The Pharma Innovation Journal 2020; 9(11): 218-221

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2020; 9(11): 218-221

www.thepharmajournal.com
Received: 25-07-2020
Accepted: 05-09-2020

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Stability analysis of sweet sorghum genotypes over the season [*Sorghum bicolor* (L.) moench]

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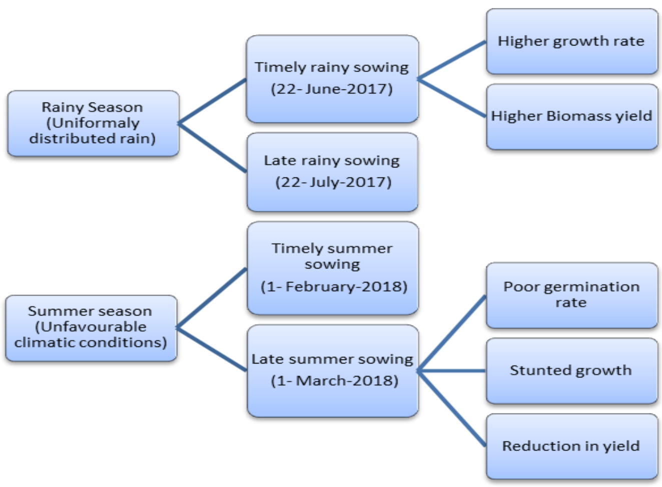
Abstract
An experiment was conducted to study green cane yield stability and adaptability involving twenty three sweet sorghum genotypes and one hybrid in four contrasting sowing dates. The objective of the research is to analyze genotype-environment interaction (GxE) on multi-seasonal data for the green cane yield (t/ha) parameter of sweet sorghum. Therefore, stability analysis was carried out by Eberhart and Russell 1966 model to identify stable genotypes for green cane yield which is great in demand by distilleries. From the comparative ranking of the environment, it was clear that the June sowing date showed positive environmental indicators for green cane yield (t ha^{-1}). Whereas, July, February and March sowing dates showed negative environmental indicators, suggesting that the environment is unfavorable for this trait. Based on the stability analysis, the genetic standard the genotype CSSV-19SS, RSSV-545, RSSV-430 shown average stable performance whereas, RSSV-260, hybrid RSSH-50 showed unstable performance for different environments.



Keywords: Sweet sorghum, Sowing date, Green cane yield, Genotype x Environment interaction

Introduction
Sweet sorghum is similar to grain sorghum, but it can be distinguished from fodder sorghum by high biomass and high sugar content in the stalk tissue, which is easily fermented to produce ethanol. Sweet sorghum has properties that make it a viable source of bioethanol production, *i.e.*, i) less water and fertilizer requirements Almodaresand Hatamipour[1] ii) short life cycle Mathur *et al.*[2] iii) potential to be an eco-friendly to nature Qi Xie and Zhihong Xu[3] v) provide food: for human and feed for livestock with clean fuel for cooking. In short, sweet sorghum is considered to be one of the best alternative source for biofuel production, to achieve targeted bioethanol production there is a continuous demand of feedstock to distilleries all year round in India. Sweet sorghum is usually planted during the rainy season to get good juice and bio-yield, but it's habituated poorly to post rainy and summer season. This means that the genes that work best during the rainy season are not necessary the best performers in the post rainy or summer season. However the environment specific genotypes need to be study through the genetic testing under a variety of climatic conditions which would helpful to recommend well balanced genotypes over the seasons.

Materials and Methods

The twenty three sweet sorghum genotypes and one hybrid were grown at All India Coordinated Sorghum Improvement Project, Rahuri, Maharashtra. Total four sowing dates were used to mark mean calculations: i) timely rainy- 22nd June 2017 ii) late rainy- 22nd July 2017 iii) timely summer- 1st February 2018 iv) late summer- 1st March 2018. The experiment was carried out in Randomized Block Design with two replications. The gross and net plot size were 3.90 x 3.0 m and 3.60 x 1.80 m, respectively, with spacing 60 x 15 cm and the recommended dose of fertilizer was 100:50:50 NPK kg/ha applied to the soil. The half dose of nitrogen and full dose of phosphorous and potash was given at the time of sowing. The remaining half dose of nitrogen was applied at 35 days after sowing.

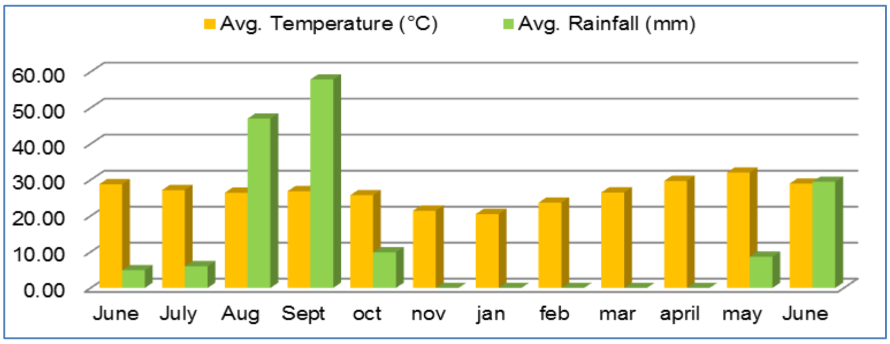


Fig. 1: Weather data during the experimental period from June 2017 to June 2018

The three plants in each plot were randomly selected in a net plot area and tagged for recording of green cane yield parameter. The experimental data were analyzed using Eberhart and Russell,[4] model based on these stability parameters, regression coefficient (S^2di), mean performance ($\bar{x}$) and linear response (bi).

Results and Discussion

Effect of different four sowing dates on green cane yield (t ha^{-1}): The cane yield is an associated trait of biomass component in sweet sorghum. From the results, the grand mean of green cane yield (t ha^{-1}) was recorded highest in the month of June sowing date (43.42 t ha^{-1}) followed by July (39.06 t ha^{-1}) due to uniformly distributed rain (497.80 mm) and favorable climatic conditions prevailing during the growth period. These findings corroborated with the results of Ratnavathi *et al.*[5] who reported higher green cane yield in June planting followed by February and December. Environmental conditions influence the performance of sweet sorghum, especially in summer season in which crop failed to reach its maximum potential due to unfavorable climatic conditions. So; the lowest mean green cane yield (t ha^{-1}) was (22.63 t ha^{-1}) recorded in March sowing date followed by February.

Table 1: Effect of sowing dates on green cane yield (t ha^{-1}) at physiological maturity

Sr. No.	Genotypes	Green cane yield (t ha^{-1})			
		Timely rainy	Late rainy	Timely summer	Late summer
1.	RSSV 350	37.94	33.44	26.06	25.45
2.	RSSV 494	45.71	41.46	14.68	13.54
3.	RSSV 493	42.49	38.31	20.26	19.20
4.	RSSV 313	43.11	38.61	22.41	21.31
5.	RSSV 495	31.81	27.18	12.41	10.89
6.	RSSV 355	37.22	32.92	19.33	17.91
7.	RSSV 503	35.61	31.24	21.35	19.98
8.	RSSV 386	40.09	35.65	29.09	28.67
9.	RSSV 540	45.31	41.26	26.15	24.86
10	RSSV 542	31.86	27.49	25.24	23.85
11.	RSSV 466	35.38	31.13	30.63	28.33
12.	RSSV 454	38.64	34.27	31.78	28.16
13.	RSSV 499	27.83	23.27	21.11	19.65
14.	RSSV 453	36.92	32.68	28.94	26.72
15.	RSSV 545	42.39	38.09	30.45	28.81
16.	SPV 2057	33.79	29.16	27.56	25.40
17.	RSSV 260	71.12	66.55	23.03	21.63
18.	RSSV 269	61.35	57.04	29.34	27.13
19.	RSSV 512	53.07	48.89	16.31	14.98
20.	RSSV 430	48.70	44.07	24.48	23.20
21.	SSV 84 (C)	37.08	32.71	28.09	24.31
22.	CSV 19SS (C)	54.51	50.33	32.84	30.26
23.	RSSH 50 (C)	72.62	68.25	20.41	19.89
24.	AKSSV 22SS (C)	37.61	33.37	19.65	19.07
	Grand Mean	43.42	39.06	24.23	22.63
	S.E. ±	4.66	3.41	2.46	2.12
	CD at 5%	13.61	9.86	7.38	3.36

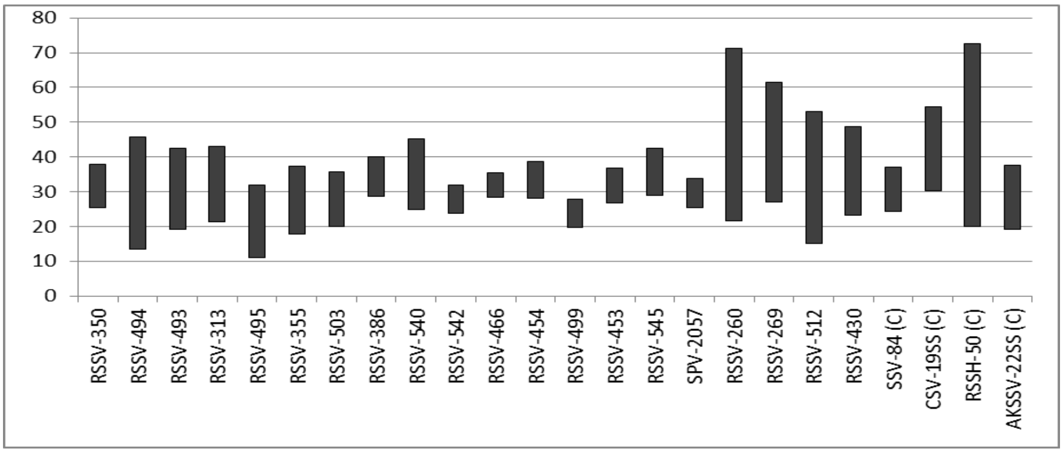


Fig. 2: Genotype x Environment interaction in green cane yield (t ha-1) at physiological maturity

Table 2: Estimate of environmental index for green cane yield character under different environment

Sr.No.	Characters	Environmental index			
		June	July	Feb	March
1.	Green cane yield (t ha^{-1})	35.72	-1.49	-16.31	-17.91

Table 3: Pooled analysis of variance for green cane yield of sweet sorghum genotypes

Source	Df	Green cane yield (t ha^{-1})
Varieties	23	162.57^{**++}
Env.+ (Var.* Env.)	72	677.69^{**++}
Environments	3	14926.89^{**++}
Var.* Env.	69	58.16^{**++}
Environments (Lin.)	1	44780.69^{**++}
Var.* Env.(Lin.)	23	104.68^{**++}
Pooled Deviation	48	33.44^{**++}
Pooled Error	92	20.74^{**++}
Total	95	552.97^{**++}

$^{*,\,**}$Significance at P=0.05 and 0.01, respectively when tested against pooled deviation

$^{+,\,++}$Significance at P=0.05 and 0.01, respectively when tested GxE

Analysis of variance for stability: The pooled analysis of variance for green cane yield parameter showed highly significant differences among the genotypes and environments.

Table 4: Estimate of stability of sweet sorghum genotypes for green cane yield (t ha^{-1}) for different environment

Sr. No.	Genotypes	Green cane yield (t ha^{-1})		
		$\bar{X}$	Bi	S^2di
1.	RSSV 350	37.15	0.72*	-22.63
2.	RSSV 494	37.82	1.27	-6.66
3.	RSSV 493	40.38	1.21*	-27.09
4.	RSSV 313	39.45	1.01	-26.97
5.	RSSV 495	27.22	0.88*	-26.25
6.	RSSV 355	34.83	0.96*	-27.17
7.	RSSV 503	36.53	1.00	-17.70
8.	RSSV 386	41.70	0.85	-11.78
9.	RSSV 540	44.86	1.17*	-24.95
10	RSSV 542	35.06	0.75	0.52
11.	RSSV 466	42.40	0.96	37.43
12.	RSSV 454	42.04	0.81	4.30
13.	RSSV 499	29.63	0.65	-7.85
14.	RSSV 453	39.77	0.82	-4.12
15.	RSSV 545	44.70	0.99	-9.67
16.	SPV 2057	35.51	0.64	-7.55
17.	RSSV 260	50.02	1.24	198.28**
18.	RSSV 269	50.30	1.12	19.88
19.	RSSV 512	41.88	1.35	27.23
20.	RSSV 430	42.45	1.02	-20.69
21.	SSV 84 (C)	38.41	0.81	-12.25
22.	CSV 19SS (C)	49.71	1.05	-24.16
23.	RSSH 50 (C)	53.98	1.63	160.07**
24.	AKSSV 22SS (C)	37.31	1.10	-23.43
	Population Mean	40.55	1.00	-
	S.E. ±	3.33	0.13	-

Conclusion

As per (Eberhart and Russell 1966) model the selection of ideal genotypes is based on high mean performance, regression coefficient (bi) nearer to unity and deviation from regression (S^2di) as small as possible or zero. From the relative ranking of the environment (table 2) as evident from additive environment it is observed that June sowing date shown positive environmental indices for green cane yield (t ha^{-1}) and July, February and March sowing dates showed negative environmental indices suggesting that environment was unfavorable for this trait. The findings supports to several researchers like Madhusudhana *et al.*[6], Muppidathi *et al.*[7] and Narkhede *et al.*[8] and Kishore and Singh[9]. Based on stability parameters, among the 23 sweet sorghum genotypes and one hybrid the genotype CSSV-19SS, RSSV-545, RSSV-430 shown average stable performance and RSSV-260, hybrid RSSH-50 showed unstable performance for different environments. The recommendation derived from this study is, the June is the most appropriate and suitable sowing time for sweet sorghum cultivation to get maximum green cane yield which result in maximum bioethanol production as compared to July, February and March sowing dates and CSV-19SS is a promising genotype for rainy as well as summer season sowings. Therefore, this research would helpful to reduce high fluctuations of bioethanol production in semi-arid India.

Conflict of Interest

No conflict of interest declared

Funding

This work was financially supported by grants from the All-India Coordinated Research Project on Sorghum (AICRP), at Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India.

Acknowledgment

The authors would like to thank Department of Agricultural Botany, Mahatma Phule Krishi Vidyapeeth Rahuri, Maharashtra, India for technical support.

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