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AGRONOMIC TRIALS ON SUGARCANE CROP UNDER FAISALABAD CONDITIONS, PAKISTAN

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Abstract

In the present studies field experiments were conducted to study the production potential of September planted Sugarcane (*Saccharum officinarum* L.) under varying agro-management practices for the year 2007-2008. Two sugarcane clones viz., S2002-US-637 and CP 85-1491 show good growth potential were evaluated at five bio-fertilizer and chemical fertilizer levels in different combinations. Fifty percent bio-fertilizer + 50% recommended dose of chemical fertilizer increased the cane yield along with reduced environmental pollution. In field experiments, I_4 & P_4 treatment significantly affected agronomic characteristics such as cane height (cm), cane diameter (cm), cane yield (000 t ha^{-1}), whereas number of tillers ha^{-1}, number of mill-able canes ha^{-1} and sugar recovery % were non significantly affected over control. The sugarcane promising clone S2002-US-637 showed better performance over CP 85-1491. The interaction V_2 P_4 significantly affected all parameters except sugar recovery %. Furadon 20 kg ha-1 at sowing + Furadon 40 kg ha-1 in April / May + Furadon 40 Kg ha-1 in June/ July controlled the pests of sugarcane and increased the yield of promising sugarcane clones. The interaction I_4V_2 significantly affected all parameters except sugar recovery %. Trench planting saves 50% irrigation water but alternate skip irrigation further improves cane yield in addition to saving of same amount of water.

Introduction

Sugarcane (*Saccharum officinarum* L.) is an important cash crop of Pakistan, plays vital role in economic uplift of the farmers and survival of ever expanding sugar industry in Punjab. Pakistan is an important cane producing country and is ranked fifth in world cane acreage and 15th in sugar production. Sugarcane is grown on over a million hectares and provides the raw material for Pakistan's 84 sugar mills -- which comprise the country's second largest agro-industry after textiles (Rehman, 2009). Thus evolution of new high cane and sugar yielding varieties and improved production technology i.e., Better Management Practices (BMPs) are current need for improving livelihoods of sugarcane growers and other crops and ultimately betterment of mill owners also (Nasir, 2006; Iftikhar *et al.*, 2010). Addition of organic matter in soil improves the physico-chemical and biological properties of soil. The cultivated soils in tropical tracts may contain 2-5% organic matter. 1-2% organic matter is considered a normal level of cultivated soils. In arid and semi arid regions, the organic matter is considerably low due to oxidation process. The soil having less than I% organic matters are organic deficient soils (Azam *et al.*, 2001). The organic deficient soils can not support plant growth. Plants show pale appearance in nutrient deficient soils (Malik, 2006). There are various sources of organic matter or farm-yard manure (FYM), green manure crops in sequence or as an intercrop, sugar mills waste (filter press cake and bio-compost in cane fields), crop residues (Nasir & Qureshi, 1999). To obtain potential yields; 50% of total N requirements should be made available in the form of FYM and 50% applied in the form of fertilizer (Fasihi & Malik, 1989). Application of inorganic fertilizer to soils, after thorough mixing

with well rotten FYM, has been found to reduce the fixation of applied phosphorus and enhances crop yields. It was observed that FYM mobilizes other nutrients especially P for better uptake by plant (Chaudhary & Qureshi, 1980). Makhdum *et.al. (1997)*, reported that earthing up after May resulted in less infestation of Gurdaspur Borer *Acigona stenialus* and comparatively less lodging of millable cane in the NWFP.

In order to test and validate Better Management Practices (BMPs), three agronomic trials regarding bio-fertilizer, bio-pesticide and irrigation were conducted in 2006-07 on sugarcane crop under Faisalabad conditions to fight against pests of sugarcane, shortage of irrigation water and boost up the production of sugarcane. Then same trials were repeated in 2007-08 also at the research farm and farmer's fields so that BMPs tested on research farm could be replicated at farmer's fields. Moreover, two promising sugarcane varieties of Sugarcane Research Institute were tested at sugarcane farm Faisalabad. The varieties were studied in Faisalabad zone recording different parameters i.e., tillering capacity, mill able cane count, cane height, cane diameter, cane yield and quality performance of varieties. The trials on sugarcane were conducted to achieve the following objectives:

- To see the response of promising sugarcane varieties / clones to different combinations of bio-fertilizer with chemical fertilizers and to search alternatives of chemical fertilizers.
- To find out the efficacy of bio-pesticide (Biosal) to control the pests of sugarcane and its impact on growth and yield of promising sugarcane clones as bio-pesticides are economical and environment friendly.
- To determine water use efficiency in different planting methods/ techniques to fight against drought and save the irrigation water which is a current global issue.

Materials and Methods

The experiment, comprising 5 fertilizer treatments and two varieties/ promising lines (S2002-US-637, CP 85-1491), was laid out in Randomized Complete Block Design (RCBD) factorial with 3 replications. The crop was sown in 120 cm apart, 20 cm deep trenches in 5 x 9.6 m plots using 75,000 double budded sets per hectare as seed rate on 30th October, 2007. The experiment comprised of the following two varieties and five fertilizer treatments.

A. Varieties / Clones

1. V_1= S2002-US 637
2. V_2= CP 85-1491

B. Fertilizer treatments

1. F_1= 50% bio fertilizer (62 kg/ha) + 50% of the recommended dose of NPK (84-56-56 NPK kg ha^{-1}).
2. F_2= 75% of the proposed bio-fertilizer (93 kg/ha) +25% of the recommended NPK (42-28-28 NPK kg ha^{-1}).
3. F_3= Bio-fertilizer @ 124 kg/ha (proposed).
3. F_4= NPK @ 168-112-112 kg /ha (recommended).
5. F_5= No fertilizer (Control).

The bio-fertilizer & chemical fertilizer were applied in respective plots as per treatment. The crop was given three inter cultures and sixteen irrigations to all treatments.

C. Bio-pesticides / Pesticides

1. P_1=No pesticide.
2. P_2=Bio-pesticide @ 2.471 L ha^{-1}.
3. P_3= Chloropyrifos 40 EC @ 4.942 L ha^{-1} at sowing + Furadon 3-G @ 40kg ha^{-1} in April/ May.
4. P_4= Furadon 3-G @ 20 Kg ha^{-1} at sowing + Furadon 3-G @ 40 Kg/ha in April / May + Furadon 3-G @ 40 Kg/ha in June/ July.

The bio-pesticide and pesticides were applied in respective plots as per treatment. The crop was given three inter cultures and sixteen irrigations to all treatments.

D. Irrigation Application Methods

I_1= Flood irrigation by Siphon in flat sowing at 120 cm apart rows.
I_2= Normal irrigation with S1phon after earthling up 90 DAS in trench planning at 120 cm apart rows.
I_3= Skip irrigation after earthling up 90 DAS in trench planting at 120 cm apart rows.
I_4= Alternate skip irrigation after earthing up 90 DAS in trench planting at 120 cm apart rows.

The earthling up 90 DAS and irrigation was applied in respective plots as per treatment. The crop was given three inter cultures and sixteen irrigations to all treatments.

The data on the number of tillers per unit area were recorded on plot basis. The number of mill-able canes and cane yield were recorded at crop harvest (Nov. 15, 2008) on plot basis and then converted into per hectare. From each plot, ten canes were randomly selected and tagged. They were sent to the laboratory for quality analysis after taking their length and girth. Sugar recovery % age was calculated using following formula:

$$\text{CCS \%} = \frac{3\,P}{2}\quad\frac{(1\,-F+5)}{100} - \frac{B}{2}\quad\frac{(1-F+3)}{100}$$

Sugar recovery % = CCS % x 0.94

where
P = Pol
F = Fibre
B = Brix
CCS = Commercial cane sugar

The data collected were analyzed statistically and the least significant difference (LSD) test at 5% probability was used to compare the means of different treatments.

Results and Discussion

A set of field experiments were conducted to study the production potential of September planted Sugarcane (*Saccharum officinarum* L.) under varying agro-management practices for the year 2007-2008. Investigations were carried out at the Sugarcane Research Farm, AARI, Faisalabad. In the present experiment two sugarcane promising clones viz., S2002-US-637 and CP 85-1491 were evaluated at five bio-fertilizer and chemical fertilizer levels in different combinations. Experiments were laid out in randomized complete block design with factorial arrangement and replicated three times.

Table 1. Integrated effect of bio- and chemical fertilizer on promising sugarcane clones.

Treatments	No. of tillers (000/ Ha.)	No. of millable canes (000/ ha.)	Cane height (cm)	Cane diameter (cm)	Cane yield (t/ ha.)	Sugar recovery (%)
Fertilizer levels						
F_1	98.30 A	70.30 A	248.20 A	2.85 A	100.50 A	12.85 AB
F_2	101.50 A	70.80 A	219.50 C	2.40 BC	97.20 C	12.14 C
F_3	100.20 A	67.50 AB	234.11 B	2.63 AB	99.40 A	12.68 ABC
F_4	99.10 A	68.00 AB	224.60 C	2.50 B	98.00 C	12.32 BC
F_5	85.60 B	59.60 B	207.27 D	2.18 C	95.60 D	13.13 A
LSD	10.82	7.91	4.32	0.24	1.18	0.60
Varieties						
V_1	120.10 A	85.70 A	230.60 A	2.55 A	100.15 A	12.71
V_2	71.40 B	50.40 B	220.20 B	2.47 B	94.10 B	12.53
LSD	11.77	6.97	3.20	0.35	1.01	N.S
Interaction						
V_1F_1	117.00 BC	81.30 AB	253.00 A	3.04 A	103.10 A	12.65 ABC
V_1F_2	130.40 AB	92.40 A	224.00 C	2.40 BCD	100.40 BC	12.47 ABC
V_1F_3	122.50 AB	85.10 AB	240.00 B	2.69 AB	102.50 A	12.80 AB
V_1F_4	131.30 A	92.90 A	226.30 C	2.56 BC	100.60 B	12.48 ABC
V_1F_5	106.40 C	75.00 B	211.00 D	2.16 D	98.90 CD	13.11 AB
V_2F_1	79.10 D	60.50 C	243.00 B	2.74 AB	98.10 D	13.06 AB
V_2F_2	71.20 DE	48.10 CD	210.00 D	2.42 BCD	94.20 FG	11.70 C
V_2F_3	73.30 DE	51.00 CD	227.10 C	2.60 BC	96.90 E	12.52 ABC
V_2F_4	62.00 E	43.10 D	215.00 D	2.52 BCD	95.40 EF	12.14 BC
V_2F_5	67.00 DE	47.00 CD	200.20 E	2.23 CD	92.00 G	13.18 A
LSD 0.05 %	14.21	11.23	5.95	0.32	1.45	0.86

The data presented in the Table 1 revealed that maximum tillering (101,500 ha^{-1}) were recorded in F_2 and minimum tillering (85,600 ha^{-1}) was given by F_5 (check). Out of two varieties V_1 (S2002-US 637) produced more number of tillers (120,100 ha^{-1}) than V_2 (CP85-1491) with 70,400 ha^{-1}. The interaction of $V_I F_4$ (S2002-US 637 X 168-112-112 NPK kg ha^{-1}) was the best, with 131,300 tillers ha^{-1}. The highest number of mill-able canes (70,800 ha^{-1}) was produced in F_2, while the lowest i.e. 59,600 tillers ha^{-1} were observed in F_5. The variety V_1 (S2002-US-637) produced significantly more number of millable canes (85,700 ha^{-1}) than V_2 (CP85-1491) with 50,400 millable canes ha^{-1}. The V_1F_4 interaction was the best, which produced 92,900 ha^{-1} number of millable canes. Cane length and cane diameter are very important yield contributing parameters in sugarcane. The data indicated that significantly the longest canes (248.20 cm) were produced by F_1, and the canes of shortest length (207.27 cm) were found in F_5. The variety V_1 produced significantly canes of greater height (230.60 cm) than V_2 with 220.20 cm cane length. The V_1F_1 interaction was the best, which produced cane of 253.00 cm height. The canes of significantly greater diameter (2.85 cm) were observed in F_1, whereas the canes of least thickness (2.18 cm) were found in F_5. The variety V_1 produced significantly canes of greater diameter (2.55 cm) than V_2 with cane diameter of 2.47 cm. The V_1F_1 interaction was the best, which produced cane of 3.04 cm diameter. The treatment F_1 (50% bio-fertilizer i.e. 62 kg ha^{-1} + 50% of recommended dose of NPK i.e., 84-56-56 NPK kg ha^{-1}) gave significantly higher cane yield (100.50 t ha^{-1}) than all

other treatments except F_3 (Bio-fertilizer @ 124 kg ha^{-1}) with cane yield of 99.40 t ha^{-1} with which it was at par. The treatment F_4 (recommended dose of fertilizer i.e. 168-112-112 NPK kg ha^{-1}) gave significantly higher cane yield (98.00 t ha^{-1}) than F_5 (control) with 95.60 t ha^{-1} cane yield but was at par with F_2 (75% of the bio-fertilizer + 25% of the recommended dose i.e., 42-28-28 NPK kg ha^{-1}) with cane yield of 97.20 t ha^{-1}. The variety V_1 produced significantly higher cane yield (100.15 t ha^{-1}) than V_2 with 94.10 t ha^{-1} cane yield. The V_1F_1 interaction was the best, which produced 103.10 t ha^{-1} cane yield. Sugar recovery of different treatments was different in two clones. The F_5 produced significantly the highest sugar recovery of 13.13 %, while the lowest sugar recovery 12.14% was produced by F_2. The variety V_1 produced higher sugar recovery (12.71%) than V_2 with 12.53% sugar recovery. The V_2F_5 interaction was the best, which produced 13.18% sugar recovery. F_1 treatment significantly affected agronomic characteristics such as cane height (cm), cane diameter (cm), number of tillers (000 ha^{-1}), number of millable canes (000 ha^{-1}), cane yield (000 t ha^{-1}) over control in sugarcane promising clone S2002-US-637 than CP 85-1491. The two clones showed non-significant difference in quality parameter such as sugar recovery %. The interaction V_1 F_1 significantly affected all parameters except sugar recovery %.

The data presented in Table 2 revealed that maximum tillering (139,100 ha^{-1}) was recorded in P_4 and minimum tillering (120,600 ha^{-1}) was given by P_1 (check). Out of two varieties V_2 (S2002-US 637) produced more number of tillers (159,110 ha^{-1} than V_1 (CP 85-1491) with 93,900 tillers ha^{-1}. The interaction of V_2 P_2 was the best with 172,400 tillers ha^{-1}. The highest number of mill able canes (100,300 ha^{-1}) was produced in P_4, while the lowest number of mill able canes (86,200 ha^{-1}) was observed in P_1. The variety V_2 produced significantly more number of mill able canes (117,100 ha^{-1}) than V_1 with 65.50 000 mill able canes ha^{-1}. The V_2 P_2 interaction was the best, which produced 124.30 000 ha^{-1}number of mill able canes. Cane length and cane diameter are very important yield contributing parameters in sugarcane. The data indicate that significantly the longest canes (250.44 cm) were produced by P_4, and the canes of shortest length (217.33 cm) were found in P_1. The variety V_2 produced significantly canes of greater height (233.00 cm) than V_1 with cane of 232.40 cm height. The V_2 P_4 interaction was the best, which produced 250.90 cm cane height. The canes of significantly greater diameter (2.90 cm) were observed in P_4, whereas the canes of least thickness (2.37 cm) were found in P_1. The variety V_2 produced significantly canes of greater diameter (2.50 cm) than V_1 with canes of 2.42 cm diameter. The V_2 P_4 interaction was the best, which produced canes of 3.01 cm diameter. The treatment P_4 (Furadon 20 kg ha^{-1} at sowing + Furadon 40 kg ha^{-1} in April/May + 40 kg ha^{-1} in June/July) gave significantly higher cane yield (100.20 t ha^{-1}) than all other remaining treatments. The treatment P_1 (no pesticide) gave significantly lower cane yield than all other treatments. The variety V_2 produced significantly higher cane yield (100.26 t ha^{-1}) than V_1 with cane yield of 93.30 t ha^{-1}). The V_2 P_4 interaction was the best, which produced 103.11 t ha^{-1} cane yield. Sugar recovery of different treatments was different in two clones. The P_1 produced the highest sugar recovery of 12.10%, while the lowest sugar recovery 11.00% was produced by P_3. The variety V_2 produced significantly higher sugar recovery (11.80%) than V_1 with 11.45% sugar recovery. The V_2 P_1 interaction was the best, which produced 12.32% sugar recovery.

Table 2. Integrated effect of bio- and chemical pesticides on sugarcane pests in different promising clones.

Treatments	No. of tillers (000/ Ha.)	No. of millable canes (000/ ha.)	Cane height (cm)	Cane diameter (cm)	Cane yield (t/ ha.)	Sugar recovery (%)
Pesticide levels						
P_1	120.60	86.20	217.33 D	2.37 C	93.60 D	12.10
P_2	132.00	95.70	229.28 C	2.49 BC	95.50 C	11.35
P_3	130.40	94.50	239.11 B	2.71 AB	98.10 B	11.00
P_4	139.10	100.30	250.44 A	2.90 A	100.20 A	11.46
LSD	N.S	N.S	5.99	0.21	0.74	N.S
Varieties						
V_1	93.90 B	65.50 B	232.40	2.42	93.30 B	11.45 B
V_2	159.11 A	117.10 A	233.00	2.50	100.26 A	11.80 A
LSD	28.47	17.80	N.S	N.S	1.02	0.12
Interaction						
$V_1 P_1$	90.30 B	63.25 B	218.00 D	2.35 D	90.35 F	12.00 AB
$V_1 P_2$	91.52 B	65.21 B	231.00 BC	2.46 CD	93.00 E	11.80 AB
$V_1 P_3$	98.10 B	70.35 B	237.60 BC	2.66 ABCD	96.45 D	10.40 B
$V_1 P_4$	106.60 B	78.53 B	250.50 A	2.87 AB	97.60 C	11.29 AB
$V_2 P_1$	150.43 A	106.45 A	216.30 D	2.41 D	98.50 C	12.32 A
$V_2 P_2$	172.40 A	124.30 A	230.00 C	2.55 BCD	99.00 B	11.45 AB
$V_2 P_3$	165.50 A	120.40 A	238.10 B	2.80 ABC	101.40 A	11.90 AB
$V_2 P_4$	170.10 A	122.45 A	250.90 A	3.01 A	103.11 A	12.02 AB
LSD 0.05 %	33.03	22.40	7.95	0.34	1.09	1.73

The data presented in Table 3 revealed that maximum tillering (160,200 ha^{-1}) was recorded in I_4 (alternate skip irrigation) and minimum tillering (147,000 ha^{-1}) was given by I_3 (skip irrigation). Out of two varieties V_2 (S2002-US 637) produced more number of tillers (175,000ha^{-1}) than V_1 (CP85-1491) with 120,000 tillers ha^{-1}. The interaction of V_2 I_4 was the best with 191,400 tillers ha^{-1}. The highest number of millable canes (114,200 ha^{-1}) were produced in I_4, while the lowest number of millable canes (105,000 ha^{-1}) were observed in I_3. The variety V_2 produced significantly more number of millable canes (127,480 ha^{-1}) than V_1 with 82,200 millable canes ha^{-1}. The $V_2 I_4$ interaction was the best, which produced 140,100 ha^{-1} numbers of millable canes. Cane length and cane diameter are very important yield contributing parameters in sugarcane. The data indicate that significantly the longest canes (248.00 cm) were produced by I_3, and the canes of shortest length (230.00 cm) were found in I_1. The variety V_2 produced significantly canes of greater height (244.30 cm) than V_1 with canes of 240.15 cm height. The $V_2 I_4$ interaction was the best, which produced 251.40 cm cane height. The canes of significantly greater diameter (2.88 cm) were observed in I_4, whereas the canes of least thickness (2.30 cm) were found in I_1. The variety V_2 produced significantly canes of greater diameter (2.65 cm) than V_1 with 2.52 cm cane diameter. The V_2 I_4 interaction was the best, which produced 3.00 cm cane diameter.

The treatment I_4 (Alternate skip irrigation after earthing up 90 DAS in trench planting at 120 cm apart rows) gave significantly higher cane yield (100.40 t ha^{-1}) than all other remaining treatments. The treatment I_1 (Flood irrigation by siphon in flat sowing at 120 cm apart rows) gave significantly lower cane yield (95.50 t ha^{-1}) than all other remaining treatments except I_2 (Normal irrigation with siphon after earthing up 90 DAS in trench planting at 120 cm apart rows) with which was at par. The variety V_2 produced significantly higher cane yield (100.50 t ha^{-1}) than V_1 with cane yield of 94.30 t ha^{-1}. The $V_2 I_4$ interaction was the best, which produced 102.00 t ha^{-1} cane yield. Sugar recovery of different treatments was not affected significantly by different irrigation treatments while sugar recovery was significantly different in two varieties. The variety V_1 produced significantly higher sugar recovery (12.50%) than V_2 with 11.90% sugar recovery. The $V_1 I_1$ interaction was the best, which produced 12.70% sugar recovery.

Table 3. Irrigation trial on flat versus trench planting in promising sugarcane clones.

Treatments	No. of tillers (000/ Ha.)	No. of millable canes (000/ ha.)	Cane height (cm)	Cane diameter (cm)	Cane yield (t/ ha.)	Sugar recovery (%)
Irrigation levels						
I_1	153.30	109.45	230.00 C	2.30 C	95.50 C	12.39
I_2	154.60	113.00	239.20 B	2.49 B	96.30 C	12.24
I_3	147.00	105.00	248.00 A	2.79 AB	98.45 B	12.20
I_4	160.20	114.20	245.10 A	2.88 A	100.40 A	12.10
LSD	N.S	N.S	6.02	0.30	0.84	N.S
Varieties						
V_1	120.20 B	82.20 B	240.15	2.52	94.30 B	12.60 A
V_2	175.00 A	127.48 A	244.30	2.65	100.50 A	11.90 B
LSD	30.20	27.10	N.S	N.S	0.78	0.18
Interaction						
$V_1 I_1$	128.10 B	91.20 B	230.10 E	2.27 C	91.20 F	12.70
$V_1 I_2$	123.30 B	94.10 B	239.20 CDE	2.46 ABC	92.00 F	12.65
$V_1 I_3$	112.60 B	80.50 B	245.60 ABC	2.77 ABC	96.00 D	12.35
$V_1 I_4$	125.70 B	88.00 B	243.00 ABC	2.70 ABC	95.10 E	12.33
$V_2 I_1$	180.00 A	129.10 A	232.50 DE	2.35 BC	98.40 C	12.05
$V_2 I_2$	185.20 A	132.30 A	241.00 BCD	2.54 ABC	99.20 BC	11.83
$V_2 I_3$	178.00 A	126.50 A	249.60 AB	2.84 AB	101.00 AB	12.04
$V_2 I_4$	191.40 A	140.10 A	251.40 A	3.00 A	102.00 A	11.84
LSD 0.05 %	32.37	23.05	8.90	0.47	1.27	N.S

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