yield. The highest correlation was observed with stem thickness (r = 0.34).

Panicle breadth was significant positively associated with stalk yield, juice yield, juice volume, total sugars index, juice extraction, panicle weight, grain yield and 1000-seed weight. The highest correlation was observed with panicle yield (r = 0.87).

Grain yield was significant positively associated with juice yield, juice volume, total sugars index, juice extraction, panicle weight, panicle breadth and 1000-seed weight. The highest correlation was observed with panicle weight (r = 0.92).

1000-seed weight was significant positively associated with panicle weight, panicle breadth and grain yield. The highest correlation was observed with grain yield (r = 0.46).

Table 9. Phenotypic correlation coefficients between different sugar related traits, yield and yield components among genotypes of sweet sorghum evaluated across environments

	DFL	PH	ST	SY	JY	JV	Bri	BY	TSS	TSI	JE	EY	PW	PL	PB	GY	1000S
DFL	1	0.73**	0.73**	0.69**	0.32**	0.33**	0.15	0.77**	0.15	0.33**	-0.46**	0.77**	-0.14	0.25*	-0.03	-0.35**	-0.50**
PH		1	0.70**	0.78**	0.50**	0.50**	0.37**	0.81**	0.38**	0.55**	-0.27*	0.85**	0.05	0.27*	0.08	-0.10	-0.33**
ST			1	0.88**	0.59**	0.59**	0.00	0.90**	0.00	0.55**	-0.29*	0.86**	0.20	0.34**	0.18	0.02	-0.22
SY				1	0.80**	0.80**	0.15	0.98**	0.15	0.77**	-0.11	0.95**	0.31*	0.18	0.34**	0.13	-0.15
JY					1	1.00**	0.23	0.65**	0.23	0.97**	0.45**	0.64**	0.45**	-0.08	0.52**	0.35**	0.05
JV						1	0.24	0.65**	0.23	0.97**	0.45**	0.64**	0.45**	-0.09	0.53**	0.36**	0.05
Bri							1	0.09	1.00**	0.45**	0.17	0.32*	-0.16	-0.12	-0.08	-0.10	-0.21
BY								1	0.10	0.62**	-0.31*	0.97**	0.23	0.26*	0.25	0.03	-0.21
TSS									1	0.44**	0.16	0.32*	-0.16	-0.12	-0.09	-0.10	-0.21
TSI										1	0.44**	0.67**	0.35**	-0.10	0.43**	0.28*	-0.01
JE											1	-0.30*	0.32*	-0.37**	0.37**	0.41**	0.15
EY												1	0.14	0.24	0.18	-0.04	-0.25*
PW													1	0.10	0.87**	0.92**	0.35**
PL														1	-0.04	0.01	-0.24
PB															1	0.77**	0.31*
GY																1	0.46**
1000S																	1

DFL: days to 50% flowering, PH: plant height, ST: stem thickness, SY: stalk yield, JY: juice yield, JV: juice volume, Bri: brix %, BY: bagasse yield, TSS: total soluble solids, TSI: total sugar index, JE: juice extraction %, EY: ethanol yield, PW: panicle weight, PL: panicle length, PB: panicle breadth, GY: grain yield, 1000S: 1000-seed weight

5. DISCUSSION

Sorghum (*Sorghum bicolor* L. Moench) is a C_4 herbaceous annual grass that is cultivated since time immemorial. Sweet sorghum is a multipurpose crop (food, feed, fodder and fuel) that has the potential as an alternative biofuel feedstock without impacting food and fodder security. It has wide flat leaves and a round or elliptical panicle with full of grain at maturity. It is a crop of high universal value since it can be cultivated in tropical, subtropical, temperate, and semi-arid regions as well as in poor quality soils of the world. It is termed as ‘‘the sugarcane of the desert’’ or ‘‘the camel among crops’’ due to its drought hardy characteristics (Sanderson *et al.,* 1992). The plant accumulates high concentrations of soluble sugars (10–15 %) in the plant stalk sap or juice (Srinivasa Rao *et al*., 2009).

The sugar content in the juice extracted from sweet sorghum stalks varies from 16-23% (Reddy *et al*., 2005). Sugar concentration of sweet sorghum increases as a function of the duration of growth, commonly peaking at the grain dough stage, and generally decreased with delayed planting irrespective of sampling stage (Ferraris, 1981; Geng *et al*., 1989). Increasing stalk sugar yields is becoming an important objective in sweet sorghum breeding (Murray *et al*., 2009, Srinivasa Rao *et al*., 2009). Genetic enhancement of the crop for increased sugar yield is very critical to make sweet sorghum more profitable to the farmers and the industry, while sustaining grain yield, juice volume, plant height, plant girth and other important components. The knowledge on nature of gene action for sugar yield and its component traits like Brix% and juice content in the breeding material can provide useful information for selecting efficient breeding procedure for genetic enhancement.

The nature of inheritance of quantitative traits especially stalk sugar related traits, yield and yield components will help the breeder in deciding potential parents among several high stalk sugar yielding types in a breeding programme. With this background, an investigation was carried out to study the genetics of various stalk sugar traits, yield and yield component traits using hybrid parents (B & R lines) in L × T design. The information generated will be helpful in selection of suitable parents for development of high stalk sugar yielding crosses.

The objectives of the present study were: (1.) To assess the extent of heterosis for stalk sugar yield traits and identification of heterotic cross combinations of B and R lines across environments. (2.) To estimate general combining ability of parents and specific combining ability of crosses for stalk sugar yield traits. (3.) To study the nature and magnitude of gene action in the inheritance of stalk sugar related traits, yield and yield components.

After partitioning of genotypic variance into additive, dominance and epistasis by Fisher during 1918, different methods have been suggested to estimate the proportion of these components and to apply the proper breeding programmes based on this information. Methods suggested by Mather (1949) and Jinks and Jones (1958) involve the mean or variance and covariance may be of not only the parent and F_{1s} but also of the backcross generations. This involves great amount of labour, besides breeder has to wait for minimum of three generations to get the required information. To overcome these problems, biometricians developed methods like diallel analysis (Hayman, 1954a, 1954b & 1957; Griffings, 1956) and line x tester analysis (Kempthorne, 1957). All these methods require information of parents and F_{1s} only. Among these methods line x tester analysis uses large number of male and female parents compared to diallel analysis and z x n methods to study a given number of crosses, so that chances of getting some useful information and material for further breeding programme would be high.

Therefore, in the present study Line x Tester analysis was carried out using data recorded across environments for stalk sugar yield traits in B x R crosses of sweet sorghum [*Sorghum bicolor (L.) Moench*]. The experimental material involving 49 cross developed in L x T (7 x 7) design, their parents and a check (CSH 22SS) was evaluated for stalk sugar yield and its related traits, yield and yield components at two locations *viz.,* E1: Regional Agricultural Research Station, Bijapur, and E2: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, during *kharif* season of the year 2013. Planting was done in the month of June.

The characters studied with respect to stalk sugar yield and its related traits, yield and yield components were days to 50% flowering, plant height, stem thickness, stalk yield, juice yield, juice volume, brix %, bagasse yield, total soluble solids, total sugar index, juice extraction (%), ethanol yield, panicle weight, panicle length, panicle breath, grain yield and 1000-seed weight.

The data recorded in two locations were subjected to statistical analysis location wise as well as across environments. The results on genetic analysis of stalk sugar yield and its related traits, yield and yield components are discussed below under the following headings.

- Analysis of variance (ANOVA)
- Parental performance
- Heterosis estimates
- Combining ability analysis
- Correlations
- Prospects of breeding for heterotic hybrids in sweet sorghum
- Future line of work

5.1 Analysis of variance

The analysis of variance for all entries including fourteen parents, forty nine crosses and a check for stalk sugar related traits, yield and yield components at individual environments (Bijapur and ICRISAT) and across environments revealed that treatment variances for all the characters studied were highly significant. This indicates the presence of variability among genotypes. From the analysis of variance of parents and crosses, it was clear that MSS for parents and crosses were highly significant for all traits indicating presence of sufficient variability among genotypes for the traits studied.

5.2. Parental performance

The hybrid parental lines (B and R) were differed significantly for all the traits studied across environments (Table 3c) except panicle length among male lines. Among the female lines IS 13871, Wray and SPSSV 30 were found to be early maturing parents (Table 4). Similarly ICSB 1335 and ICSB 374 were found to be early maturing genotypes among testers. The line IS 22670 was recorded with high value of plant height, stem thickness, stalk yield, bagasse yield and ethanol yield. The genotype IS 27206 was tall with high value of ethanol yield. NTJ 2 was having thicker stem with highest stalk yield, juice yield, juice volume and total sugar index. The genotypes, SPSSV 30 and IS 27206 were recorded with high values of brix (%) and ethanol yield, respectively. With respect to yield parameters the line NTJ 2 was recorded with high values of panicle weight, grain yield and 1000-seed weight.

Among the testers, ICSB 351 and ICSB 374 were early maturing genotypes. SPV 1411 was tall with high stalk yield and juice yield. NSSV 13 was tall with high stem thickness, stalk yield, juice yield, juice volume, bagasse yield, brix (%), total soluble solids, total sugar index, juice extraction (%) and ethanol yield. ICSB 323 was recorded with high brix (%), total soluble solids and total sugar index, and PMS 90B with high stem thickness. With respect to yield parameters, PMS 90B was having high panicle weight, grain yield, panicle length, panicle breadth and 1000-seed weight. The genotype, NSSV 13 was recorded with high panicle weight, grain yield, panicle breadth and 1000-seed weight. SPV 1411 was having high values of 1000-seed weight, and ICSB351 & ICSB 374 were longest panicle among the testers.

5.3 Heterosis estimates

The number of crosses showing significant heterosis in desired direction and their ranges of heterosis estimates for stalk sugar related traits and yield and yield components are discussed in the Table 10a for Bijapur location, Table 10b for ICRISAT location and Table 10c for across environments.

5.3.1 Days to 50 percent flowering

Negatively significant estimates of relative heterosis, heterobeltiosis and over standard check (CSH 22SS), were recorded in 8, 22 and 22 crosses, respectively in desired direction at Bijapur (Table 5a), 16, 29 and 29 crosses, respectively at ICRISAT (Table 5b) and 10, 24 and 25 crosses, respectively across environments (Table 5c). The results were in accordance with the findings of Rajashekhar (2007), Talekar (2010) and Pothisoong and Jaisil (2011). The magnitude of relative heterosis, heterobeltiosis and standard heterosis was recorded up to -16.83%, -26.99% and -24.06%, respectively at Bijapur; up to -22.57%, -31.97% and -31.72%, respectively at ICRISAT; up to -17.38, -28.57 and -27.9%, across environments respectively (Table

10a, 10b and 10c). However, it was reported by Pothisoong and Jaisil (2011) that F_1 hybrids showed % heterosis over better male parent for days to flowering, up to -7.83 among the 20 sweet sorghum hybrids studied. Similarly, Rajashekhar (2007) noticed significantly higher standard heterosis for days to 50 % flowering in three hybrids among 144 sweet sorghum hybrids developed by crossing 9 female lines and 16 male lines in a line × tester fashion.

5.3.2 Plant height

There were 16 and 3 crosses at Bijapur (Table 5a), 37 and 10 crosses at ICRISAT (Table 5b) and 30 and 4 crosses across environments (Table 5c) which showed respectively positive significant relative heterosis and heterobeltiosis. Whereas 2, 12 and 9 crosses at Bijapur, ICRISAT and across environments, respectively were significantly taller than the standard check (CSH 22SS). The magnitude of relative heterosis, heterobeltiosis and standard heterosis was recorded up to 74.68%, 38.11% and 33.87%, at Bijapur; 53.26%, 26.17% and 41.9%, at ICRISAT and 49.77%, 15% and 31.46%, across environments respectively (Table 10a, 10b and 10c). Similar, positive heterosis was reported by Rajashekhar (2007), Makanda *et al.* (2009), Talekar (2010) and Pothisoong and Jaisil (2011). Substantial magnitude of standard heterosis was reported by Sankarapandian *et al.* (1994b) for plant height (up to 46.9 %) among 21 hybrids derived from 3 CMS lines, 7 testers. Similarly, Pothisoong and Jaisil (2011) observed heterosis over better male parent for plant height, upto 8.06 among 20 sweet sorghum hybrids. Significant mid-parent and better parent heterosis were also observed in LxT analysis reported by Sandeep *et al.* (2009), Choudhari (1992) and Agarwal and Shrotria (2005). Standard heterosis was also reported by Agarwal and Shrotria (2005).

5.3.3 Stem thickness

At Bijapur there were 21 and 17 crosses, (Table 5a), 13 and 15 crosses, at ICRISAT (Table 5b) and 21 and 15 crosses, across environments (Table 5c) respectively, that showed positively significant relative heterosis and heterobeltiosis. At Bijapur, ICRISAT and across environments 1, 20 and 7 crosses, respectively were recorded with significantly thicker stem than standard check (CSH 22SS). The magnitude of relative heterosis, heterobeltiosis and standard heterosis were noticed upto 58.78%, 42.08% and 16.38%, at Bijapur; up to 43.16%, 32.4% and 40.37%, at ICRISAT and up to 45.2%, 36.5% and 24.14%, across environments respectively (Table 10a, 10b and 10c). Similar, positive heterosis was reported by Rajashekhar (2007). Whereas, Makanda *et al.* (2009) reported negative heterosis.

5.3.4 Stalk yield

There were 17 and 22 crosses, at Bijapur (Table 5a), 42 and 33 crosses, at ICRISAT (Table 5b) and 29 and 16 crosses, across environments (Table 5c) respectively which showed positive significant relative heterosis and heterobeltiosis. at Bijapur, ICRISAT and across environments. Where as none, 20 and 3 crosses have recorded with significantly higher stalk yield than standard check (CSH 22SS). The magnitude of relative heterosis, heterobeltiosis and standard heterosis were recorded up to 137.89%, 103.27% and 0.96%, at Bijapur; up to 198.85%, 119.7% and 104.36%, at ICRISAT and up to 156.14%, 86.99% and 31.35%, across environments respectively (Table 10a, 10b and 10c). Therefore, there is potential to exploit heterosis in new sweet sorghum cultivar development. Substantial magnitude of standard heterosis was observed for millable stalk yield (up to 1.5 %) in a study involving 3 CMS lines, 7 testers and 21 hybrids (Sankarapandian *et al.,* 1994b). For stem biomass production Corn (2008) reported better parent heterosis values ranging between 27% to 43%.. In a set of 28 grain sorghum × sweet sorghum hybrids, 11 hybrids showed significant high-parent heterosis for green stalk yield (Selvi and Palanisamy, 1987). Sandeep *et al*. (2009) reported significant mid-parent heterosis and better parent heterosis for cane weight. Similar, positive heterosis was reported by Rajashekhar (2007), Makanda *et al.* (2009), Pfeiffer *et al.* (2010), Talekar (2010), Pothisoong and Jaisil (2011), Umakanth *et al.* (2012) and Rani *et al.* (2013).

5.3.5 Juice yield

There were 20 and 13 crosses, at Bijapur (Table 5a), 39 and 33 crosses at ICRISAT (Table 5b) and 21 and 13 crosses, across environments (Table 5c) respectively which showed positive significant relative heterosis and heterobeltiosis. For significantly high juice yield than standard check (CSH 22SS), none, 11 and 1 crosses were recorded at Bijapur, ICRISAT and across environments. juice yield. The magnitude of relative heterosis, heterobeltiosis and standard heterosis were noticed up to 171.48%, 128.03% and 4.23%, at Bijapur; up to 208.2%, 115.1% and 98.8%, at ICRISAT and up to 152.36%, 92.55% and 23.96%, across environments respectively (Table 10a, 10b and 10c). Similar substantial magnitude of standard heterosis was observed for juice yield (up to 122.6 %) in a study involving 3 CMS lines, 7 testers and 21 hybrids (Sankarapandian *et al.,* 1994b). In a study involving 144 sweet sorghum hybrids developed by crossing 9 female lines and 16 male lines in a line × tester fashion, Rajashekhar (2007) noticed significantly higher standard heterosis juice yield in three hybrids. In a line × tester analysis involving 16 hybrids produced by crossing eight parents, Umakanth *et al.* (2012) reported that significant and positive mid-parental heterosis was recorded in 11 hybrids for total biomass and juice yields. Reasonable amount of heterosis in respect of juice yield was also reported by Choudhari (1992).

5.3.6 Juice volume

There are 19 and 13 crosses, respectively at Bijapur (Table 5a), 39 and 32 crosses, respectively at ICRISAT (Table 5b) and 21 and 13 crosses, respectively across environments (Table 5c) which showed positive significant relative heterosis and heterobeltiosis. Whereas, none, 11 and 1 crosses at Bijapur, ICRISAT and across environments, respectively were recorded with significantly high juice volume than standard check (CSH 22SS). The magnitude of relative heterosis, heterobeltiosis and standard heterosis were recorded in the study up to 170.66%, 126.72% and 4.24%, at Bijapur; up to 207.77%, 114.44% and 97.58%, at ICRISAT and up to 152.29%, 92.87% and 23.45%, across environments respectively (Table 10a, 10b and 10c). Similarly, Sandeep *et al.* (2009) reported significant mid-parent heterosis and better parent heterosis for juice volume. And Rajashekhar (2007) noticed significantly higher standard heterosis for juice volume in three hybrids out of 144 sweet sorghum hybrids 9 female lines and 16 male lines in a line × tester fashion. Similar, positive heterosis was reported by Rajashekhar (2007), Makanda *et al.* (2009), Pfeiffer *et al.* (2010), Talekar (2010), Umakanth *et al.* (2012) and Rani *et al.* (2013).

5.3.7 Brix

There were 15 and 10 crosses at Bijapur (Table 5a), 18 and 3 crosses, at ICRISAT (Table 5b) and 13 and 3 crosses, across environments (Table 5c) respectively that showed positive significant relative heterosis and heterobeltiosis. Whereas, 23, 8 and 10 crosses at Bijapur, ICRISAT and across environments, respectively were recorded significantly high brix % than standard check (CSH 22SS). In the present study the magnitude of relative heterosis, heterobeltiosis and standard heterosis were observed up to 63.64%, 50% and 58.57%, at Bijapur; up to 19.72%, 12% and 24.79%, at ICRISAT and up to 32.4%, 24.15% and 31.29%, across environments respectively (Table 10a, 10b and 10c). However, Corn (2008) reported better parent heterosis values ranging between -24% and 7% for stem brix. It was reported that none out of a set of 28 grain sorghum × sweet sorghum hybrids (Selvi and Palanisamy, 1987), one cross out of 24 hybrids (Choudhari, 1992) and one in 60 sweet sorghum hybrids (Senthil and Khan, 1997). In a study comprising 61 hybrids, Makanda *et al*. (2009) reported that there was significant variation among genotypes for stem brix and associated traits and the top 20 stem brix performers were constituted by 17 hybrids (exhibiting heterosis of up to 112%) and three parents. Sandeep *et al*. (2009) reported significant standard heterosis in respect of juice brix was observed in two hybrids. Pothisoong and Jaisil (2011) studied 20 sweet sorghum hybrids and it was revealed that F_1 hybrids showed % heterosis over better male parent for percent brix, 7.60.

Pfeiffer *et al*. (2010) reported positive heterosis for brix in six hybrids, the greater juice yield and higher sugar content of selected hybrids such as A3 N100 × Dale could produce more total syrup or ethanol than current pure-line sweet sorghum varieties. Therefore, the high magnitude of heterosis for brix observed in the present study indicated that there is potential to exploit heterosis in new sweet sorghum cultivar development.

5.3.8 Bagasse yield

There were 22 and 18 crosses, at Bijapur (Table 5a), 41 and 30 crosses, at ICRISAT (Table 5b) and 29 and 18 crosses, across environments (Table 5c) respectively, that showed positive significant relative heterosis and heterobeltiosis.

However, 3, 22 and 8 crosses at Bijapur, ICRISAT and across environments, respectively showed significantly high bagasse yield than standard check (CSH 22SS). The magnitude of relative heterosis, heterobeltiosis and standard heterosis was observed in the present study up to 160.61%, 120.62% and 24.25%, at Bijapur; up to 198.87%, 118.82% and 161.19%, at ICRISAT and up to 165.01%, 109.05% and 54.96%, across environments respectively (Table 10a, 10b and 10c).

5.3.9 Total soluble solids

There were 17 and 10 crosses, at Bijapur (Table 5a), 18 and 3 crosses, at ICRISAT (Table 5b) and 14 and 4 crosses, across environments (Table 5c) respectively that showed positive significant relative heterosis and heterobeltiosis. Significantly high total soluble solids for, 23, 8 and 10 crosses at Bijapur, ICRISAT and across environments, respectively were recorded than standard check (CSH 22SS). The magnitude of relative heterosis, heterobeltiosis and standard heterosis were recorded in the present study up to 62.46%, 49.15% and 57.71%, r at Bijapur; up to 19.44%, 11.88% and 24.53%, at ICRISAT and up to 31.9%, 27% and 30.91%, across environments respectively (Table 10a, 10b and 10c). Similar, positive heterosis was reported by Talekar (2010) and Rani *et al.* (2013). Substantial magnitude of standard heterosis was reported by Sankarapandian *et al.* (1994b) for total soluble solids (up to 7.4 %) among 24 hybrids derived from 3 CMS lines and 7 testers. Agarwal and Shrotria (2005) also observed the presence of significant mid-parent, better parent and standard heterosis for the trait among 50 hybrids derived from a cross between 5 CMS lines and 10 restorer lines in L × T fashion.

5.3.10 Total sugar index

There were 16 and 11 crosses, at Bijapur (Table 5a), 40 and 33 crosses, at ICRISAT (Table 5b) and 23 and 8 crosses, across environments (Table 5c) respectively which showed positive significant relative heterosis and heterobeltiosis. However, none, 12 and 1 crosses at Bijapur, ICRISAT and across environments, respectively were recorded for significantly high total sugar index than standard check (CSH 22SS). The magnitude of relative heterosis, heterobeltiosis and standard heterosis were observed in the present study up to 204.6%, 129.96% and 6.62%, at Bijapur; up to 224.01%, 127.3% and 95.9%, at ICRISAT and up to 157.26%, 76.1%

and 34.63%, across environments respectively (Table 10a, 10b and 10c). Similar, positive heterosis was reported by Pfeiffer *et al.* (2010) and Talekar (2010).

5.3.11 Juice extraction *percentage*

There were 6 and 6 crosses, at Bijapur (Table 5a), 11 and 3 crosses, at ICRISAT (Table 5b) and 5 and 2 crosses across environments (Table 5c) respectively which showed positive significant relative heterosis and heterobeltiosis. However, 6, 2 and 1 crosses at Bijapur, ICRISAT and across environments, respectively were recorded for significantly high juice extraction percentage than standard check (CSH 22SS). The magnitude of relative heterosis, heterobeltiosis and standard heterosis were observed up to 47.22%, 30.94% and 34.61%, at Bijapur; up to 19.4%, 11.14% and 17.43%, at ICRISAT and up to 21.82%, 15.55% and 14.94%, across environments respectively (Table 10a, 10b and 10c). Similar, positive heterosis was reported by Talekar (2010), Pothisoong and Jaisil (2011) and Rani *et al.* (2013). Selvi and Palanisamy (1987) observed high parent heterosis in two hybrids in a set of 28 grain sorghum × sweet sorghum hybrids for per cent extractable juice. Similarly, % heterosis over better male parent for per cent cane juice extracted was reported up to 34.89% among 20 sweet sorghum hybrids studied by Pothisoong and Jaisil (2011).

5.3.12 Ethanol yield

There are 27 and 21 crosses, at Bijapur (Table 5a), 43 and 29 crosses, at ICRISAT (Table 5b) and 27 and 17 crosses, across environments (Table 5c) respectively which showed positive significant relative heterosis and heterobeltiosis. However, 4, 18 and 8 crosses at Bijapur, ICRISAT and across environments, respectively were recorded for significantly high ethanol yield than standard check (CSH 22SS). Similar, positive heterosis was reported by Talekar (2010), Umakanth *et al.* (2012) and Rani *et al.* (2013). The magnitude of relative heterosis, heterobeltiosis and standard heterosis were observed up to 152.25%, 94.9% and 22.97%, at Bijapur; up to 199.33%, 121.83% and 148.24%, at ICRISAT and up to 162.31%, 74.34% and 66.05%, across environments respectively (Table 10a, 10b and 10c). Significant mid-parent heterosis and better parent heterosis for ethanol yield were also reported by Sandeep *et al*. (2009) among 18 hybrids developed by crossing 3 lines with 6 testers. Vinaykumar (2009) reported significant standard heterosis for ethanol yield in six hybrids in L × T analysis involving 72 hybrids produced by crossing 4 CMS lines with 18 testers.

5.3.13 Panicle weight

There were 35 and 26 crosses, at Bijapur (Table 5a), 26 and 20 crosses, at ICRISAT (Table 5b) and 28 and 22 crosses, across environments (Table 5c) respectively that showed positive significant relative heterosis and heterobeltiosis. However, 4 crosses at Bijapur showed significantly higher panicle weight than the check while, none of them showed significant heterosis over the standard check (CSH 22SS) for panicle weight at ICRISAT and across environments. Similar, positive heterosis was reported by Rajashekhar (2007). The magnitude of relative heterosis, heterobeltiosis and standard heterosis were observed up to 452.94%, 439.4% and 40.44%, at Bijapur; up to 173.74%, 138.69% and -9.84%, at ICRISAT and up to 275.09%, 245.89% and -6.79%, across environments respectively (Table 10a, 10b and 10c).

5.3.14 Panicle length

There were 16 and 9 crosses, at Bijapur (Table 5a), 27 and 12 crosses, at ICRISAT (Table 5b) and 21 and 9 crosses, across environments (Table 5c) respectively, that showed positive significant relative heterosis and heterobeltiosis. However, 4, 6 and 5 crosses at Bijapur, ICRISAT and across environments, respectively were recorded for significantly higher panicle length than standard check (CSH 22SS). The magnitude of relative heterosis, heterobeltiosis and standard heterosis were observed up to 52.03%, 47.04% and 31.06%, at Bijapur; up to 56.88%, 51.37% and 49.04%, at ICRISAT and up to 43.82%, 43.68% and 39.98%, across environments respectively (Table 10a, 10b and 10c).

5.3.15 Panicle breadth

There were 22 and 15 crosses, at Bijapur (Table 5a), 21 and 15 crosses, at ICRISAT (Table 5b) and 18 and 14 crosses, across environments (Table 5c) respectively that showed positive significant relative heterosis and heterobeltiosis. However, only one crosses at Bijapur and none of the crosses at ICRISAT and across environments showed significantly high panicle breadth than standard check (CSH

22SS). The magnitude of relative heterosis, heterobeltiosis and standard heterosis were observed up to 69.23%, 54.76% and 10.86%, at Bijapur; up to 62.6%, 51.32% and 4.25%, at ICRISAT and up to 47.88%, 35.2% and -3.46%, across environments respectively (Table 10a, 10b and 10c).

5.3.16 Grain yield

There were 33 and 24 crosses, at Bijapur (Table 5a), 27 and 23, crosses at ICRISAT (Table 5b) and 26 and 19 crosses across environments (Table 5c) respectively had showed positively significant relative heterosis and heterobeltiosis. However, 5 crosses at Bijapur and none at ICRISAT and across environments, showed significantly higher grain yield than standard check (CSH 22SS). Similarly, positive heterosis was reported by Rajashekhar (2007), Talekar (2010) and Pothisoong and Jaisil (2011). The magnitude of relative heterosis, heterobeltiosis and standard heterosis were observed in the present study up to 1020.42%, 639.39% and 55.01%, at Bijapur; up to 290.14%, 231.43% and -13.77%, at ICRISAT and up to 452.77%, 440.38% and -1.89%, across environments respectively (Table 10a, 10b and 10c).

5.3.17 1000-seed weight

There are 14 and 8 crosses at Bijapur (Table 5a), 15 and 9 crosses at ICRISAT (Table 5b) and 12 and 6 crosses across environments (Table 5c) respectively which showed positive significant relative heterosis and heterobeltiosis. Whereas only one hybrid at ICRISAT and none of the crosses at Bijapur and across environments showed significantly high thousand seed weight than standard check (CSH 22SS). Similar, positive heterosis was reported by Rajashekhar (2007) and Talekar (2010). The magnitude of relative heterosis, heterobeltiosis and standard heterosis were observed in the present study up to 61.33%, 59.98% and 13.81%, at Bijapur; up to 31.39%, 28.13% and 16.85%, at ICRISAT and up to 33.76%, 27.9% and 7.65% across environments respectively (Table 10a, 10b and 10c).

5.4 Combining ability analysis

The combining ability analysis gives an indication of the variance due to GCA and SCA, which represents a relative measure of additive and non-additive genetic

Table 10a. Number of crosses showing significant heterosis level with respective direction and ranges of heterosis for stalk sugar related traits, yield and yield components in sweet sorghum evaluated at Bijapur

Sl.no.	Character	Relative heterosis (%)			Heterobeltosis (%)			Standard heterosis (%)		
		Positive (No's)	Negative (No's)	Range (%)	Positive (No's)	Negative (No's)	Range (%)	Positive (No's)	Negative (No's)	Range (%)
1	DFL	15	8	-16.83 to 63.28	7	22	-26.99 to 59.49	16	22	-24.06 to 53.38
2	PH	16	0	-11.7 to 74.68	3	3	-23.76 to 38.11	2	19	-33.51 to 33.87
3	ST	21	4	-38.55 to 58.78	17	8	-41.94 to 42.08	1	37	-54.04 to 16.38
4	SY	26	5	-75.94 to 137.89	22	16	-78.36 to 103.27	0	47	-90.47 to 0.96
5	JY	20	15	-85.28 to 171.48	13	28	-85.36 to 128.03	0	47	-94.71 to 4.23
6	JV	19	16	-84.98 to 170.66	13	30	-85.04 to 126.72	0	47	-94.66 to 4.24
7	Bri	16	14	-36.11 to 63.64	10	27	-46.51 to 50.00	23	7	-35.71 to 58.57
8	BY	28	5	-73.27 to 160.61	22	13	-76.79 to 120.62	3	42	-89.1 to 24.25
9	TSS	17	13	-35.6 to 62.46	10	27	-45.96 to 49.15	23	7	-35.19 to 57.71
10	TSI	16	14	-78.83 to 204.6	11	24	-83.22 to 129.96	0	47	-92.3 to 6.62
11	JE%	6	29	-65.05 to 47.22	6	41	-72.39 to 30.94	6	42	-74.59 to 34.61
12	EY	27	4	-60.73 to 152.25	21	13	-64.68 to 94.9	4	36	-82.8 to 22.97
13	PW	35	9	-69.31 to 452.94	26	14	-80.55 to 439.4	4	34	-83.29 to 40.44
14	PL	16	0	-15.16 to 52.03	9	8	-32.99 to 47.04	4	8	-31.34 to 31.06
15	PB	22	10	-36.68 to 69.23	15	14	-43.45 to 54.76	1	37	-50.15 to 10.86
16	GY	33	9	-80.77 to 1020.42	24	15	-85.95 to 639.39	5	34	-92.89 to 55.01
17	1000S	14	5	-60.22 to 61.33	8	16	-62.99 to 59.98	0	33	-65.85 to 13.81

DFL: days to 50% flowering, PH: plant height, ST: stem thickness, SY: stalk yield, JY: juice yield, JV: juice volume, Bri: brix %, BY: bagasse yield, TSS: total soluble solids, TSI: total sugar index, JE: juice extraction %, EY: ethanol yield, PW: panicle weight, PL: panicle length, PB: panicle breadth, GY: grain yield, 1000S: 1000-seed weight

Table 10b. Number of crosses showing significant heterosis level with respective direction and ranges of heterosis for stalk sugar related traits, yield and yield components in sweet sorghum at ICRISAT

Sl.no.	Character	Relative heterosis (%)			Heterobeltosis (%)			Standard heterosis (%)		
		Positive (No's)	Negative (No's)	Range (%)	Positive (No's)	Negative (No's)	Range (%)	Positive (No's)	Negative (No's)	Range (%)
1	DFL	17	16	-22.57 to 46.95	6	29	-31.97 to 15.15	16	30	-31.72 to 54.48
2	PH	37	2	-12.22 to 53.26	10	13	-31.01 to 26.17	12	18	-33.33 to 41.9
3	ST	30	0	-0.01 to 43.16	15	2	-9.69 to 32.4	20	8	-12.38 to 40.37
4	SY	42	3	-28.75 to 198.85	33	5	-52.37 to 119.7	20	19	-65.6 to 104.36
5	JY	39	4	-68.34 to 208.2	33	7	-76.4 to 115.1	11	24	-84.45 to 98.8
6	JV	39	4	-68.76 to 207.77	32	8	-76.73 to 114.44	11	24	-84.67 to 97.58
7	Bri	18	3	-34.07 to 19.72	3	19	-40.48 to 12	8	16	-38.02 to 24.79
8	BY	41	2	-20.61 to 198.87	30	3	-44.16 to 118.82	22	18	-54.2 to 161.19
9	TSS	18	3	-33.68 to 19.44	3	19	-40.06 to 11.88	8	16	-37.61 to 24.53
10	TSI	40	4	-73.35 to 224.01	33	8	-81.38 to 127.3	12	26	-87.38 to 95.9
11	JE%	10	13	-62.56 to 19.4	3	26	-67.43 to 11.14	2	29	-72.97 to 17.43
12	EY	43	2	-48.71 to 199.33	29	3	-60.29 to 121.83	18	19	-56.49 to 148.24
13	PW	26	7	-56.01 to 173.74	20	14	-71.81 to 138.69	0	49	-87.35 to -9.84
14	PL	27	3	-20.45 to 56.88	12	5	-22.51 to 51.37	6	14	-34.52 to 49.04
15	PB	21	8	-31.75 to 62.6	15	24	-42.06 to 51.32	0	48	-61.15 to 4.25
16	GY	27	15	-92.14 to 290.14	23	18	-94.27 to 231.43	0	49	-98.4 to -13.77
17	1000S	15	5	-47.65 to 31.39	9	14	-58.51 to 28.13	1	38	-66.82 to 16.85

DFL: days to 50% flowering, PH: plant height, ST: stem thickness, SY: stalk yield, JY: juice yield, JV: juice volume, Bri: brix %, BY: bagasse yield, TSS: total soluble solids, TSI: total sugar index, JE: juice extraction %, EY: ethanol yield, PW: panicle weight, PL: panicle length, PB: panicle breadth, GY: grain yield, 1000S: 1000-seed weight

Table 10c. Number of crosses showing significant heterosis level with respective direction and ranges of heterosis for stalk sugar related traits, yield and yield components in sweet sorghum across environments

Sl.no.	Character	Relative heterosis (%)			Heterobeltosis (%)			Standard heterosis (%)		
		Positive (No's)	Negative (No's)	Range (%)	Positive (No's)	Negative (No's)	Range (%)	Positive (No's)	Negative (No's)	Range (%)
1	DFL	15	10	-17.38 to 43.7	7	24	-28.57 to 26.9	16	25	-27.9 to 53.93
2	PH	30	0	-6.5 to 49.77	4	8	-18.95 to 15	9	19	-30.59 to 31.46
3	ST	21	1	-14.54 to 45.2	15	4	-18.27 to 36.5	7	26	-34.09 to 24.14
4	SY	29	0	-21.55 to 156.14	16	3	-38.3 to 86.99	3	29	-71.96 to 31.35
5	JY	21	1	-54.91 to 152.36	13	5	-63.3 to 92.55	1	38	-83.94 to 23.96
6	JV	21	1	-55.35 to 152.29	13	5	-63.73 to 92.87	1	38	-84.17 to 23.45
7	Bri	13	3	-19.19 to 32.4	3	17	-27.05 to 24.15	10	5	-20.74 to 31.29
8	BY	29	0	-29.6 to 165.01	18	1	-30.27 to 109.05	8	28	-69.73 to 54.96
9	TSS	14	2	-18.97 to 31.9	4	17	-26.78 to 27	10	5	-20.49 to 30.91
10	TSI	23	0	-59.22 to 157.26	8	5	-69.5 to 76.1	1	29	-85.9 to 34.63
11	JE%	5	14	-50.63 to 21.82	2	32	-57.04 to 15.55	1	34	-66.12 to 14.94
12	EY	27	0	-14.65 to 162.31	17	3	-37.91 to 74.34	8	25	-71.84 to 66.05
13	PW	28	3	-54.76 to 275.09	22	8	-57.49 to 245.89	0	48	-78.29 to -6.79
14	PL	21	0	-13.92 to 43.82	9	3	-20.48 to 43.68	5	13	-31.44 to 39.98
15	PB	18	3	-32.83 to 47.88	14	12	-41.95 to 35.2	0	42	-50.07 to -3.46
16	GY	26	5	-77.94 to 452.77	19	9	-81.26 to 440.38	0	48	-91.39 to -1.89
17	1000S	12	4	-54.99 to 33.76	6	9	-57.74 to 27.9	0	35	-66.33 to 7.65

DFL: days to 50% flowering, PH: plant height, ST: stem thickness, SY: stalk yield, JY: juice yield, JV: juice volume, Bri: brix %, BY: bagasse yield, TSS: total soluble solids, TSI: total sugar index, JE: juice extraction %, EY: ethanol yield, PW: panicle weight, PL: panicle length, PB: panicle breadth, GY: grain yield, 1000S: 1000-seed weight

variances (breeding value). Breeders use these variance components to infer the gene action and to assess the genetic potentialities of the parents in cross combinations. The ultimate choice of parents to be used in a breeding programme is determined by *per se* performance and their behaviour in cross combinations assessed through systematic studies in relation to general combining ability and specific combining ability. Some idea on the usefulness of the parents may be obtained from their individual performance. It is necessary to assess genetic potentialities of parents in hybrid combinations.

In the present investigation, an attempt was made to obtain information on the magnitude of GCA and SCA variance for the trait as a whole and *gca* and *sca* effects for individual parents and crosses, respectively for17 traits through combining ability analysis the results are discussed as below.

5.4.1 Analysis of variance for combining ability

From the analysis of variance for combining ability for stalk sugar related traits, yield and yield component traits at Bijapur, ICRISAT and across environments (Table 6a, 6b and 6c), it was revealed that variance among lines was significant for all the characters, whereas variance among testers was significant for all the characters except for plant height and panicle length at Bijapur and also for panicle length at across environments. However, the variance due to line × tester interaction was significant for all the characters indicating predominance of non-additive gene action in genetic control of all these characters.

The analysis of variance for combining ability in present study reveals that variance due to SCA was higher in magnitude than GCA for all the traits. Further, the values of the ratio of GCA/SCA variance was less than unity for all the traits supports the predominance of non-additive gene effects governing the expression of all these characters (Table 6a, 6b and 6c respectively). These results on stalk sugar related traits, yield and yield components showing predominance of non-additive gene action indicates scope for heterosis exploitation for the traits studied. Similar reports have been given by Kenga *et al.* (2004), Rajashekhar (2007), Indhubala *et al.* (2010), Makanda *et al.* (2010), Talekar (2010), Vinaykumar *et al.* (2011) and Umakanth *et al.* (2012) obligated the fact of higher SCA variance than the GCA variance for most of the traits. On the contrary, Makanda *et al.* (2009) reported that GCA variance was higher than SCA variance.

5.4.2 General combining ability effects

The concept of combining ability as introduced by Sprague and Tatum (1942) assume greater importance in crop improvement programme. Genotypes with high GCA reflect their superiority in producing good cross combinations. Considering this, it was possible to identify a set of good combiners for sugar related traits as well as productivity traits. Based on consistent performance over two locations, best combining parental lines could be identified for each of the traits. Those estimates of *gca* effects of parents help in identifying superior parents to be utilized for production of superior genotypes in segregating populations by concentration of desirable genes with additive effect and also heterotic crosses. The present study helped to identify lines and testers with high *gca* effect for all the traits studied.

The lines exhibited greater variation for all the traits in both location and across environments, whereas at Bijapur, the traits brix, total soluble solids, panicle weight, panicle breadth and grain yield testers were contributed more. This indicates that large contribution of lines to greater *gca* effects than that of testers for these characters (Table 7a, 7b and 7c). On the contrary, Indhubala *et al.* (2010) reported that testers contribution is greater than that of lines for the all the traits in their studies.

Similar results were reported by Sanjana *et al.* (2011). However, at Bijapur, testers contributed more. For yield traits also, lines contributed more whereas for panicle weight, panicle breadth and grain yield testers contributed more at Bijapur.

However, estimation of *gca* effects of lines and testers indicated that, no single line or tester was a good general combiner at Bijapur, ICRISAT and across environments for all the characters studied. At Bijapur, the lines, NTJ 2 followed by ICSV 25333 and SPSSV 30 were considered as good general combiners as they exhibited significant *gca* effects in the desirable direction for 13, 9 and 8 characters respectively. Among the testers, Prabhani Moti followed by ICSB 323 and NSSV 13 exhibited significant *gca* effects in the desirable direction for 10, 8 and 6 characters, respectively and these testers can be considered as good general combiners among the testers.

Table 11. Good combining parents identified for each of the stalk sugar related traits, yield and yield components in sweet sorghum across environments

Sl. no.	Characters	Parents with significant *gca* effects in favourable direction		Range of significant *gca* effects
		Lines	Testers	
1	**DFL**	IS 13871, Wray and SPSSV 30	ICSB 351, ICSB 323 and ICSB 480	-19.92 to 37.84
2	**PH**	IS 27206 and IS 22670	SPV 1411 and NSSV 13	-0.65 to 0.67
3	**ST**	IS 27206, IS 22670 and NTJ 2	NSSV 13	-2.91 to 4.35
4	**SY**	IS 27206, NTJ 2 and IS 22670	SPV 1411, NSSV 13 and ICSB 374	-38.65 to 30.5
5	**JY**	NTJ 2, ICSV 93046 and IS 27206	SPV 1411, NSSV 13 and PMS 90 B	-13.94 to 13.23
6	**JV**	NTJ 2, ICSV 93046 and IS 27206	SPV 1411, NSSV 13 and PMS 90 B	-13878.62 to 13143.1
7	**Bri**	SPSSV 30 and Wray	NSSV 13	-1.17 to 1.7
8	**BY**	IS 27206, IS 22670 and NTJ 2	NSSV 13, ICSB 374 and SPV 1411	-24.71 to 30.04
9	**TSS**	SPSSV 30 and Wray	NSSV 13	-1.02 to 1.49
10	**TSI**	NTJ 2, ICSV 93046 and IS 27206	SPV 1411, NSSV 13 and PMS 90 B	-15.18 to 14.08
11	**JE %**	SPSSV 30, ICSV 93046 and NTJ 2	SPV 1411, ICSB 323 and PMS 90 B	-8.00 to 6.20
12	**EY**	IS 27206, IS 22670 and NTJ 2	NSSV 13 and SPV 1411	-2666.03 to 2943.24
13	**PW**	ICSV 93046, NTJ 2 and SPSSV 30	ICSB 480, PMS 90 B and ICSB 351	-2.12 to 1.66
14	**PL**	IS 27206	PMS 90 B	-4.22 to 5.61
15	**PB**	ICSV 93046 and NTJ 2	ICSB 480, SPV 1411 and PMS 90 B	-0.59 to 0.65

16	**GY**	NTJ 2, ICSV 93046 and SPSSV 30	ICSB 351, ICSB 480 and PMS 90 B	-1.46 to 1.21
17	**1000S**	NTJ 2, IS 13871 and ICSV 93046	PMS 90 B and SPV 1411	-7.29 to 4.64

DFL: days to 50% flowering, PH: plant height, ST: stem thickness, SY: stalk yield, JY: juice yield, JV: juice volume, Bri: brix %, BY: bagasse yield, TSS: total soluble solids, TSI: total sugar index, JE: juice extraction %, EY: ethanol yield, PW: panicle weight, PL: panicle length, PB: panicle breadth, GY: grain yield, 1000S: 1000-seed weight

At ICRISAT, the lines NTJ 2 followed by ICSV 93046, ICSV 25333 and IS 22670 were considered as good general combiners with significant *gca* effects in the desirable direction for 12, 8, 8 and 8 characters, respectively. Among the testers, PMS 90 B followed by NSSV 13 showed significant *gca* effects in the desirable direction for 13 and 11 characters, respectively and thus these testers can be considered as good general combiners among the testers.

Across the environments, the lines NTJ 2 followed by ICSV 93046 and ICSV 25333 were considered as good general combiners as they exhibited significant *gca* effects in the desirable direction for 13, 8 and 6 characters, respectively. Among the testers, NSSV 13, Prabhani Moti followed by PMS 90 B exhibited significant *gca* effects in the desirable direction for 10, 9 and 8 characters, respectively and hence these testers can be considered as good general combiners among the testers. Promising parents identified based on combining ability analysis for various stalk sugar related traits, yield and yield components in sweet sorghum across environments are given in Table 11.

5.4.3 Specific combining ability effects

The results obtained on specific combining ability effects of crosses at Bijapur, ICRISAT and across environments (Table 8a, 8b and 8c respectively) help in identifying superior cross combinations. The present study helped to identify superior hybrid combinations with high *sca* effect at desirable direction for all the traits studied (Table 12).

5.4.3.1 Days to 50 per cent flowering

For days to 50 per cent flowering, out of 49 crosses studied, fourteen crosses at Bijapur, eight crosses at ICRISAT and eleven crosses across environments has shown significantly negative *sca* effect in desirable direction. Among these, SPSSV 30 × NSSV 13, NTJ 2 × ICSB 374, Wray × ICSB 374, IS 22670 × PMS 90 B and ICSV 25333 × PMS 90 B were the top ranking crosses for days to 50% flowering across environments with respect to their *sca* effects.

5.4.3.2 Plant height (m)

Among the 49 crosses studied four crosses at Bijapur, seven crosses at ICRISAT and eleven crosses across environments shown significant negative *sca* effects which are desirable for this trait. Among these, ICSV 25333 × ICSB 323, IS 13871 × NSSV 13, ICSV 25333 × ICSB 374, NTJ 2 × Prabhani Moti and Wray × NSSV 13 were the top ranking crosses for days to 50% flowering across environments with respect to their *sca* effects.

5.4.3.3 Stem thickness (mm)

Out of 49 crosses evaluated, ten crosses at Bijapur, similarly two crosses NTJ 2 × Prabhani Moti and IS 22670 × ICSB 374 at ICRISAT and twelve crosses across environments exhibited significantly positive *sca* effects. Among these, IS 22670 × ICSB 374, IS 22670 × ICSB 351, Wray × NSSV 13, IS 13871 × NSSV 13 and ICSV 93046 × PMS 90B were the top ranking crosses for stem thickness across environments with respect to their *sca* effects.

5.4.3.4 Stalk yield (t ha^{-1})

Fourteen crosses at Bijapur, seventeen crosses at ICRISAT and fifteen crosses across environments were exhibited significantly positive *sca* effects out of 49 crosses evaluated. Among these, IS 22670 × ICSB 374, SPSSV 30 × ICSB 480, IS 22670 × ICSB 351, IS 13871 × NSSV 13 and NTJ 2 × Prabhani Moti were the top ranking crosses for stalk yield across environments with respect to their *sca* effects.

5.4.3.5 Juice yield (t ha^{-1})

Out of 49 crosses studied, twenty crosses at Bijapur, seventeen crosses at ICRISAT and eleven crosses across environments were exhibited significantly positive *sca* effects. Among these, NTJ 2 × Prabhani Moti, ICSV 93046 × PMS 90B, ICSV 25333

× ICSB 351, IS 22670 × ICSB 351 and Wray × NSSV 13 were the top ranking crosses for juice yield across environments with respect to their *sca* effects.

5.4.3.6 Juice volume (L ha^{-1})

Among 49 crosses studied, twenty crosses at Bijapur, sixteen crosses at ICRISAT and eleven crosses across environments were exhibited significantly positive *sca* effects. Among these, NTJ 2 × Prabhani Moti, ICSV 93046 × PMS 90B, ICSV 25333 × ICSB 351, IS 22670 × ICSB 351 and Wray × NSSV 13 were the top ranking crosses for juice volume across environments with respect to their *sca* effects.

5.4.3.7 Brix (%)

Out of 49 crosses evaluated, twelve crosses at Bijapur, six crosses at ICRISAT and twelve crosses across environments were exhibited significantly positive *sca* effects. Among these ICSV 93046 × NSSV 13, ICSV 93046 × ICSB 351, IS 13871 × ICSB 374, SPSSV 30 × PMS 90B and Wray × Prabhani Moti were the top ranking crosses for brix (%) across environments with respect to their *sca* effects.

5.4.3.8 Bagasse yield (t ha^{-1})

Fourteen crosses at Bijapur, seventeen crosses at ICRISAT and fourteen crosses at across environments were exhibited significantly positive *sca* effects out of 49 crosses evaluated. Among these SPSSV 30 × ICSB 480, IS 22670 × ICSB 374, IS 22670 × ICSB 351, IS 13871 × NSSV 13 and IS 22670 × NSSV 13 were the top ranking crosses for bagasse yield across environments with respect to their *sca* effects.

5.4.3.9 Total soluble sugar (%)

Of the 49 crosses studied, the *sca* effects were positively significant for twelve crosses at Bijapur, six crosses at ICRISAT and twelve crosses at across environments. Among these ICSV 93046 × NSSV 13, ICSV 93046 × ICSB 351, IS 13871 × ICSB 374, SPSSV 30 × PMS 90B and Wray × Prabhani Moti were the top ranking crosses for total soluble sugars across environments with respect to their *sca* effects.

5.4.3.10 Total sugar index

Among 49 crosses studied, seventeen crosses at Bijapur, fifteen crosses at ICRISAT and eleven crosses at across environments exhibited significant positive *sca* effects. Among these NTJ 2 × Prabhani Moti, ICSV 25333 × ICSB 351, IS 22670 × ICSB 374, Wray × NSSV 13 and SPSSV 30 × Prabhani Moti were the top ranking crosses for total sugar index across environments with respect to their *sca* effects.

5.4.3.11 Juice extraction (%)

Seventeen crosses at Bijapur, eleven crosses at ICRISAT and fourteen crosses at across environments were exhibited significantly positive *sca* effects out of 49 crosses evaluated. Among these SPSSV 30 × NSSV 13, SPSSV 30 × Prabhani Moti , Wray × ICSB 374, ICSV 93046 × ICSB 323 and ICSV 25333 × ICSB 351 were the top ranking crosses for Juice extraction (%) across environments with respect to their *sca* effects.

5.4.3.12 Ethanol yield (L ha^{-1})

Among 49 crosses studied, fourteen crosses at Bijapur, fourteen crosses at ICRISAT and twelve crosses at across environments were exhibited significant positive *sca* effects. Among these IS 22670 × ICSB 374, IS 13871 × NSSV 13, SPSSV 30 × ICSB 480, ICSV 25333 × PMS 90 B and IS 22670 × ICSB 351 were the top ranking crosses for ethanol yield across environments with respect to their *sca* effects.

5.4.3.13 Panicle weight (t ha^{-1})

Out of 49 crosses studied the *sca* effects were positively significant for fourteen crosses at Bijapur, thirteen crosses at ICRISAT and thirteen crosses at across environments. Among these, IS 22670 × ICSB 351, NTJ 2 × PMS 90 B, ICSV 25333 × ICSB 480, SPSSV 30 × NSSV 13 and ICSV 93046 × ICSB 323 were the top ranking crosses for panicle weight across environments with respect to their *sca* effects.

5.4.3.14 Panicle length (cm/)

Among 49 crosses studied, five crosses at Bijapur, four crosses at ICRISAT and eleven crosses across environments were exhibited significantly positive *sca* effects. Among these, ICSV 25333 × ICSB 374, NTJ 2 × ICSB 323, Wray × ICSB 374, IS 13871 × Prabhani Moti and SPSSV 30 × Prabhani Moti were the top ranking crosses for panicle length across environments with respect to their *sca* effects.

5.4.3.15 Panicle breadth (cm/)

Thirteen crosses at Bijapur, fourteen crosses at ICRISAT and fourteen crosses across environments were exhibited positively significant *sca* effects out of 49 crosses evaluated. Among these NTJ 2 × ICSB 323, IS 22670 × ICSB 351, NTJ 2 × PMS 90 B, ICSV 25333 × ICSB 480 and SPSSV 30 × NSSV 13 were the top ranking crosses for panicle breadth across environments with respect to their *sca* effects.

5.4.3.16 Grain yield (t ha^{-1})

Among 49 crosses studied, twenty one crosses at Bijapur, fourteen crosses at ICRISAT and nine crosses across environments exhibited positively significant *sca* effects. Among these, NTJ 2 × PMS 90 B, IS 22670 × ICSB 351, ICSV 93046 × ICSB 323, SPSSV 30 × NSSV 13 and SPSSV 30 × Prabhani Moti were the top ranking crosses for grain yield across environments with respect to their *sca* effects.

5.4.3.17 1000-seed weight (g)

Out of 49 crosses evaluated, five crosses at Bijapur, three crosses at ICRISAT and nine crosses across environments were exhibited positively significant *sca* effects. Among these, IS 22670 × Prabhani Moti, Wray × NSSV 13, ICSV 25333 × ICSB 480, SPSSV 30 × NSSV 13 and IS 13871 × PMS 90 B were the top ranking crosses for 1000-seed weight across environments with respect to their *sca* effects.

5.5 Correlations

The correlation co-efficients between stalk sugar yield in terms of brix and various sugar related component traits were estimated in order to determine the extent of association between the traits. The results are presented in Table 9.

Table 12. List of promising crosses of sweet sorghum showing significant heterosis and combining ability estimates in a desirable direction across environment for stalk sugar related traits, yield and yield components

Sl.no.	Cross	Yield traits/significant heterosis			Yield traits/ significant *sca* effect
		Mid parent heterosis	Better parent heterosis	Standard check heterosis	
1	IS 13871 × NSSV 13	PH, ST, SY, Bri, BY, TSS and EY	DFL, ST, TSS and EY	DFL, Bri and TSS	PH, ST, SY, JY, JV, Bri, BY, TSS, TSI, EY, PW and PB
2	IS 22670 × ICSB 351	PH, ST, SY, JY, JV, BY, TSI, EY, PW, PB and GY	ST, SY, BY, EY, PW, PB and GY	PH, ST, BY and EY	PH, ST, SY, JY, JV, BY, TSI, JE%, EY, PW, PL, PB and GY
3	IS 22670 × ICSB 374	PH, ST, SY, JY, JV, BY, TSI and EY	ST, SY, JY, JV, BY, TSI and EY	PH, ST, SY, BY and EY	ST, SY, JY, JV, BY, PB and 1000S
4	IS 27206 × PMS 90 B	PH, ST, SY, JY, JV, Bri, BY, TSS, TSI, EY and PL	ST, SY, JY, JV, BY, TSI and EY	PH, ST, BY, EY and PL	DFL, ST, SY, Bri, BY, TSS, TSI and EY
5	IS 27206 × ICSB 351	PH, ST, SY, JY, JV, Bri, BY, TSS, TSI, EY, PW and GY	ST, SY, JY, JV, BY and EY	PH, ST, BY and EY	SY, JY, JV, Bri, BY, TSS, TSI, JE%, EY and PB
6	IS 27206 × ICSB 480	PH, ST, SY, JY, JV, BY,	ST, SY, JY, JV, BY, TSI,	PH, BY and EY	PH, SY, JY, JV, Bri, BY, TSS, TSI,

Table 12 (conti….)

		TSI, EY, PW, PL, PB and GY	EY, PW, PB and GY		JE%, EY, PW, PB, GY and 1000S
7	ICSV 93046 × PMS 90B	ST, SY, JY, JV, BY, TSI, JE%, EY, PW, PB and GY	DFL, ST, SY, JY, JV, BY, PW, PB and GY	-	ST, SY, JY, JV, TSI, JE%, PW, PB and GY
8	ICSV 93046 × ICSB 323	DFL, ST, SY, JY, JV, BY, TSI, EY, PW, PL, PB, GY and 1000S	DFL, ST, SY, JY, JV, BY, TSI, EY, PW, PB, GY and 1000S	DFL	DFL, ST, SY, JY, JV, TSI, JE%, PW, PB and GY
9	NTJ 2 × SPV 1411	PH, ST, SY, JY, JV, BY, TSI and EY	PH, SY, JY, JV, BY, TSI and EY	JY, JV and TSI	PH, ST, SY, JY, JV, BY, TSI and EY
10	Wray × NSSV 13	PH, ST, SY, JY, JV, BY, TSS, TSI, EY and PL	DFL, PH, ST, TSI and PL	Bri and TSS	PH, ST, SY, JY, JV, TSI, PW, PB and 1000S
11	SPSSV 30 × ICSB 480	PH, SY, JY, JV, BY, TSI, EY, PW, PL, PB, GY and 1000S	SY, BY, EY, PW, GY and 1000S	DFL	SY, JY, JV, BY, TSI, EY and PL

DFL: days to 50% flowering, PH: plant height, ST: stem thickness, SY: stalk yield, JY: juice yield, JV: juice volume, Bri: brix %, BY: bagasse yield, TSS: total soluble solids, TSI: total sugar index, JE: juice extraction %, EY: ethanol yield, PW: panicle weight, PL: panicle length, PB: panicle breadth, GY: grain yield, 1000S: 1000 seed-weight

Stalk sugar related traits of brix (%) were significant and positively associated with other stalk sugar yield components like plant height, total soluble solids, total sugar index and ethanol yield. The results confirm the earlier reports by Zou *et al.* (2011). The significant and positive association of brix (%) with total soluble solids and other component revealed the importance of brix as simple reliable selection criteria for stalk sugar yield in sweet sorghum.

Intensity of total soluble sugars was significant positively associated with plant height (r = 0.38), brix (r = 1.00), total sugar index (r = 0.44) and ethanol yield (r = 0.32).

Total sugar index was significant and positively associated with days to 50% flowering (r = 0.33), plant height (r = 0.55), stem thickness (r = 0.55), stalk yield (r = 0.77), juice yield (r = 0.97), juice volume (r = 0.97), brix (%) (r = 0.45), bagasse yield (r = 0.62) and total soluble sugars (r = 0.44).

Considering estimates of significantly high magnitude and positive correlation coefficients of brix (%) with majority of stalk sugar related traits in the present study, the trait brix (%) may be used as selection criteria in breeding for high sugar yielding sweet sorghum crosses.

5.6 Prospects of breeding heterotic hybrids in sweet sorghum

The lines viz., Wray and SPSSV 30 were recorded with significant *gca* effects for earliness, high brix (%) and total soluble solids (Table 11). NTJ 2, ICSV 93046 and ICSV 25333 were good combining lines for juice yield, juice volume and total sugar index. Whereas, ICSV 25333, IS 22670 and NTJ 2 were good combining lines for bagasse yield and ethanol yield. NTJ 2 and ICSV 93046 were recorded significant *gca* effects for juice extraction (%), panicle weight, panicle breadth, grain yield and 1000-seed weight. ICSV 25333 and IS 22670 were recorded with significant *gca* effects for plant height, stem thickness, stalk yield, bagasse yield and ethanol yield.

Among the testers, Prabhani Moti and NSSV 13 were good combining testers for the traits, plant height, stalk yield, juice yield, bagasse yield, total sugar index and ethanol yield. NSSV 13 was also recorded significant *gca* effect in favorable direction for stem thickness, brix (%) and total soluble solids. PMS 90B was good combining tester for juice yield, juice volume, total sugar index, juice extraction (%), panicle weight, panicle length, panicle breadth, grain yield and 1000 seed weight.

Among the 49 crosses evaluated eleven promising crosses were identified (Table 12) that were recorded with significant *sca* effects in desired direction for various stalk sugar related traits and yield and yield component *viz.*, IS 13871 × NSSV 13, IS 22670 × ICSB 351, IS 22670 × ICSB 374, IS27206 × PMS 90B, ICSV 25333 × ICSB351, ICSV 25333 × ICSB 480, ICSV 93046 × PMS 90B, ICSV 93046 × ICSB 323, NTJ 2 × Prabhani Moti, Wray × NSSV13 and SPSSV 30 × ICSB 480. It was noticed that each of these crosses involving at least one good combining parent showing significant *gca* effects for various traits (Table 11). These crosses were also showed significant estimates of heterosis over mid parent, better parent and standard heterosis for various traits (Table 12). Across environments at least 7 to 10 crosses were shown significant positive heterosis over standard check CSH 22SS for the traits plant height, stalk yield, brix (%), bagasse yield, total soluble solids and ethanol yield.

The top seven crosses that showed significant heterosis over standard check across environments (Table 5c) for plant height, stem thickness, bagasse yield and ethanol yield were *viz.*, IS 22670 × NSSV 13 (31.46%, 12.69%, 42.74% and 42.35%, respectively), ICSV 25333 × ICSB 374 (28.43%, 14.29%, 42.24% and 54.40%), ICSV 25333 × ICSB 323 (27.90%, 9.10%, 23.74 and 40.52%), IS 22670 × ICSB 351 (22.36%, 17.00%, 34.47% and 34.17%), IS 22670 × ICSB 374 (20.25%, 24.14%, 54.96% and 66.05%), ICSV 25333 × ICSB 351 (17.67%, 11.16%, 26.49% and 47.95%,) and ICSV 25333 × PMS 90B (16.61%, 18.03%, 31.70% and 52.10%,. Among these, latter four crosses were shown significant positive *sca* effects for majority of the traits studied (Table 12).

The top six crosses that showed significant standard heterosis (>20%) for brix and total soluble solids were ICSV 93046 × NSSV 13 (31.29% and 30.91%), SPSSV 30 × PMS 90B (24.82% and 24.51%), Wray × NSSV 13 (24.70% and 24.40%), SPSSV 30 × NSSV 13 (23.50% and 23.21%), SPSSV 30 × ICSB 323 (21.58% and 21.32%) and Wray × Prabhani Moti (21.22% and 20.96%). Only two crosses *viz.,* SPSSV 30 × NSSV 13 (23.50%) and SPSSV 30 × ICSB 351 (16.79%) that showed significantly high standard heterosis for brix % and total soluble solids were also recorded significant standard heterosis for earliness (-19.29% and -23.22%, respectively).

However, none of the crosses studied were shown significant standard heterosis across environments (Table 10c) for grain yield and yield components (panicle weight, panicle breadth and 1000-seed weight).

5.7 Future line of work

1) The good combining hybrid parents (male and female lines) identified for various sugar related traits may be utilized in developing heterotic hybrids of sweet sorghum.

2) The good combining female hybrid parents can be converted to male sterile lines where ever not available

3) The potential hybrids identified for various stalk sugar related traits and yield and yield components may be tested in multi-location and large scale trials before their utilization on commercial scale.

4) As majority of top performing crosses for sugar related traits were late maturing, it is desired to develop early maturing hybrids for moisture stress environments while utilizing good combining hybrid parents identified for earliness in the present study.

6. SUMMARY

An experiment was conducted to evaluate the hybrids of sweet sorghum for stalk sugar related traits, yield and it's components, which were obtained by using 14 parental lines (B and R) in a Line x Tester (7 × 7) mating design (Kempthorne, 1957). The hybrid parental lines included were seven male parents (PMS 90 B, ICSB 323, ICSB 351, ICSB 374, ICSB 480, Parbhani Moti and NSSV 13) and seven female parents (IS 13871, IS 22670, ICSV 25333, ICSV 93046, NTJ 2, Wray and SPSSV 30) with high and low brix %, respectively. An attempt was made to study the genetic nature of all the stalk sugar related traits, yield and yield components in the B and R lines. The objectives set for the experiment were: 1. To assess the extent of heterosis for stalk sugar yield traits and identification of heterotic cross combinations of B and R lines across environments. 2. To estimate general combining ability effects of parents and specific combining ability effects of crosses for stalk sugar yield traits. 3. To study the nature and magnitude of gene action in the inheritance of various traits.

The experimental material involving 49 hybrids, 14 parents and a check (CSH 22SS) was evaluated for stalk sugar yield and its related traits, yield and yield components at two locations viz., Regional Agricultural Research Station, Bijapur and International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru during *kharif* (rainy season) 2013. Planting was taken up during June month. The observations were recorded on stalk sugar yield and its related traits, and yield and yield components *viz*., days to 50% flowering, plant height, stem thickness, stalk yield, juice yield, juice volume, brix (%), bagasse yield, total soluble solids content, total sugar index, juice extraction percentage, ethanol yield, panicle weight, panicle length, panicle breadth, grain yield and 1000 seeds weight. The material was evaluated in a randomized complete block design (RCBD) with three replications. Statistical analysis was done on ANOVA, heterosis estimates, combining ability analysis, variability, heritability, genetic advance and correlations. The results obtained are summarised under following sections.

1. Analysis of variance (ANOVA): The ANOVA indicated that the genotypes were differing significantly for all the traits studied indicating the presence of genetic variability in the material used in the present study.

2. Combining ability analysis: The analysis of variance for combining ability revealed that the magnitude of SCA variance was higher than the magnitude of GCA variance for all the traits and the ratio of GCA/SCA variance was lesser than the unity at Bijapur, ICRISAT and across environments. Hence, indicating predominance of non-additive gene action in controlling these traits.

Among the female parents, the lines (ICSV 25333, ICSV 93046, NTJ 2 and SPSSV 30) at Bijapur, (IS 22670, ICSV 25333, ICSV 93046 and NTJ 2) at ICRISAT and lines (ICSV 25333, ICSV 93046 and NTJ 2) across environments were found to be good combiners for stalk sugar yield and its related traits, yield and it's components in terms of brix, total soluble solids, total sugar index etc. The remaining lines (IS 13871, IS 22670 and Wray) at Bijapur, (IS 13871, Wray and SPSSV 30) at ICRISAT and lines (IS 13871, IS 22670, Wray and SPSSV 30) across environments were found as poor combiners for stalk sugar yield and all the component traits recorded. Among male parents, the lines Parbhani Moti and ICSB 323 at Bijapur, PMS 90 B and NSSV 13 at ICRISAT and Parbhani Moti, PMS 90 B and NSSV 13)across environments were found to be good combiners for stalk sugar yield and its related traits, yield and yield components in terms of brix, total soluble solids, total sugar index etc. With respect to stalk sugar yield component traits, the parent NTJ 2 recorded significant favorable *gca* effect for most of the traits studied at Bijapur, ICRISAT and across environments, followed by Parbhani Moti (at Bijapur and across environments) and PMS 90 B (at ICRISAT). The parents, IS 13871 and PMS 90 B (at Bijapur), ICSB 323, ICSB 351 and IS 13871 (at ICRISAT) and IS 13871, ICSB 351 and ICSB 374 (across environments) were found to be poor combiners for all the stalk sugar yield and its related traits, yield and yield components studied.

Among the crosses, IS 13871 × PMS 90 B, ICSV 25333 × ICSB 480, ICSV 93046 × PMS 90B and ICSV 93046 × Parbhani Moti (at Bijapur), IS 13871 × NSSV 13, ICSV 25333 × ICSB 351, IS 22670 × ICSB 351, ICSV 25333 × ICSB 374 and Wray ×

NSSV 13 (at ICRISAT) and IS 13871 × NSSV 13, IS 22670 × ICSB 351, ICSV 25333 × ICSB 351, ICSV 25333 × ICSB 480 and Wray × NSSV 13 (across environments) showed significant *sca* effect for most of the stalk sugar yield and its related traits and yield and yield components.

3. Heterosis: The heterosis studies indicated the expression of relative heterosis, heterobeltosis and standard heterosis in several crosses for most of the characters in both desirable direction as well as undesirable direction.

Across environments at least 7 to 10 crosses were shown significant positive heterosis over standard check CSH 22SS for the traits plant height, stalk yield, brix (%), bagasse yield, total soluble solids and ethanol yield.

The top seven crosses that showed significant heterosis over standard check across environments for the traits plant height, stem thickness, bagasse yield and ethanol yield were *viz.,* IS 22670 × NSSV 13 (31.46%, 12.69%, 42.74% and 42.35%, respectively), ICSV 25333 × ICSB 374 (28.43%, 14.29%, 42.24% and 54.40%, respectively), ICSV 25333 × ICSB 323 (27.90%, 9.10%, 23.74 and 40.52%, respectively), IS 22670 × ICSB 351 (22.36%, 17.00%, 34.47% and 34.17% respectively), IS 22670 × ICSB 374 (20.25%, 24.14%, 54.96% and 66.05% respectively), ICSV 25333 × ICSB 351 (17.67%, 11.16%, 26.49% and 47.95%, respectively) and ICSV 25333 × PMS 90B (16.61%, 18.03%, 31.70% and 52.10%, respectively). Among these later four crosses were shown significant positive *sca* effects for majority of the traits studied (Table 12b).

The top six crosses that showed significant standard heterosis (>20%) for brix and total soluble solids across environments were ICSV 93046 × NSSV 13 (31.29% and 30.91%), SPSSV 30 × PMS 90B (24.82% and 24.51%), Wray × NSSV 13 (24.70% and 24.40%), SPSSV 30 × NSSV 13 (23.50% and 23.21%), SPSSV 30 × ICSB 323 (21.58% and 21.32%) and Wray × Parbhani Moti (21.22% and 20.96%). Only two crosses *viz.,* SPSSV 30 × NSSV 13 (23.50%) and SPSSV 30 × ICSB 351 (16.79%) that showed significantly high standard heterosis for brix % and total soluble solids were also recorded significant standard heterosis for earliness (-19.29% and -23.22%, respectively).

However, none of the crosses studied were shown significant standard heterosis across environments or grain yield and yield components (panicle weight, panicle breadth and 1000 seeds weight).

4. Variability, heritability and genetic advance: Across environments the marginal difference between GCV and PCV estimates, high heritability estimates and high per cent genetic advance over mean were recorded for the panicle length and 1000 seeds weight. This indicates scope for improvement for these traits. The high difference between values of GCV and PCV, low heritability and percent genetic advance over mean estimates were observed for juice extraction %. Heritability estimates were moderate for seedling height. Whereas the brix, total sugar index and total soluble solids have moderate difference between GCV and PCV estimates, moderate heritability estimates and moderate per cent genetic advance over mean.

5. Correlations: Across environments stalk sugar yield in terms of brix and various sugar related component traits were significantly and positively associated with stalk sugar yield and its related traits. Brix was significantly positively correlated with traits plant height, total soluble solids, total sugar index and ethanol yield. Total soluble solids was significantly positively correlated with traits plant height, brix, total sugar index and ethanol yield. Total sugar index was significant positively associated with days to 50% flowering, plant height, stem thickness, stalk yield, juice yield, juice volume, brix, bagasse yield and total soluble sugars.

6. Potential parents and hybrids identified across environments: The lines (restorers) *viz.*, Wray and SPSSV 30 were recorded with significant *gca* effects for earliness, high brix (%) and total soluble solids. NTJ 2, ICSV 93046 and ICSV 25333 were good combining lines for juice yield, juice volume and total sugar index. Whereas, ICSV 25333, IS 22670 and NTJ 2 were good combining lines for bagasse yield and ethanol yield. NTJ 2 and ICSV 93046 were recorded significant *gca* effects for juice extraction (%), panicle weight, panicle breadth, grain yield and 1000 seeds weight. ICSV 25333 and IS 22670 were recorded with significant *gca* effects for plant height, stem thickness, stalk yield, bagasse yield and ethanol yield.

Among the testers (maintainer lines), Parbhani Moti and NSSV 13 were good combining testers for the traits, plant height, stalk yield, juice yield, bagasse yield, total sugar index and ethanol yield. NSSV 13 was also recorded significant *gca* effect in favorable direction for stem thickness, brix (%) and total soluble solids. PMS 90B was good combining tester for juice yield, juice volume, total sugar index, juice extraction (%), panicle weight, panicle length, panicle breadth, grain yield and 1000 seed weight.

Among the 49 crosses evaluated, eleven promising hybrids were identified (Table 12b) that recorded with significant *sca* effects in desired direction for various stalk sugar related traits , yield and it's component *viz.,* IS 13871 × NSSV 13, IS 22670 × ICSB 351, IS 22670 × ICSB 374, ICSV 253333 × PMS 90B, ICSV 25333 × ICSB 351, ICSV 25333 × ICSB 480, ICSV 93046 × PMS 90B, ICSV 93046 × ICSB 323, NTJ 2 × Parbhani Moti, Wray × NSSV13 and SPSSV 30 × ICSB 480. It was noticed that each of these crosses involving at least one good combining parent showing significant *gca* effects for various traits. These crosses also showed significant estimates of heterosis over mid parent, better parent and standard heterosis for various traits. These crosses can be exploited in breeding for high sugar yielding hybrids in sweet sorghum. Expression of major components like stalk sugar yield and its related traits; yield and yield components either individually or together is expected to contribute significantly for enhancing stalk sugar yield and ultimately augment the transport grade ethanol production for national blending program.

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Appendix Ia. Meteorolgical data for year of 2013 at Regional Agricultural research station, Bijapur

Months	Temperature		RH%	Rainfall (mm)
	Maximum°C	Minimum°C		
January	31.6	15.0	29	4.2
February	32.8	17.9	28	8.6
March	36.3	20.4	22	1.4
April	38.7	23.1	21	31.6
May	39.3	23.9	24	50.3
June	31.7	21.7	55	89.6
July	28.5	21.4	71	206.6
August	30.4	20.6	54	72.0
September	30.7	20.9	60	194.8
October	30.7	20.5	55	112.5
November	29.2	15.8	45	0.0
December	29.0	11.6	35	0.0
Total				**771.6**

Appendix Ib. Meteorological data for the year 2013 at International Crops Research Institute for the Semi-Arid Tropics, Patancheru

Months	Temperature		RH%	Rainfall (mm)
	Maximum°C	Minimum°C		
January	30.6	15.38	38.74	1
February	31.06	16.34	33.6	10.09
March	35.66	18.98	27.35	-
April	37.47	22.53	33.53	60.39
May	40.23	25.85	29.12	3.39
June	32.78	22.4	53.96	102.4
July	28.59	21.4	70.22	226.69
August	28.22	21.13	71.61	164.8
September	30.11	21.16	67	277.6
October	29.41	20.4	65.61	207.2
November	28.42	15.55	49.66	20.69
December	27.77	11.4	40.7	-
Total				**1074.25**

Appendix II. Mean performance of hybrids and standard check for stalk sugar related traits, yield and yield component in sweet sorghum

SL.No.	Genotype	DFL			Plant height (m)			Stem thickness (mm)			Stalk weight (t ha^{-1})		
		E1	E2	E1 × E2	E1	E2	E1 × E2	E1	E2	E1 × E2	E1	E2	E1 × E2
1	IS 13871 × PMS 90 B	68	64	66	2.26	2.63	2.44	19.68	21.19	20.44	46.04	50.80	48.42
2	IS 13871 × ICSB 323	70	69	70	2.12	2.33	2.23	16.50	19.60	18.05	33.35	48.52	40.93
3	IS 13871 × ICSB 351	69	63	66	2.05	2.37	2.21	16.82	19.32	18.07	33.87	29.95	31.91
4	IS 13871 × ICSB 374	75	69	72	1.93	2.60	2.26	12.50	19.02	15.76	36.39	37.04	36.71
5	IS 13871 × ICSB 480	71	62	67	1.89	2.50	2.19	16.78	19.51	18.15	40.88	35.29	38.08
6	IS 13871 × Parbhani Moti	67	61	64	2.31	2.63	2.47	17.83	19.81	18.82	44.90	36.29	40.60
7	IS 13871 × NSSV 13	79	75	77	2.57	3.50	3.04	25.27	22.72	23.99	89.31	84.81	87.06
8	IS 22670 × PMS 90 B	99	103	101	2.81	3.87	3.34	16.39	25.88	21.13	46.42	153.21	99.81
9	IS 22670 × ICSB 323	107	104	106	2.67	3.73	3.20	19.50	25.63	22.57	58.89	105.83	82.36
10	IS 22670 × ICSB 351	104	109	106	3.63	4.10	3.87	28.56	27.39	27.97	122.69	132.77	127.73
11	IS 22670 × ICSB 374	118	118	118	3.30	4.30	3.80	30.39	28.97	29.68	122.35	176.56	149.45
12	IS 22670 × ICSB 480	102	102	102	3.17	3.17	3.17	18.21	25.89	22.05	62.56	50.04	56.30
13	IS 22670 × Parbhani Moti	94	109	101	3.49	4.60	4.03	18.67	24.01	21.34	68.90	136.05	102.48
14	IS 22670 × NSSV 13	112	127	120	3.78	4.53	4.15	26.17	27.71	26.94	141.85	132.89	137.37
15	ICSV 25333 × PMS 90 B	118	123	120	2.94	4.43	3.69	26.17	30.27	28.22	82.96	177.93	130.45
16	ICSV 25333 × ICSB 323	119	126	123	3.28	4.80	4.04	22.50	29.67	26.08	96.69	147.76	122.22
17	ICSV 25333 × ICSB 351	130	129	129	2.74	4.70	3.72	25.00	28.15	26.58	93.54	149.76	121.65
18	ICSV 25333 × ICSB 374	131	137	134	3.15	4.97	4.06	25.67	28.98	27.33	114.07	155.41	134.74
19	ICSV 25333 × ICSB 480	116	127	121	2.82	4.60	3.71	22.17	26.52	24.34	121.91	133.81	127.86
20	ICSV 25333 × Parbhani Moti	120	122	121	2.88	3.60	3.24	22.46	23.79	23.13	87.97	60.36	74.17

Appendix II (Conti…..)

21	ICSV 25333 × NSSV 13	136	138	137	2.40	4.00	3.20	25.00	30.47	27.73	64.94	140.96	102.95
22	ICSV 93046 × PMS 90B	82	83	83	2.29	2.87	2.58	23.22	23.37	23.30	116.05	101.26	108.66
23	ICSV 93046 × ICSB 323	80	77	79	2.44	3.07	2.75	23.33	22.26	22.79	120.23	78.99	99.61
24	ICSV 93046 × ICSB 351	91	72	82	2.01	2.90	2.46	14.56	22.10	18.33	28.56	52.89	40.72
25	ICSV 93046 × ICSB 374	85	93	89	2.20	3.27	2.73	20.75	20.42	20.59	88.50	70.81	79.66
26	ICSV 93046 × ICSB 480	83	78	81	2.31	3.13	2.72	19.56	19.21	19.38	83.28	71.35	77.32
27	ICSV 93046 × Parbhani Moti	84	82	83	2.98	3.43	3.21	21.56	21.00	21.28	129.50	84.27	106.88
28	ICSV 93046 × NSSV 13	116	90	103	2.36	3.40	2.88	16.83	24.07	20.45	48.93	124.67	86.80
29	NTJ 2 × PMS 90 B	85	84	85	2.52	3.13	2.83	23.67	24.40	24.03	94.11	115.64	104.87
30	NTJ 2 × ICSB 323	85	74	80	2.31	3.17	2.74	25.89	23.08	24.48	125.20	103.23	114.22
31	NTJ 2 × ICSB 351	76	75	75	2.13	3.23	2.68	20.44	24.75	22.60	59.82	91.98	75.90
32	NTJ 2 × ICSB 374	79	77	78	2.45	3.27	2.86	21.78	24.32	23.05	88.74	107.70	98.22
33	NTJ 2 × ICSB 480	89	87	88	2.32	3.43	2.88	21.56	21.45	21.50	71.75	87.84	79.80
34	NTJ 2 × Parbhani Moti	95	95	95	2.37	4.50	3.44	21.75	26.01	23.88	83.54	177.78	130.66
35	NTJ 2 × NSSV 13	95	96	96	2.35	3.43	2.89	22.50	23.42	22.96	85.81	105.55	95.68
36	Wray × PMS 90 B	74	68	71	2.16	3.23	2.70	15.22	19.41	17.31	31.10	71.05	51.08
37	Wray × ICSB 323	72	73	73	2.13	3.27	2.70	15.94	20.44	18.19	45.44	80.91	63.18
38	Wray × ICSB 351	67	64	66	2.58	3.07	2.82	17.83	20.43	19.13	43.10	42.00	42.55
39	Wray × ICSB 374	68	65	67	2.66	3.17	2.91	18.00	19.80	18.90	58.38	64.78	61.58
40	Wray × ICSB 480	88	65	77	2.00	3.03	2.52	15.00	20.55	17.77	30.69	65.09	47.89
41	Wray × Parbhani Moti	74	74	74	2.34	3.27	2.80	16.28	21.50	18.89	62.54	86.53	74.54
42	Wray × NSSV 13	85	79	82	3.01	3.77	3.39	25.00	24.42	24.71	56.46	113.53	84.99
43	SPSSV 30 × PMS 90B	126	69	98	1.88	3.30	2.59	12.00	21.29	16.65	13.39	60.81	37.10

Appendix II (Conti…..)

44	SPSSV 30 × ICSB 323	78	76	77	2.50	3.20	2.85	21.17	21.20	21.18	81.83	62.14	71.99
45	SPSSV 30 × ICSB 351	70	67	68	2.78	3.23	3.01	20.00	20.16	20.08	63.83	52.87	58.35
46	SPSSV 30 × ICSB 374	74	72	73	2.57	3.10	2.83	21.83	20.73	21.28	69.88	65.73	67.81
47	SPSSV 30 × ICSB 480	74	70	72	2.31	3.23	2.77	18.22	20.89	19.55	109.94	78.66	94.30
48	SPSSV 30 × Parbhani Moti	75	71	73	2.83	3.70	3.27	19.78	21.25	20.51	80.96	81.38	81.17
49	SPSSV 30 × NSSV 13	74	70	72	2.48	3.73	3.11	18.44	22.05	20.25	55.83	80.21	68.02
50	CSH22SS (Check)	89	89	89	2.82	3.50	3.16	26.11	21.70	23.91	140.50	87.07	113.78
	Mean	89	87	88	2.47	3.36	2.91	20.02	22.58	21.30	69.94	84.63	77.29
	Minimum	67	61	64	1.88	2.33	2.19	12.00	19.02	15.76	13.39	29.95	31.91
	Maximum	136	138	137	3.78	4.97	4.15	30.39	30.47	29.68	141.85	177.93	149.45
	SE ±	2.89	2.45	1.70	0.22	0.14	0.11	1.16	0.95	0.72	5.02	4.36	3.32
	Lsd (5% level)	8.09	6.86	4.74	0.61	0.39	0.30	3.25	2.65	2.00	14.05	12.20	9.26
	Lsd (1% level)	10.70	9.07	6.25	0.81	0.51	0.39	4.30	3.50	2.63	18.58	16.12	12.20
	CV %	5.60	4.90	4.75	15.41	7.18	8.90	10.05	7.26	8.23	12.43	8.92	10.40

E1 = Bijapur location
E2 = ICRISAT location
DFL: days to 50% flowering

Appendix II (Conti…..)

SL.No.	Genotype	Juice weight (t ha^{-1})			Juice volume (L ha^{-1})			Brix (%)			Bagasse weight (t ha^{-1})		
		E1	**E2**	**E1 × E2**	**E1**	**E2**	**E1 × E2**	**E1**	**E2**	**E1 × E2**	**E1**	**E2**	**E1 × E2**
1	IS 13871 × PMS 90 B	8.63	15.63	12.13	8520	15541	12030	11	13	12	37.17	35.11	36.14
2	IS 13871 × ICSB 323	4.07	12.52	8.30	4012	12252	8132	13	14	13	28.99	35.79	32.39
3	IS 13871 × ICSB 351	4.54	7.50	6.02	4353	7433	5893	8	15	11	29.17	22.39	25.78
4	IS 13871 × ICSB 374	4.56	11.78	8.17	4444	11482	7963	15	14	15	31.50	24.99	28.24
5	IS 13871 × ICSB 480	6.33	10.52	8.43	6111	10444	8278	10	14	12	34.37	24.73	29.55
6	IS 13871 × Parbhani Moti	7.94	10.31	9.12	7716	10222	8969	10	14	12	36.81	25.95	31.38
7	IS 13871 × NSSV 13	7.53	29.10	18.31	7363	28904	18133	16	16	16	81.53	55.66	68.60
8	IS 22670 × PMS 90 B	4.61	50.49	27.55	4414	50247	27330	11	15	13	41.47	102.57	72.02
9	IS 22670 × ICSB 323	8.89	32.89	20.89	8520	32691	20606	13	16	14	49.54	72.68	61.11
10	IS 22670 × ICSB 351	8.52	37.13	22.83	8333	36977	22655	12	14	13	113.94	95.57	104.75
11	IS 22670 × ICSB 374	8.14	54.01	31.08	7932	53689	30810	12	16	14	113.93	122.24	118.08
12	IS 22670 × ICSB 480	7.41	5.93	6.67	7284	5827	6556	14	13	14	54.99	43.99	49.49
13	IS 22670 × Parbhani Moti	6.75	39.56	23.16	6543	39280	22912	13	16	15	62.01	96.32	79.16
14	IS 22670 × NSSV 13	13.09	43.85	28.47	12870	43679	28275	12	15	13	128.61	88.93	108.77
15	ICSV 25333 × PMS 90 B	9.78	50.16	29.97	9722	50044	29883	15	15	15	73.01	127.71	100.36
16	ICSV 25333 × ICSB 323	14.23	41.29	27.76	13981	41091	27536	14	15	15	82.23	106.35	94.29
17	ICSV 25333 × ICSB 351	14.16	36.09	25.12	13951	35924	24937	14	16	15	79.19	113.59	96.39
18	ICSV 25333 × ICSB 374	12.12	40.24	26.18	11852	40118	25985	14	15	14	101.68	115.09	108.39
19	ICSV 25333 × ICSB 480	19.62	33.68	26.65	19506	33580	26543	14	15	15	102.02	100.06	101.04
20	ICSV 25333 × Parbhani Moti	12.32	14.76	13.54	12147	14667	13407	14	10	12	75.43	45.55	60.49

Appendix II (Conti…..)

21	ICSV 25333 × NSSV 13	7.78	42.81	25.30	7500	42518	25009	11	15	13	56.94	97.85	77.40
22	ICSV 93046 × PMS 90B	38.35	41.38	39.86	37963	41230	39596	8	14	11	77.44	59.81	68.63
23	ICSV 93046 × ICSB 323	36.81	37.10	36.96	36420	36993	36706	12	15	14	83.25	41.84	62.54
24	ICSV 93046 × ICSB 351	3.75	16.04	9.90	3673	15778	9725	16	15	15	24.64	36.60	30.62
25	ICSV 93046 × ICSB 374	17.11	38.30	27.70	16389	37926	27157	10	15	12	71.00	42.22	56.61
26	ICSV 93046 × ICSB 480	18.21	32.09	25.15	17963	32030	24996	12	15	14	64.88	39.23	52.05
27	ICSV 93046 × Parbhani Moti	28.52	36.13	32.33	28148	36059	32104	13	14	14	100.80	48.08	74.44
28	ICSV 93046 × NSSV 13	5.02	47.73	26.38	4815	47333	26074	18	19	18	43.72	76.64	60.18
29	NTJ 2 × PMS 90 B	21.90	49.58	35.74	21605	49476	35540	13	15	14	71.98	66.00	68.99
30	NTJ 2 × ICSB 323	27.89	44.84	36.36	27500	44746	36123	12	15	14	97.05	58.37	77.71
31	NTJ 2 × ICSB 351	7.16	29.73	18.44	7037	29597	18317	10	14	12	52.53	62.17	57.35
32	NTJ 2 × ICSB 374	20.06	49.27	34.67	19506	49126	34316	14	15	15	68.36	58.38	63.37
33	NTJ 2 × ICSB 480	10.77	38.50	24.64	10556	38415	24485	11	16	14	60.77	49.27	55.02
34	NTJ 2 × Parbhani Moti	17.08	75.78	46.43	16775	75111	45943	12	16	14	66.21	101.69	83.95
35	NTJ 2 × NSSV 13	10.87	40.21	25.54	10556	39985	25270	15	19	17	74.52	65.21	69.86
36	Wray × PMS 90 B	7.78	32.30	20.04	7654	32163	19909	14	16	15	23.09	38.67	30.88
37	Wray × ICSB 323	6.57	33.81	20.19	6389	33654	20022	16	17	16	38.54	46.96	42.75
38	Wray × ICSB 351	9.51	13.78	11.64	9414	13732	11573	9	17	13	33.30	28.18	30.74
39	Wray × ICSB 374	18.84	28.66	23.75	18333	28537	23435	12	16	14	39.19	36.05	37.62
40	Wray × ICSB 480	2.80	29.84	16.32	2716	29748	16232	14	17	16	27.72	35.19	31.45
41	Wray × Parbhani Moti	9.73	37.63	23.68	9444	37503	23474	15	18	17	52.56	48.87	50.72
42	Wray × NSSV 13	12.05	49.22	30.64	11914	49088	30501	17	17	17	43.89	64.25	54.07
43	SPSSV 30 × PMS 90B	1.94	25.94	13.94	1944	25815	13880	19	16	17	11.28	34.85	23.06

Appendix II (Conti…..)

44	SPSSV 30 × ICSB 323	28.54	26.22	27.38	28148	26109	27128	14	20	17	53.11	35.86	44.49
45	SPSSV 30 × ICSB 351	13.85	18.03	15.94	13488	17926	15707	15	18	16	49.75	34.78	42.26
46	SPSSV 30 × ICSB 374	12.19	28.50	20.35	11852	28347	20100	10	16	13	57.50	37.14	47.32
47	SPSSV 30 × ICSB 480	19.49	29.99	24.74	19259	29765	24512	12	18	15	90.20	48.49	69.34
48	SPSSV 30 × Parbhani Moti	27.43	37.79	32.61	27037	37704	32370	13	18	15	53.26	43.54	48.40
49	SPSSV 30 × NSSV 13	17.76	37.14	27.45	17253	37067	27160	15	19	17	37.83	43.03	40.43
50	CSH22SS (Check)	36.79	38.12	37.45	36420	38015	37217	12	16	14	103.51	48.89	76.20
	Mean	12.78	30.44	21.61	12599	30291	21445	13	16	14	56.96	54.29	55.62
	Minimum	1.94	5.93	6.02	1944	5827	5893	8	10	11	11.28	22.39	23.06
	Maximum	38.35	75.78	46.43	37963	75111	45943	19	20	18	128.61	127.71	118.08
	SE ±	1.04	1.99	1.12	996.86	1971.08	1104.41	0.61	0.70	0.46	4.49	3.16	2.55
	Lsd (5% level)	2.92	5.56	3.12	2790.34	5517.30	3076.23	1.71	1.96	1.29	12.56	8.86	7.10
	Lsd (1% level)	3.86	7.35	4.12	3688.06	7292.35	4054.32	2.27	2.59	1.71	16.60	11.71	9.36
	CV %	14.14	11.30	12.33	13.70	11.27	12.24	8.25	7.81	8.03	13.64	10.10	11.19

E1 = Bijapur location
E2 = ICRISAT location

Appendix II (Conti…..)

SL.No.	Genotype	Total soluble solids (%)			Total sugar index			Juice extraction (%)			Ethanol yield (L ha^{-1})		
		E1	E2	E1 × E2	E1	E2	E1 × E2	E1	E2	E1 × E2	E1	E2	E1 × E2
1	IS 13871 × PMS 90 B	9.77	11.61	10.69	1.04	2.26	1.65	18.76	31.16	24.96	2889	3221	3055
2	IS 13871 × ICSB 323	11.11	12.10	11.61	0.55	1.84	1.20	12.27	25.95	19.11	2542	3436	2989
3	IS 13871 × ICSB 351	6.71	13.56	10.14	0.36	1.25	0.81	13.39	25.19	19.29	1538	2409	1973
4	IS 13871 × ICSB 374	13.27	12.53	12.90	0.73	1.77	1.25	12.57	31.72	22.14	3315	2471	2893
5	IS 13871 × ICSB 480	9.19	12.45	10.82	0.70	1.61	1.15	15.57	29.86	22.71	2505	2425	2465
6	IS 13871 × Parbhani Moti	9.04	12.77	10.91	0.86	1.62	1.24	17.75	28.43	23.09	2606	2613	2610
7	IS 13871 × NSSV 13	14.44	14.52	14.48	1.32	5.18	3.25	8.47	34.29	21.38	9269	6423	7846
8	IS 22670 × PMS 90 B	9.95	13.27	11.61	0.54	8.25	4.40	10.07	32.96	21.52	3278	10767	7022
9	IS 22670 × ICSB 323	11.08	14.15	12.61	1.17	5.75	3.46	15.08	32.03	23.55	4353	8160	6256
10	IS 22670 × ICSB 351	10.36	12.60	11.48	1.07	5.76	3.41	7.00	27.94	17.47	9260	9545	9402
11	IS 22670 × ICSB 374	10.65	14.15	12.40	1.05	9.45	5.25	6.65	30.63	18.64	9550	13724	11637
12	IS 22670 × ICSB 480	12.10	11.81	11.96	1.09	0.85	0.97	11.88	11.83	11.85	5246	4095	4670
13	IS 22670 × Parbhani Moti	11.81	13.85	12.83	0.95	6.76	3.85	9.80	29.05	19.43	5784	10591	8187
14	IS 22670 × NSSV 13	10.21	13.56	11.89	1.63	7.33	4.48	9.26	32.97	21.12	10427	9524	9975
15	ICSV 25333 × PMS 90 B	12.98	13.56	13.27	1.57	8.44	5.00	12.05	28.18	20.12	7573	13744	10659
16	ICSV 25333 × ICSB 323	12.69	13.56	13.12	2.20	6.93	4.56	14.78	27.93	21.36	8241	11454	9847
17	ICSV 25333 × ICSB 351	12.69	14.15	13.42	2.20	6.32	4.26	15.10	24.07	19.59	7983	12753	10368
18	ICSV 25333 × ICSB 374	12.10	12.98	12.54	1.76	6.47	4.11	10.76	25.85	18.30	9796	11844	10820
19	ICSV 25333 × ICSB 480	12.69	13.45	13.07	3.07	5.57	4.32	16.07	25.13	20.60	10249	10673	10461

Appendix II (Conti…..)

20	ICSV 25333 × Parbhani Moti	12.40	8.90	10.65	1.87	1.61	1.74	14.00	24.45	19.23	7410	3196	5303
21	ICSV 25333 × NSSV 13	9.77	13.27	11.52	0.91	7.02	3.96	11.98	30.30	21.14	4395	10299	7347
22	ICSV 93046 × PMS 90B	6.86	12.72	9.79	3.22	6.58	4.90	33.13	40.87	37.00	4147	5992	5069
23	ICSV 93046 × ICSB 323	10.94	12.98	11.96	4.98	5.96	5.47	30.69	46.95	38.82	7200	4306	5753
24	ICSV 93046 × ICSB 351	14.44	12.83	13.64	0.66	2.55	1.60	13.10	30.42	21.76	2821	3763	3292
25	ICSV 93046 × ICSB 374	8.46	13.36	10.91	1.70	6.31	4.00	19.33	51.41	35.37	4740	4305	4523
26	ICSV 93046 × ICSB 480	10.94	12.98	11.96	2.41	5.16	3.79	22.19	45.06	33.63	5503	4030	4767
27	ICSV 93046 × Parbhani Moti	11.23	12.69	11.96	3.93	5.69	4.81	22.01	42.93	32.47	8945	4849	6897
28	ICSV 93046 × NSSV 13	15.89	16.33	16.11	0.95	9.63	5.29	10.28	38.35	24.31	5522	9964	7743
29	NTJ 2 × PMS 90 B	11.23	12.95	12.09	3.00	8.02	5.51	23.56	43.21	33.38	6322	6749	6536
30	NTJ 2 × ICSB 323	10.36	13.56	11.96	3.55	7.54	5.55	22.21	43.76	32.99	7965	6277	7121
31	NTJ 2 × ICSB 351	8.61	12.69	10.65	0.75	4.67	2.71	12.07	32.39	22.23	3561	6240	4901
32	NTJ 2 × ICSB 374	12.69	13.33	13.01	3.09	8.14	5.61	22.61	45.55	34.08	6884	6170	6527
33	NTJ 2 × ICSB 480	10.06	14.44	12.25	1.31	6.85	4.08	15.13	43.75	29.44	4771	5621	5196
34	NTJ 2 × Parbhani Moti	10.38	14.15	12.26	2.16	13.22	7.69	20.45	42.63	31.54	5435	11416	8426
35	NTJ 2 × NSSV 13	12.83	16.48	14.66	1.68	8.17	4.93	12.68	38.22	25.45	7567	8486	8027
36	Wray × PMS 90 B	12.40	14.15	13.27	1.18	5.64	3.41	25.31	45.32	35.31	2289	4333	3311
37	Wray × ICSB 323	13.85	14.84	14.35	1.10	6.24	3.67	14.48	41.59	28.04	4212	5538	4875
38	Wray × ICSB 351	7.73	15.31	11.52	0.90	2.62	1.76	22.12	32.83	27.47	2039	3428	2734
39	Wray × ICSB 374	10.79	14.15	12.47	2.45	5.02	3.74	32.31	44.36	38.34	3330	4047	3689
40	Wray × ICSB 480	12.69	14.73	13.71	0.43	5.46	2.94	9.10	45.90	27.50	2776	4123	3450
41	Wray × Parbhani Moti	13.56	16.22	14.89	1.58	7.57	4.58	15.78	43.48	29.63	5594	6300	5947
42	Wray × NSSV 13	15.31	15.31	15.31	2.26	9.36	5.81	21.25	43.57	32.41	5316	7826	6571

Appendix II (Conti…..)

43	SPSSV 30 × PMS 90B	16.33	14.32	15.33	0.39	4.58	2.49	14.65	42.62	28.63	1458	3947	2703
44	SPSSV 30 × ICSB 323	12.10	17.76	14.93	4.26	5.76	5.01	35.25	42.15	38.70	5178	5053	5115
45	SPSSV 30 × ICSB 351	12.98	15.72	14.35	2.17	3.52	2.85	21.65	34.18	27.91	5103	4334	4718
46	SPSSV 30 × ICSB 374	8.69	13.94	11.32	1.28	5.00	3.14	17.45	43.17	30.31	3948	4143	4046
47	SPSSV 30 × ICSB 480	10.94	15.92	13.43	2.61	5.87	4.24	17.90	38.08	27.99	7785	6136	6960
48	SPSSV 30 × Parbhani Moti	11.23	15.98	13.61	3.76	7.51	5.64	33.88	46.55	40.21	4734	5534	5134
49	SPSSV 30 × NSSV 13	13.56	16.77	15.17	2.92	7.72	5.32	32.26	46.24	39.25	4122	5741	4932
50	CSH22SS (Check)	10.36	14.26	12.31	4.67	6.75	5.71	26.19	43.78	34.98	8479	5537	7008
	Mean	11.37	13.71	12.54	1.75	5.28	3.51	18.36	36.23	27.29	5106	5948	5527
	Minimum	6.71	8.90	9.79	0.36	0.85	0.81	6.65	11.83	11.85	1458	2409	1973
	Maximum	16.33	17.76	16.11	4.98	13.22	7.69	35.25	51.41	40.21	10427	13744	11637
	SE ±	0.54	0.61	0.41	0.19	0.39	1.15	1.13	1.43	0.92	445.58	399.24	298.86
	Lsd (5% level)	1.50	1.71	1.13	0.53	1.08	3.19	3.16	4.01	2.55	1247.24	1117.52	832.43
	Lsd (1% level)	1.98	2.26	1.49	0.70	1.43	4.20	4.18	5.31	3.36	1648.51	1477.05	1097.10
	CV %	8.17	7.73	7.96	18.72	12.65	11.51	10.65	6.86	8.16	15.11	11.63	13.17

E1 = ICRISAT location
E2 = Bijapur location

Appendix II (Conti…..)

SL.No.	Genotype	Panicle weight (t ha^{-1})			Panicle length (cm/plt)			Panicle breadth (cm/plt)			Panicle circumference (cm/plt)		
		E1	**E2**	**E1 × E2**	**E1**	**E2**	**E1 × E2**	**E1**	**E2**	**E1 × E2**	**E 1**	**E2**	**E1 × E2**
1	IS 13871 × PMS 90 B	8.96	3.78	6.37	31.3	26.8	29.1	4.8	4.1	4.4	15.1	12.8	14.0
2	IS 13871 × ICSB 323	4.80	2.89	3.85	29.6	27.4	28.5	4.0	3.6	3.8	12.6	11.3	12.0
3	IS 13871 × ICSB 351	6.63	3.20	4.92	33.6	30.4	32.0	4.2	3.4	3.8	13.2	10.6	11.9
4	IS 13871 × ICSB 374	2.28	3.91	3.09	23.5	27.3	25.4	2.7	4.3	3.5	8.5	13.4	11.0
5	IS 13871 × ICSB 480	6.99	5.17	6.08	28.7	27.8	28.3	4.6	3.5	4.1	14.5	11.1	12.8
6	IS 13871 × Parbhani Moti	6.86	5.54	6.20	33.2	29.3	31.3	4.4	3.7	4.0	13.7	11.7	12.7
7	IS 13871 × NSSV 13	2.56	4.93	3.74	27.0	29.2	28.1	3.1	4.9	4.0	9.7	15.4	12.6
8	IS 22670 × PMS 90 B	5.69	3.15	4.42	27.1	29.6	28.3	3.8	3.7	3.8	12.0	11.6	11.8
9	IS 22670 × ICSB 323	10.88	1.87	6.37	35.1	24.0	29.6	3.9	3.5	3.7	12.3	11.1	11.7
10	IS 22670 × ICSB 351	12.77	6.06	9.41	31.4	29.6	30.5	4.5	5.1	4.8	14.2	15.9	15.0
11	IS 22670 × ICSB 374	7.57	1.94	4.75	31.1	23.8	27.5	4.1	2.8	3.5	13.0	8.9	11.0
12	IS 22670 × ICSB 480	4.18	3.34	3.76	23.9	23.9	23.9	3.8	3.8	3.8	11.9	11.9	11.9
13	IS 22670 × Parbhani Moti	6.21	3.74	4.97	27.2	26.7	27.0	5.0	4.3	4.7	15.8	13.5	14.7
14	IS 22670 × NSSV 13	3.47	1.90	2.68	29.9	28.6	29.3	2.8	3.6	3.2	8.7	11.2	10.0
15	ICSV 25333 × PMS 90 B	3.48	6.37	4.93	30.1	37.6	33.8	3.2	5.3	4.3	10.0	16.8	13.4
16	ICSV 25333 × ICSB 323	4.14	4.46	4.30	34.7	34.0	34.3	3.7	4.0	3.8	11.5	12.6	12.0
17	ICSV 25333 × ICSB 351	8.41	5.64	7.03	24.7	29.8	27.3	4.7	5.0	4.8	14.6	15.7	15.2
18	ICSV 25333 × ICSB 374	4.35	6.49	5.42	38.4	43.1	40.8	3.0	5.4	4.2	9.6	17.0	13.3

Appendix II (Conti…..)

19	ICSV 25333 × ICSB 480	14.01	5.54	9.77	31.4	29.3	30.3	6.0	5.6	5.8	18.8	17.7	18.2
20	ICSV 25333 × PARBHANI MOTI	5.96	2.40	4.18	29.3	37.0	33.1	3.9	4.2	4.1	12.3	13.3	12.8
21	ICSV 25333 × NSSV 13	3.81	2.67	3.24	31.8	32.0	31.9	3.7	4.5	4.1	11.8	14.3	13.0
22	ICSV 93046 × PMS 90B	11.18	8.53	9.86	25.0	25.1	25.1	5.4	6.6	6.0	16.9	20.8	18.9
23	ICSV 93046 × ICSB 323	11.15	9.69	10.42	24.1	25.7	24.9	4.8	6.1	5.5	15.1	19.3	17.2
24	ICSV 93046 × ICSB 351	2.75	7.72	5.23	20.1	27.3	23.7	3.4	5.4	4.4	10.8	16.8	13.8
25	ICSV 93046 × ICSB 374	10.00	3.36	6.68	25.4	20.7	23.0	5.4	3.2	4.3	17.1	10.2	13.7
26	ICSV 93046 × ICSB 480	7.98	8.82	8.40	22.4	21.4	21.9	5.3	6.4	5.8	16.5	20.3	18.4
27	ICSV 93046 × Parbhani Moti	10.93	9.24	10.09	23.1	22.8	22.9	5.7	6.3	6.0	17.9	19.7	18.8
28	ICSV 93046 × NSSV 13	3.12	5.33	4.23	28.4	21.9	25.1	3.3	4.8	4.1	10.4	15.2	12.8
29	NTJ 2 × PMS 90 B	9.75	13.30	11.53	25.2	31.3	28.3	4.6	7.6	6.1	14.6	24.0	19.3
30	NTJ 2 × ICSB 323	8.87	7.27	8.07	30.2	28.3	29.3	5.9	6.1	6.0	18.4	19.3	18.9
31	NTJ 2 × ICSB 351	9.31	5.26	7.29	24.0	27.9	26.0	5.0	4.1	4.5	15.7	12.9	14.3
32	NTJ 2 × ICSB 374	7.36	8.55	7.96	27.3	27.6	27.4	3.7	5.9	4.8	11.8	18.5	15.1
33	NTJ 2 × ICSB 480	9.16	9.47	9.32	25.0	24.4	24.7	5.1	6.7	5.9	16.0	21.2	18.6
34	NTJ 2 × Parbhani Moti	7.59	3.62	5.60	24.5	21.7	23.1	4.6	4.9	4.7	14.4	15.3	14.8
35	NTJ 2 × NSSV 13	3.08	2.36	2.72	21.0	18.9	20.0	3.1	3.6	3.4	9.8	11.3	10.5
36	Wray × PMS 90 B	7.40	7.56	7.48	29.5	32.8	31.1	4.5	5.2	4.9	14.2	16.4	15.3
37	Wray × ICSB 323	7.62	4.26	5.94	26.4	27.0	26.7	3.4	4.3	3.8	10.6	13.6	12.1
38	Wray × ICSB 351	6.47	5.64	6.05	30.0	30.6	30.3	4.7	3.3	4.0	14.7	10.3	12.5
39	Wray × ICSB 374	6.23	5.13	5.68	35.1	31.5	33.3	4.5	4.7	4.6	14.2	14.7	14.4
40	Wray × ICSB 480	6.07	7.78	6.93	24.9	29.7	27.3	4.2	4.9	4.6	13.3	15.5	14.4
41	Wray × Parbhani Moti	6.14	5.36	5.75	25.5	25.6	25.5	4.0	4.9	4.5	12.6	15.5	14.1

Appendix II (Conti…..)

42	Wray × NSSV 13	2.61	7.27	4.94	28.9	28.3	28.6	3.5	5.3	4.4	10.9	16.8	13.8
43	SPSSV 30 × PMS 90B	1.67	5.01	3.34	25.0	32.2	28.6	2.7	4.3	3.5	8.5	13.4	10.9
44	SPSSV 30 × ICSB 323	9.44	2.86	6.15	25.3	21.8	23.5	4.6	3.8	4.2	14.5	12.0	13.3
45	SPSSV 30 × ICSB 351	10.94	3.95	7.44	32.7	27.4	30.1	5.3	4.3	4.8	16.5	13.4	15.0
46	SPSSV 30 × ICSB 374	10.03	2.91	6.47	27.9	21.6	24.7	5.0	4.0	4.5	15.7	12.6	14.1
47	SPSSV 30 × ICSB 480	8.69	5.72	7.20	25.6	31.1	28.3	4.6	5.4	5.0	14.3	16.9	15.6
48	SPSSV 30 × Parbhani Moti	9.28	8.26	8.77	29.1	30.1	29.6	4.8	5.5	5.2	15.2	17.4	16.3
49	SPSSV 30 × NSSV 13	5.49	8.30	6.89	28.5	27.1	27.8	4.2	5.6	4.9	13.3	17.5	15.4
50	CSH22SS (Check)	9.98	14.76	12.37	29.3	28.9	29.1	5.4	7.3	6.4	17.0	23.0	20.0
	Mean	6.45	5.14	5.79	27.3	27.2	27.3	4.2	4.6	4.4	13.1	14.5	13.8
	Minimum	1.67	1.87	2.68	20.1	18.9	20.0	2.7	2.8	3.2	8.5	8.9	10.0
	Maximum	14.01	13.30	11.53	38.4	43.1	40.8	6.0	7.6	6.1	18.8	24.0	19.3
	SE ±	0.48	0.44	0.33	2.19	1.64	1.37	0.25	0.27	0.18	0.80	0.84	0.58
	Lsd (5% level)	1.35	1.23	0.91	6.14	4.59	3.82	0.71	0.75	0.51	2.24	2.34	1.61
	Lsd (1% level)	1.79	1.62	1.20	8.11	6.07	5.03	0.94	0.99	0.68	2.96	3.10	2.13
	CV %	12.99	14.81	13.93	13.89	10.46	12.29	10.56	10.00	10.23	10.56	10.00	10.25

E1 = ICRISAT location
E2 = Bijapur location

Appendix II (Conti…..)

SL.No.	Genotype	Grain weight (t ha^{-1})			1000 seeds weight (g)		
		E1	**E2**	**E1 × E2**	**E1**	**E2**	**E1 × E2**
1	IS 13871 × PMS 90 B	5.18	2.43	3.80	35.93	30.84	33.39
2	IS 13871 × ICSB 323	2.76	1.31	2.04	32.27	27.59	29.93
3	IS 13871 × ICSB 351	3.70	2.08	2.89	27.92	26.76	27.34
4	IS 13871 × ICSB 374	0.96	2.05	1.51	26.08	28.31	27.20
5	IS 13871 × ICSB 480	3.28	3.81	3.55	25.35	25.13	25.24
6	IS 13871 × Parbhani Moti	4.20	3.83	4.02	32.77	28.42	30.60
7	IS 13871 × NSSV 13	0.62	3.02	1.82	23.19	28.58	25.89
8	IS 22670 × PMS 90 B	2.18	1.53	1.86	27.77	20.80	24.29
9	IS 22670 × ICSB 323	3.71	0.76	2.24	27.01	18.74	22.88
10	IS 22670 × ICSB 351	7.81	3.95	5.88	27.57	17.90	22.73
11	IS 22670 × ICSB 374	4.27	0.53	2.40	25.62	19.14	22.38
12	IS 22670 × ICSB 480	1.29	1.03	1.16	25.13	25.13	25.13
13	IS 22670 × Parbhani Moti	2.48	1.96	2.22	34.03	24.51	29.27
14	IS 22670 × NSSV 13	0.76	0.65	0.71	15.15	15.56	15.36
15	ICSV 25333 × PMS 90 B	1.12	2.33	1.73	22.09	18.51	20.30
16	ICSV 25333 × ICSB 323	1.09	0.50	0.80	19.47	21.38	20.43
17	ICSV 25333 × ICSB 351	5.34	1.57	3.46	26.00	12.49	19.25
18	ICSV 25333 × ICSB 374	1.34	2.33	1.83	14.88	13.38	14.13
19	ICSV 25333 × ICSB 480	6.93	1.64	4.29	22.57	17.26	19.92

Appendix II (Conti…..)

20	ICSV 25333 × Parbhani Moti	2.75	0.18	1.46	20.78	13.35	17.06
21	ICSV 25333 × NSSV 13	1.44	0.84	1.14	10.78	10.11	10.44
22	ICSV 93046 × PMS 90B	4.98	5.57	5.27	24.59	27.65	26.12
23	ICSV 93046 × ICSB 323	5.55	6.74	6.15	27.80	26.73	27.27
24	ICSV 93046 × ICSB 351	1.45	4.72	3.08	21.55	27.97	24.76
25	ICSV 93046 × ICSB 374	4.68	2.09	3.39	26.69	20.90	23.80
26	ICSV 93046 × ICSB 480	2.71	6.11	4.41	27.79	25.08	26.44
27	ICSV 93046 × Parbhani Moti	4.70	6.35	5.53	31.41	26.58	29.00
28	ICSV 93046 × NSSV 13	1.40	2.62	2.01	24.96	21.94	23.45
29	NTJ 2 × PMS 90 B	6.56	9.56	8.06	29.62	35.59	32.61
30	NTJ 2 × ICSB 323	4.21	5.15	4.68	29.83	31.36	30.59
31	NTJ 2 × ICSB 351	8.28	2.93	5.61	26.63	31.62	29.12
32	NTJ 2 × ICSB 374	2.98	4.97	3.97	30.03	28.91	29.47
33	NTJ 2 × ICSB 480	4.94	6.10	5.52	26.27	23.38	24.83
34	NTJ 2 × Parbhani Moti	4.39	1.81	3.10	27.98	26.35	27.16
35	NTJ 2 × NSSV 13	0.95	1.02	0.98	30.47	26.22	28.35
36	Wray × PMS 90 B	5.00	4.70	4.85	21.56	26.24	23.90
37	Wray × ICSB 323	5.02	2.58	3.80	25.80	21.54	23.67
38	Wray × ICSB 351	3.51	4.12	3.81	23.84	22.51	23.17
39	Wray × ICSB 374	3.43	3.36	3.40	20.89	23.07	21.98
40	Wray × ICSB 480	3.39	5.85	4.62	20.69	22.27	21.48
41	Wray × Parbhani Moti	3.37	3.51	3.44	27.40	20.66	24.03
42	Wray × NSSV 13	0.38	5.39	2.89	24.92	22.00	23.46

Appendix II (Conti…..)

43	SPSSV 30 × PMS 90B	0.58	3.79	2.18	25.12	25.22	25.17
44	SPSSV 30 × ICSB 323	5.47	1.80	3.63	21.27	18.84	20.05
45	SPSSV 30 × ICSB 351	6.45	2.59	4.52	26.64	20.17	23.41
46	SPSSV 30 × ICSB 374	2.13	1.62	1.88	17.73	18.61	18.17
47	SPSSV 30 × ICSB 480	5.80	3.91	4.85	26.01	21.50	23.75
48	SPSSV 30 × Parbhani Moti	5.51	6.18	5.85	26.29	25.17	25.73
49	SPSSV 30 × NSSV 13	3.03	5.64	4.34	21.61	23.06	22.34
50	CSH22SS (Check)	5.34	11.09	8.22	31.57	30.46	31.01
	Mean	3.22	3.05	3.13	24.93	22.90	23.92
	Minimum	0.38	0.18	0.71	10.78	10.11	10.44
	Maximum	8.28	9.56	8.06	35.93	35.59	33.39
	SE ±	0.25	0.22	0.17	2.00	1.78	1.26
	Lsd (5% level)	0.70	0.62	0.47	5.61	4.97	3.50
	Lsd (1% level)	0.92	0.83	0.62	7.41	6.57	4.61
	CV %	13.42	12.69	13.21	13.92	13.43	12.90

E1 = ICRISAT location
E2 = Bijapur location

LINE × TESTER ANALYSIS ACROSS ENVIRONMENTS FOR STALK SUGAR YIELD TRAITS IN SWEET SORGHUM [*Sorghum bicolor* (L.)Moench]

DEEPAK G. C. **2014** **Dr. G. M. SAJJANAR**
Major Advisor

ABSTRACT

Sweet sorghum which is similar to grain sorghum but with sugar rich stalks, is a new generation bioenergy crop, gaining importance as a raw material for ethanol production, and having multiple uses. The present investigation was carried out to study heterosis and combining ability for stalk sugar yield traits in the B and R lines. A total of 49 crosses derived by using 14 parental lines in a Line x Tester (7 x 7) mating design were evaluated at two locations viz., RARS, Bijapur and ICRISAT, Patancheru during *kharif* (rainy season) 2013 for stalk sugar yield traits, grain yield and yield components. The female parents (lines) used were IS 13871, IS 22670, ICSV 25333, ICSV 93046, NTJ 2, Wray and SPSSV 30, and the male parents (testers) used were PMS 90B, ICSB 323, ICSB 351, ICSB 374, ICSB 480, Parbhani Moti and NSSV 13.

The parental lines, ICSV 25333, ICSV 93046 and NTJ 2 (among lines), and Parbhani Moti, PMS 90B and NSSV 13 (among testers) were found to be good combiners for stalk sugar yield and its related traits, in terms of brix (%), total soluble solids, total sugar index etc. Among the crosses evaluated, eleven promising cross combinations *viz.*, IS 13871×NSSV 13, IS 22670×ICSB 351, IS 22670×ICSB 374, ICSV 25333×PMS 90B, ICSV 25333×ICSB 351, ICSV 25333×ICSB 480, ICSV 93046×PMS 90B, ICSV 93046×ICSB 323, NTJ 2×Parbhani Moti, Wray×NSSV13 and SPSSV 30×ICSB 480 were identified based on significant *sca* effects and significant estimates of heterosis over mid parent, better parent and standard heterosis in desired direction for various stalk sugar yield related traits, and grain yield and yield components. The good combining parents and crosses identified in the present study can be exploited in breeding for high sugar yielding hybrids in sweet sorghum.