Optimizing Seed Rates and Effects of Direct and Indirect Selection Indices in Sugarcane Crop

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ABSTRACT

Background: Under current scenario of High cost of Production of Sugarcane crop, it is need of time to decide specific seed rate for individual varieties. Sugarcane seed contributes to 10-20% of cost of production and farmers invests about Rs. 20000/- per acre on planting material. The costs of seed can be curtailed by optimizing seed rate. Similarly, seed rate varies with different varieties. In this view, a field experiment was carried out to optimize the seed rate of promising sugarcane clones.

Methods: A field experiment was carried using randomized complete block design with factorial arrangements having three replications at Sugarcane Research Institute, Faisalabad during 2016-17 and 2017-18.

Result: The results revealed that maximum cane diameter was recorded for S2008-AUS-133 at seed rate of 25000 and 50000 triple budded setts/ha. However; maximum number of canes/ha were recorded for S2008-AUS-133 at seed rate of 75000 setts/ha followed by HSF-240 at 75000 setts/ha. Maximum cane yield was noted for HSF-240 at seed rate of 75000 followed by S2008-AUS-133 at seed rate of 50000 and lowest can yield was recorded in S2003-US-127 at seed rate of 25000 triple budded setts/ha. Genotypic and phenotypic variances were higher for plant height (381.63, 133.91 cm) and cane yield (406.50, 330.65 kg/plot). Genotypic and phenotypic coefficient of variances were moderate for number of tillers (11.6%, 15.44%) and higher for cane yield (20.24%, 22.44%). It means that variability in 4 genotypes for cane yield was higher. Thus variety S2008-AUS-133 showed better performance at seed rate 75000 while during selection, number of tillers and height should be considered for further breeding program.

Key words: Correlation, Genetic advance, Heritability, Seed rate, Sugarcane, Varieties, Yield.

INTRODUCTION

Sugarcane is not only contributes 80% of world sugar production but it is also a bioenergy crop being a viable, sustainable and rational alternative to oil and its derivatives. Its energy ratio for ethanol production is five times higher than that of other crops (Luis *et al*., 2020). Its by-products has potential for the production of bioethanol and surplus bioelectricity by reducing the life cycle of greenhouse gases to overcome the global warming and climate change'(Béhou *et al*., 2019). Sugarcane is a main source of raw material for sugar and other associated groups for by products industries (Negi and Koujalagi, 2018). The factors responsible affecting the cane yield includes late planting, uneven use of seed rate without keeping in view of cane genotype / varieties, weeds population complex, low plant population (Khaliq *et al*., 2020). Commercially cultivated Sugarcane is a complex polypoid. This polypoid nature of sugarcane has resulted in lot of genetic variability. The magnitude of variability plays an important role for a breeder to start an effective selection programme (Chaudhary, 2001). Genetic improvement has played important role to increase the yield in sugarcane-producing countries that was based on studies of commercial or trial productivity data. Although many traits have been studied by the breeders but yield always remains on their top priority (Dumont *et al.*, 2019). Selection is a primary tool for creating direct hereditary changes in plants. Genotypic and phenotypic variation and heritability along with genetic advance are key to improve any trait of sugarcane (Tyagi *et al*., 1998). Forecast for effective selection heritability and genetic advance are the direct selection indices while correlation coefficients are the indirect selection indices which measures degree of relationship. The sugarcane economic yield is determined by the capability of plant to produce photosynthates and their distribution to sink. In order to realize the full benefits of the land and environmental resources, it is necessary to maintain plant population in the field by using appropriate seed rate of each variety / clone (Prabhakar *et al*., 2014). The objective of present study was to estimate the response of varieties for different seed rates, estimation of genetic variability and change in selection indices values at different seed rates.

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MATERIALS AND METHODS

The experiment was conducted at Sugarcane Research Institute, Faisalabad during spring season 2016-17 and 2017-18. The trial was designed in randomized complete block design (RCBD) with factorial arrangements having plot size with 4 meter length and 8.4 meter width with three replication was maintained at Sugarcane Research Institute, Faisalabad in spring 2017.

For good seed bed preparation, two ploughing and four cultivations followed by planking were performed. The experiment was consisted of four sugarcane varieties *viz.* HSF-240, S2008-AUS-133, S2006-US-633 and S2003-US-127 at different seed rates (25000, 50000 and 75000 setts/ha).

Nitrogen (46%), phosphorus (46% di-ammonium phosphate and 18% urea) and potash 60% sulphate of potash) recommended doses (170-110-110 NPK kg ha^{-1}) were used. All the phosphorus, potash and 1/3 nitrogen was used during crop sowing while remaining dose of nitrogen was used in to 2 equal portions; at germination completion (45 days after planting) and tillering (90 days after planting) Irrigations were given according to crop requirement. Crop was harvested manually on 15^{th} December, 2018. Commercial cane sugar was noted with standard procedure. The analysis of variance was performed following the procedure (Panse and Sukhatme, 1954). The genotypic and phenotypic variances and their coefficients, heritability in broad sense and genetic advance were determined as percent of mean as the per standard Parameters.

RESULTS AND DISCUSSION

The analysis of variance showed that mean square values were found significant for all traits and seed rate interaction except for diameter and CCS% (Table 1). Similar studies were reported in case of stalk height, cane yield and number of tillers (Alam *et al*., 2017) while for CCS% the results were found non-significant (Agrawal and Kumar, 2017). Data regarding the effect of seed rate and varieties on plant height (Table 2) depicts that there was significant effect of varieties, seed rate and their interaction on plant height.

Maximum plant height was recorded for S2008-AUS-133 followed by S2006-US-633. Minimum plant height was recorded for HSF-240 during experiment. In case of seed rate, more plant height was recorded for 25000 and 75000 setts/ha while less plant height was noted for 50000 setts/ha. The interactive effect showed that higher plant height was measured for S2008-AUS-133 at seed rate of 25000 setts/ha followed by same variety at 75000 setts/ha. Minimum plant height was measured in S2003-US-127 at seed rate of 25000 setts/ha.

In case of diameter, varieties and seed rate greatly affected the plant diameter. Interaction effect of varieties with seed rate was also significant during experiment. Sugarcane variety S2008-AUS-133 showed greater cane diameter as compared to other three varieties. Minimum cane diameter was recorded for S2003-US-127 however; it was statistically similar to S2006-US-633 and HSF-240.

In case of effect of seed rate on cane diameter, maximum diameter was measured where 25000 setts/ha were used compared to other two seed rates. The seed rate of 50000 and 75000 setts/ha produced similar cane diameter. Interactive effect of varieties and seed rate exhibited that maximum cane diameter was recorded for S2008-AUS-133 at seed rate of 25000 and 50000 setts/ha, which was statistically equal to S2006-US-633 and HSF-240 at seed rate of 50000 setts/ha. Minimum cane diameter was noted for S2006-US-633 and S2003-US-127 at seed rate of 25000 setts/ha, which was statistically equal to HSF-240 at 25000 setts/ha. At 75000 setts/ha, statistically there was no difference of cane diameter among all varieties.

Effect of seed rate was significant on number of tiller but non-significant regarding varieties. However; the interaction effect of seed rate with varieties was significant during experiment. More number of tillers was noted where 75000 setts/ha were used followed by 50000 setts/ha. While less number of tillers was observed where 25000 sets were used. The interactive effect of seed rate and varieties showed that maximum number of tillers was recorded for HSF-240 at seed rate of 75000 followed by S2006-AUS-133 at seed rate of 75000 setts/ha. Minimum number of tillers was recorded for S2008-AUS-133 at seed rate of 25000 setts/ha, however it was statistically similar to HSF-240 and S2006-US-633 at seed rate of 25000 setts/ha.

Data regarding the effect of varieties and seed rate on 1000-cane weight was significant. Maximum 1000-canes/ha were recorded for HSF-240 and S2006-US-633 followed by S2008-AUS-133. While less number of 1000-canes/ha were noted for S2003-US-127. In case of seed rate, 50000 and 75000 setts/ha produced maximum number of canes/ha while minimum number of canes/ha was recorded where 25000 setts/ha were used. Interactive effect of seed rate and varieties showed that maximum number of canes/ha (Where is this parameter in Table. Is it 1000 cane weight were recorded for S2008-AUS-133 at seed rate of 75000 setts/ha followed by HSF-240 at 75000 setts/ha. While minimum number of 1000-canes/ha was noted for S2003-US-127 and S2008-AUS-133 at seed rate of 25000 setts/ha. Seed rate and varieties significantly affected the cane yield.

Maximum sugarcane yield was recorded for S2008-AUS-133 followed by HSF-240 while minimum cane yield was recorded for S2003-US-127. In case of seed rate, maximum cane yield was obtained from where 75000 setts/ha were used followed by 50000 setts/ha. Seed rate of 25000 setts/ha produced less cane yield. Interactive effect of varieties and seed rate exhibited that maximum cane yield was noted for HSF-240 at seed rate of 75000 followed by S2008-AUS-133 at seed rate of 50000 and S2003-US-127 at seed rate of 50000 while minimum cane yield was recorded for S2003-US-127 at seed rate of 25000 setts/ha. Non-significant results of varieties and seed rate on commercial cane sugar were noted similarly, interactive effect of varieties and seed rate was also non-significant. All the varieties at all seed rate showed statistically similar.

Table 1: Effect of seed rate and sugarcane varieties on yield and yield components.

Traits	Seed quantity		Genotypes				Means	LSD at 5%
			HSF-240	S2008-AUS-133	S2006-US-633	S2003-US-127		
Stalk height	Seed rate (setts/ha)	25000	213.67g	257.33a	234.33c	205.57h	227.73 A	Seed rate = 1.14,
		50000	207.33h	219.00f	233.67c	224.67e	221.17 B	Varieties = 1.32,
		75000	228.33d	240.67b	217.33f	227.00d	228.33 A	Interaction = 2.29
		Means	216.44D	239.00A	228.44B	219.08C	Means	
Can diameter	Seed rate (setts/ha)	25000	2.40cd	2.80a	2.33d	2.33d	2.65 A	Seed Rate = 0.10,
		50000	2.60abc	2.80a	2.63ab	2.56bc	2.46 B	Varieties = 0.12,
		75000	2.50bcd	2.46bcd	2.50bcd	2.40cd	2.46 B	Interaction = 0.21
		Means	2.50B	2.68A	2.48B	2.43B	Means	
Number of tillers	Seed rate (setts/ha)	25000	1.31fg	1.25h	1.27gh	1.43d	1.31 C	Seed rate = 0.12,
		50000	1.36ef	1.41de	1.67c	1.43d	1.46 B	Varieties = Non-significant,
		75000	1.81a	1.74b	1.44d	1.33fg	1.58 A	Interaction = 0.062
		Means	1.49	1.47	1.46	1.39	Means	
1000-cane (ha)	Seed rate (setts/ha)	25000	83.00h	62.73j	97.67d	62.57j	76.49 B	Seed rate = 0.75,
		50000	91.00f	105.00c	96.00e	82.00h	93.50 A	Varieties = 0.87,
		75000	106.57b	109.57a	86.43g	69.33i	92.97 A	Interaction = 1.50
		Means	93.52A	92.43B	93.36A	71.30C	Means	
Cane yield (t ha-1)	Seed rate (setts/ha)	25000	83.00e	91.67d	92.33d	56.00h	80.75 C	Seed rate: 1.40,
		50000	72.33g	109.67b	80.00f	107.33b	92.33 B	Varieties = 1.62,
		75000	118.00a	103.33c	84.67e	83.00e	97.25 A	Interaction = 2.81
		Means	91.11B	101.56A	85.67C	82.11D	Means	
CCS%	Seed rate (setts/ha)	25000	10.66	12	12	11.33		Seed rate: non-significant,
		50000	12	12	11.33	12.33	11.5	Varieties = non-significant,
		75000	12.33	11.66	12.33	11.33	11.91	Interaction = non-significant
		Means	11.66	11.88	11.88	11.66	11.91	

Table 2: Genetic parameters for various quantitative traits for sugarcane genotypes.

Traits	Geno-typic variance	Pheno-typic variance	Environ-mental variance	Genotypic coefficient variance	Phenotypic coefficient variance	Environmental coefficient variance	Heritability	Genetic advance	Genetic advance (%)
Plant height	133.91	381.63	247.73	5.12	8.65	6.97	0.59	20.37	9.02
Clone diameter	-0.01	0.05	0.06	NS	9.19	10.06	NS	NS	NS
Number of tillers/clone	0.03	0.05	0.02	11.56	15.44	10.23	0.75	0.30	20.35
Cane yield/clone	330.65	406.48	75.83	20.24	22.44	9.69	0.90	32.00	35.61
Thousand cane weight	99.92	392.19	292.27	11.39	22.57	19.48	0.50	17.59	20.05
CCS%	-0.09	0.47	0.57	NS	5.86	6.42	NS	NS	NS

Not mentioned the statistical analysis method for measuring or calculating above indicators.

Results reported by other workers that seed rate of 75,000 kg/ha produced higher can yield in plant as well as ratoon cane crop. (Singh *et al*., 2016).Seed rate was non-significant for CCS % however on recommended seed rate CCS(t/h) was significant (Singh *et al*., 2016).CCS% was improved with seeding density of 1,00,000 setts/ha as compared to seed rate 75,000 setts/ha (Sharar *et al*., 2000). CCS% is genetically controlled and does not effect by the seed rate (Chand *et al*., 2011).

The genotypic and phenotypic coefficient of variation values were low (0 to 10%), medium (10 to 20%) and high (20% to >20%). High GCV values were noted for cane yield (20.24) while medium for number of tillers (11.56) and thousand cane weight (11.39). High PCV were also recorded for individual clone yield (22.44) and thousand clone yield (22.5) while medium was found for number of tillers (15.44). (Tyagi and Singh, 1998). The estimated phenotypic variances were higher than genotypic variances for the traits considered showing environmental influence on these traits to the total variance (Table 3). High values for genotypic and phenotypic coefficient of variance showed that selection might be effective for these traits and their phenotypic expression would be good sign for the genotypic potential (Singh *et al*., 1994). Heritability and genetic advance are categorised as low (0-30%), medium (30-60%) and high (60% and above) (Singh *et al*., 1994). The traits number of tillers and cane yield showed high heritability (Table 2). Similar results were reported by (Nair *et al*., 1998). Number of tillers also showed high genetic advance. Results were in accordance with (Tena *et al*., 2016). Heritability along with

Table 3: Correlation matrix (Pearson (n).

Variables	CY	TC/H	D/P	PH	T/P	CS
CY	**1**	**0.4521**	0.2872	**0.3460**	0.2523	0.0014
TC/H	**0.4521**	**1**	0.0972	0.0494	**0.4691**	-0.0420
D/P	0.2872	0.0972	**1**	0.1681	0.1342	0.0989
PH	**0.3460**	0.0494	0.1681	**1**	0.0105	0.2704
T/P	0.2523	**0.4691**	0.1342	0.0105	**1**	-0.1560
CCS%	0.0014	-0.0420	0.0989	0.2704	-0.1560	**1**

Values in bold are different from 0 with a significance level alpha=0.05. CY= Cane yield, TC/H= 1000-cane (ha) is this unit name is correct, D/P= Can diameter per plant, PH=plant height, Tiller per plant =T/P, CCS%= commercial sugarcane.

genetic advance estimated is more useful than alone in prediction for selection of the best genotypes (Johnson *et al*., 1955).

Correlation studies showed that yield was positively correlated with plant height and number of tillers (Table 3). Similar results were found by (Silva *et al*., 2008). Therefore these traits may be considered as direct selection indices for yield.

CONCLUSION

Experimental results revealed that maximum cane yield was noted for HSF-240 at seed rate of 75000 triple budded setts ha^{-1} followed by S2008-AUS-133 at seed rate of 50000 triple budded setts ha^{-1}. Genotypic and phenotypic coefficient of variances were moderate for number of tillers (11.6%, 15.44%) and higher for cane yield (20.24%, 22.44%). Number of tillers and height showed significant positive correlation with yield. Thus variety S2008-AUS-133 showed better performance at seed rate 75000 while during the selection number of tillers and height should be considered for selection.

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