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RESEARCH ARTICLE

Seasonal impact on biomass, juice quality and sugar attributes of sweet sorghum

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Abstract

The seasonal impact studies on biomass, juice and sugar quality was carried out during kharif (rainy) season, 2011 (June-October) and rabi (post rainy) season, 2011 (October-January). Eighteen sweet sorghum genotypes with two national checks were evaluated for different juice and sugar parameters in three replications. In kharif season, maximum juice yield, total sugars, ^{o}brix, and calculated ethanol yield were recorded in the genotypes SPH 1669, SPH 1670, SPV 2136 and SPV 2074, while same genotypes were evaluated in rabi season, the results revealed that the genotypes SPV 2069, SPV 2133 and SPV 2076 gave maximum juice yield. From this the genotypes SPV 2074 and SPH 1669 gave better juice yield, ^{o}brix and calculated ethanol yields from both the season.

Keywords: Juice quality, sweet sorghum, ethanol, sucrose, cane yield, ^{o}brix, seasonal impact.

Introduction

Sweet sorghum for getting good juice and biomass should be planting in kharif (rainy) season. It is four months crop; relatively photoperiod sensitive and also grown tall in kharif and adopt poorly in winter or rabi (post rainy) season as compare to kharif. But for continuous supply of feed stalk of sweet sorghum to the industries is one major constraint in ethanol production from sweet sorghum. To encourage the distilleries to make sweet sorghum, a major raw material in addition to sugarcane molasses for ethanol production is one of the main tasks under sweet sorghum seasonal study. Also in Kharif season of sweet sorghum, grain formation is not occurred or very less, because of high biomass formation. So for, seed requirement to sowing the sweet sorghum in all three seasons, rabi season is most important for seed production. Sweet sorghum has a great potential as an energy crop (Woods, 2001). It belongs to C4 family with a high photosynthetic activity and drought tolerance; therefore it can be cultivated in all temperature and tropical climate areas. This plant requires less fertilizers and water as compared to other crops particularly sugarcane. Sweet sorghum having the capacity of producing high green biomass 70-80% which contains maximum juice content with good ^{o}brix (Anonymous, 2002a; b). Sweet sorghum is grown normally for a period of 120 d. Sugar accumulation starts at flowering stage and peaks at physiological maturity stage (Ratnavati, 2010). Sweet sorghum juice mostly contains sucrose, glucose and fructose which are fermentable sugars which convert sweet sorghum juice into ethanol (Anderson, 2005). Sweet sorghum is one of the potential materials for production of ethanol. Sweet sorghum crop can be grown on a low fertility soil with residual moisture where sugarcane cultivation is difficult. Hence, production of alcohol from sweet sorghum juice may be profitable (Anderson, 2005).

Sweet sorghum is best suited for ethanol production because of its higher total sugar content and high biomass (Huligol *et al.,* 2004). As sweet sorghum genotypes exhibit wide variability in juice quality and extractability (Balaravi *et al.,* 1997), sweet sorghum improvement is needed for increasing the biomass, juice yield, ^{o}brix, total sugars and grain yield with different maturity backgrounds and efforts are also underway to develop sweet sorghum cultivars for rabi (post rainy season) adaptation with stay green trait, which contribute to increase harvest window. So in this study we have planted sweet sorghum in two different season in kharif and rabi with same genotypes to see the seasonal impact on sweet sorghum biomass, juice yield, ^{o}brix, total sugars and ultimately on ethanol yield.

Materials and methods

Crop types and season: Eighteen sweet sorghum genotypes with two checks were sown in the month of June 2011 in kharif season (rainy) and in October 2011 in rabi season (post rainy) at Sorghum Improvement Project, MPKV, Rahuri in three replications and harvested at physiological maturity i.e. about 110-125 d and evaluated for different juice and sugar parameters.

Experimental design and sugar estimation: Ten random plants having equal height and biomass from the net plot in triplicate were selected carefully. Total fresh cane weight after removing leaves and ear heads from the cane was recorded with the help of electronic balance and cane yield per hectare was calculated with hectare factor. These defoliated canes were crushed in three roller crusher and juice yield was measured with measuring cylinder and further calculated as juice yield L/ha with the help of net plot plant stand and hectare factor. The ^{o}brix was measured with the help of hand refractometer.

Table 1. Yield and juice quality parameters of sweet sorghum genotypes (IASSVHT, Kharif, 2011).

S. No	Name of the genotype	Fresh cane wt. (t/ha)	Juice yield (L/ha)	^{0}Brix	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	C.C.S (t/ha)	Ethanol yield (L/ha)
1.	SPSSV 39	38.3	9394	19.3	1.59	9.2	10.79	2.39	540
2.	SPSSV 40	37.7	8046	19.3	1.52	9.9	11.5	2.73	493
3.	SPV 2068	46.3	8987	18.7	1.60	10.6	12.2	3.83	584
4.	SPV 2069	32.3	6575	20.0	1.84	10.8	12.6	2.62	443
5.	SPV 2075	44.7	9666	19.7	1.65	10.4	12.0	3.41	622
6.	SPV 2076	46.3	8798	18.3	1.51	10.0	11.5	3.52	533
7.	SPH 1669	43.0	11367	20.0	1.73	11.2	12.9	3.65	785
8.	SPH 1670	45.0	10413	19.0	1.65	10.7	12.3	3.73	689
9.	SPH 1711	31.3	6957	20.3	1.47	10.0	11.5	2.18	426
10.	SPH 1712	36.3	8067	18.7	1.77	10.4	12.1	2.86	518
11.	SPH 1713	36.0	7434	19.0	1.40	10.4	11.8	2.84	469
12.	SPV 2070	26.3	6967	20.0	1.75	9.7	11.5	1.78	637
13.	SPV 2074	46.7	10332	18.7	1.79	9.9	11.7	3.41	644
14.	SPV 2133	25.3	5887	19.0	1.35	10.2	11.5	1.87	358
15.	SPV 2134	41.0	9280	20.0	1.68	11.0	12.7	3.44	629
16.	SPV 2135	37.3	8138	20.3	1.89	10.6	12.5	2.93	550
17.	SPV 2136	49.7	11263	19.7	1.73	9.5	11.3	3.25	672
18.	SPV 2137	28.0	5600	19.7	1.61	10.9	12.5	2.30	373
19.	CSV 19SS	41.3	8974	19.0	1.51	10.3	11.8	3.50	568
20.	CSH 22 SS	45.7	9918	18.7	1.39	9.8	11.2	3.16	578
Mean		38.9	8603	19.4	1.62	10.3	11.9	2.97	555
S.E ±		3.23	9.41	0.67	0.15	0.47	0.43	0.36	77
C.D at 5%		9.7	2824	2.0	0.46	1.4	1.3	1.07	230

The total sugar content in the juice were estimated by Phenol sulphuric method (Dubois *et al.,* 1956) and reducing sugars were estimated by 3,5 DNS (Miller, 1959). The calculated ethanol was estimated by Smith *et al.* (1987). The commercial cane sugar (CCS) level was estimated using following formula:

CCS% = [S-0.4 (B-S) x 0.74]

Where, S= Sucrose% in juice, B = Corrected ^{o}brix; CCS t/ha= Cane yield t/ha x CCS %/100.

Results and discussion

Under Kharif study of sweet sorghum genotypes in the Initial cum Advanced Sweet Sorghum Varietal and Hybrid Trial (IASSVHT) in 2011, the maximum fresh cane weight tons/ha was obtained in SPV 2136 with 49.7 tons/ha followed by SPV 2074 with 46.7 tons /ha, while maximum juice yield was recorded in SPH 1669 with 11367 L/ha followed by SPV 2136 with 11263 L/ha and mean juice yield L/ha is 8603 L/ha at physiological maturity stage of the crop. The ^{o}brix recorded highest in genotype SPV 2135 with 20.3, followed by SPH 1669 with 20 and superior over national check CSV 19 SS and CSH 22SS in Kharif season. The lowest reducing sugar was observed in SPV 2133 (1.35%) while highest reducing sugar was recorded in SPV 2135 (1.89%). The total sugar content of the juice was higher in SPH 1669 (12.9%), SPV 2134 (12.7%) which were superior over the national checks.

The calculated ethanol yield was recorded highest in SPH 1669 with 785 L/ha followed by SPH 1670 with 689 L/ha and lowest ethanol yield was recorded in SPV 2133 with 358 L/ha (Table 1; Figs. 1-4). From these results it was concluded that the genotypes which having higher juice yield and maximum total sugars gives ultimately higher ethanol yield. So the genotypes SPH 1669, SPH 1670, SPV 2074 and SPV 2136 were found better for juice and sugar quality parameters as compare to national checks in Kharif season. Same genotypes were evaluated for juice yield and sugar parameters in rabi season, 2011 under Initial cum Advanced Sweet Sorghum Varietal and Hybrid Trial (IASSVHT) for getting the seasonal impact on these genotypes in relation to juice quality attributes of sweet sorghum. This study revealed that maximum fresh cane weight tons/ha was recorded in SPV 2133 with 28.3 tons/ha followed by SPV 2069 with 26.3 tons/ha, while maximum juice yield was recorded in SPV 2133 with 4994 L/ha followed by SPV 2069 with 4869 L/ha with mean juice yield of 3625 L/ha and superior over national checks. The total sugars was maximum in SPV 2075 (11.40%) and lowest in SPSSV 39 (9.93%). The calculated ethanol yield was highest in SPV 2133 with 270 L/ha and in SPV 2069 with 269 L/ha with mean value 201 L/ha in rabi season (Table 2; Figs. 1-4) From these results it was concluded that genotypes SPV 2133, SPV 2069 SPV 2133 and SPH 1669 were found better for juice quality and sugar parameters in rabi season.

Table 2. Yield and juice quality parameters of sweet sorghum genotypes (IASSVHT, Rabi, 2011).

S. No.	Name of the genotype	Fresh cane wt. (t/ha)	Juice yield (L/ha)	^{0}Brix	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	C.C.S. (t/ha)	Ethanol yield (L/ha)
1.	SPSSV 39	22.3	3426	12.7	1.77	8.17	9.93	1.26	182
2.	SPSSV 40	16.0	2703	11.0	2.48	7.88	10.37	0.94	150
3.	SPV 2068	22.3	3851	11.7	2.06	7.94	10.01	1.27	205
4.	SPV 2069	26.3	4869	11.3	2.01	8.39	10.41	1.65	269
5.	SPV 2075	23.7	3628	15.0	2.21	9.19	11.40	1.39	220
6.	SPV 2076	24.3	3998	13.3	1.96	8.80	10.76	1.28	233
7.	SPH 1669	19.7	3387	13.3	2.15	8.43	10.58	1.10	192
8.	SPH 1670	20.0	3090	12.3	2.22	8.05	10.27	1.11	169
9.	SPH 1711	20.0	3779	10.3	1.97	8.06	10.03	1.27	202
10.	SPH 1712	14.0	2737	11.3	2.213	8.43	10.66	0.90	156
11.	SPH 1713	16.7	3678	11.7	2.02	8.12	10.13	0.97	198
12.	SPV 2070	17.7	3971	11.3	2.48	8.39	10.87	1.12	231
13.	SPV 2074	21.0	3978	13.3	2.39	8.11	10.50	1.09	222
14.	SPV 2133	28.3	4994	14.3	2.08	8.08	10.16	1.31	270
15.	SPV 2134	20.0	3251	12.7	2.05	8.04	10.09	1.04	175
16.	SPV 2135	18.3	2942	12.0	2.21	8.23	10.44	1.10	165
17.	SPV 2136	20.0	3264	12.7	1.89	8.78	10.67	1.26	186
18.	SPV 2137	18.0	3144	11.7	2.33	7.90	10.23	1.04	197
19.	CSV 19SS	23.7	4552	14.7	1.96	8.25	10.21	1.16	248
20.	CSH 22 SS	19.7	3250	11.7	2.15	8.25	10.40	1.18	180
Mean		20.6	3625	12.4	2.13	8.28	10.41	1.17	201
S.E ±		1.97	316	0.57	0.16	0.41	0.37	0.16	22
C.D at 5 %		5.9	949	1.7	0.47	1.24	1.10	0.48	65

Table 3. Percent increase over of kharif over rabi season on cane yield, juice yield and ethanol yield.

S. No	Genotype	Fresh cane wt. (%)	Juice yield (%)	Ethanol yield (%)
1	SPSSV 39	41.78	63.53	66.30
2	SPSSV 40	57.56	66.41	69.57
3	SPV 2068	51.84	57.15	64.90
4	SPV 2069	18.58	25.95	39.28
5	SPV 2075	46.98	62.47	64.63
6	SPV 2076	47.52	54.56	56.29
7	SPH 1669	54.19	70.20	75.54
8	SPH 1670	55.56	70.33	75.47
9	SPH 1711	36.10	45.68	52.58
10	SPH 1712	61.43	66.07	69.88
11	SPH 1713	53.61	50.52	57.78
12	SPV 2070	32.70	43.00	63.74
13	SPV 2074	55.03	61.50	65.53
14	SPV 2133	11.86	15.17	24.58
15	SPV 2134	51.22	64.97	72.18
16	SPV 2135	50.94	63.85	70.00
17	SPV 2136	59.76	71.02	72.32
18	SPV 2137	35.71	43.86	47.18
19	CSV 19SS	42.62	49.28	56.34
20	CSH 22 SS	56.89	67.23	68.86

Fig. 1. Effects of season on fresh cane yield (S. No. 1-20, sweet sorghum genotypes).

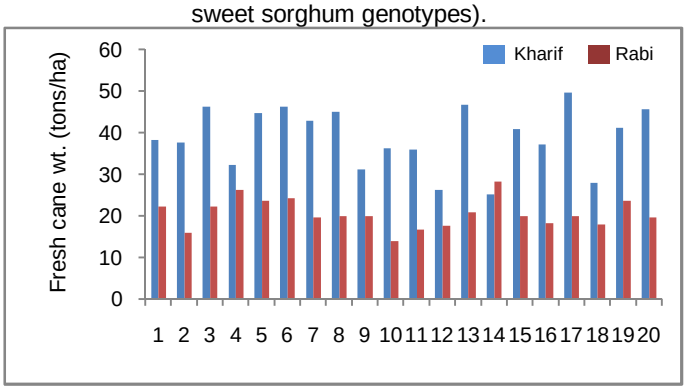


Fig. 2. Effect of season on °brix (S. No. 1-20, sweet sorghum genotypes).

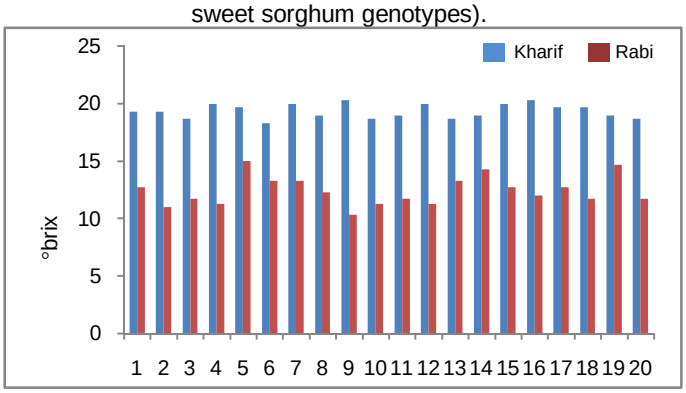


Fig. 3. Effect of season on total sugars (S. No. 1-20, sweet sorghum genotypes).

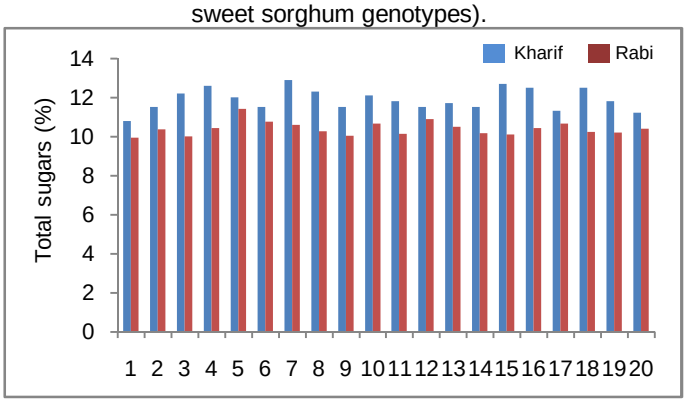
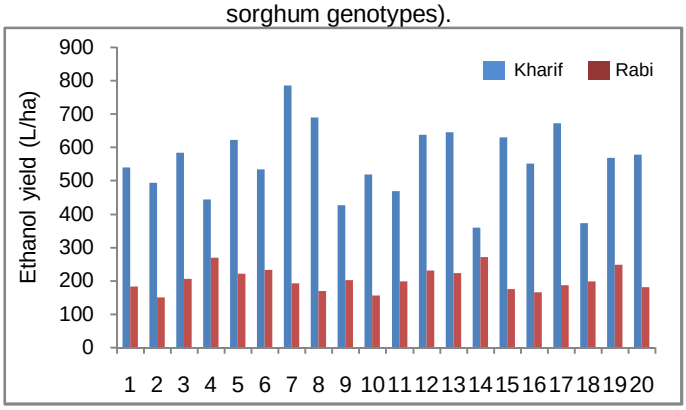


Fig. 4. Effect of season on ethanol yield (S. No 1-20, sweet sorghum genotypes).



So, the seasonal study of sweet sorghum revealed that the genotypes SPV 2074 and SPH 1669 gave good results in subject to juice and sugar quality attributes in both season, Seasonal impact revealed that about 40-55% loss in fresh cane weight, 50-60% loss in juice yield and about 50-70% loss in ethanol yield recorded in rabi season (Table 3).

Conclusion

The seasonal impact studies on biomass, juice and sugar quality was carried out with eighteen sweet sorghum genotypes with two national checks in three replications. In kharif season, maximum juice yield, total sugars, °brix, and yield were recorded in the genotypes SPH 1669, SPH 1670, SPV 2136 and SPV 2074, while same genotypes were evaluated in rabi season, the results revealed that the genotypes SPV 2069, SPV 2133 and SPV 2076 gave maximum juice yield. From this the genotypes SPV 2074 and SPH 1669 gave better juice yield, °brix and calculated ethanol yields from both the season.

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