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PERFORMANCES OF DOLOCHUN AS A SOURCE OF MAGNESIUM FOR SUGARCANE AT FARMERS FIELD UNDER OLD HIMALAYAN PIEDMONT PLAIN

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ABSTRACT

A Verification trial was conducted in 2005-2006 cropping season at farmers field of Thakurgaon and Panchagar districts to evaluate the performances of dolochun as a source of magnesium on sugarcane production. Four levels of magnesium (0. 20. 40 & 60kg ha^{-1}) from dolochun with recommended dose of NPKS were applied equally to all the treatments. Application of dolochun @ 40 kg Mg ha^{-1} significantly increased the number of millable canes, cane yield and brix percentage. The minimum number of tiller, number of millable cane and cane yield were produced in control plot with recommended NPKS fertilizers where no magnesium was applied. Results revealed that the application of dolochun at 40 kg Mg ha^{-1} with recommended fertilizers (N12, P35, K100, S25 & Zn_2 kg ha^{-1}) produced significantly higher sugarcane yield (91.37 that millable cane (88.15 x $l0^3$ ha^{-1}) and brix % (22.87) among all other treatments under study.

Key Words: Dolochun, magnesium, sugarcane, farmers field Old Himalayan Piedmont Plain

INTRODUCTION

Magnesium plays vital roles in chlorophyll synthesis, cellular pH control protein synthesis and transfer of phosphate (phosphates and ATPases) in energy metabolism of plants (Marschnerl986: Dev and Kumar, 1982). Therefore, the role of magnesium in sugarcane production was many folds. Magnesium has considerable contribution in acid soils and the toss of magnesium through leaching is very high. Further more, higher the soil acidity, the greater in the magnesium loss. Again in light textured soils, the magnesium loss is greater than that in the heavy soils. Response of Sugarcane to root growth and transport of photosynthesis from leaves to stems are impaired when the plant suffers from Mg deficiency, Sugarcane response to applied Mg has been reported by Rahman *et al.,* (1986) in acid soils of Bangladesh with low exchangeable Mg (Anon.1989). However Recently Paul *et al.,* (2004) demonstrated that the application of dolochun showed higher sugarcane yield in acid soils under old Himalayan piedmont plain Information regarding the performances of dolochun as a source Mg on sugarcane yields at farmers field in acid soils of northern part of Bangladesh is not available. Considering the above fact this verification trial was under taken to evaluate the performance of dolochun on sugarcane production under farmers' condition at Old Himalayan piedmont plain soils.

MATERIALS AND METHODS

The trial was conducted at six growers' field of Thakurgaon (Khochabari, Uttar Thakurgaon and Purougi village) and Panchagar (Mirzapur, Arwari and Boda village) in Sugar Mills zone under Old Himalayan Piedmont Plain AEZ 1. during the cropping seasons 2005-2006. The soils were sandy loam with pH *5.5* and low in organic matter (®M) content.

The experiment was set up in RCBD with six replicating each farmer as one replication. The treatment consisted of four levels of Mg (0, 20, 40 & 60 kg ha^{-1}) from dolochun. Location specific recommended doses of NPKS fertilizers were applied equally to all the treatments under study. Full amount of phosphorus, sulpher and magnesium with one third of nitrogen and potassium were applied at the time of planting. The rest two thirds of Nitrogen and Potassium were applied in two equal splits at 90 and 180 days alter planting. No magnesium was added in control plots (T0) where only recommended NPKS fertilizers were applied. The variety fed 36 was used as test crop. Four treatments were included in the study.

There are as follows:

T0: Control (Without Mg);
T1: 20 Mg ha^{-1}
T2: 40 Mg ha^{-1}
T3: 60 kg Mg ha^{-1}

The trails at all locations were harvested during last week of December 2006 and the data on germination percentage, number of tiller, number of millable cane, yield of cane and brix (%) were recorded. The data were statically analyzed (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

The use of recommended fertilizer doses with and without magnesium had significant effect on yield and yield attributes of sugarcane (Table-l). From the results of consecutive studies in 2005-2006. It is revealed that the treatment T_2 having application of Dolochun at 40kg Mg/ha with recommended fertilizers NPKSZn produced significantly higher sugarcane yield (88.34 t/ha), millable cane (88.15 xio ha^{-1}) and brix% (22.87) among all other treatments of the experiment. Evaluating the results in 2005-2006, it is observed that the highest germination (48.39%) was obtained from T_3 treatment as well as the treatment TI produced higher number of tillers (152.36 x 10^3) over T_0, T_1 and T_3 among all. It is further revealed that the treatment T_2 having dolochun at 20kg/ha with recommended fertilizers NPKSZn significantly produced the second highest sugarcane yield (86.96 t/ha) among all the rest of the treatments. The treatment T_1Showed the second highest number of millable cane (86.06 x 10^3 ha^1) among all. The present findings revealed that the addition of magnesium either from Dolochun or magnesium oxide with recommended fertilizers NPKSZn produced higher yield and yield attributes of sugarcane under study in 2005-2006 cropping season This finding is in agreement with the results of (Rahman *et al*., 1986), Saha *et al*., (1998) and Paul *et al*., (2004). It was also found that the addition of Dolochun at 40 kg Mg/ha, with recommended fertilizers NPKSZn in sugarcane, gave the highest per hectare net economic benefit of Bangladesh Taka 23375.00 (Table-2). The second highest net economic benefit of Bangladesh Taka 22414.50 was obtained from T2 treatment while the lowest from T3 treatment.

Table-1 Yield and yield parameters of sugarcane as influenced by the application of dolochun as a source of magnesium at farmers field in cropping season 2005-2006

Treatments (Mg kg ha^{-1})	Germination (%)	No. of Tiller (x 10^3 ha^{-1})	No. of Millable cane (x 10^3 ha^{-1})	Cane yield (tha^{-1})	Brix (%)
T_0:0	42.51	129.635	78.42b	69.69b	20.92d
T_1 : 20	47.66	141.80	86.06a	86.96a	21.54c
T_2 : 40	46.54	152.36	88.15a	88.34a	22.87a
T_3 : 60	48.39	148.02	84.72a	82.883	22.37b
LSD (5%)			10.34	11.26	0.27

Table-2 Economic benefit of Dolochun fertilization of sugarcane production in Cropping season 2005-2006

Added Dolochun with recommended NPKSZn at the rate of Mg (kg/ha)	Cost of Dolochun Fertilizer (Taka/ha)	Yield of Sugarcane (t/ha)	Increase in cane yield by Dolochun over recommended NPKS Zn (t ha)	Net benefit (Taka/ha)
0	-	69.69	-	
20	900.00	86.96	17.27	22414.50
40	1800.00	88.34	18.65	23375.00
60	2700.00	82.88	13.19	15106.00

Cane price in Bangladesh Taka 1350.00 per ton and Dolochun Taka 5.00 per kilogram.

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YIELD AND QUALITY COMPARISON OF PROMISING VARIETIES OF AUTUMN SOWN SUGARCANE

By
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ABSTRACT

A field experiment with 18 sugarcane promising varieties was conducted to compare their yield and quality in autumn season during 2003-2005. The experiment was laid out in Randomized Complete Block Design with 3 repeats having net plot size of 4 x 9.6 m^2. The variety CPF-243 gave the maximum yield of 108.17 t ha^{-1} which was statistically at par with HSF-242 and S96-SP-1215 with yield of 107.23 and 107.17 t/ha, respectively as against standard variety HSF-240 giving cane yield of 99.83 t/ha. These varieties also produced higher CCS t/ha of 13.61, 13.56 and 12.38 t/ha, respectively as against standard variety HSF-240 with 11.58 t ha^{-1}.

Keywords: Promising, sugarcane, yield, quality, higher, autumn.

INTRODUCTION

Agriculture is the main stay of Pakistan's economy. Nearly 22% of total output (GDP) and 44.8% of total employment is generated in agriculture. Sugarcane contributes substantially to Pakistan's economy. Sugarcane crop serves as a major raw material for production of white sugar and gur. Their share in value added of agriculture and GDP are 3.4% and 0.7%, respectively. For 2005-2006, the area under sugarcane crop was targeted at 955 thousand hectares as against 966 thousand hectares of last year. However, sugarcane has been sown in the area of 907 thousand hectares – 5% below the target and 6.1% less than last year. Sugarcane production for the year 2005-06 is estimated at 44.3 million tones against the 47.2 million tones last year. Thus sugarcane production is estimated to be lower by 6.2% over the last year with an average yield of 48.85 t ha^{-1}. Factors responsible for decline in sugarcane production include late harvesting of wheat, frost affecting the crop and farmer's shifting to other competing crops (GOP, 2006). The major cause of low yield of sugarcane is the growing of old varieties loosing yield potential due to disease infestation. Efforts made during past decades to increase cane production were mainly introduction of high yielding varieties and adoptions of improved crop production techniques (Gill, 1995).

Sarwar, *et al.,* (2003) found that the standard varieties like BF-162 and SPF-234 susceptible to red rot and smut diseases in Central and Northern Punjab. Chattha *et al.,* (2002) stressed to study the new genotypes under farmer conditions before final recommendations. Keeping in view, the present study was conducted to achieve the following objectives:

1. To evaluate the best suitable and adaptive genotype of sugarcane for commercial cultivation.
2. To compare the cane and sugar yield potential of some new sugarcane genotypes developed through fuzz at Sugarcane Research Institute, Faisalabad.
3. To develop high yielding potential varieties of sugarcane.

MATERIALS AND METHODS

A field experiment with eighteen sugarcane promising varieties (given in table) was conducted at Sugarcane Research Institute, Faisalabad to compare their yield and quality in autumn season during 2003-2004. The experiment was laid out in R.C.B.D. with three repeats

at 120 cm apart trenches having net plot size of 4 x 9.6 m^2. The experiment was sown in the first week of September. All the agronomic practices and plant protection measures were kept uniform according to the standard. The sugarcane seed rate of 70,000 DBS/ha was used for crop sowing. Fertilizer NPK @ 168-112-112 kg ha^{-1} was applied. The required data were recorded and analyzed using standard procedures and techniques and subjected to statistical analysis through MSTATC statistical computer programme (MSTAT-C, Manual, 1991).

RESULTS AND DISCUSSION

Germination % and tillers/plant

Data presented in table reveal that the germination %age of all the varieties included in experiment was not affected significantly when sown in autumn season. However, the tillering behaviour of all varieties was significantly affected and the variety CPF-243 produced the highest no. of tillers/plant (3.89) which was followed by CPHS-35 (3.73) and HSF-242 (3.60). This may be due to the reason that tillering is largely a varietal character and is partly affected by cultural practices. This explanation is in harmony with Sathyavelu *et al.*, (1991).

No. of canes ha^{-1}, cane yield and CCS t ha^{-1}

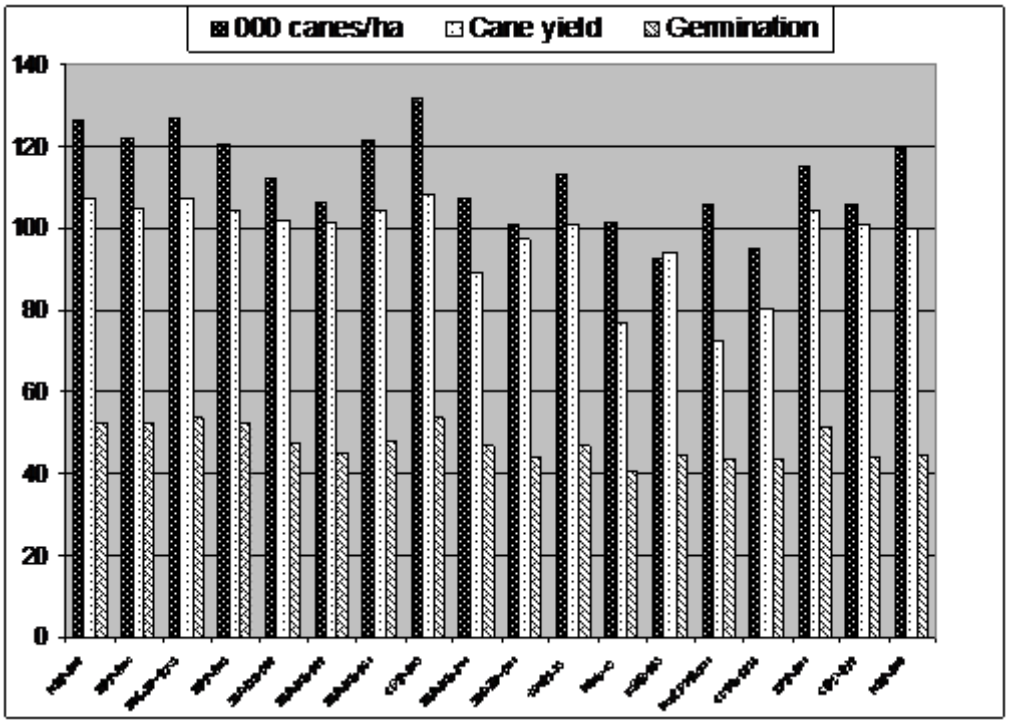
Number of canes is an important yield contributing parameter, which directly contributes to the final cane yield. The data embodied in table show that the variety CPF-243 produced the maximum thousand-cane ha^{-1} (131.45), which was followed by the variety HSF-242 (126.25). However, CPF-243 gave the maximum cane yield of 108.17 t ha^{-1} which was statistically at par with HSF-242 and S96-SP-1215 producing yield of 107.23 and 107.17 t ha^{-1} respectively as against standard variety HSF-240 giving cane yield of 99.83 t ha^{-1}. This may be due to the reason that more germination %age, tillering behaviour and more number of canes ha^{-1} of the said varieties. These varieties also produced higher CCS of 13.61, 13.56 and 12.38 t ha^{-1}, respectively as against standard variety HSF-240 producing CCS of 11.58 t ha^{-1}. Chattha et al., 2004 and Bashir et al., 2005, have also reported similar results.

Table-1 Yield and quality comparison of promising varieties of autumn sown sugarcane (Aveg.of two years)

Sr. No.	Varieties	Germination%	Tillers/plant	'000'cane/ha	CCS t/ha	Yield t/ha
1.	HSF-242	52.75	3.60 B	126.25 B	13.56 A	107.23 A
2.	SPF-244	52.86	2.26 E	122.26 C	12.56 AB	104.5 B
3.	S96-SP-1215	53.85	2.24 EF	127.08 B	12.38 AB	107.17 A
4.	SPF-245	52.75	2.26 E	120.30 D	12.02 AB	104.17 B
5.	S97-US-102	47.60	2.52 CD	112.20 H	12.77 AB	102.16 C
6.	S97-US-127	45.30	2.17 EF	106.15 J	12.15 AB	101.83 DE
7.	S97-US-161	48.09	1.59 I	121.43 C	12.45 AB	104.17 B
8.	CPF-243	53.85	3.89 A	131.45 A	13.61 A	108.17 A
9.	S97-US-214	46.99	2.26 E	107.46 I	10.64 BC	88.83 G
10.	S98-SP-341	44.32	1.91 H	101.16 K	9.34 AB	97.33 I
11.	CPHS-35	46.99	3.73 B	113.40 G	10.92 BC	101.17 CD
12.	NSG-49	40.74	1.66 I	101.63 L	9.59 CD	76.83 J
13.	NSG-555	44.60	2.60 C	92.56 N	11.11 BC	94.17 F
14.	HoCP 90-441	43.57	2.10 FG	105.97 J	7.46 D	72.5 K
15.	CP 92-1666	43.58	2.19 EF	95.13 H	8.25 D	80.5 H
16.	SPF-241	51.71	2.42 D	115.13 F	11.94 AB	104.17 B
17.	CPF-237	44.11	1.95 GH	105.55 J	12.14 AB	101.17 D
18.	HSF-240	44.78	2.16 EF	119.31 E	11.58 ABC	99.83 E
	LSD at 0.05	N.S.	0.1574	0.9675	2.204	1.132

N.S. = Non-significant

Values followed by the same letter in the same column do not differ significantly at 0.05 probability.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Cane yield
Germination
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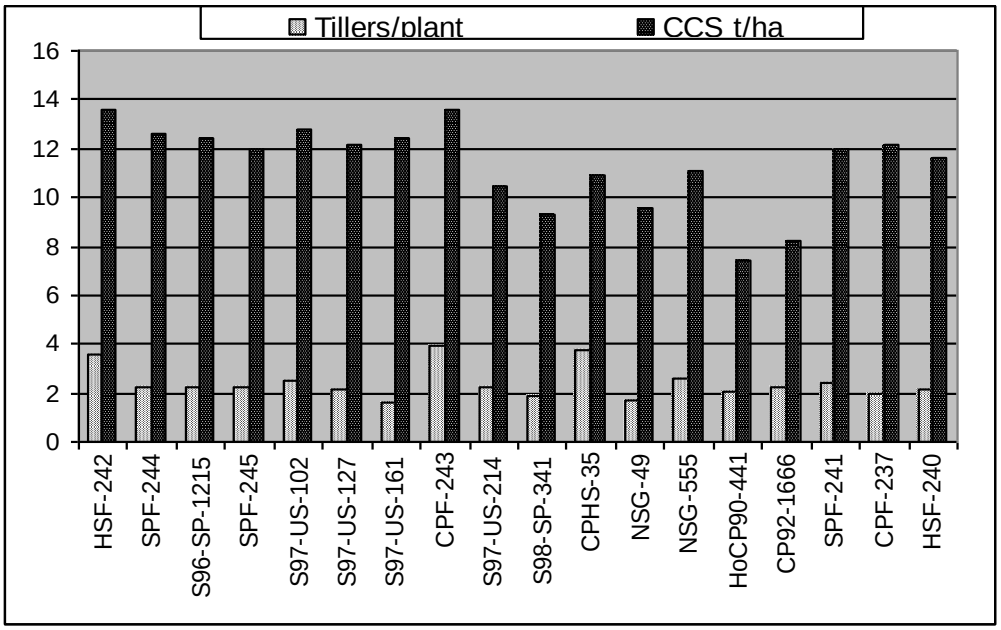
120
100
80
60
40
20
0


Tillers/plant
CCS t/ha
16
14
12
10
8
6
4
2
0
HSF-242
SPF-244
S96-SP-1215
SPF-245
S97-US-102
S97-US-127
S97-US-161
CPF-243
S97-US-214
S98-SP-341
CPHS-35
NSG-49
NSG-555
HoCP90-441
CP92-1666
SPF-241
CPF-237
HSF-240

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REGENERATION OF HIGH SUGAR NON-FLOWERING SOMACLONES OF SUGARCANE

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ABSTRACT

Somaclones of sugarcane varieties Isd 16, Isd 28, Isd 31 and clones I 273-91 and B34-104 were regenerated through callus culture using unexpanded spindle leaf segments as explants. Explants were cultured on MS medium supplemented with 2, 4-D for callus induction. Callus was cultured on MS medium supplemented with BAP 2.0 mgl^{-1} and Kn 1.0 mgl^{-1} for shoots formation. For roots formation in shoots MS medium with NAA 5.0 mgl^{-1} was used. Regenerated plants were hardened and planted in the field for variable somaclones selection. Selected somaclones were planted in field next year for observation of yield contributing characters. Finally the somaclones selected based on yield contributing characters were planted in the field and germination, tiller, millable cane, yield, flowering behaviour, and chemical analysis for pol and recovery were recorded to study the field performances compared to their donor parents. Three sub-clones of flowering donor variety Isd 16 became non-flowering with higher recovery. One sub-clone each of Isd 31, B34-104 were also showed higher recovery than their donor parents. Studied yield and yield contributing characters of sub-clones showed more or less substantial equivalency to their respective donor parents. Results revealed the regeneration of high sugar non-flowering sub-clones from profusely flowering variety to prevent early recovery deterioration of sugar due to profuse flowering behaviour of cane. The results indicate the possibilities of recovery improvement and flower inhibition of sugarcane through tissue culture technique intervening callus.

Keywords: Sugarcane, regeneration, high-sugar, non-flowering, somaclones

INTRODUCTION

It has been proposed that primary application of tissue culture in crop improvement is to take an otherwise acceptable commercial cultivar that is deficient in few characters, produce somaclones of that cultivar through tissue culture, and select variants with the desired changes (Miller, 1985). Sugarcane is often cited as the model crop in which cultivar improvement has been obtained through tissue culture (Krishnamurthi, 1978, Heinz, 1990). The role of tissue culture in traditional cultivar development programmes is an important consideration that remains to be resolve at the present time. Sugarcane varieties development using conventional breeding method including a large number of characters followed by selection takes long time. Most of the varieties become defective with few but important agricultural characters within a shorter period of time after release. It makes a great problem for varietal sustainability in the farmers' fields. A good variety rebound from the farmers' fields for only one or two characters becoming defective. Correction techniques of defective characters and rejuvenation of released varieties deserve due research attention. Tissue culture techniques may be the tool for varietal correction of few defective characters. In the present investigation the sub-clones of some sugarcane varieties/clones derived through tissue culture techniques have been evaluated under field conditions giving emphasis on sugar recovery and flowering behaviour.

MATERIALS AND METHODS

Sugarcane varieties Isd 16, Isd 28 and Isd 31 and clones I 273-91 and B 34-104 were used. All varieties/clones in the experiment are flowering in nature. Unexpanded spindle leaf sheath segments were used as explants for regeneration of plants through intervening callus. Tops were collected from the field-grown cane of six month old and were cleaned by wiping with a piece of wet clothes with savlon. Outer leaves were removed leaving 2-3 inner leaves around the spindle and cut into pieces of about 3-5cm long from the base. Then cut pieces were transferred under laminar-flow-hood and sterilized with 0.1% mercuric chloride for 10-15 minutes followed by washing 3/4 times with sterilized distilled water. Spindle pieces were exposed removing 2-3 unfurled leaves and cut into small segments (about 0.5cm x 0.3 cm). The explants segments were cultured on MS medium supplemented with 2, 4-D (3.0 mgl^{-1}) for callus induction according to Hossain *et al.,* (1996). Callus was sub-cultured on MS medium supplemented with BAP (2.0mgl^{-1}) and Kn (1.0mgl^{-1}) for shoot regeneration suggested by Nadira (2006). Regenerated shoots were cultured on MS medium supplemented with NAA (5.0mgl^{-1}) for root formation in regenerated shoots followed by Hossain *et al*. (1996). Rooted shoots were hardened and planted in the field. Over 90% plants were hardened successfully. First year selection in R_0 (regenerated plants) generation was made based on visual observation of variability in height, girth and vigor of field grown plants. Setts were collected from selected clumps and planted in the field next year. Plant height, diameter, number of internodes and weight per cane were recorded. Selected sub-clones were planted in field data on germination, tiller number, millable cane number, cane weight, yield and finally chemical analysis were made to study the comparative field performances of regenerated sub-clones with respective donor varieties/clones in the following year.

RESULTS AND DISCUSSION

Field performances of sub-clones regenerated from three varieties such as Isd 16, Isd 28, Isd 31 and two clones such as I 273-91 and B34-104 were evaluated based on germination, tiller number, millable cane, cane weight, ton cane per hectare and chemical analysis of pol (%) and sugar recover (%). Flowering behaviour of sub-clones with their respective donor varieties/clones were also studied. Data on the above characters are presented in the Table 1. Three sub-clones such as Isd 16Sc-1, Isd 16Sc-2 and Isd 16Sc-3 of donor flowering varieties Isd 16 became non-flowering. The sugarcane variety Isd 16 is a sustainable variety for commercial cultivation in the field since 1980s in Bangladesh. The profuse flowering behaviour is the only major drawbacks for cultivation in the farmers' field of this variety. Due to flowering nature of the variety Isd 16 farmers bound to harvest and supplies the canes of this variety in sugar mills as well as early crushing for gur making. For commercial cultivation non-flowering varieties with high sugar and higher yield is the best option of farmers as well as sugar mills to select the variety for cultivation. These three sub-clones (Isd 16Sc-1, Isd 16Sc-2 and Isd 16Sc-3 of donor flowering varieties Isd 16) showed the higher pol (%) cane and recovery (%) than donor variety Isd 16. The sub-clone Isd 31Sc-1 of donor variety Isd 31 and sub-clone B34-104Sc-1 of donor clone B34-104 also showed higher recovery (%) than their respective donor parents. Significant improvement of sugarcane using tissue culture methods and recovery of high sucrose sugarcane were reported elsewhere (Liu and Chen, 1978; 1980). Germination is the prerequisite for initial establishment leading higher tiller and millable cane to higher yield of cane. Higher germination was recorded from two sub-clones (Isd 16Sc-1 and Isd 16Sc-4) of donor variety Isd 16, sub-clones Isd 28Sc-1, Isd 31Sc-1 and B34-10Sc-1 of donor varieties Isd 28, Isd 31 and clone I B34-104 respectively. Among the four sub-clones of donor clone I 273-91 two sub-clones such as I 273-91Sc-2 and I 273-91Sc-3 showed higher germination than donor clone I 273-91. Higher number of tiller was recorded from the sub-clones Isd 16Sc-1, Isd 16Sc-4 of donor variety Isd 16 and from sub-clones I 273-91Sc-1, I 273-91Sc-3 and I 273-91Sc-4 of donor clones I 273-

91 respectively. Each one of sub-clone of donor varieties Isd 28, Isd 31 and clone B34-104 also showed the higher number of tiller. Higher number of millable cane from sub-clones Isd 16Sc-1, Isd 16Sc-2 and Isd 16Sc-4 was recorded than their donor variety Isd 16. Each one of sub-clone of donor varieties Isd 28, Isd 31, clone B34-104 and all four sub-clones of donor clone I 273-91 produced higher number of millable cane. One sub-clone Isd 16Sc-4 of donor variety Isd 16 gave the higher yield of cane than donor parent. All sub-clones of donor varieties Isd 28, Isd 31 and clone I 273-91 showed higher yield over their donor parents. However, sub-clones Isd 16Sc-1, Isd 16Sc-2 and Isd 16Sc-3 of donor variety Isd 16 and sub-clone B34-104Sc-1 of donor clone B34-104 gave the lower yield than their parents. Diversity of sugar recovery, yield, millable cane and tiller number, and germination of regenerated sub-clones is the positive indication to select desirable clones for variety development as well as utilization in breeding programme.

Data collected on stalk height, stalk diameter, number of internodes and weight of canes were statistically analysed and compared mean, range, and standard deviation with respective donor varieties/clones are presented in the Tables (2-5). Means were compared by t-test and standard deviation by F-test. Stalk height is one of the important characters for yield. Mean of stalk height of sub-clone Isd 28Sc-1 of donor of variety Isd 28 was highly significant and standard deviation was significant of sub-clone I 273-91Sc-3 of donor clone I 273-91. Means and standard deviation of others sub-clones and varieties/clones were statistically similar. However, means for all sub-clones except sub-clones Isd 16Sc-1 and Isd 16Sc-3 were higher than their respective donor varieties/clones. Stalk height showed significant positive correlation with cane yield (Khairwal and Babu, 1975; Mannan and Ghafur, 1983; Gajera *et al*., 1991).

Data on stalk diameter showed that mean of sub-clone Isd 16Sc-3 and standard deviation of sub-clone Isd 16Sc-2 regenerated from variety Isd 16 was highly significant and higher than donor variety. Means for sub-clones Isd 16Sc-1, Isd 31Sc-1, I 273-91Sc-2 and B34-104Sc-1 were significantly different from their donor parents Isd 16, Isd 31, clones I 273-91 and B34-104Sc-1. Ranges for all sub-clones of all donor parents were higher than their respective parents. These results corroborated with the findings of Miller (1985). Stalk diameter plays a significant role for cane weight and cane yield. Lu (1984) observed significant correlation's both for single stalk weight and cane yield with cane diameter.

Mean number of internodes per cane of sub-clone Isd 28Sc-1 and sub-clone I273-91Sc-4 showed highly significant differences while sub-clone I 273-91Sc-1 showed significant difference than their respective donor parents. Ranges were higher for almost all the sub-clones than donor parents. There were no significant differences amongst standard deviation of sub-clones to their respective donor parents. Stalk weight differ highly significantly for means of sub-clones Isd 16Sc-1 and Isd 16Sc-3 with their donor parents. Standard deviation of sub-clones I273-91Sc-1 and B34-104Sc-1 differ significantly to their donor parents. Insignificant mean difference for stalk weight of non-flowering and high sugar sub-clone Isd 16Sc-2 indicates the substantial equivalence of yield to the donor variety Isd 16. Significant positive correlation between single stalk weight and cane yield was reported by Khairwal and Babu (1975) and Mannan and Ghafur (1983).

Yield and yield contributing characters of high sugar non-flowering sub-clones showed more or less substantial equivalence to their respective donor parents. Results revealed the regeneration of high sugar non-flowering sub-clones from profusely flowering variety to prevent early recovery deterioration of sugar due to profuse flowering behaviour of cane. The results indicate the possibilities of recovery improvement and flower inhibition of sugarcane through tissue culture technique intervening callus.

Table-1 Field performances of sub-clones of varieties Isd 16, Isd 28, Isd 31 and clones I 273-91 and B 34-104

Donor Varieties /Clones	Sub-clones	Germin-ation (%)	Tiller (000/ha)	Millable cane (000/ha)	TCH	Pol (%)	Recon-very	Flowering behaviour
Isd 16	-	44.87	124.62	101.54	115.76	12.78	9.50	Flowering
	Isd 16Sc-1	48.72	173.85	120.00	91.20	14.17	10.87	Non-flowering
	Isd 16Sc-2	20.51	104.62	104.62	112.99	15.10	11.59	Non-flowering
	Isd 16Sc-3	42.31	104.62	87.69	60.51	14.06	10.59	Non-flowering
	Isd 16Sc-4	90.28	286.15	238.46	255.15	10.84	8.12	Flowering
Isd 28	-	38.46	103.08	93.85	94.79	12.50	9.29	Flowering
	Isd 28Sc-1	59.09	216.92	170.77	192.97	9.49	6.47	Flowering
Isd 31	-	39.10	152.31	89.23	105.29	12.24	9.20	Flowering
	Isd 31Sc-1	41.67	141.54	113.85	149.14	15.04	11.66	Flowering
I 273-91	-	28.21	82.69	76.92	86.15	13.17	10.05	Flowering
	I273-91Sc-1	21.79	175.38	170.77	109.29	12.31	9.02	Flowering
	I273-91Sc-2	21.79	70.80	92.31	115.70	12.07	9.15	Flowering
	I273-91Sc-3	34.62	206.15	173.85	161.68	10.80	8.31	Flowering
	I273-91Sc-4	41.03	126.15	133.85	107.08	8.04	5.70	Flowering
B34-104	-	42.63	181.54	130.78	117.70	12.31	9.20	Flowering
	B34-104Sc-1	92.31	232.31	110.78	94.16	12.31	9.25	Flowering

Table-2 Stalk height of sub-clones derived through tissue culture of varieties Isd 16, Isd 28, Isd 31 and clones I 273-91 and B 34-104

Donor varieties/clones				Sub-clones			
Name	Mean	Range	S.D.	Name	Mean	Range	S.D.
Isd 16	3.27	2.85-3.70	0.309	Isd 16Sc-1	3.12	3.00-3.35	0.152
				Isd 16Sc-2	3.31	2.70-3.95	0.525
				Isd 16Sc-3	2.91	2.65-3.15	0.222
				Isd 16Sc-4	3.82	3.00-4.45	0.652
Isd 28	3.39	3.30-3.50	0.074	Isd 28Sc-1	3.96**	3.80-4.10	0.119
Isd 31	3.63	3.20-4.00	0.291	Isd 31Sc-1	3.79	3.50-4.15	0.290
I 273-91	3.24	2.65-3.90	0.521	I273-91Sc-1	3.13	2.40-3.50	0.449
				I273-91Sc-2	3.13	2.35-3.90	0.704
				I273-91Sc-3	3.88a	3.65-4.00	0.135*
				I273-91Sc-4	3.44	3.15-3.70	0.270
B 34-104	3.41	3.00-3.90	0.375	B 34-104Sc-1	3.60	2.85-4.10	0.506

* Indicates significant at 5% level and ** at 1% level, standard deviation (s.d.) in F test and mean in t-test. Stalk height was measured in meter (m).

Table-3 Stalk diameter of sub-clones derived through tissue culture of varieties Isd 16, Isd 28, Isd 31 and clones I 273-91 and B 34-104

Donor varieties/clones				Sub-clones			
Name	Mean	Range	S.D.	Name	Mean	Range	S.D.
Isd 16	1.98	1.90-2.10	0.084	Isd 16Sc-1	1.74*	1.50-2.00	0.195
				Isd 16Sc-2	1.88	1.50-2.40	0.396**
				Isd 16Sc-3	1.64**	1.50-1.80	0.134
				Isd 16Sc-4	1.84	1.50-2.20	0.251
Isd 28	1.90	1.70-2.20	0.235	Isd 28Sc-1	2.00	1.80-2.10	0.122
Isd 31	1.96	1.80-2.10	0.152	Isd 31Sc-1	2.10*	1.80-2.30	0.212
I 273-91	1.96	1.50-2.40	0.416	I273-91Sc-1	1.56	1.40-1.80	0.152
				I273-91Sc-2	2.30*	2.00-2.60	0.283
				I273-91Sc-3	2.00	1.60-2.30	0.274
				I273-91Sc-4	1.78	1.70-1.90	0.110*
B 34-104	1.86	1.70-2.10	0.152	B 34-104Sc-1	1.74*	1.60-2.00	0.167

* Indicates significant at 5% level and ** at 1% level, standard deviation (s.d.) in F test and mean in t-test. Stalk diameter was measured in centimeter (cm).

Table-4 Internode number of sub-clones derived through tissue culture of varieties Isd 16, Isd 28, Isd 31 and clones I 273-91 and B 34-104

Donor varieties/clones				Sub-clones			
Name	Mean	Range	S.D.	Name	Mean	Range	S.D.
Isd 16	29	26-31	2.739	Isd 16Sc-1	33	30-39	3.633
				Isd 16Sc-2	28	23-37	5.639
				Isd 16Sc-3	30	26-34	3.362
				Isd 16Sc-4	24	18-27	4.669
Isd 28	33	30-38	3.391	Isd 28Sc-1	24**	21-27	2.236
Isd 31	28.40	26-31	1.817	Isd 31Sc-1	27.60	23-30	2.881
I 273-91	25	22-30	3.847	I 273-91Sc-1	32*	29-35	2.449
				I 273-91Sc-2	31	23-37	6.140
				I 273-91Sc-3	25	21-26	2.074
				I 273-91Sc-4	33**	31-37	2.881
B 34-104	21	18-25	2.646	B 34-104Sc-1	21.20	15-25	3.962

* Indicates significant at 5% level and ** at 1% level, standard deviation (s.d.) in F test and mean in t-test.

Table-5 Stalk weight of sub-clones derived through tissue culture of varieties Isd 16, Isd 28, Isd 31 and clones I 273-91 and B 34-104

Donor varieties/clones				Sub-clones			
Name	Mean	Range	S.D.	Name	Mean	Range	S.D.
Isd 16	1.14	0.90-1.30	0.178	Isd 16Sc-1	0.77**	0.60-0.98	0.168
				Isd 16Sc-2	1.09	0.64-1.64	0.504
				Isd 16Sc-3	0.69**	0.46-0.94	0.207
				Isd 16Sc-4	1.08	0.52-1.34	0.341
Isd 28	1.01	0.44-1.50	0.419	Isd 28Sc-1	1.14	0.42-1.48	0.420
Isd 31	1.18	0.98-1.54	0.229	Isd 31Sc-1	1.32	0.88-1.70	0.341
I 273-91	1.13	0.60-1.80	0.574	I273-91Sc-1	0.65	0.48-0.88	0.151*
				I273-91Sc-2	1.60	0.90-2.18	0.512
				I273-91Sc-3	0.94	0.48-1.30	0.328
				I273-91Sc-4	0.80	0.44-1.10	0.270
B 34-104	0.90	0.83-0.98	0.066	B 34-104Sc-1	0.86	0.52-1.05	0.207*

* Indicates significant at 5% level and ** at 1% level, standard deviation (s.d.) in F test and mean in t-test. Stalk weight was measured in kilogram (kg).

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AGRONOMIC PERFORMANCE OF SOME MEDIUM AND LATE MATURING SUGARCANE GENOTYPES

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ABSTRACTS

Fourteen medium and late maturing genotypes (CPHS-35, CP90-1384, CP92-1167, S96-US-228, S96-SP-302, S96-SP-574, S96-SP-1215, S96-SP-27, S96-SP-102, S96-SP-108, S96-SP-133, S96-SP-190, S96-SP-646, S96-SP-675) were tested against standard SPF-213 with the objective to judge their adoptability and sustainability behaviour at Faisalabad during crop season 2004-05, Highly variable and statistically significant observations were recorded with respect to all qualitative and quantitative parameters. CPHS-35 showed maximum tillers per plant (1.65) and sugar yield (12.09 t/ha) while highest germination (62.49 %), number of millable canes (107.552 000/ha), cane yield (118.20 t/ha) and CCS (12.53%) were recorded in S96-SP-108, S97-SP-27, S96-SP-646 and S96-SP-574 respectively.

Keywords: Sugarcane, genotypes, yield, CCS.

INTRODUCTION

Sugarcane is an important cash crop of Pakistan (Ahmad *et al.,* 1991). The average annual production of this crop in world is 1290556 thousand tons with an average yield of 65597 while in Pakistan this is 47244 thousand tons and 48907 Kgs/ha (GOP, 2006). This low yield in Pakistan may be due to the cultivation of obsolete cane varieties having low sugar yield potential and susceptibility to insect pests and diseases in addition to the outmoded production technology (Aslam *et al.,* 1998). It is very much clear that cane varieties play leading role in improving cane and sugar yield. The cultural operations just provide a suitable environment to trigger the inherent potential of cane varieties for better production (Nayyar and Malik, 1989). Thus much of the gain in yield is due to new varieties (Heinz, 1987). Thus it is evident that high yielding varieties play a pivotal role in increasing cane and sugar yield. Some of the studies made with respect to this reported investigation are reviewed in the next lines.

Arsana and Samoedi (1991) observed the performance of PS77-1553 cane variety compared with PS56, F154 and M442-51 at six irrigated and nine un-irrigated sites. They noticed that PS77-1553 produced 5%, 9% and 5% more yield as compare to PS56, F154 and M442-51 under un-irrigated conditions. Sathyavelu *et al.,* (1991) evaluated performance of some clones at eight locations against control variety (CoC. 671). CoC. 90063 crossed the control in cane yield both in plant as well as ratoon crop. Desai and Kulkarni (1992) reported that cane variety CoC-671 in Karnataka state increased the total annual crush from 9.7% in 1987-88% to 44.5% in 1991-92 and sugar recovery from 10.88% to 12.18%. It was also observed that CoC-671 produced maximum sugar recovery and pol% in February and lowest in May-June due to increasing fiber. For the same purpose, Agrawal *et al.,* (1976) evaluated variety Co.66/3 superior to CoS 611/1148 with respect to growth and yield traits as well as best quality gur production.

Keeping in view the similar kind of work done by some people in the past, the comparative studies of some sugarcane genotypes were made at Faisalabad.

MATERIALS AND METHODS

A field trial was conducted at Sugarcane Research Institute, Faisalabad involving fifteen mediums and late maturing sugarcane genotypes including standard SPF-213 during 2004-05. The crop was sown in the month of March 2004 in RCBD having plot size 41mx 9.6m in loam soil. All agronomic practices including fertilization, irrigation and plant protection measures were adopted according to crop requirements. At harvest, number of millable canes (000/ha), cane yield (t/ha) and sugar yield (t/ha) were recorded while germination and tillering after 45 and 90 DAS respectively. The commercial cane sugar was determined according to procedure laid out by Spencer and Meade (1963) from the compound samples harvested after every fifteen days from October to April. The remaining data was analyzed statistically as mentioned by Steel and Torrie (1980) to determine the significant differences among all treatments at probability level 5%.

RESULTS AND DISCUSSION

The main yield and quality contributing characteristics of different sugarcane genotypes are presented in the table and their description is presented in coming lines under various headings.

Germination

The inherent growth potential of a sugarcane genotype is determined by the germination capacity of its seed cane setts. The data given in the table revealed that there was a significant variation in germination percentage among the different genotypes. Higher values of germination percentage were noticed in two genotypes, S98-SP-108 (62.49%) and S98-SP-675 (61.66%), as compare to standard SPF-213 (56.90%). These genotypes were also statistically at par with each other. While the lowest percentage germination (27.49%) were noted in S98-SP-133. Variable germination for different cane cultivars has been reported by Hapase *et al.,* (1995).

Tillers per plant

Tillering potential of a genotype determines the ultimate crop stand and it makes up deficiencies in germination as indicated by data presented in table. Only two genotypes succeeded in producing higher number of tillers per plant than standard SPF-213 (1.60) and these were CPHS-35 (1.65) and S98-SP-108 (1.64). S96-SP-27 exhibited the minimum value of this parameter i.e. 1.05. Similar findings were claimed by Mishra and Nadiu (1997).

Number of millable canes

Cane formation is one of the most important yield contributing factors. The genotypes responded differently by producing measurable differences. Significant and variable data with respect to this parameter were recorded. Only one genotype S96-SP-27 recorded higher cane count (107.552 000/ha) as compare to standard SPF-213 (99.131 000/ha) while lowest number of millable canes were recorded in S98-SP-646 (69.44 000/ha). The experimental data reported by Bora *et al.,* (1997) states similar facts.

Cane yield

It is considered one of the most important yield-contributing factors as it is evident from data table. Five genotypes S96-SP-646, S98-SP-108, CPHS-35, S96-SP-302 and S97-SP-27 revealed higher cane yields as 118.20, 113.30, 109.00, 108.00 and 105.00 t/ha when compared with standard (104.50 t/ha). The genotype S98-SP-675 yielded the lowest cane yield as 62.76 t/ha. These conclusions are in close parallelism with those of Mahendran *et al.,* (1995).

CCS

It is the real judgment of cane quality and equally important for millers and breeders. Seven genotypes stood higher with respect to CCS as compare to standard SPF-213 (10.92%). These genotypes along with their CCS values were S97-SP-574 (12.53%), CP90-1384 (12.19%), S96-SP-1215 (11.79%), S97-US-102 (11.38%), S96-SP-228 (11.27%), CPHS-35 (11.09%) and S96-SP-203 (10.94%) respectively. This discussion coincides that of Rao *et al.*, (1995) who observed similar kind of trend.

Sugar Yield

It is the function of cane yield and corresponding CCS. Statistically significant results revealed that three genotypes produced higher sugar yields i.e. 12.09, 11.82 and 11.73 t/ha, which were CPHS-35, S96-SP-302 and S98-SP-646 respectively while compared with standard genotype SPF-213 (11.41 t/ha). The latter two genotypes were also statistically at par with the standard. This description is in accordance with Kapur and Kanwar (1991).

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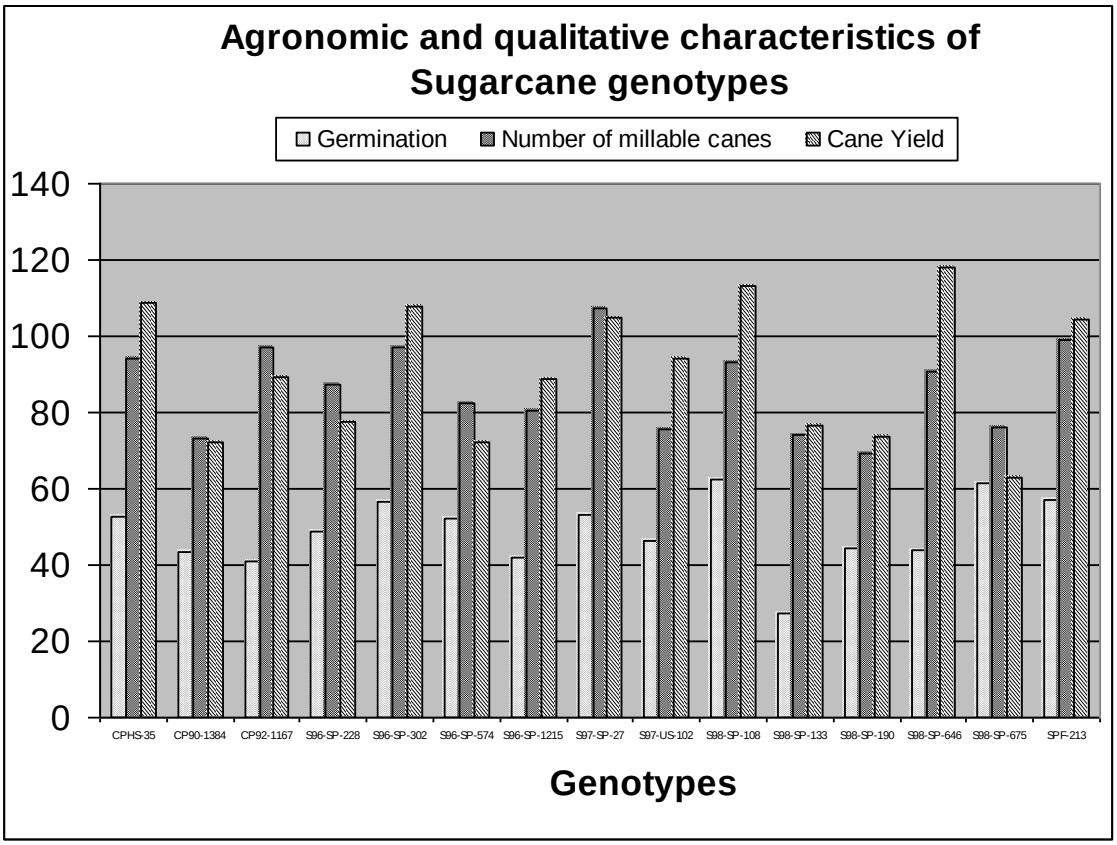
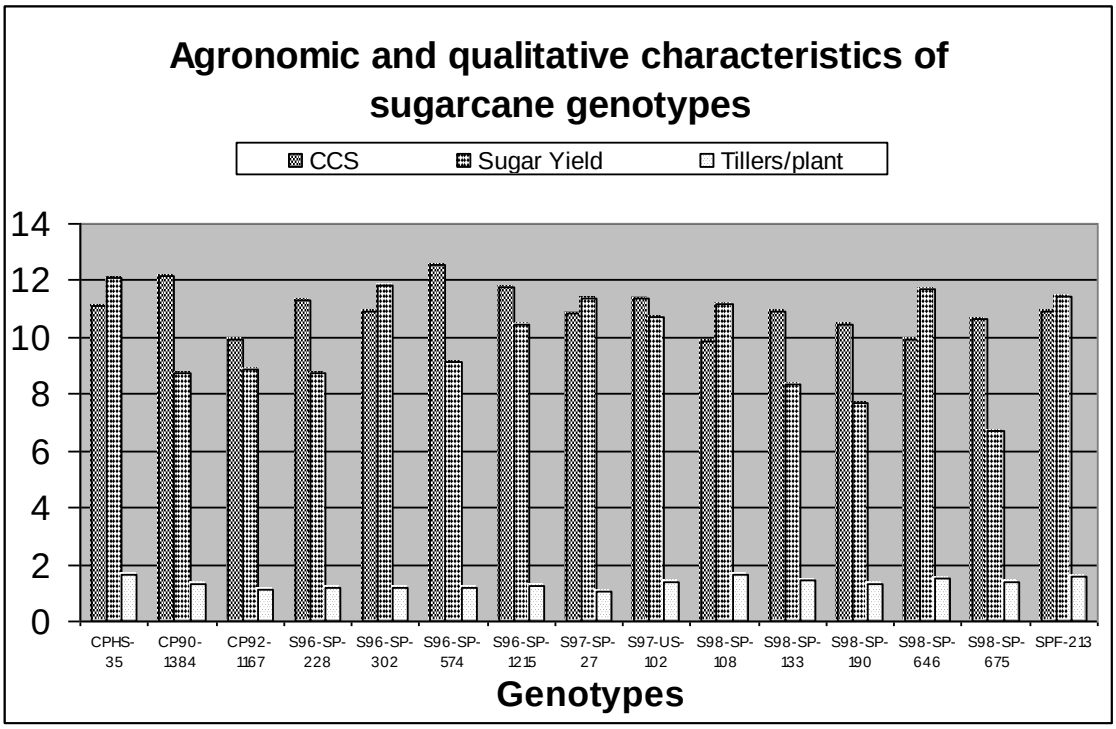
Table-1 Agronomic and qualitative characteristics of sugarcane genotypes

Sr. #	Genotypes	Germination (%)	Tillers plant^{-1}	Millable canes (000/ha)	Cane yield (t/ha)	CCS (%)	Sugar yield (t/ha)
1.	CPHS-35	52.73bcd	1.65a	94.357cd	109.00bc	11.09	12.09a
2.	CP90-1384	43.33fg	1.33abcd	73.09g	71.96g	12.19	8.77fg
3.	CP92-1167	41.18fg	1.13cd	74.826g	89.06e	9.95	8.86f
4.	S96-SP-228	48.80bcdef	1.16cd	87.152e	77.61f	11.27	8.75fg
5.	S96-SP-302	56.66ab	1.68ab	96.87c	108.0c	10.94	11.82b
6.	S96-SP-574	52.38bcde	1.19cd	82.204f	72.83g	12.53	9.12f
7.	S96-SP-1215	42.02fg	1.28bcd	80.555f	88.80e	11.79	10.46e
8.	S96-SP-27	53.09bc	1.05d	107.552a	105.00c	10.84	11.35bc
9.	S97US-102	46.30edef	1.40abc	75.781g	94.36d	11.38	10.73de
10.	S98SP-108	62.49a	1.64ab	92.968d	113.30b	9.88	11.19cd
11.	S98SP-133	27.49h	1.45abc	73.958g	76.47fg	10.91	8.34g
12.	S98SP-190	44.52defg	1.34abcd	69.444h	73.44fg	10.46	7.68h
13.	S98SP-646	44.04efg	1.53ab	90.712e	118.20a	9.93	11.73ab
14.	S98SP-675	61.66a	1.36abcd	75.955g	62.76h	10.65	6.68i
15.	SPF-213 (std.)	56.90ab	1.60ab	99.131b	104.50c	10.92	11.41bc
	LSD at 5%	8.558	0.3345	3.778	4.684	-	0.5128

Std. = Standard
LSD = Least Significant Difference.


Agronomic and qualitative characteristics of Sugarcane genotypes
Germination
Number of millable canes
Cane Yield
140
120
100
80
60
40
20
0
CPHS-35
CP90-1384
CP92-1167
S96-SP-228
S96-SP-302
S96-SP-574
S96-SP-1215
S97-SP-27
S97-US-102
S98-SP-108
S98-SP-133
S98-SP-190
S98-SP-646
S98-SP-675
SPF-213
Genotypes


Agronomic and qualitative characteristics of sugarcane genotypes
CCS
Sugar Yield
Tillers/plant
14
12
10
8
6
4
2
0
CPHS-35
CP90-1384
CP92-1167
S96-SP-228
S96-SP-302
S96-SP-574
S96-SP-1215
S97-SP-27
S97-US-102
S98-SP-108
S98-SP-133
S98-SP-190
S98-SP-646
S98-SP-675
SPF-213
Genotypes

SUGAR INDUSTRY ABSTRACTS

By
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AGRICULTURAL ENGINEERING

Discrimination of sugarcane varieties cc 85-92 and cc 84-75 using Landsat 7 Etm + satellite imagery

P.J. Murillo, J.A. Carbonell, C.A. Osorio and E. Bastidas-Obando
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This work evaluates Landsat 7 ETM+ data for discriminating between sugarcane varieties CC 85-92 and CC 84-75 in the Valle del Río Cauca in Colombia. Fields at different growing stages were chosen: 4-5, 6-7, 8-9, 10-11 and 12-14 months. Their spectral separability was calculated with Jeffries-Matusita distance. Results indicated that there is a clear discrimination between 4th and 5th month, with an overall accuracy of 80% and kappa index 0.62. This can be explained because there is a clear difference between population density stalks. The other periods didn't present spectral separability between the varieties, which suggests the use of images of better spectral resolution. This application is a preliminary step in identifying and monitoring areas planted with varieties bred by Cenicaña. The information coming from satellite imagery could be used to create a spectral library, with the objective to compare biophysical parameters between varieties such as: leaf area index (LAI), chlorophyll and biomass, among others.

Performance and characteristics of the harvester under green cane harvesting in Okinawa

Tohru Akachi
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Characteristics and performance of harvesters in Okinawa, where mechanization of sugar cane harvesting is well advanced, were reviewed based on the results of past research. There was a trend for the greater the engine power of the harvester; the higher the working efficiency, and the trash ratio and harvesting loss were lower. It turned out that large- and middle- sized wheel-type harvesters did not perform well in rain, while small crawler-type harvesters were often more operational regardless of rain. The field was most affected by soil compaction when the row width was narrower and the harvester operation speed was lower. It is expected that small harvesters will not only be introduced in areas unsuitable for middle and large sized harvesters, but also play a complementary role in areas where large- and middle-sized harvesters are already in use.

AGRICULTURAL AGRONOMY

Dry matter production and accumulation in sugarcane for use as animal feed

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The ability of sugarcane to accumulate a large quantity of N is expected to reduce environmental pollution especially of N released from excessive manure generated from the livestock sector. Based on observations that a high biomass line of sugarcane might be able to

accumulate a large quantity of N without accumulating nitrate, more detailed experiments have been conducted to investigate whether the crop could be harvested earlier and used as animal feed. A field experiment was carried out in Zentsuji, Kagawa to investigate the effects of high N inputs on accumulation of N and nitrate in above-ground parts of sugarcane following an early harvest in July at three months after planting compared to the usual harvest in November. In addition, a pot experiment was conducted with adequate water supply to minimise the limiting effect of water shortage on N accumulation and to explore the optimum N rate required for the maximum dry matter production and/or N accumulation. For early harvested sugarcane, dry matter and N accumulation was smaller than that of sorghum where the higher N rate was applied. Nitrate-N concentration in the sugarcane stem was below the critical level considered to be dangerous to livestock, while that of the maize stem exceeded the critical value. In the pot experiment, N accumulation in aboveground parts did not reach a plateau even with the highest N rate of 900 kg/ha used in this study. In conclusion, dry matter and N accumulation of early harvested sugarcane needs to be looked at in the context of the two-harvest scenario probably with higher N rates than ever tested. Low nitrate-N concentration of sugarcane stems suggests a possible advantage of sugarcane as feed.

Dual row planting a system to increase Thai farmers. cane yield and economic returns
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The purpose of this paper is to evaluate the effect of the planting system to increase sugarcane yield and economic return on growers. Farms trials to evaluate the dual row planting system were conducted on various sugarcane farms under rain fed. conditions in four locations belonging to cane growers. The trials were conducted under rain fed conditions in the Khon Kaen and Chaiyaphum districts of Northeast Thailand. Two planting methods (110.50 cm double row and 100 cm single row) were compared using two varieties (K84-200, poor tillering and K88-92, good tillering). The experimental design was a randomized complete block with four replications, and the work was conducted over the 2003.2006 periods. The results showed that dual row planting increased cane yield by 18.53 percent compared with single row planting. The increase in cane yield was found to be significantly correlated with the number of millable stalks. Cane juice quality was not affected by the different planting methods. An economic analysis showed that profits could be increased from 177.629 $/ha due to dual row planting. Based on these results, dual row planting offers the opportunity to increase productivity, and is a profitable farming system suited to Thai growers and the Thai sugar industry.

SUGARCANE BREEDING

Prospects of breeding for low starch content in sugarcane
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Characterisation of sugarcane germplasm for juice quality traits such as starch content could encourage their use for germplasm enhancement. Starch content among sugarcane germplasm was evaluated in three experiments. Experiment I had 49 accessions including 5 *Saccharum spontaneum* L., *13 S. barberi* Jesw. *11 S. robustum* Brandes and Jeswiet ex Grassl, *8 S. sinense* Roxb., *9 S. officinarum* l. *and 1 each of Erianthus* Michx. Sect. Ripidium Henard spp., *Miscanthus* Anderss. spp. *and E. bengalense* (Retz.) R. C. Bharadwaja. Experiment II had 52 *S. spontaneum* and one *S. officinarum* L. accessions. Experiment III had 76 clones

including 6 cultivars and 70 unselected clones of F1 and BC1 origin derived from crosses between *S. spontaneum* and cultivars. Experiment I and II revealed significant differences in starch levels among the *Saccharum* species, and significant differences among clones within species. Generally, the cultivated *Saccharum* species produced less starch than their wild relatives. *Saccharum* species could be ranked into high starch (*S. spontaneum*), medium starch (*S. barberi*, *S. sinense* and *S. robustum*) and low starch (*S. officinarum*) content. In Experiment III, starch content ranked as cultivars < BC1 < F1 clones. Thus, parents low in starch content could be selected even from among high starch species such as *S. spontaneum* for use in germplasm enhancement.

Selection of multipurpose high-fibre sugarcane cultivars
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To improve the added value of the sugarcane crop, a selection program was initiated at Mitr Phol Sugarcane Research Centre, Thailand to develop cultivars with improved fibre content. A set of 21 cultivars, selected on fibre, Brix, and yield was evaluated along with a standard commercial cultivar K 84-200 in a field trial (RCBD with three replications) during the period 2005 to 2006. Cane stalk samples collected from 7th month till harvest were analysed for fibre content and Commercial Cane Sugar (CCS) to establish their maturity pattern. We observed significant differences for cane yield, CCS, purity, sugar yield, fibre content and fibre yield. Fibre content ranged from 13.5% to 19.3% with two cultivars outperforming K 84-200 by more than 25% for fibre content while 12 cultivars had additional fibre content of more than 1% compared to K 84-200. Seven cultivars were multipurpose types with superior fibre content, CCS, and yield. Cultivar MPT 99-582, which recorded cane yield of 102 t/ha, CCS 13.2 and fibre content 15.5% was better performing than K 84-200 by 8, 10, 12, 23 and 21% for fibre, CCS, cane yield, sugar yield and fibre yield, respectively. Based on their performance in terms of fibre, CCS, and yield, 11 cultivars were selected and planted in multi-location trials. The present trial indicated that we could select multipurpose cultivars with improved fibre content and sugar yield. These cultivars would increase the amount of bagasse produced in sugar mills leading to a higher quantity of bagasse available either for co-generation or production of particle boards.

MOLECULAR BIOLOGY

Transgenic sugarcane with coat protein gene-based silencing shows increased resistance to sugarcane yellow leaf virus (ScYLV)
Yun J. Zhu, Heather McCafferty, Greg Osterman, Ricelle Agbayani, Susan Schenck, Alex Lehrer, Ewald Komor and Paul Moore
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Sugarcane yellow leaf syndrome (YLS), caused by *Sugarcane yellow leaf virus* (ScYLV) is worldwide in distribution where susceptible cultivars are grown. This study was undertaken to produce transgenic sugarcane that is resistant to ScYLV by means of a gene silencing mechanism. Transgenic sugarcane lines were produced by biolistic bombardment with an untranslatable virus coat protein construct. The presence of the transgene was confirmed with PCR and Southern blot analyses. Viral resistance of the transgenic plants was evaluated by inoculation with viruliferous aphid vectors followed by tissue blot immunoassay (TBIA), and inoculation results indicated the resistance levels in transgenic sugarcane were significantly higher than non-transformed controls. The uninfected transgenic plants will be used for

studying the effects of the virus on sugar and biomass yield in comparison with infected plants and may provide resistant germplasm for the sugarcane-breeding program.

SUGARCANE PATHOLOGY

Effects of sugarcane yellow leaf virus infection on sugarcane yield and root system development

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Sugarcane yellow leaf disease causes significant yield losses in susceptible sugarcane varieties. In Brazil, YLS was not recognized as an economically important disease until the early 1990s when the drastic epidemics of the disease occurred in variety SP71- 6163. Since then, breeders began to take into account its occurrence during the selection stages and its effects on vegetative development. The objective of the present work was to evaluate the effects of the *Sugarcane yellow leaf virus* (SCYLV), the causal agent of yellow leaf on sugarcane yield and root system development. The experiment was conducted in Ribeirão Preto, SP, Brazil, on Typic Hapludox soil, in variety IAC89-2135 during the plant cane cycle. SCYLV diagnosis was assayed by DAS-ELISA and RTPCR for discrimination between infected and uninfected plants. The infected plants showed significant reduction of root dry weight and fresh weight of the above ground plant parts and an increase in Brix and sucrose content in the stalks. Although infected plants maintained the root system vertical architecture, root dry weight was reduced and negatively correlated with fresh weight and stalk number, showing that alterations in root and vascular systems may constitute important effects caused by SCYLV infection.

FACTORY ENGINEERING

Flue gas scrubbing equipment for bagasse fired boilers

B.ST.C. Moor

Over the past 50 years, sugar factories have been subjected to increasing environmental pressure to conform to new clean air requirements. In most cane sugar producing countries, legislation now imposes maximum limits on particulate emissions of 100 to 200 mg/Nm3 for new boilers. The paper reviews various types of flue gas cleaning equipment, comparing their merits and disadvantages. Most traditional devices such as dry cyclones cannot achieve the new specifications. Of systems able to meet the targets, some are too costly or maintenance intensive for bagasse (or bagasse + fossil fuel) boilers, and wet scrubbers have been widely accepted as the most practical solution. Various types of wet scrubbers are in service. These are compared in respect of separation efficiency, pressure drop, capital and operating costs, maintenance and reliability. Measurements of particulates in gases from scrubbers in South Africa, Australia and the Philippines are reported. Operating issues such as pressure drops, turn down ratios, entrainment separation, ID fan selection and cleaning, and smuts separation from circulating water are discussed. Typical particle size distributions, their significance and causes of fine particles are discussed. Experience in South Africa has led to the conclusion that sieve plate scrubbers are significantly better than other types of wet scrubber in bagasse boiler applications; 22 of the 36 wet scrubbers in the industry are now of this type.

Fibre extracted with juice from mills. an omission in milling theory

B. St. C. Moor

From a recent review of literature on various aspects of sugar cane milling, it was apparent that traditional milling theory and most milling engineers / technologists ignore the fibre dropped with the juice extracted from mills. The quantity is much greater than generally assumed and has significant implications for issues such as mill capacities, mill settings, extraction, configuration of cush cush screening systems and classical milling theory (compaction, fibre fill ratios and reabsorption). There is very little reported data on fibre dropped from mills. Measurements were therefore commissioned at several milling tandem and diffuser dewatering mills. Results are reported, showing that typically 5% to 15% of fibre entering the mill exits with extracted juice. Factors influencing the wide variation in amounts include cane quality, preparation, mill configuration (number of rolls, Messchaert knives, etc.), mill and trash plate condition and settings and imbibition rates.Implications of this fibre are illustrated using a model of a milling tandem. Some conclusions are: the feed opening of the second mill of most tandems usually processes 15% to 30% more fibre than enters the first mill of the tandem;with some cush-cush configurations, this figure can be as much as 70%; this additional fibre has implications for both mill capacity and extraction; contrary to the usual assumption in mill settings, the fibre rate through the feed opening of a mill is usually 5% to 15% greater than that through the discharge opening. This greater fibre rate is unwittingly allowed for by empirical factors in the common mill setting formulae. The calculations used by mill engineers to monitor performance by compaction ratios and reabsorption are also in error, but the techniques work because the errors are consistent.

FACTORY PROCESSING

Microwave measuring technology for the sugar industry

Dipl.-Ing. Ulrich Klute

Nowadays the dry substance of sugar syrup and massecuite is measured online using the most advanced microwave measuring technology. The correlations for water content and dry substance allow for accurate control of concentration, Brix content and density in all areas of sugar production. This permits a continuous measurement during the complete crystallisation process, both in the solution and the magma phase. This report explains the measuring effect and signal analysis of microwave measurement systems and illustrates the user benefits, resulting in very good process control. Solutions are proposed for typical application problems such as incrustation, abrasion, purity dependencies and the recognition of breaks between crystallisation processes using the Micro-Polar Brix measurement system. Results acquired with different sensors in various processes and applications are presented. Besides the accurate and reliable measurement of all products from sugar beet or sugarcane, a high value is placed on simplicity, low maintenance and easy calibration to ensure optimised process control and cost. The automatic calibration feature, which requires no additional PC, is demonstrated.

Discovery of sugarenes: a major commercial breakthrough for the sugar industry

Kaman Singh and Amar Deep

Sugar was discovered in space which brought back vivid memories of the sensational discovery of Buckministerfullerene. Kaman Singh in 2004 conceived that the discovery of

sugar in space could be exploited in the synthesis of the fullerenes. Thus, discovery of sugar in space inspired us to renew efforts to synthesise C60 and, in fact, fullerene was discovered from the most common sugars, and a patent is under active consideration. The current price of C60 is very roughly the price of gold; for C70, it is about an order of magnitude larger, and that of higher fullerenes very much higher. Since nature is kind enough to gift us these life molecules (sugars), they can be considered as replaceable raw materials for mass scale production of fullerenes. Furthermore, production of fullerene from sugars would be considerably cheaper than that produced from graphite. Other researchers have synthesised fullerene from sucrose. Hence, a new term 'sugarenes' has been coined by Singh to acknowledge the potential importance of the sugars in commercial production of fullerenes.

MANAGEMENT

Cane quality payment incentives to optimise the production of sugar, ethanol and cogeneration

A.T. Wynne

The price consumers are willing to pay for renewable energy is increasing **given** the combination, among others, of rising crude oil prices and climate concerns. Sugarcane is a highly efficient converter of sunlight energy into biomass and is ideally positioned to participate on a large scale in the energy markets of the future. Brazil and a number of other countries already produce large quantities of fuel grade ethanol from sugar streams as well as cogenerating electricity from bagasse for export to the national electricity grid. Furthermore, exciting technological developments on the horizon suggest that ethanol and electricity yields per tonne of sugarcane processed will increase significantly (*e.g.* fermentation of cellulose and Fischer-Tropsch biomass to liquids). In sugar industries that have a revenue sharing partnership between millers and growers for primary products, a transparent mechanism still needs to be developed to (1) fairly and equitably channel revenue derived from multiple primary products through the sugarcane payment system and (2) create associated sugarcane payment incentives to optimise sugarcane quality and value addition. This paper unpacks the background and workings of traditional cane payment approaches and explores a possible alternative, 'contribution pricing', that has been designed to facilitate the inclusion of ethanol, cogeneration and possibly other primary products into a cane payment system. A major challenge includes negotiating the division of proceeds percentages, which ideally would need to be mill area specific but for expedience, could be negotiated centrally. Another challenge is determining transparent primary product prices, which is best done on an industry scale; *e.g.* the establishment of an 'exchange' inclusive of futures contracts, which may require significant set up costs that need to be spread over a large product volume. A 'political will' on the part of miller and grower leadership is the catalyst required to make 'contribution pricing', or variation thereof, a reality.

Catalysts for change and engines of growth for the modern sugar industry

L. D. Mamet

The sugar industry is often focused on equipment, processes and products rather than on human capital. In the transformation from a labour intensive, low skilled industry to a modern, capital intensive, highly skilled industry, there is an urgent need to concentrate on optimising the human value of the enterprise. The skills needed to succeed in the industry are changing significantly as technologies are evolving and organisational structures are adapting

to new economic parameters. The modern industry calls for individuals who are able to acquire, adapt, apply and transfer their knowledge to different contexts and under varying technological conditions, and to respond independently and creatively. This paper reviews the work of the Regional Training Centre (Mauritius) and describes the importance of capacity development at all levels in the sugar industry. Examples of better management practices, technical reskilling and up-skilling as well as workforce training will be described. Competent human resources are regarded as catalysts for change and engines of growth.

COPRODUCTS

CO-Generation thermodynamics revisited

Mike Inkson and Ben Misplon
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While most engineers understand that higher HP steam conditions result in a more efficient power station, a wide range of different HP and exhaust steam conditions have been selected around the sugar industry's export cogeneration stations. This paper examines the thermodynamics of such a station and then sets out a method to optimise it. Nature is, of course, never that simple. There also needs to be a discussion on how to optimise the thermodynamics when, as is often the case with our export stations, there are two entirely different sets of conditions: in-crop export cogeneration and out of crop generation. The paper also offers some practical advice for the conceptual design of new stations.

ISSCT Co-products workshop in Maceió, Brazil

M.R.L.V. Leal
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The ISSCT Co-Products Workshop took place on November 12–16, 2006 in Maceió, Alagoas-Brazil, hosted by STAB Leste (The Eastern Division of the Sociedade de Técnicos Açucareiros e Alcooleiros do Brasil – STAB) with the main theme as 'Coproducts as renewable feedstock for energy, fuels, plastics and other applications'. A total of 38 delegates from eight countries participated at the workshop that was organised in one opening session, two days of plenary sessions and two days of site visits. In the plenary session, 25 presentations were made, 30 minutes each, covering five themes: sugarcane for energy, ethanol production process, other co-products, ethanol programs and policies, environmental impacts of ethanol production; most presentations were concentrated on cogeneration and ethanol production. Two mills, Caeté and Coruripe, were visited as part of the program as well as the Sugar Terminal at the port of Maceió, a major outlet for the region's sugar exports. The discussions during the sessions and visits indicated the increasing interest of technicians of the sector in the diversification of the industry, mainly in the energy potential of sugarcane.