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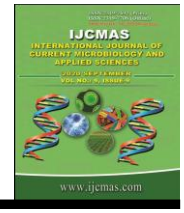

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Heterosis for Cane, Juice Yield and its Component Traits in Sweet Sorghum

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The experiment was undertaken on Line x Tester analysis for, juice yield and its component traits in crosses of A and R lines of sweet sorghum at All India Co-ordinated Sorghum Improvement Project, M.P.K.V., Rahuri, during the year 2017-18 with objectives to study the heterosis of parents and hybrids. The CMS lines (females), ten testers (males) and their thirty F_1's hybrids were studied by using L x T design. Observations were recorded on fourteen characters viz., Days to 50% flowering, Days to physiological maturity, Internode / Plant, Plant height (cm), Stem girth (cm), Total biomass yield (t/ha), Cane weight (t/ha), Cane harvest index (%), Juice yield (lit/ha), Brix (%), Reducing sugar (%), Non-reducing sugar (%), Total sugar (%), Computed ethanol yield (lit/ha). Among the fourteen characters studied, majority of the characters exhibited mid-parents as well as better parent heterosis along with standard heterosis in desirable direction in most of the hybrids, indicating the predominant role of non- fixable inter-allelic interactions and over dominance in the expression of heterosis in respect of all these traits.

Introduction

Sorghum is recognized as one of the best crops for biomass energy feedstock. The sugar and starch in sweet sorghum could be fermented to ethanol and liquid cellulose could be gasified to methane. The concept of high energy sorghum is now gaining forward. The recent national bio-fuel policy of government of India state that an indicated target of 20% percent ethanol blending with petrol viewed largely a measure of environmental sustainability and reduced the dependence on fossil fuels. The traditional route of producing ethanol as product of sugar industry will not meet this huge demand. Therefore, as demand for production of fuel ethanol, through renewable sources increase to unprecedented levels, feed stock for ethanol production will become more diverse. High biomass sweet sorghum would be a best option owing to its wider adoption. Therefore, sweet sorghum being a water use efficient non-invasive crop having under adaptability will meet the requirement of upcoming ethanol firms that has not only significant impact on sustaining the environment but also on livelihood opportunities at small farmer in semi-arid tropics.

Heterosis or hybrid vigour is the increased or decreased vigour growth, fitness or yield of a hybrid over the parental values, resulting from the crossing of genetically divers genotype. Heterosis has positive association with specific combining ability (sca) variance. 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.

Materials and Methods

The experimental material for the present study comprised of three male sterile lines, ten restorers, their resulting 30 hybrids and one hybrid check Phule Vasundhara. During *rabi* 2017- 18 three male sterile lines and ten restores were sown at Sorghum Improvement Project, M.P.K.V., Rahuri and these lines and testers were crossed in Line x Tester design to produce 30 possible hybrids. The experiment was conducted during *kharif* 2018 by using thirteen parents, their 30 hybrids along with one standard check Phule Vasundhara at Sorghum Improvement Project, M.P.K.V., Rahuri. The observations were recorded on fourteen characters viz., Days to 50% flowering, Days to physiological maturity, Internode / Plant, Plant height (cm), Stem girth (cm), Total biomass yield (t/ha), Cane weight (t/ha), Cane harvest index (%), Juice yield (lit/ha), Brix (%), Reducing sugar (%), Non-reducing sugar (%), Total sugar (%), Ethanol yield (lit/ha). In the present investigation heterosis has been estimated over mid parent (Average / Relative heterosis) and better parent (heterobeltiosis) as per Fonesca and Patterson (1968).

Results and Discussion

Heterosis, a fundamental tool, used for the improvement of crops in the form of F_1 and F_2 populations by improving the various yield contributing characters. The magnitude of heterosis was reported among the crosses, demonstrating potential of hybrid combinations of thirteen diverse parents for various traits enhancement in the present research. It is observed that, the mean squares due to lines, testers as well as lines vs tester interaction and hybrids are found significant for all the characters under studies, except the magnitude of variance in lines and testers is found non-significant for Internodes per plant, in lines it is non significant for total sugar and also for magnitude of variance in lines and lines vs. testers found non significant for brix (Table 1). Mean performance of parents for cane yield, juice yield per hectares and its contributing characters in sweet sorghum are presented in Table 2. Higher values are desirable for all traits under study except for days to 50% flowering, days to maturity and reducing sugar per cent for which lower values are preferred.

The mean performance of hybrids for different traits studied were compared with the corresponding mid parent (MP), better parent (BP) and standard check hybrids (Phule Vasundhara) and the differences are being expressed as per cent heterosis for cane, juice yield, its components traits. In sweet sorghum, positive heterosis was desirable for all the characters studied except days to 50% flowering, days to maturity and reducing sugar where negative heterosis is desirable.

Character wise results of average heterosis (H1) heterobeltiosis (H2) and standard heterosis (H3) observed in the 30 crosses (Table 3).

Earliness is a desirable character that helps to develop early maturity variety. The standard heterosis for days to 50% flowering ranged from -11.24 to -26.59 per cent over check Phule Vasundhara (Table 3). The crosses ICMS-479A x RSSV-498, ICMS-479A x RSSV-512, CMS-1409A x RSSV-498 (-26.59 %) exhibits highest negative standard heterosis followed by cross 1409A x RSSV-453 (-26.22), ICMS-479A x RSSV-503 (-26.22%) and 1409A x RSSV-512 (-26.22%). All 30 hybrids showed significant negative standard heterosis over check Phule Vasundhara. These results are in line with the earlier results of Sandeep *et al.,* (2009), Vinaykumar (2009), Bahadure *et al.,* (2015) and Kumar *et al.,* (2016). Days to maturity is often closely correlated with days to flowering, although genetic differences in the period or duration required for flowering to maturity exists. Heterosis over standard check (Phule Vasundhara) was negative in direction for most of the hybrids indicating earliness of hybrids (Table 3). The crosses ICMS-479A x RSSV-509, CMS-1409A x RSSV-498 (-18.93%) and CMS-1409A x RSSV-453 (-18.67%) showed highest negative standard heterosis followed by cross ICMS-479A x RSSV-542 (-18.41) and ICMS-479A x RSSV-542(-18.41%). All 30, crosses recorded highly significant negative standard heterosis over check, Phule Vasundhara. Internode per plant in sorghum is one of the important character, Out of 30 hybrids, 19 hybrids recorded significant average heterosis in positive direction. The heterosis over better parent ranged from -2.78 per cent (CMS- 185 x RSSV-542) to 27.27 per cent (CMS-185 X RSSV-509) and 4 hybrids recorded significant heterobeltiosis for Internode per plant. Out of 30 crosses, none of the cross exhibited positive and significant standard heterosis for this trait.

Plant height is an important character in sweet sorghum. All the 30 crosses, show highest significant positive average heterosis in desirable direction for plant height. Heterobeltiosis ranged from -0.56 (CMS-185 x RSSV-503) to 20.69 per cent (CMS-185 x RSSV-509) (Table 3). As the check Phule Vasundhara is tall in growth habit the standard heterosis for plant height ranged from -0.08 to 4.53 per cent over check Phule Vasundhara (Table 3). Four crosses showed standard heterosis in desirable direction. Maximum positive heterosis was found in crosses ICMS-479 x RSSV-260 (4.53%) followed by CMS-185 x RSSV-509 (2.77%) and CMS-1409 x RSSV-512 (2.51%), while maximum negative standard heterosis was observed in ICMS-479 x RSSV-386 (-30.84%). Similar result recorded by Agarwal and Shrotria (2005), Sandeep *et al.,* (2009), Vinaykumar (2009). Out of 30 hybrids, 22 hybrids recorded significant average heterosis and heterobeltosis in positive direction for stem girth. Only 4 cross combination were exhibited positive and significant standard heterosis for stem girth. Maximum positive heterosis was found in crosses ICMS-479 x RSSV-260 (9.62%) followed by CMS-185 x RSSV-260 (9.06%) and CMS-1409 x RSSV-503 (8.27%). The heterosis over better parent was ranged from -1.40 per cent (CMS-185 x RSSV-313) to 43.23 per cent (ICMS-479 X RSSV-260) for total biomass yield. A total of 26 hybrids recorded positive significant heterosis over better parent. The cross ICMS-479 X RSSV-260 (43.23%) recorded highest positive significant heterosis over better parent. The highest significant standard heterosis recorded in the cross, ICMS-479 X RSSV-260 (10.25%), followed by cross CMS-185 X RSSV-260 (5.15%) and CMS-1409 X RSSV-260 (5.14%). The similar results were earlier reported by Sandeep *et al.,* (2009), Vinaykumar (2009), Pfeiffer *et al.,* (2010), Tariq *et al.,* (2014), Bahadure *et al.,* (2015) and Kumar *et al.*, (2016) (Table 3).

Cane weight of a genotype serves as an indicator of juice yield as it is an important character contributing to juice yield in sweet sorghum. Average heterosis for cane weight ranged from 16 to 107.31 per cent. Heterobeltiosis ranged from -1.94 (CMS-185 x RSSV-313) to 68.04 per cent (ICMS-479 x RSSV-260) (Table 3). Out of 30 crosses, 24 crosses show highest significant positive heterobeltiosis in desirable direction for can weight. Standard heterosis over check hybrid Phule Vasundhara ranged from -3.91 per cent (CMS-1409 x RSSV-386) to 14.30 per cent (ICMS-479 X RSSV-260). Eight crosses showed standard heterosis in desirable direction. The highest significant standard heterosis recorded in the cross, ICMS-479 X RSSV-260 (14.30%), followed by cross CMS-185 X RSSV-260 (7.22%) and CMS-1409 X RSSV-260 (7.13%). The similar results were earlier reported by Sandeep *et al.,* (2009), Vinaykumar (2009), Pfeiffer *et al.,* (2010), Tariq *et al.,* (2014), Bahadure *et al.,* (2015) and Kumar *et al.,* (2016) (Table 3). Can harvest index is an important parameter in sweet sorghum. Average heterosis for cane weight ranged from 6.67 to 28.89 per cent. Heterobeltiosis ranged from -0.55 (CMS-185A x RSSV-313) to 17.38 per cent (ICMS-479A x RSSV-260). Standard heterosis over check hybrid Phule Vasundhara ranged from -1.14 per cent (CMS-1409A x RSSV-386) to 3.66 per cent (ICMS-479A x RSSV-260). Six crosses showed standard heterosis in desirable direction. The magnitude of heterosis over mid-parent for juice yield ranged from -1.98 per cent (CMS-185 X RSSV-313) to 93.25 per cent (ICMS-479 X RSSV-260). A total of 19 hybrids recorded significant positive heterosis over mid parent. The range in heterobeltiosis varied from -0.34 per cent (CMS-185 x RSSV-498) to 72.60 per cent (ICMS-479 X RSSV-260). A total of 16 hybrids recorded significant positive heterosis over better parent. The range of heterosis over standard checks, Phule Vasundhara was from 2.04 per cent (ICMS-479 X RSSV-509) to 9.41 per cent (ICMS-479 X RSSV-260). Among 30 hybrids, 2 hybrids recorded positive significant heterosis over Phule Vasundhara. The highest standard heterosis in desirable direction was recorded in the cross ICMS-479 X RSSV-260 (9.41%), followed by cross CMS-1409 x RSSV-260 (4.57%) Similar result recorded by Vinaykumar (2009), Pfeiffer *et al.,* (2010), Sidramappa *et al.,* (2012), Tariq *et al.,* (2014), and Kumar *et al.,* (2016) (Table 3). Average heterosis for percentage of brix ranged from -0.95 to 21.90 per cent. Maximum significant positive average heterosis recorded in CMS-1409 X RSSV-509 (21.90%) followed by ICMS-479 x RSSV-509 (17.31%). The heterobeltiosis ranged from -1.89 to 20.75 per cent. 10 crosses recorded significant positive heterobeltiosis. The range of heterosis over standard checks, Phule Vasundhara was from -3.64 per cent (CMS-1409 X RSSV-542) to 16.36 per cent (CMS-1409 X RSSV-509). The cross CMS-1409 X RSSV-509 (16.36%) exhibited highest significant heterosis over better parent followed by ICMS-479 X RSSV-509 (10.91%) and CMS-1409 X RSSV-498.). Similar finding reported by Meshram *et al.,* (2005), Rajashekhar (2007), Vinaykumar (2009) and Sidramappa *et al.,* (2012). Average heterosis for percentage of reducing sugar ranged from -2.33 to 64.71 per cent. Maximum significant negative average heterosis recorded in ICMS-479 x RSSV-386 (27.45%). The heterobeltiosis ranged from -2.33 to 156.67 per cent. None of the cross recorded significant negative heterobeltiosis. Standard heterosis for this trait ranged from -1.43 to 10 per cent. Out of 30 crosses 21 crosses exhibited negative and significant standard heterosis for this trait.

Table.1 Analysis of variance for combining ability and estimates of gca and sca variances in sweet sorghum

Sources	DF	Days to 50% flowering	Days to maturity	Internodes/ Plant	Plant height (cm)	Stem girth (cm)	Total biomass yield (t/ha)	Cane weight (t/ha)
Replication	2	0.49	0.70	2.077	20.98	0.008	0.84	0.69
Treatments	42	116.59**	112.25**	6.84**	6944.82**	5.53**	217.95**	217.83**
Parents	12	312.17**	300.17**	9.47**	15115.92**	0.77**	172.72**	171.32**
Line	2	3.11*	2.78**	0.44	1013.78**	0.19**	39.54**	38.29**
Testers	9	342.00**	326.90**	1.55	804.45**	0.98**	34.78**	34.79**
Line vs. Tester	1	661.88**	654.38**	98.80**	172123.48**	0.005	1680.48**	1666.13**
Parent vs. hybrid	1	145.22**	156.84**	36.66**	46282.02**	57.97**	3722.59**	3722.98**
Hybrids	29	34.67**	32.96**	4.73**	2207.21**	5.70**	115.81**	116.21**
Error	84	0.814	2.62	1.04	20.59	0.01	0.40	0.45
Estimates								
σ^2_{gca}		3.7679**	3.3884**	0.2709**	187.4018**	0.3357**	8.9385**	8.9780**
σ^2_{sca}		6.5094**	5.9005**	0.3168*	406.3949**	1.2207**	25.5500**	25.6523**
σ^2_A		7.5358	6.7767	0.5417	374.8036	0.6715	17.8769	17.9561
σ^2_D		6.5094	5.9005	0.3168	406.3949	1.2207	25.5500	25.6523
σ^2_A/var $_D$		1.1577	1.1485	1.7098	0.9223	0.5501	0.6997	0.7000

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance

Table.1 contd…

Sources	DF	Cane harvest index (%)	Juice yield (lit/ha)	Brix (%)	Reducing Sugar (%)	Total sugar (%)	Non reducing sugar (%)	Ethanol yield (lit/ha)
Replication	2	0.02977	137105.68	0.389	0.040*	0.12	0.120	1057.49
Treatments	42	71.09173**	17549920.11**	4.74**	0.49**	7.52**	6.22**	106579.82**
Parents	12	93.59920**	5504988.15**	2.07**	0.49**	10.29**	8.21**	36768.10**
Line	2	10.13121**	1049284.11**	0.33	0.16**	0.093	0.47**	734.33
Testers	9	35.30820**	4316098.87**	2.68**	0.24**	4.21**	4.66**	7183.78**
Line vs. Tester	1	961.39310**	25116399.80**	0.12	3.33**	85.45**	55.61**	375094.53**
Parent vs. hybrid	1	1192.82877	60148528.57**	18.53**	0.94**	59.21**	46.33**	689550.74**
Hybrids	29	23.09770	21065112.36**	5.37**	0.47**	4.59**	4.009**	115364.98**
Error	84	0.16487**	75487.78	0.36	0.011	0.067	0.080	354.09
Estimates								
σ^2_{gca}		1.8485 **	1672608.63**	0.3464	0.0193	0.6783**	0.5749**	12119.0461**
σ^2_{sca}		5.5310 **	3339231.72**	1.6275**	0.1573**	0.9199**	0.7253**	16776.0130**
σ^2_{A}		3.6971	3345217.2663	0.6927	0.0387	1.3567	1.1497	24238.0923

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance

Table.2 Mean performance of parents for juice yield and its contributing traits in sweet sorghum

Sr. No.	Name of parents	Days to 50% Flowering	Days to maturity	Nodes/ plant	Plant height (cm)	Stem girth (cm)	Total biomass yield (t/ha)	Cane weight (t/ha)
	Female (Lines)	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1.	CMS-185A	65	105	9	230	6.2	42.6	22.1
2.	ICMS-479A	63	103	8	210	5.8	42.8	22.4
3.	CMS-1409A	63	105	8	194	5.7	49.0	28.4
	Mean	63.67	104.33	8.33	211.56	5.9	44.82	24.3
	Male (Testers)							
4.	RSSV-542	71	111	12	385	6.2	60.3	39.7
5.	RSSV-260	101	141	14	388	6.4	56.6	36.0
6.	RSSV-509	67	107	11	337	4.9	58.8	38.2
7.	RSSV-386	77	117	12	367	5.5	60.4	39.9
8.	RSSV-498	66	106	12	388	5.3	56.7	36.1
9.	RSSV-417	67	109	12	355	5.6	59.6	39.0
10.	RSSV-453	67	108	12	368	6.0	59.4	38.7
11.	RSSV-313	79	121	12	367	6.1	67.3	46.8
12.	RSSV-512	70	111	13	379	6.8	65.2	44.6
13.	RSSV-503	68	110	13	359	6.2	59.9	39.2
	Mean	73.3	114.1	12.3	369	5.92	60.4	39.8
	SE±	0.5211	0.9478	0.588	2.599	0.0617	0.3660	0.3841
	CD at 5%	1.4650	2.6646	1.653	7.3092	0.1734	1.0290	1.0799
	C.V.	1.2911	1.4829	8.275	1.2425	1.5307	0.9727	1.4916

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance.

Table.2 contd..

Sr. No.	Name of parents	Cane harvest index (%)	Juice yield (lit/ha)	Brix (%)	Reducing sugar (%)	Total sugar (%)	Non reducing sugar (%)	Ethanol yield (lit/ha)
	Female (Lines)	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1.	CMS-185A	51.94	7671	17.7	1.43	6.77	5.3	276.3
2.	ICMS-479A	52.19	6740	17.0	1.06	7.03	5.9	250.7
3.	CMS-1409A	58.00	6574	17.3	1	7.10	6.0	248
	Mean	54.04	6995	17.3	1.16	6.96	5.8	258.33
	Male (Testers)							
4.	RSSV-542	65.86	7823	19.3	1.8	12.5	10.7	519.0
5.	RSSV-260	63.62	8573	16.7	2.2	9.9	7.7	451.0
6.	RSSV-509	64.99	8592	17.7	1.5	10.7	9.2	488.0
7.	RSSV-386	65.94	8139	17.0	2.3	8.9	6.5	382.0
8.	RSSV-498	63.69	8742	18.3	1.6	10.7	9.0	497.0
9.	RSSV-417	65.45	7980	17.3	2.0	11.8	9.8	502.0
10.	RSSV-453	65.32	10260	16.3	1.8	10.3	8.4	559.0
11.	RSSV-313	69.43	8176	16.7	1.9	10.8	8.8	470.7
12.	RSSV-512	68.43	9030	17.0	1.9	10.6	8.7	507.7
13.	RSSV-503	65.56	11683	18.3	1.4	8.6	7.2	534.3
	Mean	65.83	8899.8	17.5	1.86	10.48	8.59	491.067
	SE±	0.0054	156.81	0.34	0.06	0.15	0.16	11.19
	CD at 5%	0.0151	441	0.97	0.17	0.43	0.47	31.48
	C.V.	0.6264	2.83	3.32	5.68	2.48	3.26	3.49

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance.

Table.3 Heterosis (%) over mid-parent (MP), better-parent (BP) and standard check (Phule Vasundhara) for different characters in sweet Sorghum

Sr. No.	Crosses	Days to 50% flowering			Days to maturity			Internodes/plant		
		1			2			3		
		MP (H1)	BP(H2)	Check (H3)	MP (H1)	BP(H2)	Check (H3)	MP (H1)	BP (H2)	Check (H3)
1	CMS-185A x RSSV-542	-2.70 **	2.06	-25.84 **	-1.54	1.27	-18.41 **	11.11	-2.78	-16.67 **
2	CMS-185A x RSSV-260	-13.08 **	11.34 **	-19.10 **	-8.67 **	6.98 **	-13.81 **	23.53 **	2.44	0.00
3	CMS-185A x RSSV-509	8.59 **	10.82 **	-19.48 **	5.49 **	6.67 **	-14.07 **	40.00 **	27.27 **	0.00
4	CMS-185A x RSSV-386	1.89 *	11.34 **	-19.10 **	1.35	6.98 **	-13.81 **	25.00 **	8.11	-4.76
5	CMS-185A x RSSV-498	4.33 **	5.67 **	-23.22 **	2.84 *	3.49 **	-16.62 **	22.58 **	8.57	-9.52
6	CMS-185A x RSSV-417	3.80 **	5.67 **	-23.22 **	2.65 *	4.44 **	-15.86 **	15.63 *	0.00	-11.90
7	CMS-185A x RSSV-453	2.54 *	4.12 **	-24.34 **	1.88	3.49 **	-16.62 **	0.00	-13.51	-23.81 **
8	CMS-185A x RSSV-313	-0.46	10.82 **	-19.48 **	0.00	7.62 **	-13.30 **	0.00	-13.51	-23.81 **
9	CMS-185A x RSSV-512	7.20 **	11.34 **	-19.10 **	6.01 **	9.21 **	-12.02 **	27.27 **	7.69	0.00
10	CMS-185A x RSSV-503	12.28 **	15.46 **	-16.10 **	6.36 **	8.89 **	-12.28 **	1.54	-13.16	-21.43 **
11	ICMS-479A x RSSV-542	0.25	6.91 **	-24.72 **	-0.78	2.90 *	-18.41 **	8.20	-8.33	-21.43 **
12	ICMS-479A x RSSV-260	-3.46 **	26.06 **	-11.24 **	-3.14 **	14.52 **	-9.21 **	42.42 **	14.63 *	11.90
13	ICMS-479A x RSSV-509	2.05 *	5.85 **	-25.47 **	0.32	2.26	-18.93 **	41.38 **	24.24 **	-2.38
14	ICMS-479A x RSSV-386	2.39 *	13.83 **	-19.85 **	0.61	7.10 **	-15.09 **	22.58 **	2.70	-9.52
15	ICMS-479A x RSSV-498	1.29	4.26 **	-26.59 **	1.75	3.23 *	-18.16 **	33.33 **	14.29	-4.76
16.	ICMS-479A x RSSV-417	5.40 **	9.04 **	-23.22 **	3.46 **	6.13 **	-15.86 **	12.90	-5.41	-16.67 **
17.	ICMS-479A x RSSV-453	10.31**	13.83 **	-19.85 **	6.46 **	9.03 **	-13.55 **	9.68	-8.11	-19.05 **
18.	ICMS-479A x RSSV-313	0.47	13.83 **	-19.85 **	0.45	9.03 **	-13.55 **	9.68	-8.11	-19.05 **
19.	ICMS-479A x RSSV-512	-1.26	4.26 **	-26.59 **	-0.62	3.23 *	-18.16 **	12.50	-7.69	-14.29 *
20.	ICMS-479A x RSSV-503	0.25	4.79 **	-26.22 **	0.63	3.87 **	-17.65 **	20.63 **	0.00	-9.52
21.	CMS-1409A x RSSV-542	-1.24	4.74 **	-25.47 **	-0.31	2.54 *	-17.39 **	21.31 **	2.78	-11.90
22.	CMS-1409A x RSSV-260	-11.97 **	14.21 **	-18.73 **	-7.59 **	8.25 **	-12.79 **	27.27 **	2.44	0.00
23.	CMS-1409A x RSSV-509	2.55 *	5.79 **	-24.72 **	2.04	3.17 *	-16.88 **	37.93 **	21.21 **	-4.76
24.	CMS-1409A x RSSV-386	-5.24 **	4.74 **	-25.47 **	-3.76 **	1.59	-18.16 **	25.81 **	5.41	-7.14
25.	CMS-1409A x RSSV-498	0.77	3.16 **	-26.59 **	0.00	0.63	-18.93 **	26.67 **	8.57	-9.52
26.	CMS-1409A x RSSV-417	2.30 *	5.26 **	-25.09 **	0.16	1.90	-17.90 **	12.90	-5.41	-16.67 **
27.	CMS-1409A x RSSV-453	1.03	3.68 **	-26.22 **	-0.63	0.95	-18.67 **	19.35 **	0.00	-11.90
28.	CMS-1409A x RSSV-313	-6.54 **	5.26 **	-25.09 **	-5.31 **	1.90	-17.90 **	9.68	-8.11	-19.05 **
29.	CMS-1409A x RSSV-512	-1.25	3.68 **	-26.22 **	-0.77	2.22	-17.65 **	34.38 **	10.26	2.38
30.	CMS-1409A x RSSV-503	0.25	4.21 **	-25.84 **	0.16	2.54 *	-17.39 **	33.33 **	10.53	0.00
	S.E. (Sij) ±	0.6379	0.7366	0.7366	1.1441	1.3211	1.3211	0.7231	0.8350	0.8350
	C.D. 5%	1.2768	1.4744	1.4744	2.2902	2.6445	2.6445	1.4475	1.6714	1.6714
	C.D. 1%	1.6989	1.9617	1.9617	3.0472	3.5186	3.5186	1.9259	2.2238	2.2238

Note: * Significant4 at 5% level of significance, ** Significant at 1% level of significance

Table.3 contd...

Sr. No.	Crosses	Plant height (cm)			Stem girth (cm)			Total biomass yield (t/ha)		
		4			5			6		
		MP (H1)	BP(H2)	Check (H3)	MP (H1)	BP(H2)	Check (H3)	MP (H1)	BP (H2)	Check (H3)
1	CMS-185A x RSSV-542	12.89 **	-9.71 **	-12.66 **	-1.11	-1.29	-31.17**	34.46 **	14.76 **	-5.86 **
2	CMS-185A x RSSV-260	32.04 **	5.24 **	2.77 **	52.68 **	49.15 **	9.06 **	55.82 **	36.60 **	5.15 **
3	CMS-185A x RSSV-509	43.24 **	20.69 **	2.18 *	59.74 **	43.29 **	-0.08	47.42 **	27.14 **	1.71 *
4	CMS-185A x RSSV-386	35.27 **	10.18 **	1.59	45.02 **	37.63 **	-4.02 **	43.38 **	22.25 **	0.51
5	CMS-185A x RSSV-498	28.52 **	2.49 *	-0.08	29.21 **	20.05 **	-16.28 **	32.18 **	15.79 **	-10.71 **
6	CMS-185A x RSSV-417	17.81 **	-2.82 **	-13.24 **	8.69 **	3.50 *	-27.82 **	33.36 **	14.38 **	-7.27 **
7	CMS-185A x RSSV-453	17.64 **	-4.34 **	-11.40 **	-2.12	-3.07 *	-32.41 **	31.22 **	12.73 **	-8.96 **
8	CMS-185A x RSSV-313	32.92 **	8.27 **	-0.17	-4.82 **	-5.23 **	-33.91 **	20.77 **	-1.40	-9.66 **
9	CMS-185A x RSSV-512	31.66 **	5.89 **	0.92	31.86 **	25.88 **	-3.46 **	41.68 **	17.15 **	3.92 **
10	CMS-185A x RSSV-503	21.13 **	-0.56	-10.14 **	-2.58 *	-2.94 *	-31.80 **	36.02 **	16.51 **	-5.26 **
11	ICMS-479A x RSSV-542	15.47 **	-10.75 **	-13.66 **	16.21 **	12.72 **	-21.69 **	33.02 **	13.77 **	-6.68 **
12	ICMS-479A x RSSV-260	38.94 **	7.04 **	4.53 **	58.39 **	49.92 **	9.62 **	63.02 **	43.23 **	10.25 **
13	ICMS-479A x RSSV-509	47.44 **	19.70 **	1.34	42.99 **	32.12 **	-13.72 **	47.95 **	27.87 **	2.29 **
14	ICMS-479A x RSSV-386	16.76 **	-8.18 **	-15.34 **	-1.15	-3.17 *	-36.77 **	24.29 **	6.20 **	-12.68 **
15	ICMS-479A x RSSV-498	12.99 **	-12.90 **	-15.09 **	10.24 **	5.64 **	-31.02 **	28.85 **	13.12 **	-12.76 **
16.	ICMS-479A x RSSV-417	25.90 **	0.19	-10.56 **	-5.24 **	-6.85 **	-39.17 **	21.78 **	4.67 **	-15.14 **
17.	ICMS-479A x RSSV-453	19.08 **	-6.52 **	-13.41 **	36.00 **	32.93 **	-9.10 **	21.91 **	4.95 **	-15.25 **
18.	ICMS-479A x RSSV-313	21.16 **	-4.73 **	-12.15 **	14.49 **	11.31 **	-23.05 **	10.31 **	-9.75 **	-17.32 **
19.	ICMS-479A x RSSV-512	21.68 **	-5.45 **	-9.89 **	-2.14	-9.41 **	-30.53 **	22.48 **	1.48	-9.98 **
20.	ICMS-479A x RSSV-503	31.15 **	3.90 **	-6.12 **	40.93 **	35.96 **	-4.47 **	9.70 **	-5.83 **	-23.42 **
21.	CMS-1409A x RSSV-542	34.33 **	1.04	-2.26 *	-17.80 **	-20.78 **	-44.96 **	20.67 **	9.39 **	-10.27 **
22.	CMS-1409A x RSSV-260	38.07 **	3.52 **	1.09	54.91 **	45.71 **	6.54 **	46.37 **	36.59 **	5.14 **
23.	CMS-1409A x RSSV-509	48.24 **	16.83 **	-1.09	48.60 **	38.16 **	-10.98 **	11.03 **	1.79 *	-18.57 **
24.	CMS-1409A x RSSV-386	40.67 **	7.55 **	-0.84	36.75 **	34.83 **	-13.12 **	30.54 **	18.22 **	-2.81 **
25.	CMS-1409A x RSSV-498	19.43 **	-10.40 **	-12.66 **	27.53 **	22.99 **	-20.75 **	14.09 **	6.37 **	-17.96 **
26.	CMS-1409A x RSSV-417	26.05 **	-2.54 *	-12.99 **	25.59 **	24.27 **	-19.92 **	14.64 **	4.47 **	-15.30 **
27.	CMS-1409A x RSSV-453	24.24 **	-5.16 **	-12.15 **	26.97 **	23.31 **	-15.68 **	29.28 **	18.02 **	-4.69 **
28.	CMS-1409A x RSSV-313	29.01 **	-1.36	-9.05 **	16.80 **	12.83 **	-21.99 **	17.65 **	1.64 *	-6.88 **
29.	CMS-1409A x RSSV-512	42.29 **	7.56 **	2.51 **	41.88 **	30.54 **	0.11	30.87 **	14.63 **	1.68 *
30.	CMS-1409A x RSSV-503	43.98 **	10.85 **	0.17	60.76 **	54.09 **	8.27 **	38.91 **	26.42 **	2.80 **
	S.E. (Sij) ±	*3.2090*	3.7055	3.7055	0.0716	0.0826	0.0826	0.4527	0.5228	0.5228
	C.D. 5%	6.4235	7.4173	7.4173	0.1432	0.1654	0.1654	0.9062	1.0464	1.0464
	C.D. 1%	*8.5466*	9.8687	9.8687	0.1906	*0.2201*	0.2201	1.2058	1.3923	*1.3923*

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance

Table.3 contd...

Sr. No.	Crosses	Cane weight (t/ha)			Cane harvest index (%)			Juice yield (lit/ha)		
		7			8			9		
		MP (H1)	BP(H2)	Check (H3)	MP (H1)	BP(H2)	Check (H3)	MP (H1)	BP (H2)	Check (H3)
1	CMS-185A x RSSV-542	57.29 **	22.50 **	-8.08 **	19.34 **	6.73 **	-2.36 **	-6.37 *	-7.28 *	- 46.37 **
2	CMS-185A x RSSV-260	95.18 **	57.62 **	7.22 **	27.04 **	15.38 **	1.96 **	67.76 **	58.94 **	0.76
3	CMS-185A x RSSV-509	79.63 **	41.85 **	2.44 *	24.01 **	11.56 **	0.72	68.12 **	59.11 **	1.09
4	CMS-185A x RSSV-386	72.06 **	33.83 **	0.77	22.46 **	9.47 **	0.26	43.91 **	39.77 **	-15.88 **
5	CMS-185A x RSSV-498	54.81 **	24.88 **	-14.81 **	18.80 **	7.85 **	-4.60 **	6.17 *	-0.34	-35.57 **
6	CMS-185A x RSSV-417	55.71 **	22.05 **	-10.04 **	18.99 **	6.71 **	-2.98 **	13.53 **	11.33 **	-34.31 **
7	CMS-185A x RSSV-453	52.22 **	19.57 **	-12.39 **	18.15 **	6.06 **	-3.77 **	-11.93 **	-23.04 **	-41.61 **
8	CMS-185A x RSSV-313	33.10 **	-1.94	-13.35 **	13.78 **	-0.55	-4.09 **	-1.98	-5.01	-42.57 **
9	CMS-185A x RSSV-512	67.27 **	25.14 **	5.50 **	21.45 **	6.82 **	1.53 **	62.42 **	50.20 **	0.29
10	CMS-185A x RSSV-503	60.08 **	25.27 **	-7.24 **	19.98 **	7.52 **	-2.09 **	-9.96 **	-25.42 **	-35.57 **
11	ICMS-479A x RSSV-542	54.81 **	20.99 **	-9.21 **	18.66 **	6.35 **	-2.71 **	19.00 **	10.77 **	-35.92 **
12	ICMS-479A x RSSV-260	107.31 **	68.04 **	14.30 **	28.89 **	17.30 **	3.66 **	93.25 **	72.60 **	9.41 **
13	ICMS-479A x RSSV-509	80.39 **	42.96 **	3.25 **	24.02 **	11.80 **	0.93 *	72.81 **	54.19 **	-2.04
14	ICMS-479A x RSSV-386	40.28 **	9.49 **	-17.55 **	15.09 **	3.09 **	-5.58 **	4.28	-4.69	-42.63 **
15	ICMS-479A x RSSV-498	49.06 **	20.69 **	-17.66 **	17.28 **	6.69 **	-5.62 **	-6.93 **	-17.58 **	-46.72 **
16.	ICMS-479A x RSSV-417	36.18 **	7.12 **	-21.05 **	13.88 **	2.34 **	-6.96 **	-5.74 *	-13.07 **	-48.70 **
17.	ICMS-479A x RSSV-453	36.44 **	7.55 **	-21.19 **	13.93 **	2.48 **	-7.02 **	-16.62 **	-30.92 **	-47.59 **
18.	ICMS-479A x RSSV-313	16.28 **	-14.06 **	-24.06 **	8.73 **	-4.78 **	-8.16 **	26.64 **	15.52 **	-30.16 **
19.	ICMS-479A x RSSV-512	36.10 **	2.15	-13.88 **	14.21 **	0.66	-4.33 **	10.93 **	-3.13	-35.32 **
20.	ICMS-479A x RSSV-503	16.00 **	-8.91 **	-32.55 **	7.71 **	-3.27 **	-11.92 **	-34.32 **	-48.21 **	-55.26 **
21.	CMS-1409A x RSSV-542	33.13 **	14.23 **	-14.28 **	11.06 **	4.43 **	-4.46 **	54.33 **	42.01 **	-17.85 **
22.	CMS-1409A x RSSV-260	75.98 **	57.49 **	7.13 **	20.63 **	15.30 **	1.89 **	86.73 **	64.96 **	4.57 **
23.	CMS-1409A x RSSV-509	17.82 **	2.74	-25.80 **	6.66 **	0.93	-8.88 **	29.10 **	13.93 **	-27.61 **
24.	CMS-1409A x RSSV-386	48.94 **	27.61 **	-3.91 **	14.85 **	7.94 **	-1.14 *	51.72 **	37.13 **	-17.47 **
25.	CMS-1409A x RSSV-498	23.06 **	9.99 **	-24.96 **	8.22 **	3.39 **	-8.54 **	0.76	-11.74 **	-42.94 **
26.	CMS-1409A x RSSV-417	23.56 **	6.82 **	-21.27 **	8.42 **	2.25 **	-7.04 **	24.80 **	13.81 **	-32.84 **
27.	CMS-1409A x RSSV-453	47.19 **	27.56 **	-6.53 **	14.51 **	8.09 **	-1.93 **	-0.75	-18.58 **	-38.23 **
28.	CMS-1409A x RSSV-313	27.29 **	2.34	-9.57 **	9.73 **	0.70	-2.88 **	14.06 **	2.88	-37.80 **
29.	CMS-1409A x RSSV-512	48.36 **	21.45 **	2.39 *	14.69 **	5.95 **	0.70	78.16 **	53.93 **	2.78
30.	CMS-1409A x RSSV-503	62.70 **	40.38 **	3.95 **	17.84 **	11.05 **	1.12 *	46.19 **	14.23 **	-1.32
	S.E. (Sij) ±	0.4755	*0.5490*	0.5490	0.2871	0.3315	0.3315	194.2779	224.3328	224.3328
	C.D. 5%	0.9518	1.0990	1.0990	0.5747	0.6636	0.6636	388.8	449.0495	449.0495
	C.D. 1%	1.2663	1.4622	1.4622	0.7647	*0.8830*	*0.8830*	883	597.4657	597.4657

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance

Table.3 contd...

Sr. No.	Crosses	Brix (%) 10			Reducing sugar (%) 11			Total sugar (%) 12		
		MP (H1)	BP(H2)	Check (H3)	MP (H1)	BP(H2)	Check (H3)	MP (H1)	BP (H2)	Check (H3)
1	CMS-185A x RSSV-542	0.90	-3.45	1.82	20.83 **	34.88 **	-17.14 **	-0.69	-23.47 **	-18.47 **
2	CMS-185A x RSSV-260	-0.97	-3.77	-7.27 **	-8.26 *	16.28 **	-28.57 **	41.32 **	18.79 **	0.57
3	CMS-185A x RSSV-509	-3.77	-3.77	-7.27 **	43.82 **	48.84 **	-8.57 *	29.39 **	5.61 **	-3.69 *
4	CMS-185A x RSSV-386	0.00	-1.89	-5.45 *	2.65	34.88 **	-17.14 **	46.27 **	28.95 **	-2.56
5	CMS-185A x RSSV-498	-3.70	-5.45 *	-5.45 *	4.35	11.63	-31.43 **	36.26 **	11.21 **	1.42
6	CMS-185A x RSSV-417	-0.95	-1.89	-5.45 *	40.38 **	69.77 **	4.29	36.92 **	7.61 **	8.52 **
7	CMS-185A x RSSV-453	7.84 **	3.77	000	5.15	18.60 **	-27.14 **	15.07 **	-4.55 *	-16.48 **
8	CMS-185A x RSSV-313	14.56 **	11.32 **	7.27 **	3.92	23.26 **	-24.29 **	20.83 **	-1.85	-9.38 **
9	CMS-185A x RSSV-512	0.00	-1.89	-5.45 *	38.00 **	60.47 **	-1.43	38.46 **	13.56 **	2.27
10	CMS-185A x RSSV-503	-2.78	-4.55	-4.55	-2.33	-2.33	-40.00 **	35.36 **	20.93 **	-11.36 **
11	ICMS-479A x RSSV-542	4.59	-1.72	3.64	64.71 **	118.75 **	0.00	-10.92 **	-30.40 **	-25.85 **
12	ICMS-479A x RSSV-260	16.83 **	15.69 **	7.27 **	40.82 **	115.62 **	-1.43	41.45 **	20.81 **	2.27
13	ICMS-479A x RSSV-509	17.31 **	15.09 **	10.91 **	28.21 **	56.25 **	-28.57 **	32.71 **	9.97 **	0.28
14	ICMS-479A x RSSV-386	1.96	1.96	-5.45 *	-27.45 **	15.62	-47.14 **	1.05	-9.40 **	-31.53 **
15	ICMS-479A x RSSV-498	5.66 *	1.82	1.82	13.58 *	43.75 **	-34.29 **	21.80 **	0.93	-7.95 **
16.	ICMS-479A x RSSV-417	-4.85	-5.77 *	-10.91 **	11.83 *	62.50 **	-25.71 **	8.13 **	-13.80 **	-13.07 **
17.	ICMS-479A x RSSV-453	2.00	0.00	-7.27 **	41.86 **	90.62 **	-12.86 **	30.64 **	10.06 **	-3.69 *
18.	ICMS-479A x RSSV-313	2.97	1.96	-5.45 *	14.29 **	62.50 **	-25.71 **	-3.73	-20.62 **	-26.70 **
19.	ICMS-479A x RSSV-512	1.96	1.96	-5.45 *	12.36 *	56.25 **	-28.57 **	15.15 **	-4.10 *	-13.64 **
20.	ICMS-479A x RSSV-503	5.66 *	1.82	1.82	33.33 **	56.25 **	-28.57 **	43.28 **	30.23 **	-4.55 *
21.	CMS-1409A x RSSV-542	-3.64	-8.62 **	-3.64	10.84 *	53.33 **	-34.29 **	19.05 **	-6.67 **	-0.57
22.	CMS-1409A x RSSV-260	1.96	0.00	-5.45 *	60.42 **	156.67 **	10.00 **	39.73 **	19.80 **	1.42
23.	CMS-1409A x RSSV-509	21.90 **	20.75 **	16.36 **	21.05 **	53.33 **	-34.29 **	40.82 **	17.13 **	6.82 **
24.	CMS-1409A x RSSV-386	14.56 **	13.46 **	7.27 **	48.00 **	146.67 **	5.71	58.66 **	42.86 **	7.95 **
25.	CMS-1409A x RSSV-498	14.02 **	10.91 **	10.91 **	3.80	36.67 **	-41.43 **	32.96 **	10.59 **	0.85
26.	CMS-1409A x RSSV-417	7.69 **	7.69 **	1.82	62.64 **	146.67 **	5.71	33.80 **	7.04 **	7.95 **
27.	CMS-1409A x RSSV-453	-6.93 **	-9.62 **	-14.55 **	-4.76	33.33 **	-42.86 **	27.83 **	8.12 **	-5.40 **
28.	CMS-1409A x RSSV-313	11.76 **	9.62 **	3.64	73.03 **	156.67 **	10.00 **	31.97 **	9.23 **	0.85
29.	CMS-1409A x RSSV-512	12.62 **	11.54 **	5.45 *	49.43 **	116.67 **	-7.14	35.47 **	13.25 **	1.99
30.	CMS-1409A x RSSV-503	10.28 **	7.27 **	7.27 **	47.95 **	80.00 **	-22.86 **	51.17 **	37.98 **	1.14
	S.E. (Sij) ±	0.4253	0.4911	0.4911	0.0748	0.0863	0.0863	0.1827	0.2109	0.2109
	C.D. 5%	0.8513	0.9830	0.9830	0.1496	0.1728	0.1728	0.3657	0.4222	0.4222
	C.D. 1%	1.1327	1.3079	1.3079	0.1991	0.2299	0.2299	0.4865	0.5618	0.5618

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance

Table.3 contd...

Sr. No.	Crosses	Non reducing sugar (%)			Ethanol (lit/ha)		
		13			14		
		MP (H1)	BP(H2)	Check (H3)	MP (H1)	BP(H2)	Check (H3)
1	CMS-185A x RSSV-542	-5.05 *	-29.01 **	-18.94 **	-7.12 *	-28.84 **	-56.21 **
2	CMS-185A x RSSV-260	55.52 **	31.40 **	7.73 **	135.38 **	89.80 **	1.50
3	CMS-185A x RSSV-509	26.90 **	0.25	-2.23	115.18 **	68.51 **	-2.49
4	CMS-185A x RSSV-386	61.70 **	47.32 **	1.35	110.12 **	80.99 **	-17.94 **
5	CMS-185A x RSSV-498	43.63 **	14.10 **	9.61 **	42.59 **	10.93 **	-34.62 **
6	CMS-185A x RSSV-417	36.08 **	4.97 *	9.40 **	54.35 **	19.65 **	-28.77 **
7	CMS-185A x RSSV-453	17.07 **	-4.65	-14.26 **	-1.92	-26.71 **	-51.42 **
8	CMS-185A x RSSV-313	25.09 **	0.19	-5.85 *	17.18 **	-7.01 *	-48.10 **
9	CMS-185A x RSSV-512	38.23 **	11.55 **	2.77	120.49 **	70.26 **	2.49
10	CMS-185A x RSSV-503	44.34 **	25.73 **	-4.18	18.75 **	-9.92 **	-42.92 **
11	ICMS-479A x RSSV-542	-23.75 **	-40.87 **	-32.48 **	4.03	-22.86 **	-52.53 **
12	ICMS-479A x RSSV-260	42.09 **	25.56 **	2.94	169.07 **	109.31 **	11.94 **
13	ICMS-479A x RSSV-509	33.91 **	10.15 **	7.41 **	124.01 **	69.54 **	-1.90
14	ICMS-479A x RSSV-386	9.32 **	4.64	-28.01 **	4.48	-13.51 **	-60.79 **
15	ICMS-479A x RSSV-498	24.16 **	2.73	-1.31	10.57 **	-16.83 **	-50.99 **
16.	ICMS-479A x RSSV-417	7.62 **	-13.71 **	-10.07 **	0.09	-24.97 **	-55.34 **
17.	ICMS-479A x RSSV-453	29.10 **	9.70 **	-1.35	5.39	-23.67 **	-49.41 **
18.	ICMS-479A x RSSV-313	-7.69 **	-22.94 **	-27.59 **	19.13 **	-8.71 **	-49.05 **
19.	ICMS-479A x RSSV-512	15.74 **	-2.62	-10.28 **	23.87 **	-7.49 *	-44.31 **
20.	ICMS-479A x RSSV-503	45.91 **	33.18 **	1.49	-8.03 *	-32.44 **	-57.19 **
21.	CMS-1409A x RSSV-542	20.61 **	-5.59 *	7.80 **	79.75 **	32.82 **	-18.26 **
22.	CMS-1409A x RSSV-260	35.83 **	21.41 **	-0.46	156.18 **	98.52 **	6.17 **
23.	CMS-1409A x RSSV-509	44.74 **	20.29 **	17.30 **	77.54 **	33.88 **	-22.53 **
24.	CMS-1409A x RSSV-386	62.83 **	57.84 **	8.58 **	138.50 **	96.60 **	-10.87 **
25.	CMS-1409A x RSSV-498	38.41 **	15.73 **	11.17 **	30.29 **	-2.35	-42.45 **
26.	CMS-1409A x RSSV-417	28.74 **	4.25	8.65 **	63.38 **	22.05 **	-27.35 **
27.	CMS-1409A x RSSV-453	34.08 **	15.18 **	3.58	21.85 **	-12.05 **	-41.70 **
28.	CMS-1409A x RSSV-313	24.54 **	5.06	-1.28	47.31 **	12.46 **	-37.23 **
29.	CMS-1409A x RSSV-512	32.93 **	13.05 **	4.15	134.05 **	74.20 **	4.86 **
30.	CMS-1409A x RSSV-503	52.09 **	40.48 **	7.06 **	114.83 **	57.27 **	-0.36
	S.E. (Sij) ±	0.2009	0.2320	0.2320	13.3060	15.3644	15.3644
	C.D. 5%	0.4021	0.4643	0.4643	26.6348	30.7552	30.7552
	C.D. 1%	0.5350	*0.6178*	*0.6178*	35.4379	40.9201	40.9201

Note: * Significant at 5% level of significance, ** Significant at 1% level of significance

The cross by ICMS-479 x RSSV-386 (-47.14%) exhibited significant negative standard heterosis over check Phule Vasundhara, while the cross CMS-1409 x RSSV-260 (10%) showed maximum significant positive standard heterosis over Phule Vasundhara.

Range of standard heterosis from -2.56 to 8.52 per cent for percentage of total sugar over Phule Vasundhara was observed. Out of 30 crosses 4 crosses exhibited positive and significant standard heterosis for this trait. The cross CMS-185 x RSSV-417 (8.52%) exhibited maximum positive standard heterosis followed by cross CMS-1409 x RSSV-386 and -1409 x RSSV- (7.95), Average heterosis for percentage of total sugar ranged from -5.05 to 62.83 per cent. The heterobeltiosis ranged from -2.62 to 57.84 per cent. 16 crosses recorded significant positive heterobeltiosis. Maximum positive heterobeltiosis observed in cross CMS-1409 x RSSV-386 (57.84%) followed by CMS-185 x RSSV-386 (47.32%). Range of standard heterosis from -0.46 to 17.30 per cent for percentage of non reducing sugar over Phule Vasundhara was observed. Out of 30 crosses 10 crosses exhibited positive and significant standard heterosis for this trait. The cross CMS-1409 x RSSV-509 (17.30%) exhibited maximum positive standard heterosis followed by cross CMS-1409 x RSSV-498 (1.17). For ethanol yield, heterosis over mid parent ranged from -1.92 per cent (CMS-185 x RSSV-453) to 169.07 per cent (ICMS-479 X RSSV-260). As many as 23 out of 30 hybrids recorded positive significant heterosis over mid parent. The heterosis over better parent was ranged from -7.01 per cent (CMS-185 x RSSV-313) to 109.31 per cent (ICMS-479 X RSSV-260). A total of 16 hybrids recorded positive significant heterosis over better parent. The cross ICMS-479 X RSSV-260 (109.31 %) recorded highest positive significant heterosis over better parent. Standard heterosis over check hybrid Phule Vasundhara ranged from -0.36 per cent (CMS-1409 x RSSV-503) to 28.77 per cent (CMS-185 X RSSV-417). A total of 4 hybrids recorded positive significant heterosis over Phule Vasundhara.

The highest significant standard heterosis recorded in the cross, CMS-185 x RSSV-417 (28.77%), followed by cross ICMS-479 x RSSV-260 (11.94%) and CMS-1409 x RSSV-260 (43.61% (Table 3).

In conclusion, 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. At least 7 to 10 crosses were shown significant positive heterosis over standard check Phule Vasundhara for the traits plant height, stalk yield, brix (%), total biomass yield, cane yield, total sugar and ethanol yield but for juice yield only two crosses viz. ICMS-479A x RSSV-260, CMS-1409A x RSSV-260 were shown significant positive heterosis over standard check Phule Vasundhara. The top five crosses that showed significant heterosis over standard check Phule Vasundhara for the traits plant height, stem thickness, biomass yield and ethanol yield were *viz.,* ICMS-479 x RSSV-260, ICMS-479 x RSSV-260, CMS-185 x RSSV-260, CMS-1409A x RSSV-512, CMS-185A x RSSV-512. Also these crosses were shown significant positive sca effects for majority of the traits studied.

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