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MORPHOLOGICAL RESPONSES OF AUTUMN PLANTED SUGARCANE TO PLANTING GEOMETRY AND NUTRIENT MANAGEMENT ON DIFFERENT SOILS UNDER ARID CONDITIONS

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ABSTRACT

In field experiment morphological response of sugarcane cultivar HSF 240 to different NPK doses F_1 =0-0-0, F_2 =100-100-100, F_3 =150-150-100, F_4 =200-200-100 and F_5 =250-200-100 kg ha^{-1} and different planting patterns like G_1 =60, G_2 =75 cm, spaced single row Planting pattern, G_3 =30/90, and G_4 =30/120cm spaced paired row strip Planting pattern were studied at research area of the Gomal University Rukh Bibi campus Dara Ismaiel Khan and Main Line Lower Land Reclamation Research Station Chak No 37 TDA (Thal Development Authority) Bhakkar during 2003-04 and 2004-05. The experiment was laid out in randomized complete block design (RCBD) with a split plot arrangement in four replications giving importance to planting patterns. The analysis of pooled data of D.I Khan and Bhakkar showed that all the doses affected the yield, contributing parameters to a significant level. The maximum number of millable canes m^{-2}, weight per stripped cane recorded in 250-200-100 kg NPK ha^{-1} which were statistically nonsignificant to those recorded in 200-200-100 kg NPK ha^{-1}. However maximum stripped-cane yield was recorded in 250-200-100kg NPK ha^{-1} during both the years. Among the planting patterns significantly higher mill able canes, cane weight, and stripped-cane yield was recorded in 30/90cm spaced paired row strip planting pattern followed by 75 and 60cm spaced single row planting pattern with minimum in 30/120cm spaced paired row strip planting pattern. Significantly higher mill able canes, cane weight and stripped-cane yield were recorded in the interaction of 250–200-100 kg NPK ha^{-1} x 30/90 cm spaced paired row strip planting pattern which were at par with 200–200-100 kg NPK ha^{-1} x 30/90cm spaced paired row strip planting pattern and minimum in control x 30/120 cm spaced paired row strip planting pattern during both the years. Therefore it is concludedthat under arid conditions on Silty clay and sandy loam soils optimum stripped cane yield was obtained from nutrient dose of 200–200-100 kg NPK ha^{-1} and 30/90cm spaced paired row strip planting pattern.

Key words: *Saccharum officinarum L.*, NPK management, planting geometry, yield components, autumn planted sugarcane, Pakistan

INTRODUCTION

In Pakistan the average cane yield is much lower than production potential of our existing sugarcane cultivars due to improper nutrient management and planting geometry. Being a long duration crop 125 t ha^{-1} of Sugarcane removes an average 83 kg N, 37 kg P^2O^5, 168 kg K^2O (Yadava, 1991), therefore an adequate and balanced supply of all these nutrients in the effective root zone of crop is essential for obtaining sustainable cane yield. Ali and Afghan (2000) recorded the maximum number of mill able canes m^{-2}, weight per cane and stripped cane yield at 200-150-150 kg NPK ha^{-1}. On the other hand Iqbal *et al*. (2002) recorded the highest stripped-cane yield from the plots fertilized @ 200-150-0 kg NPK ha^{-1}. El-Tilib *et al*, (2004) reported that Phosphorus addition reflected a significant effect on stalk height, number of internodes and plant density of cane. Where as Shukla, (2003) had reported that the highest level of nitrogen 187.5 kg ha^{-1} resulted in better tiller vigor, number and retention, besides better expression in growth parameters during cropping seasons.

The economic yield is determined by the capability of plant to produce Photosynthates and their distribution to economically valuable plant parts. In order to realize the full benefits of the land and environmental resources, it is necessary to place the plants over the field in such a pattern that there is a least competition among them for essential growth factors. Mali and Singh (1985) recorded the maximum thickness of cane 7.48cm at 120cm spaced rows as compared to 90cm and 60cm spacing but opposite results had been reported by Fasihi *et al.*, (1974) that sugarcane planted in 60cm spaced rows produced a significantly greater number of mill able canes ha^{-1} than that planted either in 90cm or 120cm spaced rows Romas (1975) stated that 90cm inter-row spacing gave significantly higher cane yield than 150cm spacing. Similarly Kanwar *et al*. (1990) obtained significantly more cane yield from the crop planted in 90cm spaced rows than 60cm or 120cm spaced rows. El-Geddawy *et al.*, (2002) obtained comparatively higher cane yield at a row spacing of 100cm than 120cm or 140cm spacing.

It is worth mentioning that in past autumn planted sugarcane crop totally neglected by research workers therefore it was considered worthwhile to concrete information on planting patterns and nutrient needs of the autumn sugarcane crop under the edaphic and agro climatic conditions of Dera Ismaiel Khan situated at (031^0 28.40 N ^{0} and 071^0 58.54 E ^{0}) Silty clay soil in NWFP and Bhakkar situated at (031^0 36.365 N ^{0} and 071^0 9.844 E ^{0}) with sandy loam soil in Punjab.

MATERIALS AND METHODS

The studies were conducted at the research area of the Gomal University Rukh Bibi campus Dara Ismaiel Khan (D.I Khan) and Main line Lower Land Reclamation Research Station Chak No 37 TDA (Thal development authority) Bhakkar during 2003-04 and 2004-05.

Table-1 Soil analysis of both experimental sites

	DI Khan		**Bhakkar**	
	2003-04	**2004-05**	**2003-04**	**2004-05**
Soil Texture	**Silty clay**	**Silty clay**	**Sandy Loam**	**Sandy Loam**
N %	0.03	0.035	0.044	0.049
P ppm	8	8.5	3.55	4.75
K ppm	80	92.5	55	60

Analysis; the soil and water testing laboratory, Directorate of Land reclamation Punjab; Canal Bank Mughal Pura Lahore

The NPK doses were F_1 =0-0-0, F_2 =100-100-100, F_3 =150-150-100, F_4 =200-200-100 and F_5 =250-200-100. The planting patterns comprised of G_1=60cm, G_2=75cm spaced single row Planting pattern, G_3=30/90cm and G_4=30/120cm spaced paired row strip planting pattern. The double-budded seed was used at the rate of 70,000 setts ha^{-1}. Cane cultivar "HSF 240" was used as test crop. The experiment was laid out in a randomized complete block design (RCBD) with a split plot arrangement keeping the NPK doses in main plots and planting patterns in sub-plots. The net plot size was $24m^2$ with four replications. The crop was planted during the 1st week of September and harvested during the first week of December next year.

While of the phosphorus, potassium and 1/4 of total N was applied at the time of seed bed preparation while remaining nitrogen was applied in two equal splits at completion of germination and at the start of cane formation. The crop was kept free of weeds and irrigated as and when needed. All other agronomic practices were normal and uniform for all the treatments. The observations on number of mill able canes m^{-2}, individual stripped cane weight, and stripped-cane yield were recorded using standard procedures. The data were analyzed statistically using Fisher's analysis of variance technique and LSD test at 0.05 percent level of probability was employed to compare the differences among the treatment means (Steel and Torrie, 1984).

Table-1.1 Water received by the crop

D.I Khan		Bhakkar	
2003-04	**2004-05**	**2003-04**	**2004-05**
Water Received in mm			
1900	1700	2700	2700
Rainfall Received in mm			
328.00	584.00	373.23	380.24
Total number of Irrigations applied each of 100 mm			
19	17	27	27

RESULTS AND DISCUSSION

Mill able canes

The analysis of pooled data of D.I Khan and Bhakkar at millable cane m^{-2} (presented in Table-2) show that different NPK doses significantly affected the mill able cane m^{-2}. The maximum number of millable canes m^{-2} 13.46 and 13.58 during 2004 and 2005, respectively were recorded at 250-200-100 kg NPK ha^{-1}, (F_5) which were at par with those recorded at 200-200-100 kg NPK ha^{-1} (F_4) and minimum number of mill able canes m^{-2} (4.01 and 4.12) during 2004 and 2005, respectively were recorded in control (F_1). It was observed that 70.21, 69.74, 54.84, 42.88% and 69.66, 69.21, 54.32 and 43.48% higher number of mill able canes m^{-2} during 2003-04 and 2004-05, respectively were recorded in F_5, F_4, F_3 and F_2 respectively than control (F_1). It show that optimum numbers of mill able canes at 200-200-100 kg NPK ha^{-1} may be due to increased nutrient availability which reduced shoot mortality and improved cane development and increase in Nitrogen level more than 200 kg ha^{-1} had no significant effect on number of mill able canes m^{-2}. Increase in dose increased the number of mill able canes per unit area also reported by Akhtar *et al*., 2000, Ali *et al*., 2000.

The data on effect of different planting patterns on mill able canes m^{-2} was highly significant. Maximum number of mill able canes m^{-2} 10.39 and 10.46 during 2003-04 and 2004-05, respectively in 30/90cm paired row strip Planting pattern (G_3) followed by 75cm (G_2) and 60cm single row planting pattern (G_1) and minimum (8.17 and 8.3) during 2003-04 and 2004-05, respectively in 30/120cm paired row strip Planting pattern (G_4) were recorded. It was examined that 21.37, 15.69, 9.52% and 20.65, 16.08, 10.37% higher number of mill able canes m^{-2} during 2003-04 and 2004-05, respectively were obtained in G_3, G_2, and G_1 respectively than G_4. It was also noted that too much increase in inter strip spacing as in 30/120 cm paired row strip planting pattern number of plants per unit area had to increase to maintain optimum plant population, due to which inter plant competition increased causing adverse effects on number of mill able canes m^{-2}. Higher number of mill able canes per unit area at 100 cm apart rows than 120 or 140cm were reported by El-Geddawy *et al*., 2002.

Interactive effects of planting patterns and NPK doses on number of mill able canes were highly significant. Maximum number of mill able canes 11.75 and 11.77 m^{-2} during 2003-04 and 2004-05,respectivly were recorded in 250–200-100 kg NPK ha^{-1} x 30/90 cm spaced paired row strip planting pattern(F_5xG_3) which were at par with 200–200-100 kg NPK ha^{-1} x 30/90 cm spaced paired row strip planting pattern (F_4xG_3) and were minimum (3.73 and 3.77) during 2003-04 and 2004-05,respectively in control x 30/120 cm spaced paired row strip planting pattern (F_1xG_4). This increase in number of mill able canes m^{-2} might be ascribed to complimentary effect of increased nutrient availability and improved air circulation and light penetration in (F_4xG_3) which resulted in reduced shoot mortality and better cane development.

Individual stripped cane weight

The analysis of pooled data of D.I Khan and Bhakkar regarding individual stripped cane weight presented in Table-2 revealed that significantly different individual striped cane weight was recorded at different NPK doses. The highest individual stripped cane weight 0.99 and 1.03kg during 2003-04 and 2004-05 was recorded at 250-200-100 kg NPK ha^{-1}, however it was at par with that obtained from 200-200-100kg NPK ha^{-1}(F_4) and the lowest individual stripped cane weight 0.30 and 0.32kg during 2003-04 and 2004-05, respectively was recorded in control (F_1). It was also observed that 69.70, 69.39, 52.38 42.31% and 68.93, 68.63, 53.62, and 42.86% higher individual stripped cane weight during 2003-04 and 2004-05 was recorded in $F_{5,}$ $F_{4,}$ F_3 and $F_{2,}$ respectively than control F_1. It was seen that higher individual stripped cane weight at 200-200-100 kg NPK ha^{-1} might be due to increased nutrient availability which might have improved cane growth and development and increase in nitrogen level than 200 kg ha^{-1} had no significant effect on individual stripped cane weight. Ali and Afghan (2000) had recorded maximum individual stripped cane weight with 200-150-150 kg NPK ha^{-1}.

The Effect of different planting patterns on individual stripped cane weight was also significantly different maximum individual stripped cane weight 0.76 and 0.80kg during 2003-04 and 2004-05 was recorded in 30/90cm paired row strip Planting pattern (G_3) followed by 75 (G_2) and 60cm single row planting pattern (G_1), on the other hand minimum individual stripped cane weight 0.59 and 0.63kg during 2003-04 and 2004-05, respectively was recorded in 30/120cm paired row strip Planting pattern (G_4). It was noted that 22.37, 18.06 11.94% and 21.25, 16, and 10% higher individual stripped cane weight during 2003-04 and 2004-05, was recorded in $G_{3,}$ $G_{2,}$ and G_1 respectively than G_4. It was further noted that higher individual cane weight at 30/90cm spaced paired row planting pattern might be due to improved air circulation and light penetration which might improved photosynthetic efficiency and too much increase in inter strip spacing as in 30/120cm paired row strip planting pattern number of plants per unit area had to increase to maintain optimum plant population, due to which inter plant competition increased causing adverse effects on individual stripped cane weight.

Interactive effects of NPK doses and planting patterns on individual stripped cane weight were again significantly different. Maximum individual stripped cane weight 0.85 and 0.89kg during 2003-04 and 2004-05, respectively was recorded the interaction of 250–200-100 kg

NPK ha^{-1} x 30/90cm spaced paired row strip planting pattern (F_5xG_3)which was also at par with 200–200-100 kg NPK ha^{-1} x 30/90 cm spaced paired row strip planting pattern(F_4xG_3) minimum individual stripped cane weight (0.29 and 0.30kg) during 2003-04 and 2004-05, respectively was recorded in the control x 30/120cm spaced paired row strip planting pattern (F_1xG_4). It was examined that increase in individual stripped cane weight in (F_4xG_3) might be ascribed to complimentary effect of increased nutrient availability improved air circulation and light penetration in (F_4xG_3) which might resulted in increased cane growth and development due to improved photosynthetic efficiency.

Stripped-cane yield

The analysis of pooled data of D.I Khan and Bhakkar (Table-2) revealed that cane yield was yet again significantly different under different NPK doses and planting patterns. The highest stripped-cane yield of 147.81 and 149.37 t ha^{-1} during 2003-04 and 2004-05, respectively was recorded at 250-200-100 kg NPK ha^{-1} (F_5) followed by 200-200-100 kg NPK ha^{-1} (F_4),150-150-100 kg NPK ha^{-1}(F_3),100-100-100 kg NPK ha^{-1}(F_2)and the lowest stripped-cane yield viz. 44.06 and 45.37 t ha^{-1} during 2004 and 2005, respectively control(F_1). It was also noted that 70.19, 69.76, 54.87, 42.94% and 69.63, 69.18, 54.29 and 43.42% higher stripped cane yield was obtained during 2003-04 and 2004-05, in F_5, F_4, F_3 and F_2 respectively than the control (F_1). The increased stripped cane yield at 200-200-100 kg NPK ha^{-1} might be due ascribed to increased nutrient availability and complementary effect of N, P, and K which resulted in higher number of mill able canes m^{-2} and improved individual cane weight. These findings have also been supported by Ali (1999), Ayub (1999), Akhtar *et al.*, (2000) Ali and Afghan (2000), Ramesh(2000), Pandey and Shukla (2000), Sundara, *et al.*, (2002), Rana *et al*.,(2003) and El-Tilib *et al.*,(2004).

The highest stripped-cane yield of 114.2 and 115.10 t ha^{-1} during 2003-04 and 2004-05, respectively was recorded in 30/90cm (G_3) followed by 75cm (G_2), 60cm spaced single row planting pattern (G_1) and the lowest stripped-cane yield of 89.75 and 91.30 t ha^{-1} during 2004 during 2005, respectively in 30/120cm spaced paired row planting pattern (G_4). It was also noted that 21.41, 15.83, 9.66% and 20.68 16.12 and 10.36% higher stripped cane yield during 2003-04 and 2004-05, respectively was recorded in G_3, G_2 and G_1 respectively than G_4. It was noted that improvement in stripped cane yield 30/90cm spaced paired row planting pattern might to better air circulation and light penetration which might have enhanced the photosynthetic efficiency of plants reduced shoot mortality, increased number of mill able canes m^{-2} and individual cane weight. It was also noted that too much increase in inter strip spacing as in 30/120 cm paired row strip planting pattern number of plants per unit area had to increase to maintain optimum plant population, due to which inter plant competition increased causing adverse effects on yield and yield components of crop. Kanwar *et al.* (1990) and El-Geddawy *et al* (2002) also reported significantly higher stripped-cane yield in 90cm and 100cm row spacing, respectively.

Table-2 Morphological response of autumn planted sugarcane to nutrient managementand planting geometry on different soils under arid

CONDITIONS						
Treatments	Number of mill able Canes (m^{-2})		Individual stripped Cane weight (kg)		Stripped cane yield t ha^{-1}	
	Pooled data of D I Khan and Bhakkar					
	2003-04	2004-05	2003-04	2004-05	2003-04	2004-05
(A)-N:P:K Fertilizer nutrient Doses (kg ha^{-1})						
F_1 = 0 : 0 : 0	4.01d	4.12d	0.3d	0.32d	44.06e	45.37e
F_2 = 100:100:100	7.02c	7.29c	0.52c	0.56c	77.22d	80.19d
F_3 = 150:150:100	8.88b	9.02b	0.63b	0.69b	97.63c	99.25c
F_4 = 200:200:100	13.25a	13.38a	0.98a	1.02a	145.69b	147.19b
F_5 = 250:200:100	13.46a	13.58a	0.99a	1.03a	147.81a	149.37a
LSD	0.63	0.63	0.04	0.04	0.67	1.28
(B)-Planting patterns (G)						
G_1 = 60 cm	9.03c	9.26c	0.67c	0.70c	99.35c	101.85c
G_2 = 75 cm	9.69b	9.89b	0.72b	0.75b	106.63b	108.85b
G_3 = 30/90 cm	10.39a	10.46a	0.76a	0.80a	114.20a	115.10a
G_4 = 30/120 cm	8.17d	8.3d	0.59d	0.63d	89.75d	91.30d
LSD	0.56	0.56	0.03	0.03	0.60	1.14
(C)-F x G						
F_1 x G_1	3.86k	4i	0.29j	0.30i	42.50r	44.00n
F_1 x G_2	4.07k	4.27i	0.31j	0.32i	44.75q	47.00m
F_1 x G_3	4.36K	4.45i	0.33j	0.34i	48.00p	49.00m
F_1 x G_4	3.73K	3.77i	0.28j	0.29i	41.00s	41.50n
F_2 x G_1	6.77ij	7.18gh	0.51hi	0.54gh	74.50n	79.00k
F_2 x G_2	7.51hi	7.68fg	0.56gh	0.58g	82.65m	84.50j
F_2 x G_3	7.89hi	7.98fg	0.58gh	0.61fg	86.75l	87.75i
F_2 x G_4	5.91j	6.32h	0.44i	0.48h	65.00o	69.50l
F_3 x G_1	8.64fgh	8.86ef	0.62fg	0.67ef	95.00k	97.50h
F_3 x G_2	9.18fg	9.36e	0.66f	0.71e	101.00j	103.00g
F_3 x G_3	9.73f	9.82e	0.69f	0.74e	107.00i	88.50i
F_3 x G_4	7.95ghi	8.05fg	0.57gh	0.61fg	87.50l	88.50i
F_4 x G_1	12.84cd	13.02bc	0.96d	0.99c	141.25f	143.25d
F_4 x G_2	13.75bc	13.93ab	1.02bcd	1.06bc	151.25d	153.25c
F_4 x G_3	14.89ab	14.98a	1.09ab	1.14a	163.75b	164.75a
F_4 x G_4	11.5e	11.59d	0.83e	0.88d	126.50h	127.50e
F_5 x G_1	13.05c	13.230b	0.97cd	1.00bc	143.50e	145.50d
F_5 x G_2	13.95abc	14.23ab	1.04abc	1.08ab	153.50c	156.50b
F_5 x G_3	15.09a	15.090a	1.12a	1.14a	165.50a	166.00a
F_5 x G_4	11.75de	11.77cd	0.85e	0.89d	128.75g	129.50e
LSD	1.26	1.26	0.08	0.08	1.33	2.56

Means followed the same letter in a column do not differ significantly at 5 % level of probability.

Interactive effects of NPK doses and planting patterns on stripped cane yield were significantly comparable during both years. The maximum stripped cane yield of 165 and 166 t ha^{-1} during 2003-04 and 2004-05, respectively was obtained the interaction of 250–200-100 kg NPK ha^{-1} x 30/90cm spaced paired row strip planting pattern (F_5 x G_3) which was at par with 200–200-100 kg NPK ha^{-1} x 30/90cm spaced paired row strip planting pattern (F_4 x G_3)

and was minimum 41 and 41.5 t ha^{-1} during 2003-04 and 2004-05, respectively at control x 30/120 cm spaced paired row strip planting pattern (F_1xG_4). The optimum stripped cane yield in (F_4xG_3) might be due to complimentary effect of increased nutrient availability and improved air circulation and light penetration which might have enhanced the photosynthetic efficiency resulting in accelerated growth and development.

CONCLUSION

It can be concluded that under arid conditions in Silty clay and sandy loam soils optimum stripped cane yield could be obtained at the interaction of 200–200-100 kg NPK ha^{-1} x 30/90 cm spaced paired row strip planting pattern. The plating pattern of 30/90cm paired row strip planting had advantages over other planting patterns, it facilitates interculture and earthing up of the crop without damaging the roots, 50% reduction in the number of inter-strip ditches/furrows, thus conserving irrigation water and saving almost 50% labor and time required for earthing up, allows efficient and expeditious interculture and earthing up with tractor or bullock-drawn implements, permits systematic planting and handling of intercrops without affecting the associated cane crop. Moreover, planting of the main and intercrops in separate and independent strips not only reduces intercrop competition, but also enables the grower to meet the varying fertilizer requirements, growth patterns, and planting times of different crops, facilitates easy application of herbicides since the strips are well spaced, prevents lodging in case of wind or rain since the strips provide plant support to each other, improves the air circulation and light penetration which enhances the photosynthetic efficiency of plants and reduces crop damages from trampling by wild animals looking for a space to rest.

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INTEGRATED CONTROL STRATEGIES FOR SUGARCANE DISEASE

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ABSTRACT

Sugarcane diseases are one of the major factors for low cane and sugar yield. Major diseases are red rot (*Collectotrichum falcatum*, Went), whip smut (*Ustilago scitaminies* Syd.), Pokkah boeng (*Fusarium moniliformae* Schold), Brown Stripe (*Dreshelera sacchari* Drech.), Leaf Spot (*Helminthosporium halodes*), sugarcane rust (*Puccinia melanocephala*) and Sugarcane mosaic (where these diseases are studied?) . New red rot strains have developed which are other dangers for the sugar crop. These strains are developed in the area of north Punjab (country?) which is most suited for sugarcane diseases due to climatic conditions. In the recent years red stripe and pokkah boeng have been spreading in the north and central Punjab due to successive pre-monsoon rains. We must have a serious look upon it. Many unapproved varieties like SPF-238, CO 1148, CP70-1547 have attacked by these diseases. Integrated control management strategies of sugarcane disease are discussed in this paper.

This is not suitable abstract. Its like just introduction. Please rewrite abstract of your own study. What you have done? Why you done, Whats results? and Whats conclusion?

KEY WORDS: Sugarcane, Diseases, Management and control.

INTRODUCTION

Sugarcane diseases are either seed borne or soil borne, therefore, once the disease has spread in the field, it is almost impossible to control it even with agro-chemicals. The disease incidence can be minimized by adopting one or more control measures. No single method is successful for the control of sugarcane diseases. Integrated management of sugarcane diseases is the most suitable approach for controlling all the diseases. It includes agronomical, cultural, chemical and biological control measures. The integrated pest management is defied by Atwal, (1991) as “it is an integrated approach that aims at reducing pest status to tolerable levels by using methods that are effective, economically sound and ecological compatible. Different integrated methods of the control of different diseases are discussed in this paper.

SUGARCANE DISEASES IN PUNJAB / PAKISTAN

<u>Fungal diseases</u>

- Red Rot (*Collectotrichum falactum* Went.)
- Whip smut (*Ustilago scitaminea* H. Sydon)
- Pokkah boeng (*Fusarium moniliformae* Schold)

- Brown Stripe (*Dreshelera sacchari* Drech)
- Leaf Spot (*Helminthosporium halodes*)
- Sugarcane rust (*Puccinia melanocephala*)

<u>Bacterial Diseases</u>

- Red Stripe (*Xanthomonas rubrilineans*) (Lee stap)
- Ratoon stunting disease (*Clavibactor xyli*)

<u>Virus and Mico-plasma</u>

- Sugarcane mosaic virus
- White leaf
- Chorotic streak

DIFFERENT INTEGRATED METHODS FOR THE CONTROL OF SUGARCANE DISEASES

The following ten integrated methods are most effective for controlling the sugarcane diseases.

1. Use of agronomical methods.
2. Resistant varieties.
3. Legislation.
4. Thermotherapy.
5. Chemical treatments.
6. Rouging of diseased clumps.
7. Use of long setts.
8. Good field hygiene.
9. Collateral hosts.
10. Disinfection of seed cutters.

1. Use of Agronomical Methods

- Burning of trash
- Crop rotation
- Use of healthy seed
- Drainage in fields
- Avoid rationing of diseased crop
- Clean cultivation

2. Resistant Varieties

The Sugarcane Research Institute Faisalabad has evolved which are resistant to sugarcane diseases.

Approved varieties		Un-approved varieties		Susceptible varieties	
CP 43-33	R	S96-SP-1215	MR	CO-1148	S
CP 72-2086	R	S98-SP-108	R	L-116	S
CP 77-400	R	CP 82-1172	R	L-118	MS
SPF-213	R	S2001-US-1	R	TRITON	S
CPF-237	R	S2001-US-400	R	BF-162	MS
HSF-240	MR	S2001-US-104	R	SPF-238	S
HSF-242	MR	S2001-US-750	R	SPF-241	S
CPF-243	R	S97-US-110	MR	CoJ-84	MS
SPF-245	R	S97-US-127	R	CP 70-1547	S

3. Legislation

To avoid introduction of diseases quarantine of seed material and varieties between states is highly essential.

4. Thermotherapy

Hot water treatment at 52 ^{o}C for 18 minutes is highly useful for controlling all sugarcane diseases. (Joshi, 1954; Anwar, *et al.*, 2006)

5. Chemical Control

Seed treatment before sowing with the following fungicides is very useful for the control of sugarcane diseases.

- Dithan M-45 1:400 (0.25%)
- Vitawax 1:800 (0.125%)
- Benlate 1:1600 (0.062%)

6. Rouging Of Diseased Clumps

Disease free seed nursery is desired to be established in each mills farm and farmer's field in which diseased clumps should be roughed out.

7. Use of Long Setts

Three or four budded setts are very suitable seed setts for the control of soil born inoculums of red rot, root rot and pineapple disease

8. Good Field Hygiene

Extreme dry and wet soils should be avoided for the control of red rot and root rot diseases.

9. Collateral Hosts

Collateral hosts like sorghum should not be grown in the vicinity of sugarcane crop for the control of sugarcane mosaic virus when the grass hoppers are fed and spread SCMV.

10. Disinfection of Seed Cutter

Dipping of seed cutters indetole solution or surf washing powder while cutting the seed setts is very useful for the control of sugarcane Mosaic Virus.

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COMPARISION OF QUANTITATIVE AND QUALITATIVE TRAITS OF SUGARCANE *(SACCHARUM OFFICINARUM L.)* DIVERSE GENOTYPES

Shahid Afghan, Zia-ul-Hussnain, Khalid Hussain, Aamir Shahazad, Kazim Ali, Asia Naheed, Saadia Rizwana, Plosha Khanum and Akhtar Batool

ABSTRACT

Comparative trials for one crop cycle were conducted on biometry of thirteen sugarcane genotypes. Promising genotypes were included in the studies from most of the research institutes working on improvement of sugarcane crop in the country. Amongst these SPSG-26 was kept as standard. These studies were done from 2004 to 2007 for multiple plant and ratoon crops. The results synthesized on the basis of pooled means indicated that NSG-311 has given significantly high cane yield of 126 t ha^{-1} for both plant and ratoons, while sugar recovery of 10.45 and 10.60% for plant and ratoon crops as compared to standard check, which has given cane yield of 80.0 and 74 t ha^{-1} for plant and ratoons, respectively and sugar recovery percent cane of 8.98 and 9.80 for plant and ratoons. It is important to note that NSG-311 had produced maximum sugar yield (13.0 t ha^{-1}) followed by S96-SP-302 (11.0 t ha^{-1}), S84-I-282, S95-HS-185, and Thatta-34 (10.0 t ha^{-1}).

INTRODUCTION

Sugarcane is a crop of great agro-economic importance. In Pakistan it is planted on an area of 1.029 million hectares with average yield of 53.32 tons/hectare giving total annual cane production of 54.87 million tones (Anonymous, 2007). It plays a remarkable role in the uplift of the growers and the country by earning foreign exchange (Rehman, *et al*., 1992) and providing employment to numerous farm workers throughout the year (Hussain, *et al*., 2003). Among the various factors responsible for low yield of sugarcane, the use of low yielding varieties is considered the major one (Ahmad, 1988). It is fact that development of new sugarcane varieties is not feasible in our country due to insufficient breeding facilities or lack of infrastructure for cross breeding under artificial conditions. Therefore, sugarcane varietal development is dependent on import of germplasm and also through exotic or locally collected fuzz (Panhwar, *et a*l., 2003). Unawareness of farmers in adaptation of varieties is also the prime cause of low cane yield (Jamro *et al.*, 2000). The use of exotic germplasm for the improvement of sugarcane is an excellent example in genetic improvement. Our agricultural breeders have evolved high yielding varieties since last many years. Such varieties have a large range of adaptability than others and are grown more widely throughout the area (Majeedano, *et al*., 2003). Aslam *et al.*, (1998) recommended a new cane variety SPF-234 for cultivation in southern Punjab of Pakistan after comparing nine clones in that region. SPF-234 germination (38.48%), tillers per plant (3.32), cane weight (1.25 kg) cane stand (111296 canes/ha), cane yield (139.43 t/ha) and sugar yield (14.06 t/ha). Ricaud and Domaigue (1991) studied the performance of some newly introduced and standard commercial cultivars in Mauritius and recommended cv. M1658/78 as the excellent variety because of its higher yield and sucrose contents as well as its wide adaptation to different soils and climatic regions of island. Rehman *et al.*, (1989) studied qualitative and quantitative characteristics of eleven sugarcane varieties and declared BF-162 as the best in cane and sugar yield over the other varieties compared. So there is a dire need to evaluate high yielding varieties with the course of time.

MATERIALS AND METHODS

Research studies were laid out in Randomized Complete Block Design (RCBD) with 3 replicates. All the agronomic practices were kept constant for all varietal trials. Seed was used @ 75000 double budded setts ha^{-1}. Nutrients were given to the trials on the basis of soil analysis. However, most of application as NPK was @ 167-112-112 kg ha^{-1}. Irrigation as and when required was given to crop. The data on different traits recorded was viz. germination (%), tillers plant^{-1}, millable canes (000 ha^{-1}), cane weight (kg), cane yield (t ha^{-1}), sugar recovery % cane and sugar yield (t ha^{-1}). Quality analysis of cane juice was done for brix (%), pol (%) and purity (%) and sugar recovery % cane. Cane samples were analyzed on one-month interval from October to April. Agronomic studies were carried out on varietal response to nutrient levels, water stress, ratoonability post harvest losses, seed rate and herbicide tolerance. In addition, field observations were recorded on general agricultural characteristics.

RESULTS AND DISCUSSION

Germination (%) in this trial was the maximum for SPSG-26 followed by S96-SP-302 and CPHS-35 (Table-1). CPHS-35 produced the maximum number of millable canes followed by LRK-2001 and NSG-311. The lowest number of canes was produced from S86-US-340. Cane weight was the maximum in case of S96-SP-302 followed by Q-88 and Thatta-36 while the minimum in case of Malakand-17. Variety CPHS-35 had the maximum cane yield of 131 t ha^{-1} followed by NSG 311 (126 t ha^{-1}) and S96-SP-302 (123 t ha^{-1}). Sugarcane variety S86-US-340 had the minimum cane yield. During 2005-2007 ratoon of NSG-311 has given cane yield 126 t ha^{-1} and sugar recovery 10.60% as compared to standard check SPSG-26 giving cane yield 74 t ha^{-1} and sugar recovery 9.80%. NSG-311 had the maximum brix (19.95%) followed by Thatta-34 (19.88%) and Malakand-17 (18.67%). BF-138 gave minimum brix percentage of 15.28. Sugar recovery was the maximum in variety NSG-311 (10.5%) followed by S86-US-340 (9.39%) and Thatta-34 (9.30%). Sugarcane variety NSG-311 produced the maximum sugar yield (13.0 t ha^{-1}) followed by S96-SP-302 (11.0 t ha^{-1}) and S84-I-282, S95-HS-185, and Thatta-34 (10.0 t ha^{-1}). Data is given in the table-2.

Table-1 Response of different sugarcane varieties to biometric traits plant crop (2004-2007)

Sr. No.	**Varieties**	**Ger. %**	**Tillers plant^{-1}**	**Cane wt. (kg^{-1})**	**Millable canes (000 ha)**	**Cane yield (t ha^{-1})**	**Recovery % cane**
1	CPHS-35	59	1.43 ab	0.76 b	172120 a	131 a	7.84
2	NSG-311	58	1.52 a	0.79 b	159206 ab	126 a (+36.5)	10.45 (+14.0)
3	S96-SP-302	60	1.04 ab	1.26 a	97389 b	123 a	8.59
4	Larkana-2001	47b	0.79 b	0.75 b	160583 ab	120 ab	7.64
5	S84-I-282	52	0.89 b	0.81 a	146248 ab	118 ab	8.30
6	HS-185	58	1.04 ab	0.95 a	122928 ab	117 ab	8.94
7	Thatta-36	55	0.94 b	1.05 a	103787 ab	109 ab	8.04
8	Thatta-34	54	1.02 ab	0.84 a	127029 ab	107 ab	9.30
9	Q-88	46b	0.83 b	1.10 a	86046 bc	95.0 b	8.41
10	Malakand-17	49	0.87 b	0.65 b	129048 ab	84 bc	9.12
11	SPSG-26	61a	0.73 b	0.93 a	86052 bc	80.0 bc	8.98
12	BF-138	58a	0.91 b	0.88 ab	86001 bc	76.0 bc	7.58
13	S86 US-340	53	0.95 b	1.03 a	62350 c	64.0 c	9.39
	LSD (0.05)	6.5	0.56	0.305	48769	25.5	

Figure(s) given in parenthesis show percent variation over standard check

Table-2 Response of different sugarcane varieties to biometric traits ratoon crop (2005-2007)

Sr. No.	Varieties	Ger. (%)	Cane count (000 ha)	Yield (t ha^{-1})	Recovery (%)	Sugar (t ha^{-1})
1	NSG-311	50.0	124.0 b	126.0 a (+41.2)	10.6 (+7.54)	13.3
2	Thatta-34	50.0	121.0 b	125.0 a	10.3	12.8
3	Larkana, 2001	50.0	136.0 a	117.0 ab	8.2	9.6
4	BF-138	50.0	108.0 c	110.0 bc	9.0	9.9
5	S96SP-302	48.0	98.0 d	108.0 c	9.4	10.2
6	CPHS-35	49.0	122.0 b	98.0 d	8.3	8.2
7	Thatta-36	49.0	111.0 c	98.0 d	9.9	9.7
8	Malakand-17	52.0	106.0 c	98.0 d	9.8	9.6
	Q-88	50.0	128.0 b	97.0 d	8.3	8.1
10	HSF-242	51.0	99.0 d	93.0 de	10.7	10.0
11	S84 -I-282	52.0	107.0 c	86.0 ef	9.6	8.3
12	S86US-340	51.0	98.0 d	81.0 fg	9.7	7.9
13	SPSG-26	51.0	83.0 e	74.0 g	9.8	7.2
	LSD (5%)	-	6.52	8.53		

Figure(s) given in parenthesis show percent variation over standard check

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EFFECT OF MANAGEMENT STRATEGIES ON THE GERMINATION AND CROP ESTABLISHMENT OF SUGARCANE UNDER AGRO-CLIMATIC CONDITIONS OF JHANG

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ABSTRACT

Six field studies consisting of each one independent management practice such as varietal response to sugarcane germination, effect of sowing dates, seed age, irrigation interval, position of bud placement and sett length were carried out to test their effect on sugarcane germination at Basti Ghazi Shah Farm of Shakarganj Sugar Research Institute during spring plantation 2008. Results obtained showed that variety CPF-237 resulted statistically higher (76%) germination followed by variety HoSG-529 (60%) and HS-12 (58%). April 23rd sown setts resulted germination of (59%) than May (6th and 17th May) sown which resulted in decreased germination percentage due to desiccation with the increase in temperature. Age of cane seed showed that 1- year old seed resulted better germination percentage than 1 x ½ year old seed. Irrigation interval (6-days) resulted higher germination percentage i.e. (45%) than 2-days (35%) and 4-days (26%) after control. It was observed that irrigation intervals have irreversible relation to germination percentage. The upward placement of bud resulted higher germination percentage than downward and side placement of the buds. Seed length observations showed that 3-budded seed resulted highest (68%) germination than 6-budded and full length cane seed. It was concluded that length of sett, irrigation interval, placement of bud, sowing date, varietal selection and age of the seed are very important management strategies for germination and establishment of sugarcane which subsequently lead towards the higher tonnage of crop.

INTORDUCTION

Sugarcane (*Saccharum officinarum* L.) is a giant grass of the gramineae family. It is an important source of income and employment for the farming community of the country. It also forms essential item for industries like sugar, chipboard, and paper. Its share in value added of agriculture and GDP are 4.5 percent and 0.9 percent, respectively. Sugarcane production for the year 2007-08 is estimated at 63.9 million tons -the highest ever in the country's history against 54.7 million tons last year. (Economic Survey of Pakistan, 2008). Sugarcane was cultivated in acreage of 0.90 million hectares with cane production of 44.3 million tons in Pakistan during the growing season of 2005-2006. Punjab shared 69%, Sindh 20% and NWFP 11% of the total sugarcane area (Anonymous 2005).

Work already done by different scientists have shown that genotype, sowing time, age of seed, irrigation intervals, placement of buds and length of the seed effect the germination of the sugarcane showed diversified results in different agro-ecological conditions.

On a global perspective sugarcane (*Saccharum* spp.) is an important crop not only for sugar production but also spreading as a bioenergy crop for human society due to its phenomenal dry matter production capacity. Irrigation quantum is one of the most important abiotic stress factors limiting sugarcane production, worldwide. However, water for irrigation is a limited and continuous resource and its effective management is critical, not only in reducing wasteful usage, but also in reducing production costs and sustaining productivity (Qureshi and Afghan, 2005). It has been worked out that to produce one tone of cane, about 200-250 tons of water is required. The availability of water for sugarcane crop is almost static even decreasing in cane growing areas over the years. There is an imperative need to optimize production of sugarcane by efficiently managing water resources and their reliability (Afghan, 2003). Panji *et al*., (1963) demonstrated that top 7 or 8 buds on a horizontally placed setts germinated vigorously and formed fairly large shoots, the average fresh weight per shoot declined steeply thereafter up to the 14th bud . From there below, the average weight of shoots remained more or less at the same level up to the 21st bud at the bottom of the stalk. Yadav (1981) observed highest germination in Co-1148, a dominant variety of north India. Early maturing, high sugared variety, CoJ-64 has less germination percentage as compared to previous one. The germination percentage of mid late variety CoJ-67 was also less than Co-1148. Bellamy, S.R. and Chinnery, L. E. (1988) demonstrated that upper position of bud placement shows maximum germination percentage, while downward position of bud placement shows late and poor germination.

Therefore in view of the importance of different management practices on crop establishment, separate studies were designed to investigate the effect of management strategies on the germination of sugarcane under the prevailing agro-climatic conditions of Jhang in order to update the know how on the latest improved genotypes.

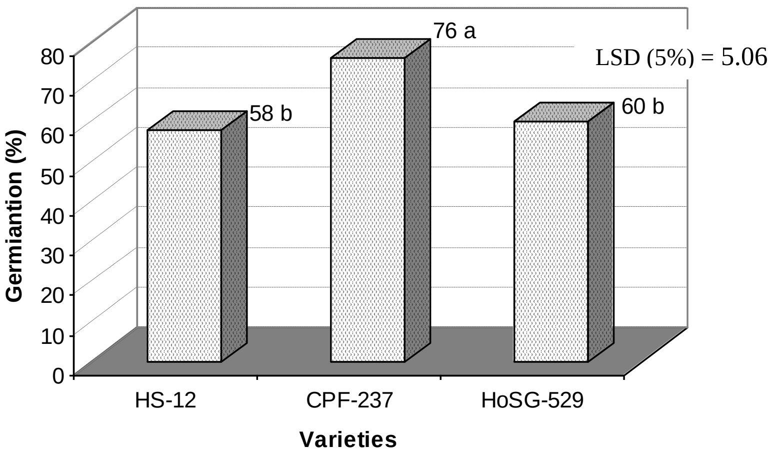
MATERIALS AND METHODS

To study the effect of management strategies on the establishment of sugarcane separate experiments were carried out at Basti Ghazi Shah Farm of Shakarganj Sugar Research Institute (SSRI) Jhang by selecting three sugarcane varieties namely HOSG-529, HS-12, CPF-237. The experiments were laid out in Completely Randomized Design (CRD) with three replications on sandy loam textured soil having pH 6.95, organic matter 0.63%, and NPK 0.03%, 9.75ppm, 167.5ppm respectively. Total rainfall recorded during experiment was 502mm. The water used for irrigation have pH 7.07, total soluble salts 531ppm, sodium absorption ratio 1.60 me/L and sodium 4.07 me/L. After four weeks of sowing data for germination % was calculated by counting sprouted seedlings divided by total number of buds per row and multiplied with 100. Fertilizer was applied as Biocompost at the rate 50 t/ha. There were 9-rows comprising 3-rows per treatment with an area of 20.8m^2. For sowing date experiment in addition to normal sowing date i.e. (23rd April) 6th May and 17th May was used while for irrigation experiment in addition to normal irrigation interval i.e. 6-days (control) 2-days and 4-days intervals after control were used with three repeats. To study the of temperature difference on germination % of sugarcane sowing of variety HS-12 was used. While to investigate the impact of seed age and irrigation intervals variety CPF-237 and HoSG-529 were used respectively. One year old seed and one and half year old seed was used for the evaluation of the germination. Three placement positions such as upper, downward and sideward bud position and three seed lengths such as three budded seed, six budded seed and full cane were used for the evaluation of the germination of sugarcane. Data obtain for different parameters was subject to analysis of variance to compare the treatments of means at 5% LSD test.

RESULTS AND DISCUSSION

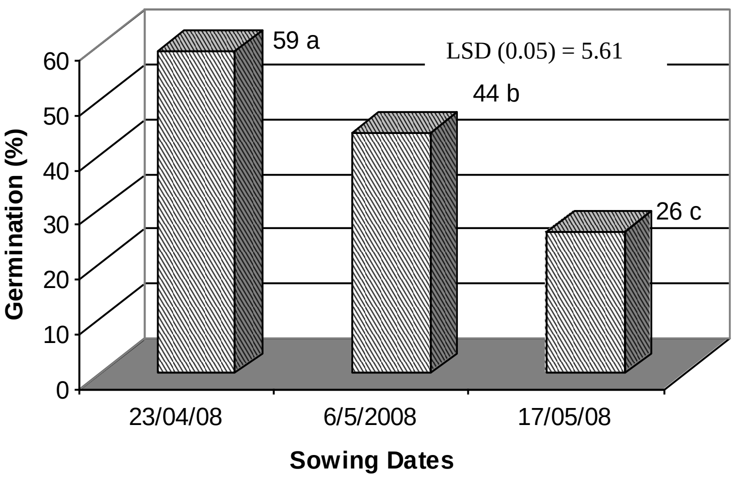
Data recorded for germination % of different varieties showed that statistically CPF-237 resulted significantly higher in germination (76%) followed by HoSG-529 (60%) and HS-12 (58%) (Fig-1). These two varieties HoSG-529 and HS-12 had non-significant difference among each other under same agro-climatic conditions. These results were in line with Rao and Prasad (1960) who reported that varietal differences in germination of sugarcane are due to its genetic make up that each variety had from its parents.

Fig.-1 Germination % age of sugarcane as affected by different varieties under the agro-climatic conditions of Jhang during spring, 2008



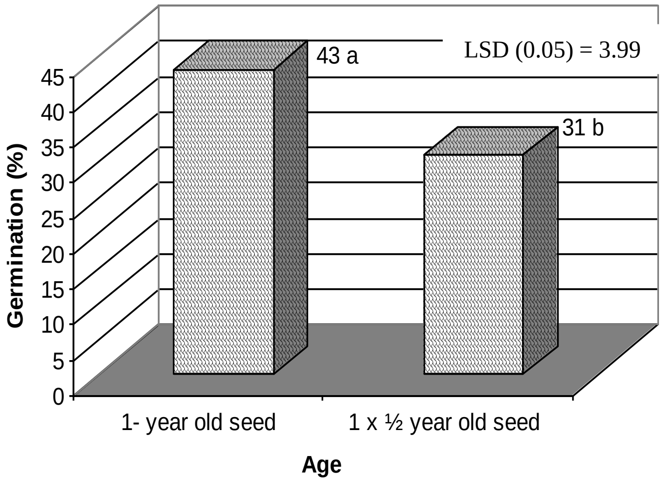
Data recorded for germination % under different sowing times with temperature is presented in Fig-2, showed statistically highly significant differences among different sowing dates. Sowing of 23rd April resulted higher germination percentage i.e. 59% while late sowing dates produced lower germination percentage because of increased temperature which caused desiccation of seed .These results are inline with Shrivastave et al (1985) who reported higher germination in autumn than spring because of lower temperature during autumn season.

Fig- 2 Effect of sowing dates on sugarcane germination (%)under the agro-climatic conditions of Jhang during spring, 2008



The data recorded to investigate the effect of seed age on germination percentage is presented in Fig-3, showed that one year old seed of variety CPF-237statistically resulted higher germination percentage i.e. (43%) than one and half year old seed (31%). This could be result of the changed chemistry within the seed that may occure with the passage of time.

Fig- 3: Effect of seed age on germination (%) of sugarcane under the agro-climatic conditions of Jhang during spring, 2008.



Data recorded from irrigation interval experiment also showed statistically significant differences in germination. Irrigation after 6-days intervals produced maximum germination percentage (45%) than 2-days and 4-days after control which resulted (35%) and (26%) germination (Table-1). Aguilera et *al*., (1999) reported the linear relationship between the growth rate of sugarcane and the optimum soil moisture regimes, because the vegetative growth is of economic importance in this crop.

Table-1 Effect of irrigation interval, bud placement and seed length on germination of sugar cane under agro-climatic conditions of Jhang during spring, 2008

Treatments	**Germination (%)**
Irrigation interval	
Control (6-days)	45 a
2-days interval over control	35 b
4-days interval over control	26 c
$LSD_{0.05}$	**3.15**
Bud positions	
Upward	58 a
Downward	34 c
Side	42 b
$LSD_{0.05}$	**4.81**
Seed length	
3-budded seed	68 a
6-budded seed	34 b
Full cane	25 c
$LSD_{0.05}$	**3.65**

Upward placement of buds showed highest germination percentage (58 %) while side placement (42%) and downward placement of bud (34%) showed poor germination percentage. This clearly indicates that the placement of buds is of great importance for germination of sugarcane. Panji *et al*., (1963) reported the similar differences in germination by placing buds in different ways. Seed length of buds revealed that 3-budded seed showed highest germination that was (58%) followed by 6-budded seed (34%) and lowest (25%) in full cane.

CONCLUSIONS

From the results of investigations carried out under field conditions on the establishment of sugarcane showed that each and every management strategy is essential for sugarcane growers to obtain higher germination percentage which had to contribute toward the final tonnage of the crop. Followings are salient achievements of these investigations to obtain higher germination of the sugarcane.

Variety CPF-237 resulted higher germination under the agro-ecological conditions of Jhang than rest of varieties tested.
April sowing resulted in better germination and crop establishment than May sown crop.
One year old seed gave better performance in terms of germination than one and half year old seed.
Upper placement gave high germination percentage than down and sideward placement of the buds.
Three budded setts produced maximum number of plants than six budded setts or full cane.
Six-days irrigation (control) gave maximum germination than 2-days and 4-days irrigation after control.

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SUGAR INDUSTRY ABSTRACTS

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Sugarcane trash collection at the small farms in southern India*

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To extend the operation of a bagasse based co-generation power plant, both the procurement of supplementary fuels and the extending of the crushing season in the sugar mill were required. The collection of sugarcane trash for use as supplementary fuel was taken up at EID Parry sugar mill at Nellikuppam in Tamil Nadu, India on a trial basis, to determine the viability of this strategy. Trials were done by windrowing trash in the field and collecting and baling it, initially using small rectangular and later, round hay balers. Windrowing was initially undertaken manually. However, a mechanical rake was later used to windrow the trash for trials. Different baler types were tested to find the factors impacting on baler productivity. Modifications were undertaken to adapt the balers to suit Indian field conditions, and appropriate field operating procedures were developed. Manual collection of trash was also introduced at places near to the mill to increase the supply of trash to the mill. Both the small rectangular balers and the round baler had similar outputs in the actual field conditions experienced. The transport efficiency was lower with round bales as they required specialised loading equipment and longer low bed trailers, which could not effectively negotiate the narrow rural roads. Rectangular bales were manually loaded and were simple to handle and transport. While the performance of balers was initially good, performance declined in the second year primarily due to maintenance and wear issues. Although the ability to bale trash was established, the throughput of the equipment must be increased to achieve a viable operation. Apart from small field size, several other field factors were also identified as obstacles to the baling and transport of residues. Farm layouts and farming practices needed to be changed to suit mechanised operations.

Pointers for better farming and research from sugarcane physiology

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Sugarcane physiology has been neglected for several decades in all cane growing countries including Australia. However an international physiology workshop in 2003 funded by the Sugar Research and Development Corporation stimulated interest in this type of research in Australia and South Africa at least. The proceedings of the workshop were published in an international journal in 2005 and some practical pointers for better farming practice were highlighted in popular Australian industry publications during 2006. In this paper we hope to capture some of the more important aspects of knowledge of cane physiology to compliment the considerable conventional wisdom to be found in the industry. Sugarcane is a deep rooted crop and can make use of water and nutrient resources deep in the profile. This has been clearly demonstrated on commercial farms. The root system is sensitive to compaction which should be limited and controlled as much as possible to allow the benefits of the deep rooting habit to be expressed. Breeding and management should aim for sustained plant population as is the norm in other broadacre crops. While this is difficult to achieve we can start by looking after soil health rather than by changing crop row arrangements unless these contribute to improve soil health. Estimates of water requirements for sugarcane are reliable and can be applied through a scheduling and water management tool like WaterSense. Sugarcane can tolerate some water stress and irrigation management should focus on sugar not cane yield. Photosynthesis is much less sensitive to water stress than stalk elongation and water can be saved making use of this knowledge as well as knowing that roots can access water deep in the profile. Shorter crops could help delay lodging which can reduce yields substantially. Options for manipulating the physiological processes described here will improve as we gain greater understanding of their genetic control.

Precision breeding to improve the usefulness of sugarcane

F.C. Botha

For centuries sugarcane has primarily been used for the production of sucrose. Conventional breeding programs have therefore concentrated on sucrose content and sucrose yield per area of land. There is an increasing realisation that sugarcane processing can deliver additional high value products. The success of a biorefinery is directly linked to the quality of the feedstock i.e. if the desired end-product is not directly present then there must be suitable precursors for conversion. Theoretically, precision breeding (PB) allows for the modification of existing metabolic pathways and/or the addition of novel metabolic steps. Several institutions worldwide now have the ability to genetically modify sugarcane by up or down regulation of current genes, or the insertion of new genes. In addition, there are large databases which provide a good indication of expression of the current genome. This allows for the targeting of specific reaction steps, but also indicates the number of reaction steps that might be needed to produce a novel product. What we have learned from sugarcane precision breeding during the past decade is that (I) novel proteins can be expressed at significant levels, (2) new traits such as pest, disease and herbicide resistance can be added, (3) the maximum catalytic capacity of targeted enzymes can be altered, (4) that the outcome of these metabolic perturbations are unpredictable and varied, and (5) that the genetic modification often results in decreased biomass production. Future genetic improvement of sugarcane as an ideal feedstock for biorefineries will rely heavily on an improved understanding of metabolic control and flux, cellular com-partmentation and availability of metabolites, and the ability to better identify potential targets for PB. The lat-ter will be dependent on metabolic and enzyme profiling and the ability to accurately model cellular metabolism.

Yield losses caused by Pachymetra root rot in northern Queensland: 10 years of breeding selection trial data

R.C. Magarey and J.I. Bull

Plant breeders conduct breeding selection yield trials each year as they select the highest yielding clones for consideration as commercial varieties. Only the highest yielding are selected for further testing with very small numbers being released as commercial varieties. Disease susceptibility varies greatly amongst the tested clones. Routine disease resistance testing is an important aspect of the breeding program. All clones for northern Queensland are screened for Pachymetra root rot resistance while only selected clones from other areas are tested. Analyses were conducted using 10 years of northern Queensland data that related the yielding ability of clones in stage 3 (FAT) trials to Pachymetra resistance. In the 1995-1999 analyses, Pachymetra root rot on average reduced tonnes cane/ha by 14.5% and tonnes sugar/ha by 11.9%; there was a slight positive effect on CCS. Data for 2000-2004 showed smaller losses and this may reflect changes in trial procedures and/or rainfall variation. The data reported here will be valuable for refining selection strategies to improve breeding efficiencies.

Eldana saccharlna Walker (Lepidoptera: Pyralidae) In sugarcane: impact and implications for the Zimbabwe sugar industry

A.R.S. Mutambara-Mabveni

Eldana saccharina was first recorded in sugarcane in the Zimbabwe sugarcane industry in 1999. The Zimbabwe Sugar Association Experiment Station (ZSAES) initiated systematic *E. saccharina* surveys in its sugar industry in 2000. Survey records from 2000 to 2005 were analysed to determine the pest status of this stalk borer. The total area and the number of fields that were free of E. saccharina steadily decreased from around 50% in 2000 to less than 20% of the area under commercial sugarcane by 2005. Average E. saccharina damage in most of the fields surveyed was between 0.1 % and 5.0% stalks bored. Carryover cane (> 12 months ratoon cane or > 14 months plant cane) in the industry increased during the period. Higher levels of damage (> 10% bored stalks) were found in older (> 13.5 months) and carryover cane. Locally bred varieties (ZN) had significantly more damage (p<O.OOOI) compared to other varieties grown in the industry. There were significant differences (p<O.OOOI) in E. *saccharina* damage levels among the different sugarcane estates. Mkwasine Estate and Hippo Valley Estates had the lowest damage levels, while farms in the out-grower schemes had the highest levels. It was estimated that the Zimbabwe Sugar Industry lost about 5000 tonnes of sugar, annually, to E. *saccharina* infestation.

Use of *Trichoderma harzianum* for the control of red rot disease of sugarcane

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T 37 and T 38 identified potent isolates of *Trichoderma harzianum* Rifai from soil samples of sugarcane rhizos-phere from different parts of the country were evaluated for the management of red rot disease. T. *harzianum* treated setts of highly susceptible variety (CoLk 7701) were planted during Feb - March (normal planting season in sub-tropics). Trials were conducted in 3 crop seasons (2004 - 07) in randomized block design with 3 replications, 27 ml plot size (6 rows at 90 cm distance x 5 m length) and 7 treatments (3 formulations, 3 combinations and control). One hundred 5-month-old canes / plot were inoculated with virulent Co/Jetotrichum *falcatum* pathotype / race (Cf 09) during July - August (28-30 OC and 90 - 95% relative humidity). Red rot flares up quickly during July - August (rainy season) in sub - tropics. T. *harzianum* spore suspension (10 6 spore / ml); *Trichoderma* multi-plied culture (TMC) in press mud applied @ 20 kg / ha and metabolites / culture filtrate at 2.5% concentrations were evaluated singly and in combinations to control the disease. In case of T. *harzianum* treament *C. falcatum* could not infect 50 - 55% canes. The cane protection was absolute (0 level disease). However, in 20 - 25% canes the spread of red rot was markedly reduced to I - 4 grade in 0 - 9 system of grading. Metabolites alone and in combination with TMC and spore suspension of either of T 37 and T 38 were effective in managing red rot. Germination recorded after 45-50 days of planting was significantly higher. The number of tillers counted in April - May was considerably enhanced. The number of mill-able canes counted at harvesting time (12 month) was significantly increased. Yield data of 12 month crop was recorded during Feb -March. Cane yield was higher (13-14 t/ ha) in *T. harzianum* applied plots. Red rot may be managed by application of T. *harzianum* since it acts directly on *C. falcatum* and induce systemic resistance in plants developed from treated sett.

BREEDING AND GENETICS

Registration of 'CP 88-1165' sugarcane

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CP 88-1165 (Reg. No. CV-I3I, PI 651884) sugarcane (a complex hybrid of *Saccharum* spp.) was developed through cooperative research conducted by the USDA—ARS, the Centra Guatemalteco de Investigaci n y Capacitaci n de la Ca a de Azucar, and the University of Florida. It was released to growers in Guatemala in September 2004. CP 88-1165 was selected from the cross CL 61-620 x CP 81-1302 made at Canal Point, FL, in January 1986. The female parent, CL 61 -620, formerly a major commercial cultivar in Florida, was developed by a private breeding program in Clewiston, FL, conducted by the United States Sugar Corp.The male parent, CP 81-1302, was advanced to the final testing stage (Stage 4) of the Canal Point (CP) cultivar development program but was not released due to susceptibility to brown rust (caused by *Puccinia melanocephala* Syd. & R Syd.). CP 88-1165 was not released in Florida because of its susceptibility to brown rust and low yield of commercial recoverable sucrose. However, after testing in Guatemala, CP 88-1 165 was released there because of its high plant cane and ratoon per hectare yields of cane and sucrose and its acceptable resistance or tolerance to smut [caused by *Ustilago scitaminea* (Sydow & R Sydow], brown rust, *Sugarcane mosaic virus* strain E (mosaic), *Sugarcane yellow leaf virus,* and red stripe *(Acidovorax avenae* subsp. *avenae)* in Guatemala.

Registration of 'L 97-128' sugarcane

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L 97-128 (Reg. No. CV-129, PI 650858) sugarcane (a complex hybrid of *Saccharum officinarum* L., S. barber/ Jeswiet, S. *spontaneum* L., and S. *sinense* Roxb. amend. Jeswiet) was released on 5 May 2004 by the Louisiana State University Agricultural Center in cooperation with the USDA-ARS and the American Sugarcane League, Inc. L 97-128 has early high sucrose content, high cane yield potential, and resistance to common brown rust disease *(Puccinia melanocephala* H. and P. Syd.). Both the cross and the early stage clonal selection were made at Louisiana State University Agricultural Centers Sugar Research Station, St. Gabriel; permanent cultivar assignment was done in 1997. The cross was made on 25 Sept. 1992. Early stage clonal selection was done as single stools in 1994 followed by first clonal line trial selection in 1995 and second clonal line trial stage selection in !996.Testing in replicated yield trials was conducted through the sugarcane growing area in south Louisiana from 1998 through 2003. Plant patent 17,636 was issued on 24 Apr. 2007.

Changes in photosynthetic rates and gene expression of leaves during a source-sink perturbation in sugarcane

A. J. McCormick, M. D. Cramer, and D.A. Watt, Background and Aims: In crops other than sugarcane there is good evidence that the size and activity of carbon sinks influence source activity via sugar-related regulation of the enzymes of photosynthesis, an effect that is partly mediated through coarse regulation of gene expression. Methods: In the current study, leaf shading treatments were used to perturb the source—sink balance in 12-month-old *Saccharum* spp. hybrid NI9 (NI9) by restricting source activity to a single mature leaf. Changes in leaf photosynthetic gas exchange variables and leaf and culm sugar concentrations were subsequently measured over a 14 d period. In addition, the changes in leaf gene response to the source—sink perturbation were measured by reverse northern hybridization analysis of an array of 128 expressed sequence tags (ESTs) related to photosynthetic and carbohydrate metabolism.

Key Results: Sucrose concentrations in immature culm tissue declined significantly over the duration of the shading treatment, while a 57 and 88% increase in the assimilation rate (A) and electron transport rate (ETR), respectively, was observed in the source leaf. Several genes (27) in the leaf displayed a >2-fold change in expression level, including the upregulation of several genes associated with C4 photosynthesis, mitochondrial metabolism and sugar transport. Changes in gene expression levels of several genes, including Rubisco (EC 4^l^l>€39) and hexokinase (HXK; EQ€7/€l/EI)i correlated with changes in photosynthesis and tissue sugar concentrations that occurred subsequent to the source—sink perturbation.

Conclusions: These results are consistent with the notion that sink demand may limit source activity through a kinase-mediated sugar signalling mechanism that correlates to a decrease in source hexose concentrations, which, in turn, correlate with increased expression of genes involved in photosynthesis and metabolite transport. The signal feedback system reporting sink sufficiency and regulating source activity may be a potentially valuable target for future genetic manipulation to increase sugarcane sucrose yield.

Domestication to crop improvement genetic resources for sorghum and *Saccharum* (Andropogoneae)

Sally L Dillon, Frances M. Shapter, Robert J. Henry, Giovanni Cordeiro, Liz Izquierdo and

Background: Both sorghum (Sorghum *bicolor)* and sugarcane *(Saccharum officinarum)* are members of the Andropogoneae tribe in the Poaceae and are each others closest relatives amongst cultivated plants. Both are relatively recent domesticates and comparatively little of the genetic potential of these taxa and their wild relatives has been captured by breeding programmes to date. This review assesses the genetic gains made by plant breeders since domestication and the progress in the characterization of genetic resources and their utilization in crop improvement for these two related species.

Genetic Resources: The genome of sorghum has recently been sequenced providing a great boost to our knowledge of the evolution of grass genomes and the wealth of diversity within *S. bicolor* taxa. Molecular analysis of the *Sorghum* genus has identified close relatives of *S. bicolor* with novel traits, endosperm structure and composition that may be used to expand the cultivated gene pool. Mutant populations (including TILLING populations) provide a useful addition to genetic resources for this species. Sugarcane is a complex polyploid with a large and variable number of copies of each gene. The wild relatives of sugarcane represent a reservoir of genetic diversity for use in sugarcane improvement Techniques for quantitative molecular analysis of gene or allele copy number in this genetically complex crop have been developed. SNP discovery and mapping in sugarcane has been advanced by the development of high-throughput techniques for ecoTILLING in sugarcane. Genetic linkage maps of the sugarcane genome are being improved for use in breeding selection.The improvement of both sorghum and sugarcane will be accelerated by the incorporation of more diverse germplasm into the domesticated gene pools using molecular tools and the improved knowledge of these genomes.

Architectural evolution and its implications for domestication in grasses

Andrew Doust

Background:The cereal crops domesticated from grasses provide a large percentage of the calories consumed by humans. Domestication and breeding in individual cereals has historically occurred in isolation, although this is rapidly changing with comparative genomics of the sequenced or soon-to-be sequenced genomes of rice, sorghum, maize and *Brachypodium.* Genetic information transferred through genomic comparisons is helping our understanding of genetically less tractable crops such as the hexa-ploid wheats and polyploid sugarcane, as well as the approx. 10 000 species of wild grasses. In turn, phylogenetic analysis helps put our knowledge of the morphology of cereal crops into an evolutionary context.

Grass Architecture: Domestication often involves a change in the pattern and timing of branching, which affects both vegetative and inflorescence architecture, and ultimately yield. Cereal grasses exhibit two main forms of vegetative architecture: the pooid and erhartoid cereals such as wheat and rice have multiple basal tillers, while panicoid cereals such as maize, sorghum and the millets have few tillers or even only a single main stem.These differences are reflected in the differences between the wild species of pooid and some erhartoid grasses, which emphasize basal branching over axillary branching, and the panicoid grasses, where axillary branching is more frequently found. A combination of phylogenetic and genomic analysis is beginning to reveal the similarities and differences between different cereal crops, and relate these to the diversity of wild grasses to which they are related. Recent work on genes controlling branching emphasizes that developmental genetics needs to be viewed in both an evolutionary and ecological framework, if it is to be useful in understanding how morphology evolves. Increasingly, exploring the phylogenetic context of the crop grasses will suggest new ways to identify and create combinations of morphological traits that will best suit our future needs.

Correlation and path coefficient analysis in sugarcane

Anand Prakash Tyagi and Praduman Lal

Correlation and path coefficient analysis was undertaken among agronomic and bio-chemical characters of importance in sugar-cane. Correlation between agronomic characters revealed positive and significant (P = 0.01) correlation between plant volume and number of millable stalks (0.874), plant volume and weight per stalk (0.812), plant volume and weight of millable stalks (0.962), plant volume and stalk thickness (0.842), number of mill-able stalks and weight of millable stalks (0.889) and other agronomic characters. There was a non-significant but positive correlation between number of millable stalks refractrometer brix (0.05), number of millable stalks and stalk height (0.285) and other characters. In case of bio-chemical characters, positive and significant (P = 0.01) correlation was recorded between Pure Obtainable Cane Sugar (POCS) and pol (0.901), POCS and purity (0.763) and pol and purity (0.780). Negative but non-significant correlation was observed between POCS and fibre. Correlation studies indicate that for sugarcane yield plant volume, plant height, number of millable stalks per stool, stalk thickness and weight of millable stalks are the most important characters. However, for biochemical characters POCS, pol and purity are the most important characters. Path coefficient analysis in the case of agronomic characters showed revealed that the weight of millable stalks was the most important character with the highest direct effect on sugarcane yield followed by stalk height, number of millable stalks and stalk thickness among agronomic traits. In bio-chemical characters highest direct effect was on percent POCS followed by percent purity and percent fibre. In nutshell correlation and path coefficient analysis in present study suggests that clones or varieties with high plant volume, plant height, and other agronomic characters should be used in hybridization programme.

Genetic diversity associated with in vitro and conventional bud propagation of *Saccharum* varieties using RAPD analysis

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Polymorphisms in the genomic DNA of eight varieties maintained by conventional bud propagation (via rhizomes) and by in vitro shoot tip cultures were detected by RAPD analysis of sugarcane varieties.The study estimated the genetic diversity induced after in vitro multiplication of these varieties. Higher (28.9%) and lower (12%) numbers of polymorphic bands were detected in plants propagated via rhizomes; the genetic similarity estimate varying from 0.63 to 0.80. Plants of SP90-3723 and SP9I-I049, or RB85-5I13 and SP90-3723, varieties involving greater genetic distances may be indicated as progenitors in breeding programmes. *In vitro* multiplication of RB86-75I5, RB85-5113, RB83-5054 and SP86-42 varieties increases genetic variability, while in vitro multiplication of SP91 -1049, SP90-1638, RB92-8064 and SP90-3723 leads to genetic similarity. Results show that the RAPD technique is an effective tool for detecting polymorphism in sugar-cane clones and it allows quick collection of the necessary information (more genetically divergent plant varieties) to guide new crossing in sugarcane breeding programmes.

Re-evaluation of sugarcane borer (Lepidoptera: Crambidae) bioeconomics in Louisiana

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The sugarcane borer, *Diatraea saccharalis (F.)* (Lepidoptera: Crambidae), is the key insect pest of sugarcane, Sacchorum spp., grown in Louisiana. For more than 40 years, Louisiana sugar-cane farmers have used a value of 10% internodes bored at harvest as the economic injury level (EIL). Three plant-cane studies were conducted to re-evaluate the long-standing sugarcane borer EIL level using the most recently released varieties of sugarcane.Varieties were exposed to artificially enhanced borer infestations; the experimental treatments consisted of borer control with insecticides or no control. Data were collected on infestation intensity, damage intensity, and associated yield losses. Crop yields from plots were obtained by mechanical harvesting, and losses were classified as field losses, e.g. losses of gross tonnage in the field and factory losses, e.g., losses that were realized at the factory as cane is being milled. Farm income is based on the product of these two measures of yield, i.e. cane yieldxsugar yield. In our study, seasonal stalk-infestation counts did not reveal any indication of preference by the borer moths for a specific variety; infestation pressure was generally uniform within a season among the varieties that we planted. Significant differences were detected among the varieties for harvest percentage of internodes bored as well as yields between borer-controlled and non-controlled plots ($P<0.05$). In general, varieties were less susceptible to losses in the field (sugarcane yields) than in the factory (sugar yields). As a group, the most recent varieties released to Louisiana growers exhibit more tolerance to the borer than varieties grown 40 years ago. The percent reduction in sugar/ha loss per 1% internodes bored has decreased from an average of 0.74 for varieties grown in the 1960s to 0.61 as a mean for the newly released varieties.Although the cost associated with an insecticide application for sugarcane borer control has increased nearly 4-fold from 1971 to present, sugar yields have increased by approximately 60% allowing farmers to offset some of these increased costs. Our economic analysis indicates that the EIL of 10% internodes bored is too high, considering the high yielding potential and susceptibility of currently grown varieties. For the most at risk farmer, the tenant farmer, a more appropriate value for the EIL is 6% internodes bored. However, this EIL can be raised 12% if a resistant variety is grown.

A semi-synthetic diet for rearing *Dipha aphidi-vora* (Lepidoptera: Pyralidae), a promising predator of woolly aphid in sugarcane

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Dipha aphidivora (Meyrick), a lepidopteran predator of sugarcane woolly aphid (SWA) *Ceratovacuna lanigera* Zehntner was successfully reared for three successive generations, for the first time on a freeze-dried beef liver-based larval semi-synthetic diet.We compared biological parameters viz., larval survival, adult weight, pre-and oviposition period, fertility, fecundity and female longevity of D. *aphidivora* reared on the semi-synthetic diet with the predators reared on SWA. Development time of larvae reared from first instar to pupation was 20.6 days on the semi-synthetic diet and 12 days on SWA, while survival of the larvae to adults was 61.8 and 91.8% on larval semi-synthetic diet and SWA, respectively. Fecundity recorded from semi-synthetic diet (41 eggs/female) was significantly less than those produced on SWA (58 eggs/female). However, fertility and longevity of the predators reared on SWA and semi-synthetic diet did not differ significantly. The study revealed the possibility of rearing D. *aphidivora* larvae using synthetic diet.

Natural occurrence of Gibberef/o fu/ikuroi and its potential for control of the woolly aphid Ceratovacuna *lanigera* (Homoptera: Aphididae) in Indian sugarcane plantations

Sayaji Mehetre, Poulomi Mukherjee and Sharad Kale

Studies were conducted to determine the natural occurrence of entomopathogenic fungi and their potential for utilisation in biological control of the woolly aphid *(Ceratovacuna lanigera* Zehntner) in Indian sugarcane plantations. A fungus *Gibberella* fu/ikuroi (Sawada) Wr. (Synonym: *Fusarium venicillioides* (Sacc.) Nirenberg, Synonym: *Fusarium moniliforme* (Sheld.) emend. Snyd. and Hans.) was found to be a promising biocontrol agent. It was further characterised and its field performance was studied. Reductions of aphid populations up to 60% were observed when the fungus was applied as two sprays at a week interval in the field.