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EFFECTS OF LIGHT INTERCEPTION ON SECOND INTERCROP PRODUCTION IN SUGARCANE

By

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ABSTRACT

An experiment was conducted at the Bangladesh Sugarcane Research Institute (BSRI) farm during 2005-2006 cropping season under irrigated condition to investigate the possibility of growing mungbean as sequential intercropping at 90 and 150 cm sugarcane row to row spacing of sugarcane varieties Isd 31 and Isd 32. Results showed that cultivation of mungbean as 2[nd] intercrop with sugarcane leaf clipping had no adverse effects on tillering, millable cane production and cane yield . Irrespective of varieties sugarcane cultivation with leaf clipping at 150 cm row to row spacing significantly increased fresh plant weight, leaf, grain number and branch production. Leaf clipping had impact on 1000 grain weight, leaf area etc. It indicates that sugarcane leaf clipping and wider spacing reduced light interception and allowed higher light availability to mungbean grown as 2[nd] intercrops resulting higher photosynthesis.

Key words: Sugarcane, light interception, sequential intercrop.

INTRODUCTION

Intercropping is a technique to increase unit yield, interim and higher monetary return. It helps diversification of crop production to fulfill diversified need of farmers (Singh *et al*., 1986). Sugarcane is a long duration crop and takes about 3-5 months for canopy development since generally it is planted in wide space (one meter apart) which allows for growing intercrops during early stage. Sugarcane growers take this advantage and grow various short duration crops like potato, onion, garlic, pulses, vegetables etc as 1[st] intercrops and mungbean, sesame etc as 2[nd] inter crops to get interim return since small sugarcane growers can not wait for such a long time to get financial return from sole crop sugarcane. Therefore, sustainable sugarcane cultivation and to meet national requirement for sugar and gur, it is almost necessary to find the possible ways of increasing economic benefit from sugarcane cultivation. Intercropping of economically important short duration winter crops with sugarcane through utilization of present limited land resource would help to sustain sugarcane cultivation in high and medium high lands, and helps to provide interim return to poor farmers. Besides, it also helps to meet the ever-increasing demand of vegetables and pulses for rising population. During growth and development, crop plants intercept and absorb growth factors (light, energy, water and nutrients) and use them to produce biomass (Trenbath, 1986). Some parts of this biomass is the harvestable yield. The needed growth factors are distributed variously in space and time. Therefore, crop complementary and supplementary relations determine the magnitude of intercrop competition (Ofori and Gamedoaghao, 2005). In intercropping system involving legume crops, supplementary relation would exist due to nitrogen fixation. Consequently, mungbean may not suffer competitions for N supplies when grown with sugarcane. Data of the present study showing sometimes increase in sugarcane yield grown with mungbean intercrop substantiate the lack of critical competition for such prominent nutrient growth factor. Higher yield advantage can be realized in intercropping system when growth patterns in terms of time (growth rapidity and maturity period) and space (plant architecture) of component crops (Ghosh *et al*., 2006).

Complementarities would occur when growth pattern of component crops in an intercrop differ in critical period of high demand for resources (Iragavarapu and Randall, 1996). Complementary relation between sugarcane and mungbean may be weak due to difference in growing pattern and plant architectural traits. Sugarcane and mungbean are plants with different architecture and likely they were not in critical competitions for light interception during the initial critical fast growth period .Kabir (1988) observed that potato, mustard, gram are most compatible first intercrops with sugarcane reduced cost of sugarcane cultivation. To sustain intercrop cultivation it needs to be more intensive-cum-remunerative through sequential intercrop production and it is important to identifying factors affecting intercrop cultivation. As such studies on interaction between canopy development and light interception specially on sequential intercrops cultivation. Therefore, an experiment was carried to study the effects of light interception on 2^{nd} intercrop mungbean cultivation with sugarcane.

MATERIALS AND METHODS

A field experiment was conducted at the Bangladesh Sugarcane Research Institute (BSRI) farm, Ishurdi, Pabna during 2005-2006 cropping season under irrigated condition following randomized complete block design with three replications. Polybag settlings of varieties Isd 31 and Isd 32 were transplanted at two row to row spacing viz 90 cm and 150 cm and plant to plant spacing maintain same initial plant population per unit area. In case of second intercrop mungbean (variety BINA Mung-5). The unit plot size was 9× 4 m. Fertilizers used for sugarcane were @ 325, 250, 185 and 165 kg ha^{-1} as Urea, TSP, MP and Gypsum respectively. No fertilizer was used for intercrop mungbean. Cultural practices such as gap filling, weeding, mulching, tying etc were done as and when required. The treatments for the experiment were as follows:

T_1 = S.cane (Isd 31; Row to Row spacing 90 cm) + Mungbean with sugarcane leaf clipping (SLC).
T_2 = Sugarcane (Isd 31; Row to Row spacing 90 cm) + Mungbean without SLC
T_3 = Sugarcane (Isd 31; Row to Row spacing 150 cm) + Mungbean with SLC
T_4 = Sugarcane (Isd 31; Row to Row spacing 150 cm) + Mungbean without SLC
T_5 = Sugarcane (Isd 32; Row to Row spacing 90 cm) + Mungbean with SLC
T_6 = Sugarcane (Isd 32; Row to Row spacing 90 cm) + Mungbean without SLC
T_7 = Sugarcane (Isd 32; Row to Row spacing 150 cm) + Mungbean with SLC
T_8 = Sugarcane (Isd 32; Row to Row spacing 150 cm) + Mungbean without SLC

Seeds of mungbean were sown between vacant spaces of sugarcane on 15, March 2006. Irrigation was done on 16 March 2006. Collection of data on yield and various yield contributing parameters of cane and intercrop was done. Tiller production of sugarcane was recorded at an interval of 15 d. Millable canes and yield was recorded at harvest. Statistical analysis on different parameters for sugarcane and intercrop were done following standard procedures.

RESULTS AND DISCUSSION

The tiller population, millable canes productions were significantly influenced by different treatment in the present investigation (Fig. 1 & 2). The highest tiller population (173.2×10^3 ha^{-1}) was recorded where sugarcane variety Isd 31 was planted at sugarcane row to row spacing 90 cm and mungbean with SLC treatment followed by treatment where sugarcane variety Isd 31 was planted at row to row spacing of 90 cm with mungbean without SLC.

Similar trend was also observed in case of millable cane production. The lowest number of tillers and millable canes were recorded at treatment (T_8) where mungbean was grown as 2^{nd} intercrop with sugarcane variety Isd 32 at row to row spacing 150 cm with or without SLC. These results indicate that sugarcane leaf clipping have no adverse effects on tiller and millable cane production and 150 cm row spacing reduced tiller and millable cane production in sugarcane. Tiller and millable cane production not only depends on spacing but on varietal characters, and present findings confirmed findings of Rahman *et al.,(*1987). Ali *et al*., (1989) observed higher number of tiller and millable cane production at 90 cm row spacing compared to 100 cm row spacing. *Kashem et al*., (2005) reported the lowest number of millable cane in variety Isd 32 compared to all other varieties. It is seen from the Fig. 3 that significantly the highest cane yield (95.4 t ha^{-1}) was obtained at treatment (T_5) where sugarcane variety Isd 32 was planted at row to row spacing 90 cm and mungbean was grown with SLC, while the lowest cane yield (73.8 t ha^{-1}) was recorded at treatment ($T_{4)}$ where sugarcane variety Isd 31 was grown with mungbean as 2^{nd} intercrop without sugarcane leaf clipping at 150 cm row spacing. Sugarcane yield varies probably due to variety grown and row spacing used in the experiment. This finding agrees with the finding of Rahman (2006) where they obtained the highest cane yield in variety Isd 32 and the lowest yield in variety Isd 31.

Results on mungbean production as second intercrop have been shown in the Table 1. It is seen from the table 1 that significantly higher leaf area, fresh and dry weight of plant, number of pod/plant, number of grain/pod, branch/plant, sundry weight of grain and 1000 grain weight were recorded where mungbean was grown as 2^{nd} intercrop at 150 cm row to row spacing of sugarcane variety Isd 31 with SLC followed by the treatment (T_7) where sugarcane variety Isd 32 was grown at row to row 150 cm spacing with SLC. It is seen from the Table 1 that leaf clipping has positive impact on different yield parameters of mungbean. It indicates that leaf clipping allowed more light and reduced light interception resulting gave higher mungbean yield as well as yield contributing characterstics of mungbean irrespective of sugarcane varieties (Isd 31 and Isd 32) grown.

The highest yield of mungbean was obtained from treatment (T_3) where sugarcane variety Isd 31 was planted at row to row spacing 150 cm and mungbean was grown at vacant space in between two rows of sugarcane with sugarcane leaf clipping followed by treatment (T_7) where sugarcane variety Isd 32 was planted at row to row spacing 150 cm and mungbean was grown at vacant space in between two rows of sugarcane with sugarcane leaf clipping while the lowest yield of mungbean was obtained from the treatment (T_2) where sugarcane variety Isd 31 was planted at row to row spacing 90 cm and mungbean was grown at vacant space in between two rows of sugarcane without sugarcane leaf clipping . These results indicate that mungbean yield significantly increased due to sugarcane leaf clipping, and comparatively higher row to row sugarcane spacing. It is also seen that mungbean yield decreased due to no sugarcane leaf clipping and narrow row spacing. Miah *et al*., (2002) reported that narrow vacant space in between two sugarcane rows influenced light interception resulting higher level of shading on 2^{nd} intercrops, and the process of photosynthesis is affected. To get proper productivity in light sensitive intercrops like mungbean needs wider space to receive required solar radiation for proper photosynthesis to contribute in ultimate yield of 2^{nd} intercrop.

Plant architectural traits, therefore, as being an important factor to provide complementarities between intercropping. Selection for improved yield under sole cropping may not necessarily lead to improved yield under intercropping and different plant traits may be more appropriate for cultivars intended for use under intercropping than for those intended for use under sole cropping (Magdy *et al.*, 2007). Some intercrop faced considerable competition for nutrient supplies from growing soil. The yield of mungbean and sugarcane intercropping suggest that mungbean was not strong competitive to sugarcane. In conclusion, a reasonable additional crop outcome could be realized by intercropping of mungbean with sugarcane as main crop. To benefit from these added crops, it is recommended to grow in wider space to receive required solar radiation for proper photosynthesis. Analyses of yield components revealed that greater light interception during the vegetative and early reproductive periods was responsible for increased yield in wider row spacing with sugarcane leaf clipping.

Table-1 Effects of sugarcane row to row spacing and sugarcane leaf clipping on yield contributing parameters of mungbean grown as 2nd intercrop

Yield Parameters	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8
Number of plants/m2	34.7b	32.9c	36.7a	36.3a	33.5bc	33.3bc	36.3a	37.4a
Leaf area (cm^2/plant)	567.8e	539.6g	816.8a	747.9c	551.7f	531.0h	798.0b	715.6d
Fresh weight of plant (g plant-1)	18.8e	17.5f	34.9a	31.0c	19.0e	16.4g	32.b	29.1d
Sundry weight of plant (g plant-1)	5.8f	5.1g	8.2a	7.3c	6.2e	6.1e	7.9b	6.8d
Number of pod/plant	6.7e	6.0g	9.9a	7.8c	6.2f	6.8e	8.6b	7.6d
Number of grain/pod	6.6e	6.2f	9.6a	8.6b	6.8d	6.2f	8.8b	8.1c
Number of leaf/plant	7.0d	6.7e	10.8a	9.7b	7.2d	6.7e	10.9a	9.3c
Number of branch/plant	1.1de	1.0e	1.7a	1.3c	1.1de	1.2d	1.6b	1.2d
Sundry weight of grain/ plant (mg $plant^{-1}$)	1092.6f	1033.1g	1511.6a	1187.2d	1153.1e	1003.7h	1469.3b	1398.9c
1000 grain weight(g)	26.9g	26.53h	36.7a	33.8c	27.9f	29.6e	34.6b	32.1d

Figures followed by common letters are not significant in the same column.

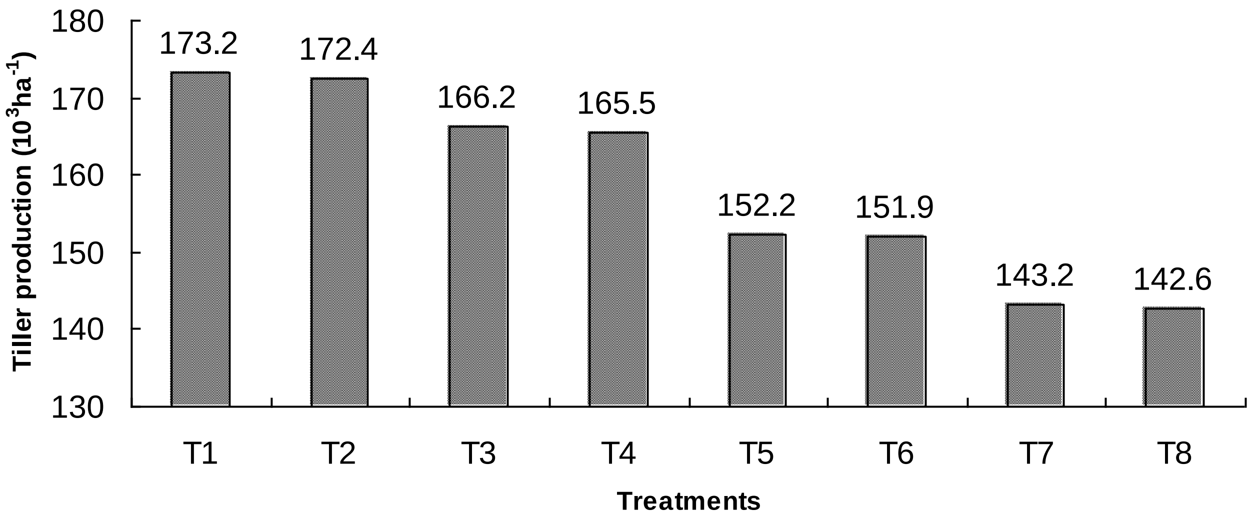

Figure 1. Effects of row spacing and sugarcane leaf clipping on tiller production.

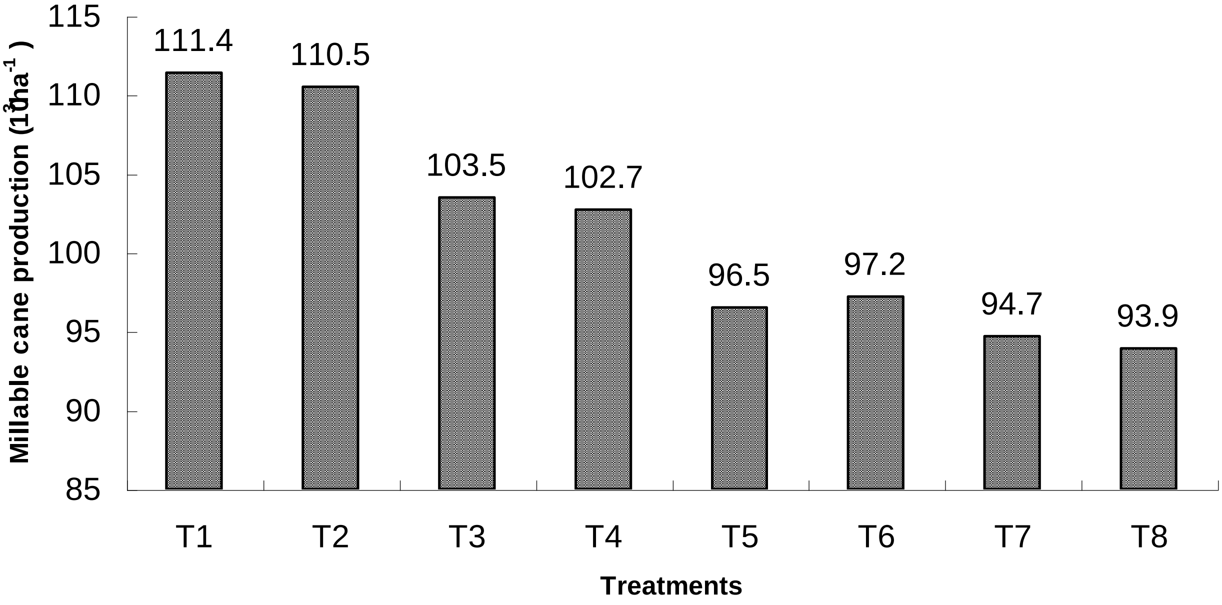

Figure 2. Effects of row spacing and sugarcane leaf clipping on millable cane production.

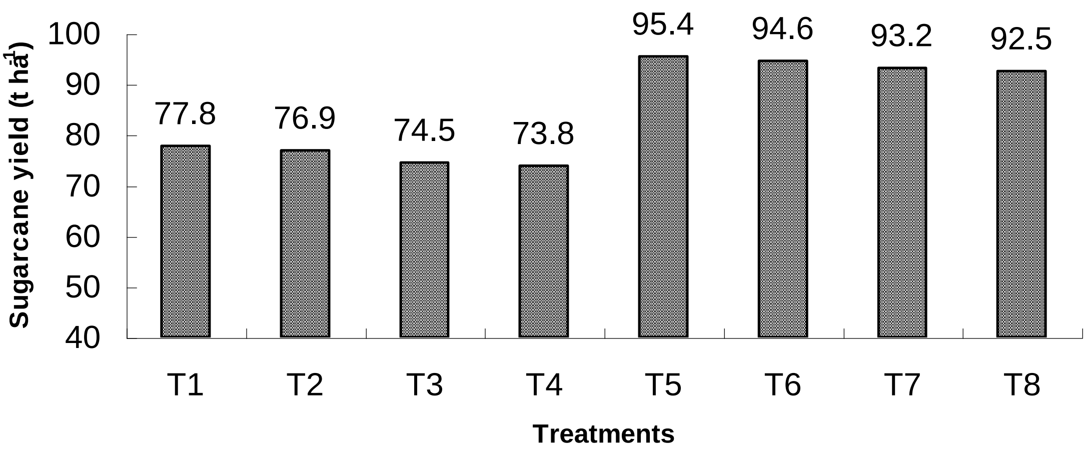

Figure 3. Effects of row spacing and sugarcane leaf clipping on sugarcane yield.

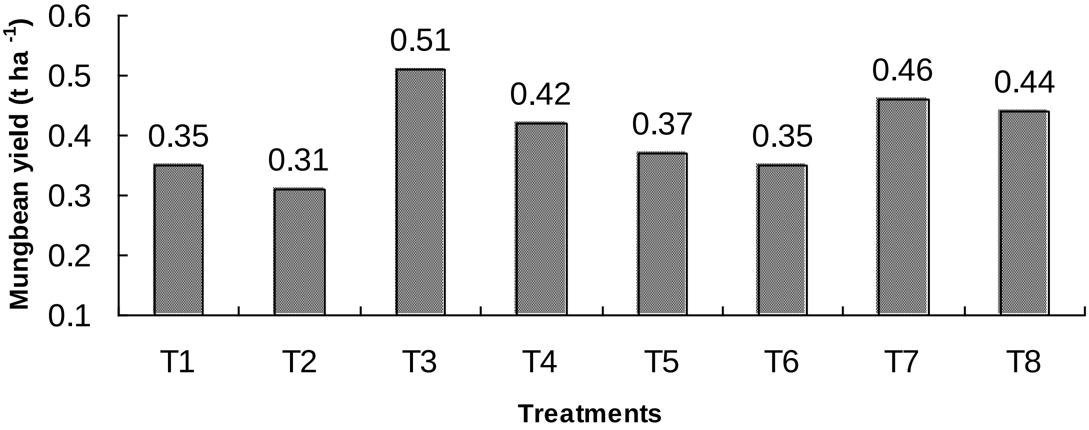

Figure 4. Effects of row spacing and sugarcane leaf clipping on Yield of mungbean.

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PERFORMANCE OF DIFFERENT MEDIUM AND LATE MATURING SUGARCANE STRAINS DURING SELECTION PROCESS

By
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ABSTRACT

A research experiment was carried out to evaluate six qualitative and quantitative traits (germination, tillering, number of millable canes, cane yield, CCS and sugar yield) of twelve medium and late maturing sugarcane strains against a medium and late maturing standard strain SPF-213. Statistically significant differences were recorded in all strains. The maximum germination (65.07%) and cane count (82.29 000/ha) were recorded in S2002-US-619 while highest cane yield (94.17 t/ha) and sugar yield (10.82 t/ha) were noticed in CP85-1491. Similarly maximum tillers per plant (2.47) and CCS (11.70%) were observed in CPHS-35 and S2002-US-327 respectively. All the remaining strains showed lower values than these recorded observations.

Keywords: ***Sugarcane, strains, cane yield, sugar yield, CCS***

INTRODUCTION

The importance of sugarcane (*Saccharum officinarum L.,*) in the agrarian economics of the world need no emphasis because of its higher value as a cash crop, a major source of sugar and basic raw material for various agro based industries. Similarly sugar industry ranks second to the textile industry and enjoys a key position in the world's economics (Jamro *et al.,* 2000). The major cane producing countries of the world like Brazil, India, China, and Thailand have higher cane production 420121, 232320, 87600 and 49572 thousand tons respectively as compare to Pakistan, which is 47244 thousand tons (GOP, 2006). The varieties play an important role in lower cane production scenario. There may be several reasons of low cane yield with respect to varieties because sugarcane varieties deteriorate after a certain period of time due to evolution of new breeds of pathogens and change in environment from year to year. Therefore a constant flow of fresh improved varieties is essential (Aslam *et al.,* 1998). In the same way, acceptability of a newly released variety depends on its yield performance. Similarly the performance of promising clones depends upon the agro-ecological conditions as a promising variety may not perform good in all agro-ecological zones due to variation of agro climatic factors (Bashar and Paul, 2005). Thus role of varieties in increasing cane yield and production can never be neglected. The studies conducted by researchers related to this topic are being presented in reviewed form in coming lines.

Khan *et al.,* (1995) evolved a cane variety Co. 84212 from the Co1148 x Co775 having cane length (2-2.3m), cane thickness (2-2.3cm), number of millable cane (85-123 000/ha), sucrose (16-17%), purity (88-91%) and sugar recovery (11.5-12.8%) at 9-10 months of maturity. Similarly Chang (1995) released cane variety ROC 21 from cross of 70-3792 x F163 for red highland soil in central Taiwan and it was resistant to leaf blight, common rust, downy mildew, smut, orange rust, leaf scorch and mosaic. Domaingue and Ricaud (1995) discussed and recommended climatic regions for different cane varieties as MI55/80 and R575 for humid and sub humid areas, M554/79 for super humid zone and M1176/77 and M261/78 for dry, non irrigated areas. Similarly, Ramirez-Oli-veraz *et al.*, (1978) studied fifty cane varieties and released five promising varieties namely PR61-902, CR52-43, PR1140, BR1140 and CP52-43 due to their better growth and juice quality while PR61-92 produced maximum cane yield in the reported study. In the same way, Naeem *et al.*, (1996) investigated the decline in biological potential of ten sugarcane genotypes in which CoL-54 maintained its biological potential by producing maximum cane yield while CoL-29 showed maximum decline.

The present study was, therefore, initiated to evaluate and compare the relative performance of some newly introduced sugarcane strains during varietal selection programme.

MATERIALS AND METHODS

The study reported here was made at Sugarcane Research Institute, Ayub Agricultural Research Institute, Faisalabad during the crop season 2005-06. The treatments comprising of thirteen medium and late maturing strains viz;

1. CP-85-1491
2. CPHS-35
3. S96-SP-1215
4. S98-SP-108
5. S2000-US-50
6. S2002-US-92
7. S2002-US-750
8. S2002-US-116
9. S2002-US-327
10. S2002-US-334
11. S2002-US-619
12. SPF-245
13. SPF-213 (std.)

The crop was sown@70, 000 DBS/ha and fertilized@168-112-112 Kgs/ha NPK in March 2005 and harvested in the same month of 2006. Similarly the plant protection measures as weeding, hoeing, earthing up and irrigation were applied according to crop condition and requirement. The data recorded during the entire course of study were comprised of the following yield and quality parameters.

a) Germination
b) Tillers per plant
c) Number of millable canes
d) Cane yield
e) CCS
f) Sugar yield

Among these parameters data on germination and tillering were recorded after 45 and 90 days of sowing while all other data parameters except CCS were recorded at harvest. However, CCS% was determined fortnightly from October to April according to the procedures described in uniform methods of chemical control of Pakistan cane sugar factories (Anonymous, 1977). The remaining data were subjected to statistical analysis to analyse the superiority of means using LSD at 5% probability levels for testing significance of differences as described by Steel and Torrie (1980).

RESULTS AND DISCUSSION

Studies on different characteristics of all strains are categorically described as follows:-

Germination

It is the most critical factor which determines the varietal potential to exploit the available resources and ultimately effects cane stand. It is evident from data table that among twelve strains, maximum germination (65.07%) was recorded in S2002-US-619 as compare to the standard SPF-213 (61.27%). It was followed by S98-SP-108 that produced 62.00% germination. While the S2002-US-116 produced the lowest germination (27.81%). The other strains produced germinates between these two limits. This findings are analogous with Verma *et al.,* (1998) who found variable germination for different cane cultivars.

Tillers per plant

Tillering potential of a strain ultimately effects cane yield positively. The perusal of data embodied in table revealed that all strains showed significant differences for tillering. The highest number of tillers per plant (2.47) were observed in CPHS-35 as compare to standard SPF-213 (1.55) while S98-SP-108 produced the lowest number of tillers (0.72). The remaining eleven strains produced tillers between these extremes. Similar reports were reported by Tiwari and Chatterjee (1998).

Number of millable canes

It directly influences cane yield as it is the combined interaction of germination and tillering. No strain succeeded in recording higher number of millable canes as compare to SPF-213 (100.00 000/ha). However S2002-US-619 ranked second by producing 82.29 000/ha millable canes. Similarly the minimum number of canes (57.99 000/ha) were counted in S2002-US-116 and S2002-US-327. This determination is in agreement with those referred by Hapase *et al.,* (1995).

Cane yield

It is the combination of functions like environmental responses and genetic potential of a strain. Variable and significant data were recorded for cane yield. As far as the cane yield is concerned, CP85-1491 yielded the highest tonnage (94.17 t/ha) and it was followed by S2000-US-50 in descending order that produced 92.43 t/ha canes. These two strains crossed standard SPF-213 (80.47 t/ha). The research work carried out by Goswami *et al.,* (1992) are in accordance with the present finding.

CCS%

CCS is the best judgment method of a strain's quality for breeders and millers. It is clear from data table that all strain varied highly for CCS. S2002-US-327 showed maximum commercial cane sugar (11.70%) and it was followed by CP85-1491, S2002-US-750, S2000-US-50, S2000-US-619, S2002-US-334 and S2002-US-92 in descending order by recording, 11.50%, 11.14% , 10.96%, 10.80%, 10.63% and 10.54% CCS as compare to the standard SPF-213 (9.81%). This discussion shows a close conciseness with those of Verma *et al.,* (1998).

Sugar yield

It is the combination of cane weight and corresponding commercial cane sugar. Only three strains produced higher sugar yields as compare to SPF-213 (7.89 t/ha) i.e. CP85-1491 (10.82 t/ha), S2000-US-50 (10.13 t/ha) and SPF-245 (8.84 t/ha). While the remaining nine strains failed to produce higher sugar yield as compare to these. The other strains produced results between these figures. The results are almost same as demonstrated by Sing *et al.,* (1992).

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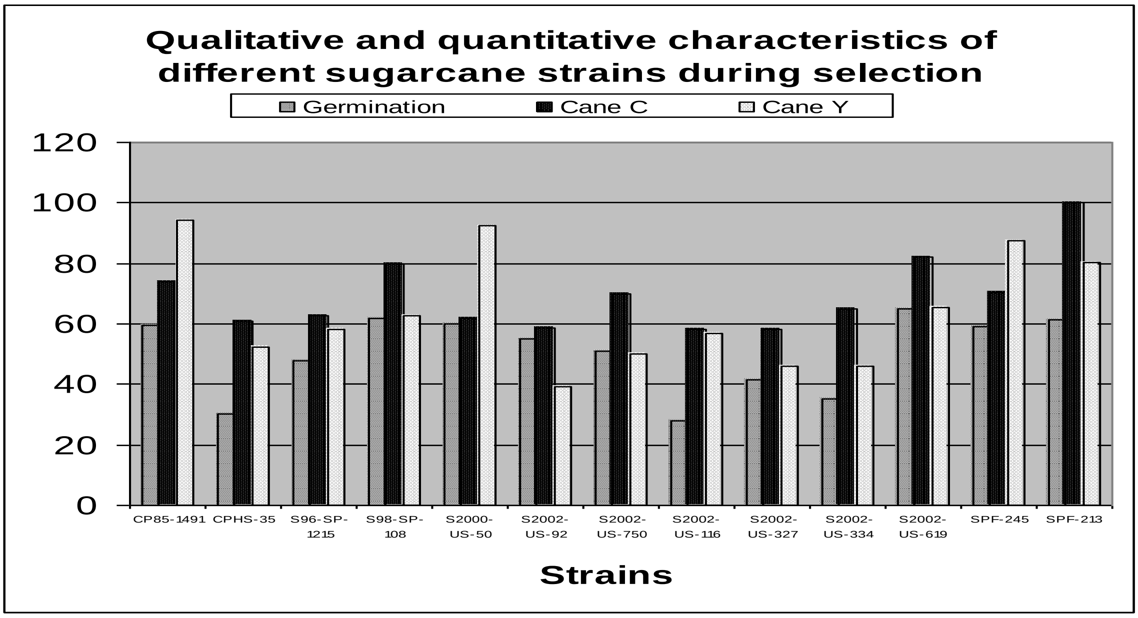
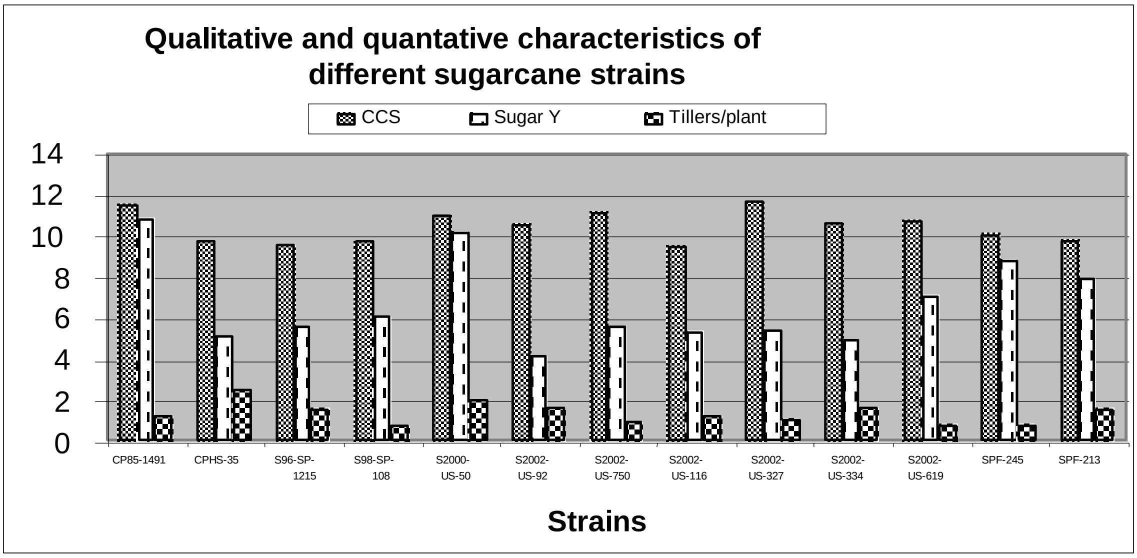
Table-1 Qualitative and quantitative characteristics of different sugarcane strains during selection process

Sr. No.	Strains	Germination (%)	Tillers/ Plant	Millable canes (000/ha)	Cane yield (t/ha)	CCS (%)	Sugar yield (t/ha)
1.	CP85-1491	59.54b	1.27e	73.96bc	94.17a	11.50	10.82a
2.	CPHS-35	30.38fg	2.47a	60.76cd	52.43def	9.73	5.10fg
3.	S96-SP-1215	48.03cd	1.55cd	62.50cd	58.08bcd	9.58	5.56defg
4.	S98-SP-108	62.00ab	0.72f	79.86b	62.50bc	9.70	6.06de
5.	S2000-US-50	60.20ab	2.02b	61.80cd	92.43a	10.96	10.13a
6.	S2002-US-92	55.26bc	1.66bc	58.68d	39.40g	10.54	4.15h
7.	S2002-US-750	50.85c	0.98ef	70.14bcd	50.00ef	11.14	5.57def
8.	S2002-US-116	27.81fg	1.30cde	57.99d	56.94cde	9.45	5.38efg
9.	S2002-US-327	41.66de	1.14def	57.99d	46.18fg	11.70	5.40efg
10.	S2002-US-334	35.41ef	1.63bc	64.93cd	45.83fg	10.63	4.87gh
11.	S2002-US-619	65.07a	0.86ef	82.29b	65.19b	10.80	7.04c
12.	SPF-245	59.07b	0.83f	70.57c	87.50b	10.10	8.84ab
13.	SPF-213 (std.)	61.27ab	1.55ef	100.00a	80.47b	9.81	7.89b

Std. = Standard





EFFECT OF PHOTOPERIODIC TREATMENT ON TASSELING IN SUGARCANE

By

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ABSTRACT

Eight flowering genotypes such as Isd 25 and I 325-86 from early, Co 1148 and BC_3 from mid, Isd 24 and I 233-87 from late, and Isd 20 and Isd 26 from sparse-flowering groups were considered to determine the effect of photoperiodic treatment on tasseling in sugarcane. For this purpose, three photoperiod lengths 12.15, 12.30 and 12.45hrs were used continuously for one month and then reduced one minute per day until it reached to 11.30hrs day length. The respective numbers of days of the treatments were 75, 90 and 105. Another set of the eight varieties were maintained in natural condition as control. The characters considered were number of days to flower initiation, number of days from flower initiation to flag leaf, number of days from flag leaf to tip emergence, total number of days to tip emergence, number of days to 50% flowering and number of days to full flowering. It was observed that the genotypes I 325-86 from early-flowering group and both the clones Co 1148 and BC_3 from mid-flowering group responded for all the characters in all the regimes of treatment used. Among the four treatments (including control), the performance of flowering under control condition was very poor, performance of 12.15hrs day length was not satisfactory while the performance of 12.30 and 12.45hrs day length was very good. Considering from all sides, 12.30hrs day length was found most suitable followed by 12.45hrs.

INTRODUCTION

Tasseling (flowering) is must for hybridization. Photoperiod is the principal desirable factor for controlling. The tasseling in sugarcane. In this crop, flowering shows a great range of variation among the clones and species. At Bangladesh Sugarcane Research Institute, (BSRI) among the breeding materials some clones and species exhibit early flowering, some are mid-flowering and some are late. So, it becomes difficult to cross the early, mid and late-flowering clones unless the flowering dates are changed forcefully. In addition, it becomes difficult in obtaining seed from late-flowering clones because of low fertility associated with cool weather (Berding, 1981). Hence, it is needed to delay early-flowering clones, advance late-flowering clones and increase the fertility of late-flowering clones. In this area, photoperiodic treatment has opened a new door to the breeders for a successful breeding programme. However, considering the fact an experiment was undertaken to find out the effect of photoperiodic treatment on tasseling in sugarcane.

MATERIALS AND METHODS

Eight flowering genotypes such as Isd 25 and I 325-86 from early, Co 1148 and BC_3 from mid, Isd 24 and I 233-87 from late, and Isd 20 and Isd 26 from sparse-flowering groups were considered as the experimental materials. On the otherhand, 12.15, 12.30 and 12.45hrs day lengths were used as photoperiodic treatment. The experiment was conducted inside and outside the photoperiod house at Bangladesh Sugarcane Research Institute (BSRI) Ishurdi, Pabna. At first, the genotypes were planted by sett in polybag in the first week of October 1998 and transplanted in drums in the last week of February, 1999. The numbers of drums maintained for each genotype were 12. Each drum was considered as one plot. The drums were kept in open place to grow the canes under natural condition. As soon as the genotypes showed 2-5 internodes 9 drums of each genotype were moved on three rail carts allowing three drums for each treatment. These three drums from each of the genotypes were considered as three replications. The remaining 3 drums were maintained as control. In all, 24 drums from eight genotypes were arranged on each of the three rail carts in split-plot design. In the experiment, genotypes were used as main plot while treatments as sub-plot. Recommended doses of fertilizers and insecticides were applied. Generally, everyday the drums were watered for two times.

The genotypes were given three treatments separately in three chambers of photoperiod house (dark chamber). It was 1 July, 1999 when the treatment was started. The respective 12.15, 12.30 and 12.45hrs treatments for chambers 1, 2 and 3 were used continuously for one month and then reduced one minute per day until it reached to 11.30hrs day length. The treatments were 75, 90 and 105 days for chambers 1, 2 and 3, respectively. Everyday the genotypes on rail cart were put in and out of the dark chamber as per schedule time. Data were recorded on number of days to flower initiation, number of days from flower initiation to flag leaf, number of days from flag leaf to tip emergence, total number of days to tip emergence, number of days to 50% flowering and number of days to full flowering. The required number of days were estimated using the leaf counting method developed by Clements and Awada (1965). For data recording, three stalks were considered from each replication.

RESULTS AND DISCUSSION

Regarding number of days to flower initiation, different varieties responded differently (Table 1). It might be due to inherent variation of the varieties. Similar results were obtained by George (1961) who found that in sugarcane the inflorescence primordia of different varieties were formed at different times. It was observed that early flowering genotypes took comparatively shorter days than the mid and late-flowering genotypes (Table 1). The results were in agreement with the findings of George and Lalouette (1962) who cited that more freely flowering (early flowering) were the variety the earlier were its floral initials. It was found that the sparse-flowering genotypes did not show any flower initiation. The results were corroborated with the findings of Paliatseas (1962) who reported that non-flowering or reluctantly flowering varieties of sugarcane were found to respond slightly or negatively to artificial treatments. Among the treatments, minimum number of days were taken by 12.30hrs followed by 12.45 and 12.15hrs day length. The maximum number of days were taken by the control. This minimum number of days in 12.30hrs treatment might be due to the optimum length of the day for flower induction. Colman (1962) reported that in sugarcane the optimum photoperiod for induction process was 12.35hrs which supports the present results. The increasing time in two mid-flowering (Co 1148 and BC_3) and one early-flowering (I 325-86) genotypes and no initiation of two late-flowering (I 233-87 and Isd 24) and one early-flowering (Isd 25) genotypes at 12.15hrs day length may be due to the effect of short day length and excess day (35^oC) and night (29^oC) temperature at induction. The results were in partial conformity with the findings of Clements and Awada (1964) who reported a daytime temperature of 28^oC to be the optimum and sugarcane flowering is reduced when this temperature exceeds 31^oC at induction. In the experiment, the artificially treated canes were found to take comparatively much less number of days than the control which might have been the results of imposed long treatment followed by short treatment. George and Lalouette (1962) pointed out that canes could be induced to arrow earlier by short day treatment after a lengthy period of imposed long days which supports the present results.

Table-1 Number of days to flower initiation of eight varieties of sugarcane under different photoperiodic treatments

Variety	Treatment				Mean
	Control	12.15 hrs	12.30 hrs	12.45 hrs	
Isd 20	-	-	-	-	-
Isd 26	-	-	-	-	-
I 233-87	67.67	-	36.33	34.00	46.00
Isd 24	70.67	-	35.00	36.00	47.22
Co 1148	60.00	38.00	28.67	31.67	39.59
BC_3	60.33	36.00	31.33	32.33	40.00
Isd 25	52.33	-	24.67	24.33	33.78
I 325-86	47.00	29.00	26.00	24.00	31.50
Mean	59.67	34.33	30.33	30.39	

In case of number of days from flower initiation to flag leaf it was observed that the different genotypes required different number of days, the early-flowering genotypes required the less number of days than the mid and late-flowering genotypes (Table 2). This difference in number of days to flag leaf development might be due to the difference of floral initiation of the genotypes. Chu and Serapion (1971) underscored the fact that distinct time intervals were needed for flower development by different varieties of sugarcane which was in close agreement with the present findings. In the study, photoperiodically controlled treatments showed comparatively less number of days for flag leaf development than the control (non-treated) which might be due to difference of initiation time as well as shortening of the day length after a long day constant treatment. The results are in conformity with the findings of Millers and Li (1995) where they found rapid flower development in photoperiodically controlled conditions than in nature.

Table-2 Number of days from flower initiation to flag leaf of eight varieties of sugarcane under different photoperiodic treatments

Variety	Treatment				Mean
	Control	12.15hrs	12.30hrs	12.45hrs	
Isd 20	-	-	-	-	-
Isd 26	-	-	-	-	-
I 233-87	60.00	-	59.33	57.67	59.00
Isd 24	60.33	-	52.67	54.00	55.67
Co 1148	58.00	56.00	54.00	54.67	55.67
BC_3	55.67	53.33	49.33	50.67	52.25
Isd 25	56.67	-	51.67	51.33	53.22
I 325-86	49.33	48.00	47.67	46.00	47.75
Mean	56.67	52.44	52.45	52.39	

In respect of number of days from flag leaf to tip emergence it was observed that the different genotypes took different number of days and the early flowering genotypes took comparatively less number of days than the mid and late-flowering genotypes (Table 3). This difference in number of days to tip emergence might be due to difference in flower initiation as well as difference in the rate of development of inflorescences. Singh (1980) found difference in inflorescence emergence in different varieties due to difference in floral initiation time and the period from cane maturity to flowering, which are in partial agreement with the present findings. In this investigation, it was observed that under decreasing day length flowering was earlier than the control. The results might have got the support of Brett and Harding (1974) who obtained profuse and earlier flowering under decreasing day lengths.

Table-3 Number of days from flag leaf to tip emergence of eight varieties of sugarcane under different photoperiodic treatments

Variety	Treatment				Mean
	Control	12.15hrs	12.30hrs	12.45hrs	
Isd 20	-	-	-	-	-
Isd 26	-	-	-	-	-
I 233-87	29.33	-	28.67	28.33	28.78
Isd 24	35.00	-	34.00	33.67	34.22
Co 1148	28.67	28.00	27.33	28.00	28.00
BC_3	26.67	27.33	27.00	27.33	27.33
Isd 25	23.33	-	22.67	22.67	22.89
I 325-86	32.00	30.00	30.33	29.33	30.42
Mean	29.33	28.44	28.33	28.22	

The total number of days required from 1st July to tip emergence of inflorescence of different genotypes under treated and non-treated (control) conditions were different. The linear regression of time of emergence on time of initiation indicated that for each day delay in initiation emergence was delayed 1.58, 1.59, 2.05 and 1.95 days for control, 12.15, 12.30 and 12.45hrs day length, respectively (Table 4). The results are in partial agreement with the findings of George and Lalouette (1962) where they found that for one day delay in formation of the inflorescence in sugarcane emergence was delayed for approximately two days. James and Miller (1971) reported that for one day delay in initiation of the inflorescence in sugarcane emergence was delayed for 1.39 days which also supports the present results partially.

In Table-5, it is observed that the number of days required for 50 % flowering were different for different genotypes which might be due to inherent characteristics of the genotypes. Early-flowering genotypes took minimum number of days while the late-flowering genotypes took maximum number of days. Clements and Awada (1965) found less number of days requirement for flowering in the early flowering varieties compared to the late flowering varieties, which corroborate the present findings. In this study, among the treatments 12.30 and 12.45hrs day lengths were found very close for number of days to 50 % flowering but 12.15hrs day length was found to take some more number of days which might be due to delay in initiation, development and emergence of inflorescence by the treatment. Compared to control minimum number of days were required by photoperiodic treated canes which might be due to shortening of day length, day and night temperatures, and air humidity difference. James (1970) obtained earliest flowering in sugarcane through gradual shortening of day length, and difference in inducing flower through photoperiodic treatment which might support the present findings partially.

Table-4 Total number of days required from July 1st to tip emergence in sugarcane under different photoperiodic treatments

Treatment	Variety	Days from July 1 to first initiation	Days from first initiation to flag leaf	Days from flag leaf to tip emergence	Days from July 1 to tip emergence	Regression* coefficient
Control	I 233-67	67.67	60.00	29.33	157.00	
	Isd 24	70.67	60.33	35.00	166.00	
	Co 1148	60.00	58.00	28.67	146.67	1.58
	BC_3	60.33	55.67	27.67	143.67	
	Isd 25	52.33	56.67	23.33	132.33	
	I 325-86	47.00	49.33	32.00	128.33	
12.15hrs	I 233-67	-	-	-	-	
	Isd 24	-	-	-	-	
	Co 1148	38.00	56.00	28.00	122.00	1.59
	BC_3	36.00	53.33	27.33	116.66	
	Isd 25	-	-		-	
	I 325-86	29.00	48.00	30.00	107.00	
12.30hrs	I 233-67	36.33	59.33	28.67	124.33	
	Isd 24	35.00	52.67	34.00	121.67	
	Co 1148	28.67	54.00	27.33	110.00	2.05
	BC_3	31.33	49.33	27.00	107.66	
	Isd 25	24.67	51.67	22.67	99.00	
	I 325-86	26.00	47.67	29.33	103.00	
12.45hrs	I 233-67	34.00	57.67	28.33	120.00	
	Isd 24	36.00	54.00	33.67	123.67	
	Co 1148	31.67	54.67	28.00	114.34	1.95
	BC_3	32.33	50.67	27.33	110.33	
	Isd 25	24.33	51.33	22.67	98.33	
	I 325-86	24.00	46.00	30.33	100.33	

* Indicates linear regression of time of emergence on time of initiation

Table-5 Number of days to 50 % flowering of eight varieties of sugarcane under different photoperiodic treatments

Variety	Treatment				Mean
	Control	12.15hrs	12.30hrs	12.45hrs	
Isd 20	-	-	-	-	-
Isd 26	-	-	-	-	-
I 233-87	168.00	-	131.33	126.33	141.89
Isd 24	175.00	-	129.67	131.67	145.45
Co 1148	155.67	132.00	118.00	121.33	131.75
BC_3	149.67	122.66	112.66	115.33	125.08
Isd 25	136.33	-	103.00	100.33	113.22
I 325-86	144.33	112.00	106.00	104.66	116.74
Mean	154.83	122.22	116.78	116.61	

In case of number of days to full flowering it was observed that the different genotypes took different number of days showing a range of 9.17 to 12.22 days (Table 6). Dutt *et al.* (1938) found that the time taken by the arrow to come out fully extended as many as 16 days in certain cases while in others the whole arrow emerged in about 7 days which supports the present findings. It was observed that in all the three photoperiodic treated canes the number of days required for full flowering were very close to one another but higher number of days were taken by the control than 12.30 and 12.45hrs day lengths which might be the results of low temperature effect during flowering time. Low temperature reduced the rate of elongation and final growth of panicle in sugarcane (Edwards and Paxton, 1979) which was in partial agreement with the present results.

Table-6 Number of days to full flowering of eight varieties of sugarcane under different photoperiodic treatments

Variety	Treatment				Mean
	Control	12.15hrs	12.30hrs	12.45hrs	
Isd 20	-	-	-	-	-
Isd 26	-	-	-	-	-
I 233-87	12.00	-	11.33	11.00	11.33
Isd 24	12.33	-	12.33	12.00	12.22
Co 1148	11.67	12.00	11.00	11.33	11.50
BC_3	9.67	9.67	8.67	8.67	9.17
Isd 25	10.67	-	10.33	10.67	10.45
I 325-86	11.33	11.00	10.00	9.33	10.42
Mean	11.28	10.89	10.61	10.50	

From the results of this experiment it is noted that the genotypes I 325-86 from early flowering group and both the clones Co 1148 and BC_3 from mid-flowering group responded for all the characters in all the regimes of treatment used. Among the four treatments, the performance of tasseling under control condition was very poor, performance of 12.15hrs day length was not satisfactory while the performance of 12.30 and 12.45hrs day lengths was very good. The last two treatments were very close to one another in different aspects. Of course, the 12.45hrs day length showed a bit higher flowering frequency over the 12.30hrs. Considering from all sides, 12.30hrs day length is suggested to follow for photoperiodic treatment under BSRI condition, however, 12.45hrs day length may also be used.

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EFFECT OF SPACING ON YIELD AND QUALITY OF AUTUMN SOWN SUGARCANE INTERCROPPED WITH SUGARBEET

By

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ABSTRACT

An intercropping trial of sugarcane with sugar-beet was carried out at Sugarcane Research Institute, Faisalabad to evaluate the effect of spacing on yield & quality and economic benefits of both the crops during the years 2003-2004 & 2004-2005. The experiment was laidout in Randomized Complete Block Design having net plot size of 3.6 x 8 m^2. Single and double rows of sugar beet were planted in sugarcane spaced at 120, 90 and 60 cm. However, the maximum cane and sugar beet yields were obtained from treatments where both the crops were planted alone. Average of two years data revealed that maximum cane yield of intercropped sugarcane (101.50 t ha^{-1}) with sugar beet yield of 59.74 t ha^{-1} was obtained when sugarcane was planted at 120 cm apart trenches with one row of sugar-beet. Hence, maximum income was also recorded in the same treatment (1,61,245 Rs. ha^{-1}) as against alone sugarcane 1,04,588 Rs. ha^{-1} and alone sugarbeet 99,141 Rs. ha^{-1}.

Keywords: Intercropping, trial, sugarbeet, maximum, sugarcane, economic.

INTRODUCTION

Sugarcane crop serves as a major raw material for production of white sugar and gur. Sugarcane is a highly water intensive cash crop plays a vital role in economic uplift of farmers. The small growers having limited resources are not in a position to afford such a long duration crop with heavy initial investment and water requirement. So, there should be a source of interim income compensating the initial investment with ultimate improved economics of the farmers. Moreover, to face the WTO challenges, the sugar production cost is required to be reduced either by improving sugar recovery of cane or by expanding the crushing season of the sugar industry with some other alternate sugar crop like sugar beet (*Beta valgaris* L.). Sugarcane and sugar beet are both the sugar crops which can be grown side by side (Khan and Minhas, 2000). Sugar-beet is known for its high tolerance to saline and alkaline conditions (Das Gupta, 1983) and irrigation requirement is fairly low, not more than 4 – 5 irrigations amounting to 37.5 – 60 cm would be required for the purpose (Das Gupta, 1985). Winter sugar-beet is a 6-7 months crop, sown in October and harvested in April and May. Sugar beet is favoured by a long and moderately cool growing season, warm days and fairly cool night, favour rapid growth. It is obvious from the said facts that sugar beet is not only the supplement crop of sugarcane but also can be grown with the sugarcane. Sugarcane and sugar-beet inter-cropping system may expand the crushing season of sugar industry upto 45 days and may also improve the sugar recovery with ultimate reduced cost of sugar production. However, the inter-cropping of sugar beet is only possible in autumn sown cane crop. Keeping in view, the present study was conducted to achieve the following objectives:

To workout the feasibility of sugar-beet intercropping in sugarcane.

1. To achieve a long awaited sustainable self-sufficiency in sugar to cater the sugar requirements of rapidly growing population.
2. To observe the sugar beet crop as a good supplement of sugarcane.
3. To open up avenues for extending the working season of sugar mills till the end of May.

MATERIALS AND METHODS

An intercropping trial of sugarcane with sugar beet was conducted at Sugarcane Research Institute, Faisalabad to workout the feasibility and effect of spacing on the yield, quality and economic benefits of both the crops during the years 2003-2004 and 2004-2005. The experiment was laid out in R.C.B.D. having net plot size of 3.6 x 8 m^2. The sugarcane variety HSF-240 was sown on a well prepared seed-bed during 1^{st} week of October in 60, 90 and 120 cm apart rows using 60,000 DBS/ha seed rate.

The alone sugarcane was planted in 120 cm apart trenches and alone sugar-beet variety Kawe Terma was planted at 60 cm apart rows. Single and double rows of sugar beet were planted in sugarcane spaced at 120, 90 & 60 cm. The sugar beet crop was thinned twice to maintain 10 cm plant to plant distance. The sugarcane and sugar beet were fertilized @ 168-112-112 and 100-50-0 kg NPK ha^{-1}, respectively. The weeds were controlled by hand hoeing and 5 irrigations were applied upto the harvest of inter-crop. The cane crop was earthed up after inter-crop harvest. The data regarding yield and sugar recovery were recorded for both the crops. The economic analysis to adjudge the adaptability of the treatments. Data were recorded by using the standard procedure and analyzed statistically through MSTATC Statistical Programme (MSTAT-C, Manual, 1991).

RESULTS & DISCUSSION

The data presented in table-1 showed that all the treatments where both the crops alone or inter-cropped at different spacings were affected significantly during 2003-2004. The maximum cane yield of 111.27 t ha^{-1} (T_1) and beet yield of 105.47 t ha^{-1} (T_8) were obtained from treatments where both the crops were planted alone with sugar yields of 10.54 t ha^{-1} and 11.98 t ha^{-1}, respectively (Bashir *et al.*, 2005). The data also revealed that maximum cane yield of inter-cropped sugarcane (107.96 t ha^{-1}) with additional sugar beet yield of 63.87 t ha^{-1} was obtained where sugarcane was planted at 120 cm apart trenches with one row of sugar beet. However, when the same spaced cane crop was inter-cropped by 2 sugar beet rows on either side of the ridge, the reduction in cane yield was much more than the increase in sugar beet yield. It is obvious that within the same spacing, the cane yield was remarkably reduced by increasing the intercrop density. The general adaptability of system depends upon the monetary gain from the system. Almost similar trend was also found among the data regarding cane and beet yield and sugar yields of both the crops during the year 2004-2005 (Table-2) and the same treatments were prominent in their performance. The data regarding gross income per hectare reveal that irrespective of the duration of the system, sugarcane – sugar-beet inter-cropping system proved economically much more beneficial than the mono-cropping system of either crop. The treatment T_2 (sugarcane at 120 cm spacing + 1 row of sugar beet) gave the maximum gross income (171840 and 150650 Rs. ha^{-1}) as against sugarcane alone (111267 and 97910 Rs. ha^{-1}) and alone sugar beet (105473 and 92810 Rs. ha^{-1}) during both years (2003-2004 and 2004-2005), respectively. Similar results were also reported by Behl and Narwal, (1977) and Chattha *et al*.,(2003).

CONCLUSION

It is concluded from the discussion that sugarcane – sugar-beet inter-cropping system is feasible and acceptable to the growers.

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Table-1 Yield and quality of autumn sown sugarcane inter-cropped with sugar beet as affected by spacing (2003-2004)

Treatments	**Beet yield t/ha**	**Sugar yield of S.beet (t/ha)**	**Sugarcane yield (t/ha)**	**Sugar Yield (t/ha)**	**Gross income Rs./ha**	**% increase over cane mono-crop**
T_1 = Sugarcane alone at 120 cm apart rows	-	-	111.27 a	10.54 N.S.	111267 d	-
T_2 = Sugarcane at 120 cm spacing + one row of sugar beet	63.87 f	6.60 f	107.96 b	10.57	171840 a	54.44
T_3 = Sugarcane at 120 cm spacing + two rows of sugar beet	75.58 e	7.64 c	87.66 c	10.62	163253 b	46.72
T_4 = Sugarcane at 90 cm spacing + one row of sugar beet	85.74 d	8.73 a	80.17 d	10.25	165907 b	49.12
T_5 = Sugarcane @ 90 cm spacing + two rows of sugar beet	91.41 c	9.21 cd	70.47 e	9.81	161947 b	45.55
T_6 = Sugarcane 60 cm spacing + one row of sugar beet	100.9 b	11.08 b	61.17 f	9.87	162093 b	45.68
T_7 = Sugarcane 60 cm spacing + two rows of sugar beet	91.5 c	9.68 c	58.30 g	10.00	149450 c	34.31
T_8 = Sugar beet alone at 60 cm apart rows	105.47 a	11.98 a	-	-	105473 e	-
LSD	4.224	0.4937	2.376	-	429.7	-

N.S.= Non significant

Values followed by the same letter in the same column do not differ significantly at 0.05 Probability

Sugarcane @ Rs. 1000/- t Sugar beet @ Rs. 1000/- t

Table-2 Yield and quality of autumn sown sugarcane inter-cropped with sugar beet as affected by spacing (2004-2005)

Treatments	Beet yield t/ha	Sugar yield. of S.beet (t/ha)	Sugarcane yield (t/ha)	Sugar Yield (t/ha)	Gross income Rs./ha	% increase over cane mono-crop
T_1 = Sugarcane alone at 120 cm apart rows	-	-	97.91 a	9.27 a	97910 e	-
T_2 = Sugarcane at 120 cm spacing + one row of sugar beet	55.61 f	5.75 g	97.04 b	9.30 a	150650 a	53.86
T_3 = Sugarcane at 120 cm spacing + two rows of sugar beet	66.51 e	6.72 f	76.56 c	9.28 a	140370 c	46.12
T_4 = Sugarcane at 90 cm spacing + one row of sugar beet	74.45 d	7.68 e	71.72 d	9.16 a	147170 b	50.13
T_5 = Sugarcane @ 90 cm spacing + two rows of sugar beet	80.44 c	8.10 d	61.51 e	8.56 c	141950 c	44.98
T_6 = Sugarcane 60 cm spacing + one row of sugar beet	88.80 b	9.75 b	54.12 f	8.73 bc	142920 c	45.97
T_7 = Sugarcane 60 cm spacing + two rows of sugar beet	80.21 c	8.48 c	51.92 g	8.90 b	132130 d	34.95
T_8 = Sugar beet alone at 60 cm apart rows	92.81 a	10.54 a	-	-	92810 f	-
LSD	1.214	0.2387	1.829	0.1779	1981	-

Values followed by the same letter in the same column do not differ significantly at 0.05 Probability

Sugarcane @ Rs. 1000/- t Sugar beet @ Rs. 1000/- t

Table-3 Yield and quality of autumn sown sugarcane inter-cropped with sugar beet as affected by spacing (Average of two years)

Treatments	Beet yield t/ha	Sugar yield of S.beet (t/ha)	Sugarcane yield (t/ha)	Sugar Yield (t/ha)	Gross income Rs./ha	% increase over cane mono-crop
T_1 = Sugarcane alone at 120 cm apart rows	-	-	104.59	9.91	104588.5	-
T_2 = Sugarcane at 120 cm spacing + one row of sugar beet	59.74	6.18	102.50	9.94	161.245	54.15
T_3 = Sugarcane at 120 cm spacing + two rows of sugar beet	71.05	7.18	82.11	9.95	151811.5	46.42
T_4 = Sugarcane at 90 cm spacing + one row of sugar beet	80.10	8.21	75.95	9.71	156538.5	49.63
T_5 = Sugarcane @ 90 cm spacing + two rows of sugar beet	85.93	8.66	65.99	9.19	151948.5	45.27
T_6 = Sugarcane 60 cm spacing + one row of sugar beet	94.85	10.42	57.65	9.30	152506.5	45.83
T_7 = Sugarcane 60 cm spacing + two rows of sugar beet	85.86	9.08	55.11	9.45	140790	34.63
T_8 = Sugar beet alone at 60 cm apart rows	99.14	11.26	-	-	99141.5	-

Values followed by the same letter in the same column do not differ significantly at 0.05 Probability

Sugarcane @ Rs. 1000/- t

Sugar beet @ Rs. 1000/- t

SUGAR INDUSTRY ABSTRACTS

By
M. Awais Qureshi and Dr. Shahid Afghan

AGRICULTURAL ENGINEERING

Evaluation of green-cane harvesting and crop management with a trash-blanket
Oscar Núñez and Egbert Spaans
Proc. Int. Soc. Sugar Cane Technol., Vol. 26, 2007

To evaluate the feasibility of green-cane harvest at San Carlos Sugar Mill in Ecuador, the agronomic parameters that may be affected when changing from burned to greencane harvest were evaluated. Two sites were harvested green by hand and compared with two adjacent sites that were also harvested manually but burned. Manual, greencane harvesting was found to be not feasible for San Carlos Mill due to the prohibitive increase in harvesting cost caused by the reduction in productivity of 68% of the field labourers. Subsequently, an experiment was undertaken with mechanical harvesters, comparing six sites that were cut green and another six adjacent sites that were burned before harvest. In mechanical green-cane harvest, the machine productivity was reduced by 43% and the trash content in the delivered cane was higher by 38%. Several advantages of the green-cane harvest were, however, found. The mass of crop residues that remained in the field after mechanical harvest was significantly larger under green harvesting (17.31 t/ha) when compared to the burned treatment (3.7 t/ha). The contents of P and K in the residues were the same, but N content in the green harvest residues (0.85%) was significantly higher than in the burned residues (0.55%). In addition, after green-cane harvest, the cost of weed control was reduced by 35% and of irrigation by 10%. While sucrose recovery was not affected, insufficient data were available to draw valid conclusions on cane yield. After considering the impact of all the parameters that were monitored, economic analysis currently favours burned-cane harvest. Conversely, we believe that if better trash-extraction was achieved and if the nutrient recycling of the trash blanket was quantified, the balance would tip in favour of green harvest. It is necessary to continue the evaluation of mechanical green-cane harvest to understand the conditions under which it is favourable and to assess its long-term effects on soil health and cane yield.

High efficient diagnosis of sugarcane farmland using NIR spectroscopy networking system
Eizo Taira, Masami Ueno, Yoshinobu and Ryota Matsukawa
Proc. Int. Soc. Sugar Cane Technol., Vol. 26, 2007

A new quality evaluation system using NIR spectroscopy for the shredded cane has been introduced into the Okinawa sugar mill groups in Japan. Using appropriate inputs based on the data from NIR spectroscopy, a simple and effective diagnosis system was developed to increase production and quality of sugarcane. The evaluation system is composed of the local systems, network system, data and file servers and others. A NIR spectrometer and a cutter grinder are main elements of the local system. The local system is installed in ten raw sugar mills on the eight islands which grow sugarcane. All data obtained by the local systems is collected into the central facility through the Internet. The NIR absorbance spectrum obtained from the each local system is collected into the centre and the components calculated. Value added functions are installed into the quality evaluation system. The analysis of the shredded cane with respect to total nitrogen, CN ratio and minerals is measured by the new system. Nutrition status of a sugarcane field is then checked by the central diagnosis system. The results are then returned to the local system, where relevant changes to fertiliser application, scheduling of farming operation and other parameters are made.

AGRICULTURAL AGRONOMY

Recent advances to improve nitrogen use efficiency of sugarcane in the South African sugar industry

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The nitrogen requirement of sugarcane in South Africa has been the subject of extensive research. Results of more than 200 trials conducted over the past four decades have shown that the response to applied N can be highly variable and that N use efficiency by the crop can be influenced by ecological factors such as season, rainfall, nature of the soil as well as cultural practices that include variety, irrigation, N form, rate, timing and method of N placement. Local research results are reviewed and specific outcomes that have modified N use efficiency include: Soil specific nitrogen fertiliser recommendations for the main agro-climatic zones that are based on soil organic matter status and the potential of the soil to release N; For advisory purposes, an analytical method based on Near Infra-red Reflectance Spectroscopy (NIRS) was pioneered to rapidly measure the organic matter and nitrogen mineralisation potential of soil; A new laboratory test to predict potential ammonia volatilisation losses from surface-applied urea fertiliser; Improved N fertiliser use efficiency through fertigation; Classification of sugarcane varieties into one of three categories of N use efficiency and the impact on N recommendations; The use of the leaf and stalk N/Si ratio as a predictor of risk from stalk borer damage; Development of robust leaf N thresholds using a continuous model Fourier function and the use of DRIS to more accurately diagnose the nitrogen status of sugarcane. In general, the adoption by growers of a number of these research outcomes over the past two decades has resulted in an improvement of fertiliser N use efficiency from 2.0 kg N/t of harvested cane in 1980 to the current level of about 1.45 kg N/t cane, without compromising average cane yields. This represents an overall improvement in irrigated areas of about 28% in N fertiliser use efficiency.

Minimum tillage: ten years of experience

P. Prammanee, S. Saensupo, P. Weerathaworn and A. Sriwarome
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Continuous and intensive land preparation, cane burning, together with the introduction of heavy cane harvesters, loaders, and heavy trucks have all contributed to the break down of soil structure. Minimum tillage has been proposed as an alternative practice to reduce loss of soil productivity. The main objectives of this ten-year trial were to determine the effects of different soil tillage methods and nitrogen rates on sugarcane production and soil properties. The five tillage systems tested were: T1 conventional tillage, T2-T4 minimum tillage with different planting methods and T5 no tillage. Nitrogen rates were 144 and 288 kg N/ha. The minimum tillage treatment that used only a stool scrapeout gave higher yields (100 t/ha) than the conventional (92 t/ha) and no-tillage treatments (93 t/ha). The minimum tillage (T2-T4) systems had slightly higher soil bulk densities than the conventional (T1) in the first few years, while the no-tillage (T5) systems tended to have the highest. Cane in all tillage treatments did not show any significant response to nitrogen fertiliser. When considering the economic analyses, minimum tillage gave the best net profit of US$1031.2/ha compared to that of conventional tillage US$912.0.

SUGARCANE BREEDING

Introgression of *erianthus* for the development of commercial sugarcane cultivars

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Intensive research with *Saccharum spontaneum* L. was found to be time consuming and results slow to come. Even though good H1 populations were obtained, moving further was difficult. This made it mandatory to explore *Erianthus* Michx. sect. *Ripidium* Henrard, *Sclerostachya* (Hack.) A. Camus and *Narenga* Bor towards evolving better commercial cultivars which can be grown under diverse environments and to cater for co-products such as power generation, particle board, cattle feed, and molasses-derived products. During the past century, only limited attempts were made to transmit the traits of *Erianthus* into commercial sugarcane cultivars due to limitations imposed by asynchronous flowering times and anthesis, and incompatibilities. In E.I.D. Parry, *Erianthus arundinaceus* (Retz.) Jesweit was used for nobilisation through conventional breeding methods from 1998 onwards. The flowering was synchronised by using photoperiod treatment. Intergeneric hybrids were subjected to an unconventional selection system. The hybrid seedlings were observed closely for their growth and phenotypic and biochemical characters. The *Erianthus* hybrids showed greater vigour and were able to produce cane early. Thus, the hybrids were selected based on phenotypic characters viz., leaf orientations, self stripping of leaves, stalk length, stalk thickness, internode length, and stalk colour. During later stages, the populations were screened for biochemical parameters such as sucrose content of the juice. The selected H1 clones were outcrossed with commercials to develop commercial hybrids. The selected clones from the outcross population gave higher cane yield and sucrose content of juice, and higher fibre percent cane when compared with the standard commercial cultivars. Pre-commercials were obtained and tested for commercialisation and release through population testing and large mill performance.

Comparisons of sugarcane yields in trials and in commercial fields

D. Bissessur, C. Ramnawaz and K. Ramdoyal
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Sugarcane cultivars are released for commercial exploitation on the basis of results obtained from clonal trials. These trials are assumed to predict the commercial performance of cultivars in the areas where the respective cultivars are recommended for cultivation. This assumption needs investigation since there have been cases where commercial yields have failed to reflect trial yields under similar conditions. This study was therefore initiated to determine whether trials gave a good prediction of yields in commercial fields. Data from three series of final phase trials established in the subhumid zone in three different years and corresponding ones from commercial fields planted in the same year were retrieved for analysis. The first two series of analyses compared the performance of two popular cultivars, the commercial control R 570, and a drought tolerant one, M 1176/77, while the third series involved the same control and the newly released cultivar, M 1400/86. Data pairs used were mean yields of cultivars where different crops, plant cane, first, second and third ratoons were treated as separate entries. Cumulated mean yield for all crop cycles also were considered. T-tests and Model II regression analyses were used. Commercial yields plotted against experimental yields followed a Mitscherlich curve for the first series. Coefficient of determination of 62% was obtained for the cumulative crop data. Predicted values obtained for commercial yields were not significantly different from the observed yields. The new cultivars performed better than the controls in both the trials and at the commercial level. The mean yield of the respective cultivars in the trials and commercial fields were not significantly different for all three series of data. However, the magnitude of this difference in yield varied for different data sets. The implications of these observations are discussed.

MOLECULAR BIOLOGY

Molecular cloning and characterisation of a non-tir-nbs-lrr type disease resistance gene analogue from sugarcane

Q. You-Xiong, L. Jian-Wei, Z. Ji-Sen, R. Miao-Hong, X. Li-Ping and Z. Mu-Qing
Proc. Int. Soc. Sugar Cane Technol., Vol. 26, 2007

Disease resistance gene cloning is one of the main targets in modern sugarcane research. In this study, several primers were designed according to the conserved motifs in the NBS regions of known resistance genes to amplify sequences from cDNA of sugarcane variety NCo376 by polymerase chain reaction (PCR). In total, six NBS-LRR type resistance gene analogs (RGAs) were cloned, for which the deduced amino acids encoded all or parts of the internal motifs characteristic of the NBS-LRR R-gene class (Accession numbers: EF155648, EF155649, EF155650, EF155651, EF155652 and EF155653). One of them termed EF155653 had all the characteristics of NBS but had no significant similarity to any of the known genes, which suggested that it was possibly a partial sequence of a new NBS-LRR gene. Homology analysis was also conducted to evaluate the relationship between sugarcane RGAs and known plant R genes. Furthermore, all of them contained the residue W in LLVLDDVW/D motif, which confirmed that only non-TIR-NBS-LRR type resistance genes existed in sugarcane to some extent. Finally, the full-length cDNA of cRGA1 (Accession number: EF155648), termed *SNLR* gene, has been cloned and its expression profile under the treatment of *Ustilago scitaminea*, SA and H2O2 was investigated by real-time RT-PCR (Accession number: EF155654). The results showed that *SNLR* gene could be to some extent influenced by *Ustilago scitaminea* and SA, but not by H2O2.

Fifth ISSCT molecular biology workshop report

Asha Dookun-Saumtally, Angélique D.Hont, Erik Mirkov, Barbara Huckett and Eugenio C. Ulian
Proc. Int. Soc. Sugar Cane Technol., Vol. 26, 2007

The 5th International Society of Sugar Cane Technologists (ISSCT) Molecular Biology Workshop was hosted by the Mauritius Sugar Industry Research Institute (MSIRI) from 3.7 April 2006. It was organised by Asha Dookun-Saumtally and the MSIRI staff. Initially, some 35 participants were expected, but a week prior to the Workshop, several cancellations were received and it ended up attended by 23 participants. However, this did not affect the Workshop and it had a concomitant advantage in that discussion times were extended and the interaction among participants was excellent. The Workshop covered five themes: (1) Genetics, physiology, mapping agronomic traits and disease resistance traits; (2) genetic improvement, marker assisted breeding and genetic diversity; (3) sugarcane genomics; (4)

sugarcane transformation; and (5) scientific and technical advances. Besides the technical sessions, participants had the opportunity to visit different Departments at the MSIRI. Field trips were also programmed during the Workshop.

SUGARCANE PATHOLOGY

A review of the 2006 international society of sugar cane technologists. pathology workshop

Jack C. Comstock, Barry J. Croft, Govind G. Rao, Salem Saumtally and Jorge I. Victoria
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This paper summarises the activities of the International Society of Sugar Cane Technologists. (ISSCT) pathology workshop held between 23.27 January 2006, at the INRA Research Centre in Petit Bourg, Guadeloupe, FWI. The workshop was hosted by CIRAD and organised by Jean Heinrich Daugrois and the CIRAD staff. It was attended by 30 delegates from 13 countries. Initially, each of the attendees described the disease situation and research activities in their respective country followed by oral and poster presentations for the first three days. The last two days there were sugarcane disease observations in commercial fields, field plots and laboratory visits at CIRAD Sugarcane Research Station with sight seeing tours of Guadeloupe. The presentations were on the following topics: pathogen variability, disease diagnosis and new diseases, disease impact, disease management, plant resistance, epidemiology, and disease spread. The workshop ended with everyone learning from each other and having an enjoyable time. A post-workshop tour of the West Indies Central Sugar Cane Breeding Station in Barbados was attended by five delegates.

Impact of post-harvest delays and temperature on cane deterioration

L.A. Perry, C. Hunter and D.A. Watt
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Post-harvest cane deterioration in the South African sugar industry results in revenue loss estimated to be ZAR 6 million per annum. Consequently, the South African Sugarcane Research Institute has recently embarked on a major project to model the factors and effects of post-harvest cane deterioration, with a view to formulating recommendations to reduce deterioration-associated losses. Severity of deterioration is influenced by the length of the harvest-to-crush delay, ambient temperature and harvesting practices. For example, burning of cane prior to harvest may result in rind splitting, which provides entry for microbes that may exacerbate deterioration. The work reported here investigated the effects of these factors on deterioration under controlled conditions, with the ultimate purpose of providing empirical data to facilitate model development. Cut stalks of 18 month-old Saccharum spp. hybrid cv. N19 (N19) were incubated for varying time periods (2 to 9 days) under two diurnal temperature regimes: 8oC/21oC and 21oC/31oC. These ten-year mean diurnal temperature ranges mimicked the summer and winter temperatures at the coldest and warmest growing areas in the industry, respectively. In addition, the effects of burning were simulated by the inoculation of internode 11 with 5.37 × 108 colony forming units of Leuconostoc mesenteroides, a major causative agent of post-harvest deterioration. Samples (n = 5) of inoculated and uninoculated stalks were subjected to biochemical, microbiological and standard mill room analyses. Metabolites measured were those found in the stalk and those produced as by-products of microbial metabolism, including sucrose, glucose, fructose, mannitol, lactic acid, dextran, starch and ethanol. Microbial proliferation and infection between internodal compartments were monitored by standard microbiological selective culturing techniques. The results obtained are discussed in terms of the effects that length of post-harvest delay, ambient temperature and stalk damage have on cane quality and the appearance of specific deterioration-associated products that present processing problems.

COPRODUCTS

An overview of bagasse gasification R&D activities at sugar research and innovation
P.A. Hobson
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Sugar Research and Innovation (SRI) has been involved for some years in developing aspects of bagasse gasification technology. This has been undertaken with the long-term aim of implementing advanced cycle, high efficiency power generation in the sugar industry or the production of a gaseous feedstock for alcohols and other industrial commodities. Many of the R&D outcomes achieved at SRI in the area of gasification can be traced back to the formation in 1998 of the Queensland Biomass Integrated Gasification (QBIG) program. This program was set up to develop gasification for boosting power generation in the sugar industry. Under the QBIG program, major research projects were undertaken in the areas of bagasse and cane trash gasification kinetics, ash characteristics in bagasse gasifiers, the development of a continuous pressurised bagasse feeder, cane harvest residue recovery systems to improve gasifier utilisation and economies of scale as well as a financial appraisal of gasification for power generation. It became evident from this latter study that there was significant scope for reducing costs via a staged and highly factory integrated introduction of this technology, and a study was initiated to determine optimum strategies for the large scale adoption of gasification technology across the industry. On a more fundamental level, SRI has been collaborating with Hokkaido and Monash universities in a project aimed at utilising the potassium that occurs naturally in biomass as a catalyst in cracking high molecular weight tars produced during gasification. This catalysed reforming process occurs at relatively low temperatures (500°C to 700°C) and has the potential to deliver significant gasifier cost and efficiency advantages. The role of SRI in this project has been to develop computational fluid dynamics (CFD) and process models with which to implement laboratory data in a thermodynamically optimised gasification cycle. This paper draws together the R&D activities undertaken at SRI to provide a positive picture with respect to the technical feasibility of implementing gasification technology for power generation and highlights some of the financial barriers to the large scale adoption of the technology in Australia.

A techno-economical method to guide decision making over the energy-sugar-ethanol combined production under the changing world market conditions
A. Torres, G. Blanco, M. Herryman, O. Almazan and A. Cabello
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The ways and means of linear programming models for the analysis of different combined electricity-sugar-ethanol production schemes were designed and tested to guide the process of profitable decision making under different national sugar policies, production costs, world market conditions, etc. The models provide a simple and comprehensive tool to work with under the complex and unstable behaviour of commodity prices.