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PERFORMANCE OF SUGARCANE SOMACLONES UNDER DIFFERENT IRRIGATION AND FERTILIZERS DOSES

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Abstract

In vitro grown plantlets (somaclones) were regenerated through callus culture. Selected somaclone along with parent were tested under different fertilizer and irrigation levels for agronomic and qualitative traits of parent/clones. Maximum plant height, and internodes (plant^{-1}) was observed in NIA-98 somaclone. The tillers (plant^{-1}), weight plant^{-1}, cane yield, sucrose and purity were greater in AEC82-1026 somaclone and maximum stem girth was obtained in BL4 somaclone from the combination of 150-80-100 NPK (kg ha^{-1}) with 25 irrigations during the growing season. It was concluded that the application of 150-80-100 kg NPK ha^{-1} and 25 irrigations during the growth period of sugarcane were efficient for achieving better agronomic and qualitative traits of sugarcane somaclones.

Introduction

Sugarcane is an important commercial crop in developing and developed countries. There are many factors which influence the cane yield and predominantly poor agricultural practices, stresses like water and nutrient, susceptibility to pathogens like virus, bacteria, fungi and nematodes and low cane yielding varieties which cause a significant loss in total yield. In Pakistan cane improvement through conventional method is hampered due to sporadic flowering. Therefore alternative methods like mutation breeding and tissue culture techniques could be applied for the development of new genotypes (Heinz & Mee, 1969; Khan *et al.,* 1999). Anbalogan *et al.*, (2000) reported that some phenotypic variability was the result of physiological changes during *in vitro* conditions (Bairu *et al.,* 2011). Hence such plantlets normally revert to their parent type in field conditions. Aneuploids may have lower or higher number of chromosome and plantlets regenerated from these cells could express different genetic behavior. This technique provides a promising future in sugarcane breeding programmes.

Improved irrigation efficiency based on a fundamental understanding of crop water requirements and use under various conditions is increasingly important (Khan *et al.,* 2013 a & b). It was also reported fertigation practices very greatly depending on local conditions (Robert & Enciso, 2006). Fertility probably is the most controllable cultural factor affecting the growth of green house crop (Kang & Vanlersel, 2002). Imbalanced fertilizer used seems to be one of the factors responsible for the constantly low growth and cane yield. Therefore adequate quantities of nutrients are necessary for plant growth and yield of crop. Khan *et al*., (2005) recommanded 128-63-70 kg NPK ha^{-1} as average fertilizer dose for sugarcane. Increasing Nitrogen (N) rate up to 225 kg ha^{-1} significantly increased the commercial cane yield, while higher N level decreased cane juice. It was reported that sugarcane stores a higher sucrose when nitrogen is limited 6 to 8 weeks prior to harvest (Miller & Gilbert, 2006). Higher P application increased both cane yield and stalk weight. The varietals differences were reported for the requirement of P fertilizer in sugarcane (Sreewarome *et al.,* 2005). Nutrition with adequate potassium (K) plays a particular role in stress physiology. Potassium directly or indirectly plays its role in enzyme function and the creation of cell turgor responsible for the movement of water and solutes in the plants. Potassium also plays role in the transfer of nitrate from the roots to the shoots and leaves (Krauss, 2003; Abbas *et al*., 2012).

There are two factors to consider in reviewing the water requirements of sugarcane; one is the actual amount of water required to produce the sugarcane and the other is the management of the water table in the cane field (Eusufzai *et al*., 2000). There is a high correlation between the amount of water used by the sugarcane plant and the amount of dry matter produced (Mathew & Varughese, 2005). In many production areas, the requirement for ample water to produce a sugarcane crop is seldom met by rainfall alone so that supplemental irrigation is required. Given the high cost of irrigation water, drought tolerance could be a major component of sugarcane improvement programs to achieve higher and more stable yields. In addition to reducing yields, drought also predisposes plants to other stresses such as stalk borers and diseases (Siddique *et al*., 2003). In present study sugarcane somaclones produced from different sugarcane varieties (NIA-98, AEC82-1026 and BL4) were evaluated for low water requirement, high cane yield, sucrose content and nutrient under field condition.

Materials and Methods

The selected somaclone NIA-98, AEC82-1026 and BL4 along with parent/clone were tested under different fertilizer and irrigation levels from sowing to harvesting. The experimental layout was RCBD (factorial) design with 3 replications and plot size was 5 x 5 m^2 and row to row distance was one meter apart form each other. The sowing was done in the month of September and normal agronomical practices were followed through out the growth period. The experiment comprised of the following varieties, fertilizer and irrigation treatments.

Factor (A) = NPK levels =04
F_1 = 0- 0-0 NPK Kg ha^{-1}
F_2 = 150- 80-100 NPK Kg ha^{-1}
F_3 = 200-120-150 NPK Kg ha^{-1}
F_4 = 250-160-200 NPK Kg ha^{-1}

Factor (B) = Irrigation levels = 03
I_1 = 20 irrigations from sowing to harvest
I_2 = 25 irrigations from sowing to harvest
I_3 = 30 irrigations from sowing to harvest

Factor (C) = Sugarcane somaclone/parent = 06
C_1= NIA-98 (Somaclone)
C_2 = NIA-98 (Parent)
C_3 = BL4 (Somaclone)
C_4 = BL4 (Parent)
C_5 = AEC82-1026 (Somaclone)
C_6 = AEC82-1026 (Parent)

Statistical analysis: Data were statistically analyzed through MSTATC computer software. The LSD value for mean comparison was calculated only if the general treatment F test was significant at a probability of ≤ 0.05 (Gomez & Gomez, 1984).

Results

Effect of NPK fertilizer: The data presented in the Table 1 revealed that maximum plant height (145.50cm), cane girth (2.46 cm), tillers plant^{-1} (6.93^{-1}), internodes plant^{-1} (26.66^{-1}), weight plant^{-1} (5.30 kg), cane yield (128.80 t ha^{-1}), fibre % (12.33) and sugar yield (10.35 t ha^{-1}) was observed in F2 (150-80-100 NPK kg ha^{-1}), whereas minimum plant height (71.70 cm), cane girth (1.97 cm), tillers plant^{-1} (5.57^{-1}), internodes plant^{-1} (17.55^{-1}), weight plant^{-1} (4.21), cane yield t ha $^{-1}$ (78.94), fibre % (11.33) and sugar yield (6.17 t ha^{-1}) were recorded in F1 (control). The maximum CCS% (12.78) and purity% (87.51) were noted in the F1 control plots where no fertilizer was applied in the field.

Interactive effect of clones/parents x fertilizer had significant effect on all agronomic and qualitative traits observed. Maximum plant height (149.11 cm) and internodes plant^{-1} (30.00^{-1}) in NIA-98 somaclone was observed by application of 150-80-100 NPK kg ha^{-1}. The maximum stem girth (2.80 cm) was observed when 150-80-100 NPK kg ha^{-1} was applied in BL4 somaclone, whereas tillers plants^{-1} (9.24^{-1}), weight plant^{-1} (7.98 kg), cane yield (169.33 t ha^{-1}), fibre (13.30%) and sugar yield (12.44 t ha^{-1}) was significantly higher in AEC82-1026 somaclone supplied with same dose of NPK fertilizer. The minimum plant height 52.67 cm, tillers plant^{-1} 2.61, internodes plant^{-1}14.66 , weight plant 2.58^{-1}, cane yield t ha^{-1} 55.89 and sugar yield 4.72 t ha^{-1} were found in BL4 parent in control plots where no fertilizer was applied, whereas stem girth was low (1.86cm) in NIA-98 parent. However significantly higher CCS (14.10%) and purity (87.55%) were found in control plots where no fertilizer was applied to AEC82-1026 somaclone. The BL4 parent was inefficient in recording qualitative traits with low CCS (11.43%) and purity (84.66%) at higher fertilizer application of 250-160-200 (Table 1).

Effect of irrigation: The data presented in the Table 2 revealed that maximum plant height (119.67 cm) tillers plants^{-1}, (6.88) stem girth (2.27 cm), internodes plant (24.11^{-1}), cane weight plant^{-1} (5.16 kg), cane yield (115.71 t ha $^{-1}$), fibre (11.96%) and sugar yield (9.39 t ha^{-1}) was observed in 25 irrigation level. The minimum plant height (102.97 cm) tillers plants^{-1}, (5.87) stem girth (2.09 cm) internodes plant (20.59 $^{-1}$), cane weight plant $^{-1}$ (4.53kg), cane yield (104.53t ha $^{-1}$), fibre (11.65%) and sugar yield (8.06t ha^{-1}) was recorded 20 irrigation level. Decrease in irrigation level beyond 20 irrigations, also increased CCS (12.96%) and purity (87.13%) followed by CCS (12.32%) and purity (86.93%) 25 irrigation levels (Table 2).

Interactive effect of clones/parents x irrigation had significant effect on all agronomic and qualitative traits observed. Application of 25 irrigations recorded maximum plant height (131.92 cm) and internodes plant^{-1} (28.58) in NIA-98 somaclone. The maximum stem girth (2.65 cm) was observed when 25 irrigations were applied to BL4 somaclone, whereas tiller plant^{-1} (8.95^{-1}), cane weight plant^{-1} (7.50 kg), cane yield (116.08 t ha^{-1}) fibre (12.70%) and sugar yield (8.43 t ha^{-1}) were significantly higher in AEC82-1026 somaclone supplied with same level of irrigation. Application of 20 irrigations was observed minimum plant height (100.00 cm), internodes plant^{-1} (17.41) cane weight plant^{-1} (2.80), cane yield (54.75 t ha^{-1}), fibre (11.29%) and sugar yield t ha^{-1}(4.36) in BL4 parent. The AEC82-1026 somaclone had maximum CCS (13.82%) and purity (88.50%) with the application of 20 irrigations followed by sucrose (13.72%) and purity (87.77%) in same somaclone with the application of 25 irrigation However, the excess application i.e., 30 irrigations recorded minimum CCS (11.36%) and purity (84.91%) in BL4 parent (Table 2).

Economics of fertilizer practices: The optimum fertilizer requirement of sugarcane and its achievable yields was compared in the light of value cost ratios (VCRs). The VCR should be higher than 2 to secure a profitable return to the farmer. Under high risk conditions a VCR of about 3 is preferable. Economic feasibility of the fertilizer practices is an essential element of improving crop productivity (Iftikhar *et al.,* 2010). Very often the farming is based on sound economics and the farmers generally adopts only those improved practices or innovations, which are more paying and easily workable. Presently, price is the only index for the farmers to decide about their production plans as no other guidelines or production policies are available to him. If the market prices are higher in a particular year, than there is tendency on the part of the growers to bring more area under sugarcane during the next year which generally results in over production. The sugarcane production is, therefore, marked with serious alternate gluts in the markets and so the profitability aspect of each fertilizer practice was also studied. On the basis of current market prices of fertilizer and the farm gate prices of the sugarcane, the obtainable incomes from the additional yields were worked out. Table 3 reflects the comparative economics of different fertilizer levels used in the present experiment. Evidently, there could be no additional income from the control plot, which did not receive any fertilizers. The calculated value cost ratio from different fertilizer applications varied between 2.0 to 6.13 which is fully in accordance with the prevailing prices. Treatment 2 (150 N: 80 P_2O_5:100 K_2O) significantly out-yielded control and gave comparatively higher value cost ratio than the other treatments (Table 3). All the fertilizer levels were found highly profitable over the control. This shows that the use of fertilizers in balanced amount will always remain profitable for the sugarcane growers. The existing profitability levels can considerably be improved with the use of NPK fertilizers in balanced amount.

Table 1. Agronomic and qualitative traits of sugarcane under the interactive effect of NPK x parents /clones.

	Plant height (cm)	Tillers plants^{-1}	Stem girth (cm)	Internodes plant^{-1}	Cane weight plant^{-1} (kg)	Cane yield (t ha^{-1})	CCS (%)	Purity (%)	Fibre (%)	Sugar yield t ha^{-1}
F1- 0-0-0	71.70 d	5.57 d	1.97 d	17.55 d	4.21d	78.94d	12.78 a	87.51 a	11.33 d	6.17d
F2-150-80-100	145.50a	6.93 a	2.46 a	26.66 a	5.30a	128.80a	12.67 b	86.11 b	12.33 a	10.35 a
F3-200-120-150	130.70c	6.57 b	2.20 b	23.29 b	5.03b	124.06b	11.98 d	85.75 d	11.97 b	10.16b
F4-250-160-200	113.57b	6.24 c	2.04 c	22.11 c	4.60c	103.87c	12.38 c	85.87 c	11.60 c	8.39c
LSD 5%	0.67	0.07	0.07	0.31	0.03	1.58	0.04	0.32	0.03	0.56
					NPK (kg ha^{-1}) x parents/clones					
F1V1-NIA98S	92.11l	6.30 j	1.86 kl	21.22 h	4.40 kl	95.67 k	12.14 g	8555 k	12.04 e	7.88k
F1V2-NIA98P	83.67 m	5.11 l	1.74 m	17.00 l	4.01 m	83.78 o	12.02 i	84.77 l	11.82 f	6.97o
F1V3-BL4S	62.44 p	6.14 k	2.54 b	17.88 kl	3.16 p	66.78 q	12.13 g	86.77 ghi	11.06 m	5.50q
F1V4-BL4P	52.67 q	2.61 s	2.25 efg	14.66 n	2.58 s	55.89 r	11.83 k	85.55 k	11.15 l	4.72r
F1V5-AEC82-1026S	74.67 n	7.15 h	1.84l m	18.77 k	5.96 e	102.78 j	14.10 a	87.55 a	11.6 1h	7.28j
F1V6- AEC82-1026P	64.67 o	6.14 k	1.62 n	15.77 m	5.15 h	68.78 q	12.53 f	84.88 l	11.38 jk	5.48q
F2V1-NIA98S	149.11 a	8.65 c	2.50 b	30.00 a	5.26 g	151.89 c	12.84 e	87.00 fgh	12.21 d	11.82c
F2V2-NIA98P	137.67 c	7.46 g	2.22 fg	28.66 b	5.10 h	124.11 f	12.03 hi	86.33 c	12.97 b	10.31f
F2V3-BL4S	95.67 k	4.35 m	2.80 a	22.44 g	3.56 n	106.33 i	12.47 f	87.77 de	11.96 e	8.52i
F2V4-BL4P	83.67 m	3.56 p	2.70 a	23.55 f	3.01 q	93.22 l	12.20 g	86.88 ghi	11.67 gh	7.64l
F2V5-AEC82-1026S	142.00 b	9.24 a	2.36 cd	28.44 b	7.98 a	169.33 a	13.61 b	89.22 b	13.30 a	12.44a
F2V6- AEC82-1026P	131.33 d	8.33 de	2.15 gh	26.88 c	5.77 f	127.89 e	13.03 d	88.33 c	11.84 f	9.81e
F3V1-NIA98S	130.89 de	8.22 e	2.30 def	28.00 b	4.83 i	141.67 d	12.54 f	87.22 fg	12.95 b	11.29d
F3V2-NIA98P	129.22 ef	6.81 i	1.84l m	24.11 ef	4.60 j	123.00 f	11.94 ij	86.66 hij	12.68 c	10.30f
F3V3-BL4S	104.00 j	3.96 n	2.54 b	21.00 hi	4.30 l	109.56 h	12.86 e	87.88 cde	11.48 i	8.51h
F3V4-BL4P	99.22 jk	3.23 q	2.44 bc	19.88 j	3.66 n	92.11l m	12.12 gh	86.22 j	11.43 ij	7.59m
F3V5-AEC82-1026S	128.67 f	8.83 b	1.96 jk	25.55 d	7.47 b	162.89 b	13.65 b	88.11 cd	11.83 f	11.93b
F3V6- AEC82-1026P	126.22 g	8.36 d	2.09 hi	21.22 h	6.41 d	115.11 g	12.91 e	86.55 hij	11.50 i	8.91g
F4V1-NIA98S	117.00 i	7.93 f	1.98 ij	24.55 e	4.57 j	122.89 f	11.78 k	85.55 k	11.81 f	10.43f
F4V2-NIA98P	104.44 j	6.76 i	2.20 fgh	21.77 gh	4.43 k	107.89 hi	11.45 l	84.88 l	11.71 g	9.43hi
F4V3-BL4S	95.67 k	3.74 o	1.74 m	20.11 ij	3.31 o	86.56 n	11.86 jk	87.44 ef	11.37 jk	7.29n
F4V4-BL4P	92.11l	2.86 r	2.34 cde	21.22 h	2.86 r	73.11 p	11.43 l	84.66 l	11.33 k	6.38p
F4V5-AEC82-1026S	127.67 fg	8.67 c	2.17 gh	24.77 de	7.10 c	142.67 d	13.13 c	86.22 j	11.13 lm	10.86d
F4V6- AEC82-1026P	120.22 h	7.50 g	1.87 kl	20.22 ij	5.33 g	90.11 m	12.21 g	86.44 ij	11.13 lm	7.38m
LSD5%	2.10	0.11	0.11	0.98	0.10	2.15	0.09	0.52	0.07	0.71

Table 2. Sugarcane agronomic and qualitative traits under the interactive effect of irrigation x sugarcane parents/clones.

Irrigation level	Plant height (cm)	Tillers $plants^{-1}$	Stem girth (cm)	Internodes $plant^{-1}$	Cane weight $plant^{-1}$ (kg)	Cane yield ($t\ ha^{-1}$)	CCS (%)	Purity (%)	Fibre (%)	Sugar yield $t\ ha^{-1}$
I1-20 Irrigation	102.97c	5.87 c	2.09 c	20.59 c	4.53c	104.53c	12.96 a	87.13 a	11.65 c	8.06c
I2-25 Irrigation	119.67a	6.88 a	2.27 a	24.11 a	5.16a	115.71a	12.32 b	86.93 b	11.96 a	9.39a
I3-30 Irrigation	113.47b	6.23 b	2.13 b	22.51 b	4.66b	106.51b	12.07 c	86.37 c	11.81 b	8.82b
LSD5%	0.93	0.03	0.03	0.39	0.03	0.73	0.03	0.17	0.03	0.63
	Interaction irrigation x variety									
I1V1-NIA98S	123.42 b	7.62 f	2.18 d	23.75 d	4.69 i	90.08d	12.90 e	87.16d e	11.70 f	6.98d
I1V2-NIA98P	117.58 c	7.62 f	1.86 ij	20.91 f	4.22 k	77.75g	12.16 h	86.33 gh	12.55 b	6.39g
I1V3-BL4S	110.08f g	4.34 m	2.52 b	18.91 h	3.38 n	66.42j	13.10 d	87.41 cd	11.67 f	5.07j
I1V4-BL4P4	100.00 j	3.00 p	2.28 c	17.41 i	2.80 o	54.75 l	12.53 f	86.58 fg	11.43 ij	4.36l
I1V5-AEC82-1026S	115.75 d	8.38 c	2.06 ef	23.00 de	6.78 c	101.83c	13.82 a	88.50 a	11.86 e	7.36c
I1V6-AEC82-1026P	111.00 ef	6.45 j	1.91 hi	19.58 gh	5.32 f	72.92h	13.27 c	86.83 ef	11.55 g	5.49h
I2V1-NIA98S	131.92 a	8.50 b	2.33 c	28.58 a	5.18 g	100.50c	12.11 h	87.08 de	12.53 b	8.29c
I2V2-NIA98P	122.75 b	7.08 h	1.98 fgh	25.58 b	4.90 h	87.92e	12.01 i	86.41 fgh	12.28 c	7.32e
I2V3-BL4S	115.25 d	5.20 l	2.67 a	19.91 g	3.87 l	74.08h	11.88 jk	87.66 bc	11.54 gh	6.23h
I2V4-BL4P4	106.17 h	3.31 o	2.54 b	22.66 e	3.45 mn	63.92k	11.80 k	86.00 hi	11.36 jk	5.41k
I2V5-AEC82-1026S	123.25 b	8.95 a	2.07 ef	25.50 bc	7.50 a	116.08a	13.72 b	87.77 b	12.70 a	8.43a
I2V6-AEC82-1026P	118.67 c	8.26 d	2.06 efg	22.41 e	6.09 d	81.83f	12.39 g	86.50 fg	11.47 hi	6.60f
I3V1-NIA98S	122.58 b	7.20 g	2.14 de	25.50 bc	4.43 j	100.33c	11.96 ij	86.41 fgh	12.35 c	8.38c
I3V2-NIA98P	118.75 c	6.08 k	1.80 j	22.16 e	4.48 j	86.83e	11.39 l	85.75 i	12.05 d	7.62e
I3V3-BL4S	108.67 g	4.10 n	2.48 b	22.25 e	3.50 m	71.08i	12.02 i	87.08 de	11.31 kl	5.91i
I3V4-BL4P4	104.08 i	2.89 q	2.35 c	19.41 gh	2.84 o	55.58l	11.36 l	84.91 j	11.29 l	4.89l
I3V5-AEC82-1026S	114.75 d	8.10 e	1.96 gh	24.66 c	7.11 b	110.25b	13.32 c	87.75 bc	11.52 gh	8.27b
I3V6-AEC82-1026P	112.00 e	6.86 i	1.83 ij	21.08 f	5.59 e	73.33h	12.35 g	86.33 gh	11.36 jk	5.93h
LSD5%	1.81	0.10	0.09	0.85	0.08	1.69	0.08	0.45	0.06	0.66

Table 3. Comparative economic of different fertilizer levels on sugarcane.

Treatment	Cost of fertilizer (Rs.)	Cane yield	Additional yield	Gross income (Rs)	Net income (Rs)	Value cost ratio
0N:0P:0K	___	59.00	_____	_____	____	___
150N:80P:100K	31261	78.94	19.94	29602	191648	6.13
200N:120P:150:	45455	101.09	42.09	379087	157837	3.47
250N:160P:200K	59683	91.07	32.07	341512	120262	2.0

Sugar yield per unit area can be increased only, if there is simultaneous increase in the production of sugarcane and the recovery of sugar. There is lack of improved high yielding sugarcane varieties and absence of mechanisms to carry out the package of technology and inputs to the farmers. The share of improved variety in the enhancement of cane yield and sugar recovery is about 20-25%, while rest is contributed by production technology (Rehman, 2009). Since the increase in cane and sugar yield in our country has mainly been due to an increase in the acreage (Khan *et al.*, 2005), therefore, the evolution of high yielding clones and good production technology is urgently needed, which could definitely increase the cane and sugar yield per unit area.

Discussion

In this study application of 150-80-100 NPK kg ha^{-1} with 25 irrigation during cane growth period vales of agronomic traits of AEC82-1026. Further increase in irrigation and fertilizers increased vegetative growth instead of yield components. It was observed by many workers that sugarcane plant height and number of tiller increased with the application of proper rates of NPK (Ayub *et al.,* 1999). Cane length and number of tillers were significantly increased by adequate application of NPK and irrigation level. Alexander *et al.,* (2003) reported that N, P and K application beyond 100% of the recommended dose had produced only marginal increase in cane and sugar yield. Wayagari *et al.,* (2001) and Abbasi (2005) also reported that cane yield was significantly greater when optimal commercial chemical fertilizer were applied as compared to other organic fertilizer sources. Verma 1999 reported that nitrogen applied to sugarcane field gave the highest cane yield. N fertilizer gave good response only with adequate supply of irrigation water to sugarcane crop. Nitrogen strongly stimulates growth, expansion of the crop canopy and interception of solar radiation (Milford *et al.*, 2000) to primarily produce more millable canes.

In this study application of potassium and phosphorus with nitrogen to sugarcane produced maximum cane yield. K is capable of raising sugar yields without a concomitant increase in the yield of cane (Maher *et al.,* 2008). Potassium deficiency suppressed photosynthesis, dry matter low K resulting in high reducing sugars and low sucrose. Regarding phosphorus, very meager research work was assigned for the response of cane to the added phosphorus and potassium fertilizers (EL-Tilib *et al.*, 2004). Previous reports shows that better cane yields in sugarcane could be achieved 20% more with adequate application of phosphorus (Morris *et al.,* 2002). Phosphorus was found indispensable for a healthy root system and necessary for plant life processes. The excess application of fertilizer and irrigation recorded minimum sucrose and purity. The depression in purity of juice caused by higher level of fertilizer may be manly due to the accumulation of NPK bodies in cane juice which probably reduce the purity % of juice. These results are supported by those found by (Singh *et al*., 2000)

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