Electronic Journal of Plant Breeding, 2(3):334- 341 (Sep 2011)
ISSN 0975-928X

Research Article

A study on the nature and magnitude of variations in different traits in sugarcane

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(Received:19 Jul 2011; Accepted:24 Aug 2011)

Abstract:
Nature and magnitude of the variation for different agronomic traits in sugarcane under subtropical conditions of North-western Uttar Pradesh was studied. An estimation of heritability and genetic advance of these components under different environmental conditions was worked out. Fourteen sugarcane genotypes in three crop year experiment were analysed for 15 different characters and variance at phenotypic and genotypic levels, broad sense heritability, genetic advance and pooled analysis of variance were worked out. Coefficients of variation were high for the number of canes per plot, cane yield, cane weight, commercial cane sugar at 8 month stage and for sugar yield at harvesting. The highest heritability values were obtained for juice brix %, juice sucrose % and CCS % at 12 month stage, juice brix %, juice sucrose % at 8 month, cane weight, cane yield and sugar yield per plot. The lowest heritability values were observed for number of internodes, CCS % at 8 month stage, cane diameter and juice extraction % at 12 month stage. Genetic Advance was high for cane weight, cane height, number of canes per plot and cane yield. High magnitude of coefficient of variations, high heritability and maximum genetic gain for number of millable canes, cane weight and cane height showed emphatic role of these characters in clonal selection for improvement in cane and sugar yield. Variance analysis indicated significant genetic differences among the varieties for all characters.

Key words: Sugarcane, variation, heritability, genetic advance, cane yield, sugar yield.

Introduction:

Sugarcane, *Saccharum officinarum* L., is an old energy source for human beings, fulfilling about 70 per cent sugar needs of the world. India is unique for being the second largest producer and biggest consumer of sugar in the world. In India, sugarcane is the only source of sugar and it is an important crop in sub-continent and its cultivation was extended to nearly all tropical and subtropical regions. Uttar Pradesh is an important sugarcane growing state yet it is far behind in productivity (Avg.61.4t/ha cane yield) as compared to other states like, Tamil Nadu, Karnataka and Maharashtra (Avg.88.6 t/ha) Variety is the pivot around which entire production system revolves. Improvement in production factors through identification of new varieties suitable for varied agro-climatic conditions of the state through cane breeding and improved production technologies will improve the productivity of the state.

Material and Methods

The present study involves evaluation of fourteen sugarcane cultivars representing early and mid late maturity and released for commercial cultivation in Uttar Pradesh. These varieties are: Co 1148; Co J 64; Co S 687; Co S 767; Co S 88230; Co S 94257; Co S 94270; Co S 95222;Co S 95255; Co S 96258; Co S 96260; Co Se 92423 and UP 22. The material was drawn from U.P. Council of Sugarcane Research, Shahjahanpur and tested at Sugarcane Research Station, Muzaffarnagar, Uttar Pradesh.

The experiment was laid in a replicated trial for a period of three crop years from 1998 to 2001. The cane metric characters were studied at harvest (12 month stage) and juice quality characters were studied at 8 and 12 month stages. The various data recorded during these three crop years are i) Number of canes per plot, ii) Cane yield per plot (kg.), iii) Cane weight (gm.), iv) Cane height (cm.), v) Cane thickness (cm.), vi) Number of internodes alongwith Juice analysis at eight month stage, vii) Brix per cent in Juice, viii) Sucrose per cent in Juice, ix) Commercial cane sugar per cent (CCS per cent), x) Extraction per cent, and Juice analysis at 12 month stage, xi) Brix percent in Juice, xii) Sucrose per cent in Juice, xiii) Commercial cane sugar per cent, xiv) Extraction per cent and xv) Commercial cane sugar yield per plot (kg.). The characters were analyzed as per the standard procedure techniques developed by Panse and Sukathme (1958); Goulden (1952) and further subjected to analysis of variance and covariance. Since same number of varieties were tested for a

period of three years in a similar design with the same number of replications, a combined statistical analysis was made in order to obtain the extent of interaction of the varieties with years represented by the trials. The combined analysis of variance was carried out treating the data as a two way classification as in an ordinary randomised block design. The error variances obtained in the individual trials over years were pooled to obtain a joint estimate of the error variance $\bar{S}^2$ (Pooled error). The expectations of the mean squares for varieties, interaction and pooled error in the combined analysis were considered to be as follows:

Source of variation	Expected values of M.S.S.
Varieties (phenotypic)	$\sigma_e^2 + r\sigma_m^2 + rp\sigma_v^2$
Interaction (genotype x years)	$\sigma_e^2 + r\sigma_m^2$
Pooled error $\bar{S}6^2$e	σ_e^2

Where σ_e^2, σ_v^2 and σ_m^2 and 'r' stand for the variance ascribable to experimental error, varietals effects and interaction (g x y) components and 'r' for number of replications. The presence of interaction was tested by comparing the mean squares for (g x y), i.e., interaction with the estimate of error variance by 'F' test. If it is found to be less than the table value of 'F', the interaction was not suspected. In such a case, a more precise estimate of error was obtained for testing the varietal and year differences by pooling the sum of squares for (g x y) and the error sum of squares and this was used to test the varieties over years.

The heritability values over the years were calculated from the combined analysis for the characters grouped for three years by using the standard formula given by Hansen *et. al.* (1956) and the genetic advance was calculated by using the formula given by Allard (1960).

Results and Discussion

The mean values for these fifteen different characters during the period showed that the variation between years was large for the characters such as number of canes per plot, cane weight, number of internodes, cane yield and sugar yield while the same was small for thecharacters such as cane height, cane thickness. The remaining characters were almost unchanged across years.(Table 1).

For canes per plot, Co 1148 (392.88), Co S 94270 (362.77), Co S 96260 (411.11) produced more cane population over the years. The varieties Co S 94257, Co S 92423 and Co S 88230 showed low cane population during the period. The variety Co S 94270 exhibited a uniform trend with respect to this character while other varieties showed variation.

For cane weight, five varieties, namely, Co Se 92423 (957.77 g), Co S 88230 (933.88), Co S 94257, Co S 95222 and Co S 95222 recorded significantly heavier canes. However, lowest cane weight was recorded in variety Co S 687 (611.66 g) followed by Co J 64 (618.88 g). For cane height, it was evident that variety Co S 94270 (236.66 cm) produced the tallest cane. The varieties Co S 94257, Co S 95255, Co S 88230, Co Se 92423 and Co S 96260 could be classified as significantly superior with respect to this character. Similarly Co S 687 showed the lowest cane height (202.22 cm.). Cane thickness showed that the variation for this character over the years was not high. Variety Co Se 92423 (2.12 cm), Co S 88230 and Co S 94257 may be classified as thicker cane while Co S 687 and Co J 64 can be cliassfied as thinner canes. For number of internodes per cane none of the variety was found to be significantly superior.

The data pertaining to juice brix per cent (at 8 and 12 month stages) showed that juice brix per cent at 8 month was uniform for almost all varieties over years. Significantly higher mean value for juice brix was observed in Co S 95255 (19.17) followed by Co J 64 (19.11) and Co S 687 (19.06) and lowest was recorded by Co S 95222 (16.81). The varieties, namely, Co S 96258 (23.41), Co S 687 (23.37), Co S 95255 (23.21), Co S 88230 (23.11) and Co J 64 (22.77) recorded significantly higher juice brix at 12 month-stage over the years. The lowest juice brix per cent over the years was found in Co S 95222 (21.57). The data of Juice sucrose per cent (at 8 and 12 month stages) indicated that four varieties, Co J 64, Co S 687, Co S 96258 and Co S 88230 had given significantly better juice quality at 8 month stage. The Co S 96258 (16.16) had given highest mean juice sucrose per cent at this stage. At 12 moth stage, varieties, Co S 95255 (20.27), Co S 96258 (20.08), Co S 88230 (19.65), Co S 687 (19.52) and Co S 96260 (19.37) showed significantly higher juice sucrose per cent over the years. The lowest mean juice sucrose per cent at 12 month stage was found in Co 1148 (17.67).

From the data of commercial cane sugar per cent (8 and 12 month stages), the varieties Co S 96258 (10.79) and Co S 687 (10.74) gave significantly higher CCS per cent at 8 month stage over the years. At 12 month stage, the varieties, Co S 95255 (13.91), Co S 96258 (13.68), Co S 88230 (13.33), Co S 96260 (13.16) and Co S 687 (13.12) had recorded significantly higher mean CCS per cent over the years. The lowest mean CCS per cent at this stage was found in Co 1148 (11.62). Juice extraction per cent in different varieties over the

year was almost similar at 8 and 12 month. The maximum mean juice extraction per cent at 8 month stage was observed in Co J 64 (46.39), Co S 96258 (46.34), Co S 687 (46.09), Co S 95255 (45.83) and Co S 88230 (45.82) which was significantly higher. At 12 month stage, the variety Co S 88230 (51.30) gave highest juice extraction per cent over the years followed by varieties Co S 95255 (50.58) significantly superior for this character over the years.

A perusal of the data on the mean cane yield per plot over the period of three crop years showed that Co S 94270 (212.22 kg.) followed by Co S 94257 (209.44 kg.) and Co S 96260 (205.66 kg.) had given superior cane yield than the rest of the varieties. The mean CCS yield per plot of each variety over the three years are presented in Table 1, showed that the variety Co S 96260 topped the list for this character and recorded 27.09 kg sugar yield per plot over the years followed by varieties Co S 94257 (26.25 kg), Co S 95255 (26.19 kg) and Co S 94270 (25.95 kg) which recorded significantly higher sugar yield per plot over the years. The lowest sugar yield was obtained in Co S 687 (18.62 kg) and UP 22 (20.72 kg).

The range of phenotypic coefficient of variation over the years was high for five characters namely, number of canes per plot, cane weight, commercial cane sugar per cent at 8 month stage, cane yield, and sugar yield. However, values for genotypic coefficient of variation were high for the number of canes per plot, cane yield, cane weight, commercial cane sugar at 8 month stage and for sugar yield at harvesting. Variance obtained at the phenotypic and genotypic levels are presented in Table 2.

Although variation over the years was significant in almost all the characters studied, the magnitude of variation was found to be varying for different characters. For example, the coefficient of variation was of higher magnitude for cane and sugar yields and yield components, number of canes per plot and cane weight compared to variation in other components. High phenotypic and genotypic variations for cane weight, cane yield and sugar yield were reported by Bakshi Ram (1994) and Anbanan and Saravanan (2010). Nair et. al. (1980) and Balasundarum and Bhagyalakshmi (1978) also confirmed high genotypic coefficient of variations for number of millable canes. This pattern of parallel variation may point out the importance of these components on the cane and sugar yields.

Broad sense heritability values were by and large high in all the characters studied (Table 3) . The highest heritability value was obtained for juice sucrose per cent (95.37%) and CCS per cent (95.25%) at 12 month stage followed by Juice sucrose per cent (93.40%) at 8 month and juice brix per cent (93.35%) at 12 month stage. The heritability estimates were also high for cane yield per plot (80.68%) and sugar yield per plot (81.40%). The lowest heritability values were seen for number of internodes (48.13%) and CCS per cent (56.99%) at 8 month stage. The heritability values of cane diameter and juice extraction per cent at 12 month stage were not very high. Though, high heritability values were seen for cane yield (80.68 %) and sugar yield (81.40 %) at harvesting.

Studies on the heritability estimates had earlier been reported in a number of characters in sugarcane by a number of workers and these estimates mainly were the outcomes of a single crop year data. For example, Brown *et al.* (1968) observed a low heritability value of 0.24 for sucrose per plot. Brown *et al.* (1969) observed the heritability values of 0.50 and 0.30 for brix and fibre respectively. Mariotti (1971) observed high heritability values for yield and its components but observed low values for erectness of stalk and sugar quality (sucrose per cent). In the present study also, high heritability values for cane and sugar yields were recorded over the years. Some of the quality components like juice brix per cent, juice sucrose per cent at 8 and 12 month stages, CCS per cent at 12 month stage had recorded high heritability values. The statistics on Genetic Advance expressed as a percentage of the mean was observed to be high for the characters, number of canes per plot (69.32%), cane weight (34.64%), cane yield (34.60%) and cane height (26.17%). Moderate genetic advance was observed for sugar yield. A very low degree of genetic advance was observed for juice extraction per cent at 12 month stage and cane thickness. But a year to year variation was observed for cane weight, juice brix and CCS per cent at 8 month stage. High degree of genetic advance for cane yield, number of canes per plot, cane weight, cane height and sugar yield indicated their reliability in selection (Table 3). Similar results of maximum genetic gain for millable cane number, cane weight , cane yield and sugar yield were also reported by Sahi et.al. (1977), Tyagi and Singh (1998) and Lourdusamy and Anbu Selvam (2009).

The analysis of variance for mean values carried out for fifteen characters based on year-wise data, represents environment, as well as the pooled analysis of variance. The mean squares due to treatments or varieties and error for all characters are presented in Table 4. The analysis of variance for mean values showed that mean squares due to varieties were highly significant for all most all varieties in three cropping environments (during 1998-99, 1999-2000 and 2000-01). However, values for cane thickness at environment –I and

juice brix per cent at 8 month stage at environment – II were found to be significant at 5% level of significance. The results indicated that there were differences among the varieties for all characters undertaken for study and varieties are genetically divergent. Combined analysis of variance showed that variety x environment interaction was highly significant for cane yield, cane weight, cane height, juice quality characters at both stages and CCS yield. However, interaction was found to be non-significant for number of malleable canes, cane thickness and number of internodes. The results of the analysis of variance are presented in Table 5.

It was inferred that that significant differences in the variances existed between varieties and years, whereas the block (replication) differences were non-significant. Similar absence of block effects in sugarcane was reported by Darroch (1959). The presence of interaction suggests that the different varieties studied might have responded differentially to the environmental influences over the years. A similar trend was observed for almost all characters studied except number of canes per plot, cane thickness and number of internodes. Thus, it would appear that these characters respond similar to the environmental influences over the years as against other characters.

It is concluded trhat sugarcane varieties are sensitive to environment and the influence of environments modify the phenotypic expressions of the characters to a very large extent. Different characters respond differentially to the seasonal fluctuations. Genotype selection merely based on yield is not effective for varietal upgradation. In the present statistical and genetic analysis, high heritability and genetic advance followed by consistent expression of cane and sugar yield alongwith their contributing characters number of millable canes, cane height and cane weight suggested worth of these characters as selection criteria for sugarcane varietal improvement.
Hence, in order to understand the behaviour of the cane and sugar yields and their components, inter relationship of these characters must be studied not only at the environmental and phenotypic levels, but also at the genetic levels by employing suitable biometrical techniques. It is recommended that before release of a variety it must be tested under targeted location in different seasons and highly adapted one should be released.

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Table 1: Mean performance of all varieties for 15 characters over all three environments

Varieties	No. of canes per plot	Cane yield kg/ plot	Cane weight (gm)	Cane height (cm)	Cane thickness (cm)	No. of internodes	Juice analysis at 8 month stage				Juice analysis at 12 month stage				
							Brix %	Sucrose %	CCS %	Extraction %	Brix %	Sucrose %	CCS %	Extraction %	CCS yield (kg/plot)
Co 1148	392.88	190.66	746.66	211.33	1.90	21.11	17.15	13.77	9.06	44.78	21.95	17.67	11.62	50.47	22.11
Co J 64	331.44	162.11	618.88	208.22	1.80	22.44	19.11	15.85	10.61	46.39	22.77	18.86	12.64	50.37	20.46
Co S 687	324.11	142.00	611.66	202.22	1.80	23.00	19.06	15.95	10.74	46.09	23.37	19.52	13.12	50.20	18.62
Co S 767	356.88	197.00	691.11	232.77	1.82	23.55	17.80	13.77	8.87	44.93	22.45	18.67	12.52	49.75	24.61
Co S 88230	285.55	191.66	933.88	223.33	2.07	21.22	18.66	15.47	10.41	45.82	23.11	19.65	13.33	51.30	25.44
Co S 93278	319.66	190.00	753.88	210.88	1.88	22.22	17.52	13.90	9.20	44.92	22.05	18.61	12.58	49.22	23.84
Co S 94257	291.00	209.44	917.77	233.44	2.02	21.66	17.53	13.83	9.01	45.59	22.29	18.66	12.57	50.28	26.25
Co S 94270	362.77	212.22	750.55	236.66	1.91	24.22	17.24	13.81	9.53	45.10	22.06	18.27	12.22	50.05	25.95
Co S 95222	356.22	202.22	905.00	222.77	1.99	24.22	16.81	13.15	8.82	44.80	21.57	17.88	11.97	49.85	24.21
Co S 95255	318.10	188.33	833.33	233.88	1.91	23.11	19.17	15.42	10.28	45.83	23.21	20.27	13.91	50.58	26.19
Co S 96258	337.55	177.11	638.88	191.77	1.93	22.22	18.99	16.16	10.79	46.34	23.41	20.08	13.68	49.92	24.24
Co S 96260	411.11	205.66	753.88	229.44	1.86	24.33	18.73	15.15	10.04	45.67	22.69	19.37	13.16	50.48	27.09
Co Se 92423	290.66	196.77	957.77	231.55	2.12	22.44	17.28	14.08	10.46	44.14	21.82	18.67	12.71	49.57	24.94
UP 22	310.77	171.77	668.88	219.00	1.83	21.00	17.74	14.55	9.69	44.42	21.91	18.07	12.07	49.52	20.72
GM	334.90	188.35	770.15	220.52	1.92	22.62	18.05	14.63	9.82	45.34	22.48	18.87	12.72	50.11	23.90
CD (5%)	26.11	15.35	59.59	8.02	0.08*	1.73	0.38	0.44	0.95	0.52	0.27	0.29	0.24	0.44	1.94
CV %	4.64	4.85	4.61	2.16	2.57	4.56	1.28	1.79	5.81	0.68	0.72	0.92	1.14	0.53	4.85

Table 2: Estimation of phenotypic (PCV) and genotypic (GCV) coefficient of variation for fifteen characters.

Name of character	I year		II year		III year		Pooled	
	PCV	GCV	PCV	GCV	PCV	GCV	PCV	GCV
Number of canes per plot	14.45	12.39	15.75	12.25	9.52	7.99	11.86	10.92
Cane yield per plot (kg)	11.44	8.95	13.72	10.96	14.71	12.54	11.05	9.92
Cane weight (gm)	17.90	17.10	16.06	13.15	18.57	18.17	16.10	15.43
Cane height (cm)	88.70	6.96	11.55	10.18	6.93	6.50	6.48	6.11
Cane thickness (cm)	8.66	5.43	7.19	4.96	6.58	5.60	5.61	4.99
Number of Internodes	10.93	5.53	10.80	5.42	6.82	4.52	6.33	4.39
8 month stage								
Juice brix per cent	6.42	6.13	4.60	2.89	5.63	5.23	4.82	4.65
Juice sucrose per cent	7.88	7.15	6.77	4.78	8.95	8.77	6.98	6.75
CCS per cent	17.37	8.36	7.57	3.25	11.45	11.26	8.86	6.69
Juice extraction per cent	2.12	1.84	2.01	1.56	2.18	1.74	1.66	1.51
12 month stage								
Juice brix per cent	3.40	3.10	3.23	2.79	3.08	2.66	2.81	2.72
Juice sucrose per cent	4.99	4.69	5.00	4.58	4.05	3.77	4.29	4.19
CCS per cent	6.17	5.77	6.18	5.60	5.31	5.01	5.24	5.12
Juice extraction per cent	1.45	1.07	1.59	1.23	1.53	1.03	1.14	1.01
CCS yield per plot (kg)	12.62	10.06	13.67	10.77	15.07	12.89	11.24	10.14

Table 3: Estimation of heritability (h^2) and genetic advance (GA) for fifteen characters.

Name of character	Heritability				Genetic advance			
	Ist Year	IInd Year	IIIrd Year	Pooled	Ist Year	IInd Year	IIIrd Year	Pooled
Number of canes per plot	73.55	60.55	70.33	84.66	74.35	62.20	48.13	69.32
Cane yield per plot (kg)	61.18	63.82	72.69	80.68	29.17	29.71	43.68	34.60
Cane weight (gm)	91.24	67.11	95.76	91.80	28.28	37.02	31.02	34.64
Cane height (cm)	61.60	77.67	88.04	88.82	28.22	34.10	24.47	26.17
Cane thickness (cm)	39.31	47.63	72.52	78.95	0.13	0.13	0.18	0.17
Number of internodes	25.57	25.22	43.98	48.13	1.38	1.08	1.52	1.42
8 months stage								
Juice brix per cent	90.98	39.45	86.28	92.93	2.20	0.67	1.79	1.66
Juice sucrose per cent	82.25	49.90	96.05	93.40	1.98	1.03	2.50	1.96
CCS per cent	23.17	18.44	96.73	56.99	0.85	0.28	2.09	1.02
Juice extraction per cent	72.03	60.21	63.32	83.00	1.47	1.14	1.27	1.29
12 months stage								
Juice brix per cent	82.73	75.00	74.80	93.35	1.27	1.10	1.10	1.21
Juice sucrose per cent	88.15	84.11	86.77	95.37	1.70	1.66	1.35	1.59
CCS per cent	87.53	82.14	89.20	95.25	1.42	1.37	1.19	1.31
Juice extraction per cent	54.85	60.05	44.84	78.87	0.81	0.97	0.73	0.93
CCS yield per plot (kg)	63.62	62.13	73.15	81.40	4.27	3.77	5.52	4.50

Table 4: Analysis of variance of mean data for fifteen characters in three environments and pooled analysis.

Character	Mean square in Environment –I		Mean square in Environment –II		Mean square in Environment –III		Pooled mean square	
	Treatment (d.f. 13)	Error (d.f. 26)	Treatment (d.f. 13)	Error (d.f. 26)	Treatment (d.f. 13)	Error (d.f. 26)	Treatment (d.f. 13)	Error (d.f. 26)
Number of canes per plot	5950.39**	636.90	5498.34**	980.99	2656.26**	327.38	4255.31**	242.20
Cane yield (kg)	1191.22**	207.92	1162.56**	184.74	2088.34**	232.39	1133.07**	83.75
Cane weight (gm)	64615.44**	2001.60	23009.51**	3230.98	72470.67**	1053.91	43655.95**	1260.81
Cane height (cm)	1103.68**	189.81	1159.73**	101.39	680.44**	29.44	568.30**	22.88
Cane thickness (cm)	0.051*	0.017	0.036**	0.0096	0.039**	0.0044	0.0301**	0.0025
Number of internodes	10.43**	5.13	6.52**	3.24	5.29**	1.57	4.03**	1.06
8 month stage								
Juice brix per cent	3.89**	0.124	1.22*	0.415	2.78**	0.140	2.17**	0.054
Juice sucrose per cent	3.64**	0.244	2.04**	0.511	4.66**	0.629	2.99**	0.069
CCS per cent	4.66**	2.44	0.787**	0.469	3.24**	0.361	1.62**	0.326
Juice extraction per cent	2.39**	0.274	1.86**	0.337	2.17**	0.352	1.52**	0.097
12 month stage								
Juice brix per cent	1.49**	0.971	1.28*	0.128	1.28**	0.129	1.15**	0.026
Juice sucrose per cent	2.44**	0.104	2.46**	0.146	1.56**	0.076	1.91**	0.030
CCS per cent	1.71**	0.776	1.73**	0.117	1.18**	0.046	1.29**	0.021
Juice extraction per cent	1.08**	0.232	1.36**	0.246	1.20**	0.349	0.846*	0.071
CCS yield per plot (kg)	24.20**	3.87	19.48**	3.28	33.08**	3.60	19.00**	1.34

Table 5: Combined analysis of variance for fifteen characters

Source of variation	Varieties		Environments		Rep. in environment		Var. x Env		Error
	MSS (d.f. 13)	Comp. FV	MSS (d.f. 2)	Comp. FV	MSS (d.f. 14)	Comp. FV	MSS (d.f. 26)	Comp. FV	MSS (d.f. 70)
Number of canes per plot	12765.92	19.07**	11502.50	17.18**	932.04	1.39	669.29	0.926	722.61
Cane yield per plot (kg)	3399.11	6.51**	17841.25	34.21**	448.49	0.860	521.48	2.24**	232.17
Cane weight (gm)	130968.6	8.99**	737712.0	50.65**	2677.30	0.183	14563.18	6.23**	2335.12
Cane height (cm)	1704.96	2.75*	47100.75	76.04**	53.46	0.086	619.41	5.20**	119.11
Cane thickness (cm)	0.090	4.96**	0.053	2.94	0.0018	0.103	0.018	1.55	0.01
Number of internodes	12.09	2.38*	360.12	70.95**	1.93	0.381	5.07	1.37	3.69
8 months stage									
Juice brix per cent	6.51	9.38**	1.42	2.05	0.273	0.393	0.694	2.74**	0.252
Juice sucrose per cent	8.99	13.23**	8.52	12.55**	0.155	0.228	0.679	2.23**	0.304
CCS per cent	4.87	2.54*	13.49	7.04**	0.354	0.185	1.91	1.74*	1.09
Juice extraction per cent	4.55	4.83**	11.36	12.05**	1.47	1.56	0.943	2.64**	0.356
12 months stage									
Juice brix per cent	3.45	11.28**	18.35	60.02**	0.103	0.339	0.305	2.31**	0.131
Juice sucrose per cent	5.74	15.84**	3.03	8.37**	0.071	0.198	0.362	2.99**	0.120
CCS per cent	3.88	10.38**	7.54	20.16**	0.045	0.120	0.374	4.18**	0.089
Juice extraction per cent	2.54	4.59**	86.82	156.70**	0.256	0.462	0.554	1.81*	0.305
CCS yield per plot (kg)	57.00	5.76	199.83	20.21**	7.44	0.753	9.88	2.47**	4.00