Pakistan Sugar Journal

April-June 2010 Contents Vol. XXV, No.02

Editorial Board

M. Asghar Qureshi Chairman
Dr. Shahid Afghan Member
Dr. Muhammad Zubair Member
Dr. Shahid Mahboob Rana Member

Published
Under the patronage of
Shakarganj Sugar Research Institute

Subscription
Dr. Shahid Afghan,
Shakarganj Sugar Research Institute
Toba Road, JHANG
Ph: 047-7629337-41
Email: shahid.afghan@shakarganj.com.pk

Subscription Rate
Pakistan Rs.300/-
OVERSEAS US$25/-

Recognized by
Higher Education Commission Pakistan

Cited by
Pakistan Press International (PPI)
Australian Associated Press (AAP)

ISSN 1028-1193

2 **Economic potential of intercropping Raya in autumn planted sugarcane**
Muhammad Aslam, Arshad Ali Chattha, Muhammad Bakhsh

7 **Integrated control strategies for sugarcane disease**
Muhammad Shafiq Anwar, Hafiz Walayat Ali Khan, Muhammad Munir, Arshad Ali Chattha and Amjad Zia

10 **Population growth and demand and supply situation of sugar and gur in Bangladesh**
G. M. Monirul Alam, M. M. Alam and M. A. S. Miah

15 **Varietal suitability assessment under rainfed condition in high barind tract of Bangladesh**
M. K. Bashar; M. S. Rahman; M. M. Hossain and T. Ahmed

19 **Sugar Industry Abstracts**
M. Awais Qureshi and Shahid Afghan

Panel of Referees

Dr. P. Jackson	*Principal Scientist, CSIRO, AUSTRALIA*
Dr. Benjamin L. Legendre	*Interim Director, Audubon Sugar Institute, USA*
Dr. Yong-Bao Pan	*Research Plant Molecular Geneticist, USDA-ARS, USA*
Dr. Mac Hogarth	*Group Manager BSES, AUSTRALIA*
Dr. Sizuo Matsuoka	*Director, Canavialis SA, BRAZIL*
Dr. Ruksana Bajwa	*Director, Michology & Plant Pathology University of Punjab*
Dr. Iftikhar Ahmed	*DG National Agri. Res. Center Islamabad - PAKISTAN*
Dr. Shahina Fayyaz	*Director, National Nematological Research Center, Karachi*
Dr. Irfan ul Haq	*Prof. Pathology PMAS Arid Agriculture University Rawalpindi*
Dr. S. M. Mughal	*National Professor, Higher Education Commission of Pakistan*
Dr. Asif Tanvir	*Professor, Dept. of Agronomy, University of Agriculture Faisalabad*
Dr. Aamir Ali	*Asstt. Professor, Dept. of Bio-Science, University of Sargodha*

© 2008 SSRI, All rights reserved, no part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise without prior written permission of the Publisher.

ECONOMIC POTENTIAL OF INTERCROPPING RAYA IN AUTUMN PLANTED SUGARCANE

*Muhammad Aslam, **Arshad Ali Chattha, ***Muhammad Bakhsh
* S.cane Res. Station, Khanpur, ** S.cane Res. Inst., Faisalabad., ***Oilseeds Res. Station, Khanpur

ABSTRACT

Agro-economic studies on intercropping raya by gupchat and drill method in autumn planted sugarcane were carried out at Sugarcane Research Station, Khanpur during the year, 2006. Sugarcane was sown alone in September and after harvesting Raya in March or in combination with raya varieties i.e.,Khanpur raya and Anmol raya by gupchat and drill method. The results indicated non-significant effect of intercrops on germination and significant on yield and its attributing characters. Cane planted alone superseded in yield and its allied components. However, the additional harvests of intercrop raised the gross and net income of intercropping treatments. Sugarcane intercropped with "Khanpur raya" by gupchat method gave the highest net income of Rs. 106.25 thousands per hectare followed by sugarcane sown in March after harvesting "Khanpur raya". Key words: Sugarcane, intercropping, Khanpur raya and Anmol raya.

INTRODUCTION

Economically high Agricultural productivity is a prerequisite to foster an efficient and competitive agricultural industry. As sugarcane production involves a heavy long term financial investments so there should be a source of interim income especially for the small growers, which will reduce the sugar production cost also. Intercropping is a convincing approach to achieve a reasonable interim income. Autumn planted sugarcane passe: a dormant growth phase of about four months in its early days due to low winter temperature and makes a little use of soil and water resources. In order to derive benefits from this early slow growth and to make better use of resources, an additional sweep of short duration intercrop can be harvested. However, adjustment in crop management practices is needed for successful maturity of either of the crops. Nazir *et al., (9)* received the highest yield of alone cane (91.13t/ha) closely followed by cane + mash (87.08t/ha) and cane + soyabean(86.71t/ha). Higher B.C.R. (3.02) was recorded from sugarcane intercropped with mash bean. Malik and Kamoka(8) observed that raya over shadowed the cane crop and affected the tillering and cane density adversely. Though yield reduction of 9.63 percent was reported but the net income from cane + raya was significantly higher than cane alone. Aslam *et al.,* (2) found that intercropping mung and maize did not affect the germination and tillering of sugarcane. While cane formation and yield was measurably depressed. The cane + mung intercrop gave significantly higher net income with 23.23% gain over cane alone. Aslam *et al., (3)* conducted a field trial and reported higher cash returns (Rs.23197/ha) by intercropping mung in sugarcane. In another field experiment Aslam *et al., (4)* concluded that intercropped soyabean and mung been did not affect the cane yield and its components significantly. Intercropping treatments gave slightly better net income than sole sugarcane. According to Aslam *et* a/., (5), although intercropping raya and sunflower depressed cane yield, yet the net income was relatively greater than that from September planted alone cane. Afzal *et* a/.(l) under took a study on intercropping sunflower in spring planted sugarcane and recorded statistically similar cane yields in alone and intercropped sugarcane. Chattha *et al.,* (7) planted sugar beet in sugarcane and recorded a magnificent increase in gross income due to intercropping.

The present field study was carried out to explore the economic feasibility of intercropping raya in autumn planted crop of sugarcane.

MATERIALS AND METHODS

The trial was conducted ai Sugarcane Research Station, Khanpur during year, 2006 to find out the economic potential of intercropping raya in autumn planted sugarcane. A commercial sugarcane cultivar SPF.234 was planted in the second week of September at 1.2m row distance, while raya was intercropped in the first week of October. The planting of sugarcane was done by dry method using a seed rate of 75000 DBS/ha, The field was fertilized at the rate of 168:112:112 Kgs NPK/ha. Full dose of Phosphorous and Potash was applied at the time of sowing. Nitrogen was applied in three split doses, 1/3 at the completion of cane germination, 1/3 at tillering of sugarcane in the last week of January and the remaining 1/3 N was added after harvesting the intercrop in March. The experiment comprised of seven treatments as detailed below.

T_1= Sugarcane alone in September
T_2= Sugarcane after harvesting "Khanpur Raya".
T_3= Sugarcane after harvesting "Anmol Raya"
T_4= Sugarcane + "Khanpur Raya" sown by gupchat
T_5= Sugarcane + "Anmol Raya" sown by gupchat
T_6= Sugarcane + "Khanpur Raya" sown by drill
T_7= Sugarcane + "Anmol Raya" sown by drill

The experiment was planted in Randomized Complete Block Design with four replications and a net plot size of 3.6 x 12m. Raya was intercropped as per treatments. Thinning of intercrop was done twice, at 6 inches and 9 inches plant height. All other cultural operations were performed as and when required by the crops. The yield of intercrop was recorded after harvesting and drying the grains in the first week of March. In treatments 2 and 3 sugarcane was sown in the third week of March. Meanwhile observations were recorded on germination and tillering of sugarcane. Data on cane density, weight and yield were recorded at harvest during the last week of December. The recorded data were then analysed by using Analysis of Variance techniques and Least Significant Difference test was applied at five percent probability level to compare the treatment means (10).

RESULTS AND DISCUSSION

Germination and Tillering

The data presented in table-1 indicate that different intercropping treatments did not affect the germination of sugarcane probably because it has emerged out during the germination phase of intercrop before t!?e start of active plant competition. The tabulated data depict the depressing effect of intercrop on the tiller formation. The depressing effect was more pronounced where raya was sown by gupchat. However, the intercrop varietal difference was non significant in this regard. Sugarcane planted alone in September produced maximum tillers/plant (3.11), followed by sugarcane sown alone in March at the harvest of raya (2.63). The lowest tillers per plant (1.30) have been recorded in the plots where raya was sown by gupchat method. Relatively more reduction in the expression of tillering potential in these treatments was probably due to the closer competition as compared to the drill sown treatments. The depressing effect of intercrops on cane tillering has also been reported by Aslam *et al.,* (5) and Malik and Kamoka (8).

Millable Cane Density and Weight

Millable cane density in an important yield attributing character and is the interaction of germination, tillering and tiller mortality. The mean cane stand differences were statistically significant as shown by the data embodied in table 2.

September planted sole cane gave significantly high cane density of 102.78 thousand canes per hectare. It was matchingly followed by the sugarcane sown in March after harvesting raya. The sugarcane intercropped with raya sown either by gupchat or drill, reduced cane formation significantly. The depressing effect of raya on cane formation may be attributed to the corresponding lower tillering and relatively more tiller mortality due to shading effect of the intercrop. Similar conclusions have also been drawn by Aslam *et al.,* (5) and Malik and Kamoka (8).

The data recorded in table-1 for hundred cane weight reveal significant differences among the means of different treatments. The cane stalks planted in September either alone or with intercrops were heavier than the spring planted cane probably because of the prolonged growth period available to the former. The minimum hundred cane weight of 93.50kg was recorded for the cane planted after harvesting raya in March.

Crop Yields

The final crop yield is the ultimate goal of each and every grower. A perusal of the data given in table 2 exhibit that the differences among the means of cane yield in the treatments were statistically significant. Autumn planted alone sugarcane produced the highest cane yield(115.33t/ha). None of the other treatments could match it. The sugarcane intercropped with raya sown by drill method gave slightly more yield than the gupchat treatments but these were statistically at par with one another. Sugarcane planted after the harvest of raya in March gave the least tonnage of 95.60 per hectare. These yield losses were compensated by the additional harvests of intercrop. The "Khanpur Raya" when planted alone gave a produce of 2.37t/ha. The same variety of raya produced 2.1 It/ha when intercropped by gupchat method and 1.72t/ha when sown by drill method. The raya variety Anmol produced lower than Khanpur Raya in all the treatments. The yield results are quite in line to those of Aslam *et al., (4),* Chattha *et al.,(7)* and Malik and Kamoka(8).

Economic Benefits

The economics of different crop combinations worked out in terms of gross income, cost of production and net income is given in table-3. The data show that the gross income received from either of the intercropping combinations was higher than the alone cane sown in September. The highest gross income of Rs. 214.10 thousands per hectare has been calculated for sugarcane intercropped with "Khanpur Raya" by gupchat method followed by the sugarcane planted after harvesting Khanpur Raya (Rs.208.57 thousands /ha). Net income was also greater for sugarcane intercropped with "Khanpur Raya" by gupchat method. The EMV of all the intercropping treatments was greater than'T' which advocates the higher net returns from intercropping treatments. The highest EMVs of 1.51 and 1.42 show economic superiority of sugarcane + Khanpur Raya sown by gupchat and sugarcane sown after harvesting Khanpur raya, respectively. Similar economic gains due to intercropping have also been reported by Aslam *et al.*(2,3,4,5), Bahadar *et al.(6)* and Malik and Kamoka (8).

REFERENCES

Mzal, M., A. A.Chattha, M. Zafar, M. A. Iqbal and A.Jabbar.2003.Study on intercropping sunflower in spring planted sugarcane.Pak.Sug.J., 18(6):65-67

Aslam, M., G. Muhammad and K.B.Malik.1994. Economic feasibility of intercropping mung and maize under different inter row strips of Sugarcane. Proc. PaK. Soci. Sug. Tech., 29th Ann.Conv;23-25 Aug.,PP. 128-34.

Aslam, M., G. Muhammad, M. A. Javed and K.B. Malik. 1997. Agro-Economic studies on intercropping mung and soybean in Sugarcane. J. Agri. Res., 33(6):373-78

Aslam, M., M.Javed and A. A. Chattha. 1998.Economic feasibility of intercropping Soybean in Sugarcane at reduced densities. J. Agri. Res., 36(4): 334-41.

Aslam, M., M. Javed and K. B. Malik. 1998.Economic feasibility of intercropping Raya and Sunflower at different plant densities in autumn planted Sugarcane, Pak. Sug. J., 13 (2): 15-19.

Badar K., M. Sadiq, M. Suban, A. U. Khaj O. Khan and D. Khan.2007. Production potential of sugar beet intercropping with sugarcane under various plar-ln geometry system. Pak. Sug. J., 22 (l): 76-81.

Chattha, A. A., M. A. Grawal, M. Zafar and F. Ahmad. 2003. Feasibility of sugarcane sugarbeet intercropping system in central Punjab. Pak.Sug.J.,18(6):65-67.

Malik, K. B. and M. N. Kamoka. 1992. Agro-economic study of intercropping potato and raya in autumn crop of sugarcane. Pak. J. Agri, 13 (2): 126-131.

Nazir, M. S., T. Mahmood, R. Ahmad and N.A.Ali.1991. Intercropping short duration kharif crops in spring cane. Proc. Awareness Setninars (Part-I), Pub. Dir. Agri. M, Punjab Lahore PP.233-237.

Steel, R.G. D. and J. H. Torrie. 1980. Principles and Procedures of statistics. McGraw Hill Book Co. Inc., New York.

Table-1 Germination, Tillering and Cane weight as affected by different intercropping systems

Sr. No.	Treatment	Germination %	Tillers /plant	100-cane weight (Kg)
1.	Sugarcane alone in Sept.	44.40	3.11 a	112.25 a
2.	Sugarcane after KPR Raya	41.59	2.63 b	95.00 b
3.	Sugarcane after Anmol Raya	42.30	2.55 b	93.50 b
4.	Sugarcane + KPR Raya Gupchat	44.63	1.33d	108.75 a
5.	Sugarcane + Anmol Raya Gupchat	44.65	1.30 d	107.25 a
6.	Sugarcane + KPR Raya drill	44.84	1.52 c	109.00 a
7.	Sugarcane + Anmol Raya drill	44.83	1.54 c	110.25 a
	LSD 0.05	N.S.	0.11	5.65

Treatments having no or same letter do not differ significantly (P=0.05)

Table-2 Cane density and yield as affected by different intercropping systems

S.No.	Treatments.	Cane density (000/ha)	Cane yield (t/ha)	Variation (%)	Raya yield (t/ha)
1.	Sugarcane alone in Sept.	102.78 a	115. 33 a	...	—
2.	Sugarcane after KPR Raya	100.58 a	95.60c	17.10	2.37
3.	Sugarcane after Anmol Raya	102.36 a	96.58 c	16.26	1.76
4.	Sugarcane+KPR Raya Gupchat	95.66b	104.05 b	9.78	2.11
5.	Sugarcane+Anmol Raya Gupchat	94.79 b	101. 33 be	11.79	1.68
6.	Sugarcane+KPR Raya drill	96.35 b	105.09 b	8.87	1.72
7.	Sugarcane+Anmol Raya drill	95.48 b	105. 32 b	8.67	1.58
	LSD 0.05	2.03	6.22	—	—

Treatments having no or same letters do not differ significantly (P-0.05)

Table-3 Economic analysis of different intercropping systems

Sr. No	Treatments	Mean yield (t/ha) Cane	Raya	G. Income Rs.000/ha	Cost of production Rs.000/ha	Net income Rs.000/ha	Estimated Monitory Value (EMV)
1.	Sugar cane alone in Sept	115.33	—	172.99	102.49	70.50	—
2.	Sugarcane after KPR Raya	95.60	2.37	208.57	107.81	100.75	1.42
3.	Sugarcane after Anmol Raya	96.58	1.76	193.27	107.11	86.16	1.22
4.	Sugarcane+KPR Raya Gupchat	104.05	2.11	214.10	107.85	106.25	1.51
5.	Sugarcane+Anmol Raya Gupchat	101.73	1.68	198.79	106.61	92.18	1.30
6.	Sugarcane+KPR Raya drill	105.09	1.72	204.93	107.52	97.41	1.38
7.	Sugarcane+Anmol Raya drill	105.32	1.58	201.43	107.36	94.07	1.33

Sugarcane @ Rs.l500/ton and Raya @ Rs.27500/ton

INTEGRATED CONTROL STRATEGIES FOR SUGARCANE DISEASE

Muhammad Shafiq Anwar[1], Hafiz Walayat Ali Khan[1], Muhammad Munir[1], Arshad Ali Chattha[1] and Amjad Zia[2]
[1] Sugarcane Research Institute, AARI, Faisalabad;
[2] M. Sc. (Hons) Student, University of Agriculture, Faisalabad

ABSTRACT

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

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 this paper.

SUGARCANE DISEASES IN PUNJAB / PAKISTAN

Fungal diseases

- 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*)

Bacterial Diseases

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

Virus and Mico-plasma

- Sugarcane mosaic
- 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 been 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 in the dettole solution or surf washing powder while cutting the seed setts is very useful for the control of sugarcane Mosaic Virus.

REFERENCES

Anwar, M.S., H.W.A. Khan, M. Umer and A.A. Chattha. 2006. Variabilties of red rot (*Collectotrichum fallcatum*, went) in sugarcane germplasm. Abst. 41st Ann. Conv. PSST. 21-22. Aug. 2006 Rawalpindi, PP. 28.

Atwal, A.S. 1991. Agricultural pests of India and South East Asia. Kalyani Publishers, Ludhaina. PP. 330-343.

Joshi, N.C. 1954. Hot water treatments of setts for the control of red rot and smut diseases of sugarcane. Indian sugar, N.S., 4, PP. 2.

POPULATION GROWTH AND DEMAND AND SUPPLY SITUATION OF SUGAR AND GUR IN BANGLADESH

G. M. Monirul Alam, M. M. Alam and M. A. S. Miah
Bangladesh Sugarcane Research Institute, Ishurdi, Pabna, Bangladesh

ABSTRACT

During 1990-91 to 2005-06 average total area under sugarcane was 89 thousand hectares only 1.07 per cent of the total cultivated area where as production was 4167 thousand tons. For the same period average yield of sugarcane was 46.6 t ha-1 and sugar production was 170 thousand tons. Availability of sugar both from internal production and importation during the aforementioned period was 0.49 million tons on an average. Mean domestic production and importation of sugar and jaggery (locally called 'gur') were 0.89 million tons met 54% of the country's demand and deficit was 0.75 million tons (45% of the internal demand). Per capita availability of sugar and gur were 3.92 kg and 3.17 kg as against demand of 10 kg sugar and 3 kg gur respectively during the period. The growth rates of sugarcane cultivation area, sugarcane production, yield, gur production and sugar import during the aforementioned period were -1.11, -1.01, 0.62, - 4.37, 0.18 and 18.82 % respectively. Date palm and palmyra palm plantation may be an alternative source of sugar and gur to meet up the increasing demand of sugar and gur in Bangladesh.

Key words: Sugarcane, sugar, gur, demand, supply, gap

INTRODUCTION

Sugar is indispensable for health and if it is not taken directly, it must be taken from other sources of carbohydrates in the food. Since sugar, as it is called, a cheap source of instant energy, a person should take it liberally. According to the nutritionists (CSIR, 1957), "a person requires a minimum of 44 Ib (20 kg) of sugar or equivalent quantity of gur per year in his (or her) diet". It is believed that there is a strong positive relation between total sugar consumption and health standard of a nation. According to FAO recommendation (13.0 kg sugar per person per annum) at present Bangladesh requires 1.80 million tons of sugar for 140 million people. The annual per capita consumption of sugar in the country is 5.80 kg (Sugar + gur in terms of sugar). In the neighboring countries as Sri Lanka, India and Pakistan are 12.50 kg, 13.47 kg and 20.50 kg respectively, while in the developed countries between 25-30 kg (Bench mark survey, 1996). Per capita consumption of sugar is very important in the context of health, IQ, calorie intake of the nations. Hence, it is necessary to produce more domestic sugar and gur to maintain our minimum health standard for our growing population through the increase production of sugarcane in Bangladesh.

In Bangladesh, sugar industry is the most important agro-based rural industry. But now the existence of this industry is questionable due to its huge losses each year. Although, more than 0.6 million farm-families are dependent on sugar industry for their subsistence. Most of the sugar mills are located in the North-western zones of the country where concentration of sugarcane cultivation is high. Currently, on an average the principal raw materials, sugarcane, for producing sugar is growing in 0.18 million hectare of land of which almost 50% is located in the sugar mills zones, where sugarcane is mostly used for sugar production and remaining 50% is situated in the non-mill zones, where sugarcane is mostly diverted for gur and juice production (Bench mark survey of Sugarcane, 1996). Sugar industry added value to final output in the form of sugar and its by-product. Further it is value added in our national economy when the final output is marketed to the consumer via dealer (distributer,

wholesaler and retailer). Therefore, there is a wide scope of increasing sugar production and its by-product through sugarcane processing which will meet up not only to growing demand of sugar but also to create enormous scope of employment in the country. Furthermore, sugar industry plays an important role to develop infrastructure in rural areas, rural employment, income of the farm families, contributes to national exchequer, foreign exchange saving, poverty reduction and value addition to the sugar as well as by-product industries (Alam *et al*., 2005).

With the present population growth rate at 1.48 per cent per annum, the population will be at 20 cores in 2020 (Economic Review, 2006). At present, 14 sugar mills are in operation under BSFIC (Bangladesh Sugar and Food Industries Corporation) with a capacity of 0.20 million tons of sugar production per year. Bangladesh liberalized her economy during early 1990s and entered into free market economy, which lead reduction of import tariffs to all commodities including agricultural commodities. As Bangladesh is not self sufficient in sugar production it is needed to import sugar to meet increasing demand of sugar. However, due to government policy remarkable changes have been happened in crop practices during early nineties. It might be due to the confluence of irrigation and power tiller technology. Farmers are now showing almost rational attitude towards selecting enterprises. Sugarcane crop has to compete with high value short duration crops like HYV rice, vegetables, pulses etc to sustain. So, there is a great threat to retain land under sugarcane cultivation in order to meet up ever increasing demand of sugar.

MATERIALS AND METHORDS

All the sugar mills of Bangladesh were selected for the study. Data were generally collected from published sources like annual report/MIS report of Bangladesh Sugar and Food Industries Corporation (BSFIC), Bangladesh Sugarcane Research Institute (BSRI), Directorate of Agricultural Extension (DAE), Bangladesh Bank (BB) and Bangladesh Bureau of Statistics from 1990-91 to 2005-06 crushing seasons. Descriptive statistics and time series data were used to analyse the data of the study. For growth analysis exponential growth rate model was used.

$$y = ae^{bt} \quad \text{or, } \log e^{y} = \log e^{a} + bt$$

Where,

y = Sugarcane area, production, yield, sugar production,
t = time period, and
$e^{b} - 1$ be the compound growth rate.

RESULTS AND DISCUSSION

Acreage, production and yield of sugarcane

There have been considerable temporal fluctuations in both acreage and production of sugarcane. Fluctuations in sugarcane production consequently result in temporal fluctuations in sugar production. The main factors attributed to these production variations were reducing of sugarcane areas which is subjected to relative profitability of competitive crops, damages of sugarcane due to natural calamities and non-availability of sugarcane to the sugar mills for milling. Availability of sugarcane for milling is highly co-related with the price of sugarcane offered by the sugar mills. During 1990-91 to 2005-06 average total area under sugarcane was 89 thousand hectares where as production was 4167 thousand tons. For the same period average yield of sugarcane was 46.6 t ha^{-1} and sugar production was 170 thousand tons. At present, total cultivated area in Bangladesh is 8.29 million hectares of which only 1.07 per cent under sugarcane cultivation (BBS, 2005). The growth rates of sugarcane cultivation area,

sugarcane production, yield and sugar production during the aforementioned period were -1.11, -1.01, 0.62 and -4.37% respectively.

Table-1 Acreage, production and yield of sugarcane in Bangladesh (1990-91 to 2005-06)

(In Thousand**)**

Year	Area (ha.)	Per cent increase/ decrease	Production of Sugarcane (ton)	Per cent increase/ decrease	Yield (t ha^{-1})	Per cent increase/ decrease	Sugar Production (ton)	Per cent increase/ decrease
1990-91	95	-	4696	-	49.19	-	246	-
1991-92	96	1.1	4491	-4.4	47.03	-4.4	196	-20.7
1992-93	88	-8.3	4247	-5.4	48.28	2.7	187	-4.1
1993-94	92	4.5	4576	7.8	49.61	2.8	222	18.2
1994-95	99	7.6	5030	9.9	50.81	2.4	270	22.0
1995-96	96	-3.0	4341	-13.7	45.25	-10.9	184	-31.9
1996-97	86	-10.4	4098	-5.6	47.33	4.6	135	-26.4
1998-98	88	2.3	4191	2.3	47.56	0.5	166	23.0
1998-99	94	6.8	4124	-1.6	43.71	-8.1	153	-8.1
1999-00	86	-8.5	3526	-14.5	42.82	-6.6	123	-19.3
2000-01	75	-12.8	3362	-4.7	44.90	10.0	98	-20.4
2001-02	88	17.3	4476	33.1	50.71	12.9	204	107.7
2002-03	105	19.3	4595	2.7	44.59	-14.0	177	-13.2
2003-04	84	-20.0	3948	-14.1	46.52	6.7	119	-32.8
2004-05	78	-7.1	3516	-10.9	44.99	-3.3	106	-11.0
2005-06	75	-3.8	3458	-1.6	46.84	1.9	133	25.5
Mean	89	-	4167	-	46.6	-	170	-
Growth rate	-1.11	-	-1.63	-	0.62	-	- 4.37	-

Source: BSFIC Annual Reports (1990-91 to 2005-06) and BBS (2005)

Domestic sugar and gur production and importation of sugar: The gaps

During nineties per capita incomes of the people have increased higher than previous two decades. This indicates improved economic profile of the people. Last few years importation of sugar increased tremendously due to improved economic profile to met up the required amount of sugar, as Bangladesh is not self sufficient in sugar production. The demand of sugar and gur is increasing with the increase of population in our country. Due to low recovery, supply shortage of sugarcane to mills and under capacity utilization sugar production is not increasing and mean production during 1990-91 to 2005-06 was 0.17 million tons far below than installed capacity of 0.21 million tons (Table 2). Despite government's efforts in achieving required amount of sugar and gur (10.0 kg sugar and 3.0 kg gur per person per annum), the gap between demand and supply of sugar and gur in the country is still high. Taking annual per capita 10.0 kg demand of sugar in 2005-2006 season internal demand of sugar stand at 1.40 million tons. Sugar production in 2005-06 was 0.13 million tons which met only 9 percent of the internal demand of sugar. Bangladesh, through BSFIC and private agencies imported 1.20 million tons of sugar about 85% of internal demand of sugar in 2005-2006 against the effective demand of 1.40 million tons of sugar. During 1990-91 to 2005-06 mean domestic production and importation of sugar and gur were 0.89 million tons met 54% of the country's demand and deficit was 0.75 million tons (45% of the internal demand). Availability of sugar both from internal production and importation during the period 1990-91 to 2005-06 was 0.49 million tons on an average. Per capita sugar availability was 3.92 kg and per capita availability of gur was 3.17 kg as against demand of 10 kg sugar and 3 kg gur respectively during the period. For the last 16 years from 1990 to 2006 there were deficit of around 0.75 million tons of sugar and gur on an average (Table 2). Illegal border trade or either a lower per capita consumption of sugar or both met up this huge deficit amount of sugar. This deficit can be met up either by increasing domestic sugar production as there is scope to increase domestic sugar production upto 0.21 million tons by

increasing recovery per cent, full capacity utilization and management improvement or either by importation of sugar.

Table-2 Production, demand and import of sugar and gur in Bangladesh (1990-2006)

Year	Population (million)	Per capita demand of sugar and gur @13Kg. (‘000 ton)	Sugar production (‘000 ton)	Sugar import (‘000 ton)	Gur production (‘000 ton)	Supply of sugar and gur (‘000 ton)	Deficit (‘000 ton)
1990-91	109.6	1425	246	138	432	816	609
1991-92	111.4	1448	195	50	482	682	766
1992-93	113.2	1472	187	64	415	666	806
1993-94	117.7	1530	221	86	334	641	889
1994-95	119.9	1559	270	156	285	711	848
1995-96	122.1	1587	184	28	371	583	1004
1996-97	124.4	1617	135	207	463	805	812
1997-98	126.7	1647	166	160	415	741	906
1998-99	129.1	1678	153	191	359	703	975
1999-00	131.5	1709	123	115	427	665	1044
2000-01	132.0	1716	98	328	436	862	854
2001-02	133.0	1729	205	210	306	721	1008
2002-03	134.0	1742	177	600	322	1099	643
2003-04	134.0	1742	119	700	450	1269	473
2004-05	140.0	1820	106	1000	450	1556	264
2005-06	140.0	1820	133	1200	450	1783	37
Mean	126.0	1640	170	324	400	894	746
Growth rate	-	1.16	- 4.37	18.82	0.18	-	-

Source: BSFIC Annual Reports (1990-91 to 2005-06), Bangladesh Bank (2006) and BBS (2005).

Strategies for overcoming the situation / How to meet the demand of sugar and gur?

In one hand, the demand of sugar and gur for various purposes keeping pace with population growth is increasing. On the other hand, sugarcane cultivation is now gradually being pushed to low-lying marginal lands prone to water-logging, flooding, drought and salinity stresses due to increased demand/production of cereal and vegetables crops. So, there is hardly scope to increase sugarcane acreage to meet the higher demand of sugar and gur for ever increasing population in Bangladesh. Date palm and palmyra palm gur may be an alternative source of sugar to supplement the increased demand for sugar and gur. According to BBS report, date palm and palmyra palm is grown in around 10755 to 10767 hectares of land and total estimated juice production is 3.34 to 3.48 million tons and @ 10% gur recovery about 0.334 to 0.348 million tons of gur is produced per year in Bangladesh. Date palm and palmyra palm is grown in homestead, embankment, ponds, road sides, and in marginal lands. These trees can survive in severe drought, flood and water logging conditions. There is an enormous scope to increase number of plant population as well as its juice and gur production in Bangladesh, and higher demand of gur can be met out of date palm and palmyra palm and generate rural employment and reduce poverty specially in rural areas.

In Bangladesh, there are 4000 Km of high ways, 145000 Km Kancha roads, 2500 Km bricks soling roads, 5000 Km flood-control embankment (dam) and cross dam 12000 Km. Meter gauge rail 2000 Km and broad gauge rail 1000 Km. In Bangladesh, these types of

fallow/grassing lands are around 0.1 million hectares. Therefore, total of these rail/road/embankment, stands around 0.33 million kilometers (two sides). The 0.33 million kilometers of land maintaining 5 m plant to plant distance, over 65 million trees can be grown. If juice is harvested from on an average, 2/3 rds of total population, 0.86 million tons of gur could be produced annually. It is estimated that a family of 5-6 member can be met from earning of 100 trees, and thereby 0.7 million families can survive and millions of people can be employed. Besides, millions of additional trees can be grown through application of agro forestry approach in the crop fields.

CONCLUSIONS

Due to population growth, increasing land for sugarcane cultivation is not possible which is also decreasing, so to meet up future demand of sugar and gur planting of date palm and palmyra palm in homestead, embankment, ponds, road sides, marginal lands and ail (demarcation mark) that remain fallow would be an alternative. This will increase the production of juice, gur and sugar as sugarcane used for juice and gur making will be reduced. It will also increase the income of the rural people and thus contribute to reduce poverty and upliftment of nutritional status of rural people.

REFERENCES

Alam, M.M, Haque, M.I. and Alam, G.M.M. 2005. Economics of sugar industries performance in Bangladesh. Bangladesh J. Sugarcane, 24-27: 98-100.

Bangladesh Economic Review, 2006. Economic Adviser's Wing, Finance Division, Ministry of Finance, Dhaka, Bangladesh.

CSRI, 1957. The Wealth of India: Industrial Products-part IV, Councial of Scientific and Industrial Research, New Delhi, India. p. 182.

Bangladesh Bureau of Statistics (BBS). (2005). Bangladesh Economic Survey, Finance Division, Ministry of Finance, Dhaka, Bangladesh.

Bangladesh Bank (BB). (2006). Economic Trends, Statistical Department, Bangladesh Bank, Dhaka, Bangladesh.

BSFIC, 1990-2006. Annual Report, Bangladesh Sugar and Food Industries Corporation, 115-120, Motijhill C/A, Dhaka-1000, Bangladesh.

Kranti Associates (1996). Bench Mark Survey on Sugarcane. Dhaka, Bangladesh.

VARIETAL SUITABILITY ASSESSMENT UNDER RAINFED CONDITION IN HIGH BARIND TRACT OF BANGLADESH

M. K. Bashar; M. S. Rahman, M. M. Hossain and T. Ahmed
Bangladesh Sugarcane Research Institute, Ishurdi, Pabna-6620, Bangladesh

ABSTRACT

A comparative study was under taken with six newly released sugarcane varieties viz. Isd 30, Isd 32, Isd 33, Isd 34, Isd 35 and Isd 36 were conducted at farmer's field in High Barind Tract under rainfed condition during 2004-05 and 2005-06 cropping season. The results revealed that Isd 32 produced significantly higher cane yield (72.39 and 64.70 t ha^{-1}) followed by Isd 35 (64.00 and 46.80 t ha^{-1}) and Isd 33 (57.40 and 49.80 t ha^{-1}) during the year 2005-06 and 2004-05 respectively. Thus, there is an ample scope to increase productivity of sugarcane by using varieties Isd 32, Isd 33 and Isd 35 in High Barind Tract of Bangladesh under rainfed condition.

Key words: Variety, Suitability, Assessment, Rainfed.

INTRODUCTION

In Bangladesh, major cultivated area of High Barind Tract (>85%) is still under rainfed condition. Sugarcane is a relatively drought tolerant crop and it may be grown at low rainfall zones but germination failure is the main limiting factor for sugarcane cultivation in rainfed condition. If germination can be ensured it is possible to grow sugarcane successfully in High Barind Tract under rainfed condition just after harvesting of T. Aman.

Bangladesh Sugarcane Research Institute developed some new varieties, which do not perform equally well in all Agro-Ecological Zones (Miah *et al.,* 1994). The yield of a particular variety depends upon its heredity potential of the genotype and environment where it is exposed to during the course of its life cycle (Yadava, 1993). Although most of the recommended varieties of sugarcane now grown in the sugar mill zones of Bangladesh but that promising varieties may not show better performance in all the ecological zones due to variations of Agro-climatic factors (Anon. 1979). Moreover sugarcane varieties gradually degenerate over a considerable period of cultivation and show a tendency to decline in yield and vigor (Barnes, 1954 and Humbert, 1959). The highest number of millable cane, height and girth might have contributed to cane yield as reported by Singh and Sangwan, 1980. Miah *et al.,* 1986 also observed that the sugarcane clones having tall cane, maximum diameter and higher number of millable canes have produced higher cane yield per unit area. Most of the farmers of Bangladesh get low cane yield due to late plantation, adoptions of inadequate pests and diseases control measures and poor agronomic management. Introduction of suitable varieties with packages of recommended technologies may help to bring substantial improvement in cane and gur yield which interim will increase the farmer's income and upgrade their livelihoods. In view of the above factors this experiment was undertaken to evaluate cane varieties for suitable High Barind Tract region under rainfed condition.

MATERIALS AND METHODS

The experiment was conducted at farmers field in High Barind Tract of Rajsashi area under rainfed condition during the cropping season 2004-2005 and 2005-06 with six treatments as varieties viz. Isd 30, Isd 32, Isd 33, Isd 34, Isd 35 and Isd 36. The experiment was laid out in a Randomized Complete Block (RCB) design with four replications. Plantation was done with two budded setts in the last week of october 2004 and 2005 after good shower when the field was at a moisture of field capacity i.e. Zoe condition. Before plantation setts were pre-germinated by heap method covered with rice straw for ensured germination. Plot size of each treatment was 8m x 8m where row-to-row distance was maintained an one meter. Necessary intercultural operations were done as and when required. Data were recorded at different growth stage of crop. Brix reading was recorded by hand refractrometer from standing cane in field. Can yield data was recored at harvest in December 2005 and 2006. Means of treatments were compared by LSD test statistically using "Analysis of Variance" technique (Steel and Torrie, 1960).

RESULTS AND DISCUSSION

Table-1 shows that no significant difference was found in germination, tiller production among the tested varieties but differences were observed in millable cane where Isd 33 produced the highest number of millable cane (81.71 $x10^3$ ha^{-1}) followed by Isd 34 (81.09 $x10^3$ ha^{-1}) but it was at per statistically. The lowest number of millable cane was recorded in Isd 30 (51.29 x 10^3 ha^{-1}), which differed significantly over all other varieties. . In case of yield, the highest cane yield was recorded in Isd 32 (64.70 t ha^{-1}) followed by Isd 33 (57.40 t ha^{-1}) and that differed significantly. But no significant yield difference was observed among Isd 34, Isd 35 and Isd 36. The highest brix of 21.85% was recorded in Isd 35, which significantly differed among all other varieties. However lowest brix of 17.87% was recorded in Isd 32.

Result presented in Table 2 reveals that, the tested varieties showd significant differences in percent germination, number of tiller production, number of millable cane, yield and percent brix in cane. Among the test varieties Isd 34 showed the highest germination of 41.37 % followed by 40.96 % in Isd 36 and 40.47 % in Isd 35, which were statistically at per but differed statistically over Isd 33, Isd 32 and Isd 30. The highest number of tillers (224.80 $\times10^3$ ha^{-1}) was recorded in Isd 35 followed (212.10 $\times10^3$ ha^{-1}) in Isd 36 which were statistically identical but significantly differed over Isd 30, Isd 32, Isd 34 and Isd 36. However cane variety Isd 32 produced highest number of millable cane (110.68$\times10^3$ ha^{-1}) followed by Isd 34 (92.70 $x10^3$ ha^{-1}) and Isd 35 (91.71 $x10^3$ ha^{-1}). The lowest number of millable cane was recorded in Isd 30 (76.35 $x10^3 ha^{-1}$) whose effect statistically significant over all other varieties. Again highest yield of 72.39 t ha^{-1} was obtained in Isd 32 followed by 64.00 t ha^{-1} in Isd 35. The yields of Isd 33, Isd 34 and Isd 35 were 63.38, 62.57 and 64.00 t ha^{-1} respectively and showed statistically similar. The lowest yield was found in Isd 36 (57.37 t ha^{-1}). In case of percentage of brix , Isd 35 was superior (20.20%) followed by Isd 36 (19.95%), which was statistically identical but they significantly differed over Isd 30, Isd 32, Isd 33 and Isd 34.

Chowdhury *et al.*, 1999 supported our results where they reported that different varieties with Isd 16, Isd 18, Isd 20, Isd 22 and Isd 28 produced different yield of 71.80, 58.50, 77.27, 72.63 and 42.09 t ha^{-1} respectively at different level of field trial. Rashid *et al.,* 1999 also reported that sugarcane varieties Isd 2/54 and L.J.C showed yields of 69.20 and 71.26 t ha^{-1}

respectively. It was revealed that newly released varieties had higher cane yields than that variety earlier.

The varieties tested in the present experiment produced much higher yield compared to national average of 41.60 t ha^{-1} (BBS, 1995) and there is a great scope to improve cane productivity by using newly released BSRI varieties in the High Bariand Tract under rainfed condition. From the present findings Isd 32 and Isd 33 may be recommended for commercial cultivation in Tigh Barind Tract under rainfed condition to ensure higher momentary income for the cane growers and also benefited to our country.

It may be concluded that the variety Isd 32 and Isd 33 produced significantly higher yield sugarcane yield and Isd 35 shown higher percent of brix in cane among all other tested varieties both the crop seasons. However, it is being found that all the newly released sugarcane varieties showed superiority in yield over national average. Thus, it can be suggested to cultivate these sugarcane varieties for sustainable production in High Barin Tract under rainfed condition.

REFERENCES

Anonymous 1979. Studies on cultivation methods for the newly released sugarcane varieties. F 176-177. Taiwan Sugar, 26(2):56.

Anonymous 1995. Year book of Agricultural Statistics. Dhaka. p.67

Barnes, A. C.1954. Agriculture of Sugarcane. Leonard Hill Ltd. 9 Eden Street, London pp.: 98-102.

Chowdhury, S. N. A., M. A. Kader, M. O. Goni, and M. A. Rashid. 1999. Yield performance of sugarcane varieties in differenttechnology based demonstration plots. Bangladesh J. Sugarcane. 21:85-88.

Humbert, R. P. 1959. The growing of sugarcane. Amesterdam: Elsevier Publishing Company. pp.:2-6.

Miah, M. A., A. Awal, M. A. Karim, and A. K. M. Azad. 1986. Performance of Some varieties/promising clones in the sandy soil of Setabganj Sugar Mills. Bangladesh J. Sugarcane. 8:61-63.

Miah, M. A., A.Awal, S. M. N. Nahar, Sk. A. Mannan, and M. Y. Ali. 1994. Performance of Some Promosing Clones and Released Varieties of Sugarcane in Himalayan Piedmont plain Soils. Bangladesh J. Sugarcane. 16:116-119.

Rashid, M. A., M. B. Ahmed, S. Rahman, and D. H. Scarisbrick. 1999. Effiect of different sources of settlings on yield and yield parameters of some selected sugarcane varieties. Bangladesh J. Sugarcane. 21:105-113.

Singh, P. and R. S. Sangwan. 1980. Studies on the genetic variability for stalk characters in sugarcane. Indian Sugar, 30: 409-412.

Steel, R. G. D. and J. H. Torrie. 1960. Principal and Procedures of Statistics. Mc Graw Hill, New York, 481p.

Yadava, R. L. 1993. Agronomy of Sugarcane. International Book Distributing Co., Lucknow. p.375.

Table-1 Performance of BSRI bred sugarcane varieties in respect of yield and yield attributes at High Barind Tract of Rajshahi area under rainfed condition , 2004-2005

Varieties	Germination (%)	No. of Tillers (10^3 ha^{-1})	No.of millable cane (10^3 ha^{-1})	Yield (t ha^{-1})	Brix (%)
Isd 30	35.24	209.41	51.29c	55.50b	18.60c
Isd 32	37.15	210.00	68.64b	64.70a	17.87d
Isd 33	34.54	196.37	81.71a	57.40b	18.72c
Isd 34	35.41	204.53	81.09a	48.40c	18.60c
Isd 35	34.20	202.09	68.22b	46.80c	21.85a
Isd 36	35.76	192.62	68.58b	49.80c	20.68b
Lsd (5%)	NS	NS	6.75	5.26	0.60

* In a column figures having similar letter do not differ significantly whereas figures with dissimilar letters differ significantly as per DMRT at 5% level of probability..

Table-2 Performance of BSRI bred sugarcane varieties in respect of yield and yield attributes at High Barind Tract of Rajshahi area under rainfed condition, 2005-2006

Varieties	Germination (%)	No. of Tillers (10^3 ha^{-1})	No.of millable cane (10^3 ha^{-1})	Yield (t ha^{-1})	Brix (%)
Isd 30	32.47c	166.20bc	76.35c	61.93bc	18.50b
Isd 32	37.83b	153.10c	110.68a	72.39a	17.25c
Isd 33	36.37b	126.50c	85.15bc	63.38b	18.75b
Isd 34	41.37a	160.40c	92.70b	62.57b	18.39b
Isd 35	40.47a	224.80a	91.71b	64.00b	20.20a
Isd 36	40.96a	212.10ab	108.47bc	57.37c	19.95a
Lsd (5 %)	2.53	46.26	11.93	4.56	1.00

* In a column figures having similar letter do not differ significantly whereas figures with dissimilar letters differ significantly as per DMRT at 5% level of probability..

SUGAR INDUSTRY ABSTRACTS

M. Awais Qureshi and Shahid Afghan
Shakarganj Sugar Research Institute, Jhang

A compact history of genetic transformation and its influence on crop development
B. I. Huckett

The term 'crop biotechnology' did not occur in the scientific literature in the 1970s and was sparse in the 1980s. In the following decade its occurrence increased by an order of magnitude, reflecting the dramatic way in which the new range of molecular genetic tools and novel approaches for investigating and manipulating living organisms influenced biological and agricultural research. Understanding and developing the process of genetic transformation was a key element in this movement, starting with studies of prokaryotic systems and advancing later to more complex ones. The trend is clearly continuing exponentially into the 21st century. Within the biotechnological revolution there have been many sub-developments producing novel biological insights, ultimately affecting crop production and strategic management of agriculture.

Production methods and farming systems of sugarcane under the fast track land reform programme in a semi-arid region in Zimbabwe
M. Shoko, S. I. Mkwamba, D. Tsingo and C. Shoko

In 2000 the Government of Zimbabwe adopted the fast track land reform programme (FTLRP) for the whole of the country. It therefore affected the South Eastern Lowveld that is the main sugarcane growing region, and the black settler farmers (A2 farmers) were given plots. A survey of the sugarcane production methods and farming systems by these A2 farmers was conducted in the area over two year, i.e. 2006 to 2008. The major objective of this study was to assess the contributions to sugar production from these small-holder farmers from 2003 to 2008. Another objective was to relate their practices to technical policy issues and institutional innovations. The research area included Hippo Valley, Mkwasine and Triangle, and 91 farms in the three areas were included in the study. The majority of farmers practiced monoculture cane production with insignificant plough-outs. Very low cane and sugar yields were obtained by more than 90%t of the farmers. The low yields are as a result of poor sugarcane agronomic practices and poor financial support from Government and other financiers. The A2 farmers also feel that the price of sugar has been discouraging. Ratoon stunting disease and smut were noted as the most economic diseases by the farmers.

"SCAMP" and "safegauge for nutrients': Two new decision support tools for minimising off-site movement of nutrients

Minimising the off-site movement of nutrients from sugarcane blocks is a priority management issue both from productivity and an environmental viewpoint. The Six Easy Steps approach to nutrient management in the sugar industry makes soil-specific nutrient recommendations and identifies appropriate management strategies by taking account of differences in key properties of individual soil types. SCAMP *(Soil* Constraints and Management Package) is a decision support framework that systematically derives soil-specific management strategies. SCAMP uses basic soil properties such as texture, pH,

organic carbon content, structure, consistence, drainage and permeability to identify soil constraints to productivity and to provide strategies for managing these constraints. SCAMP also identifies the likely pathway(s) of nutrient loss from the soil (runoff, drainage, denitrification) and suggests management strategies for minimising these losses. SCAMP is configured as an Access database, and printed soil/site reports of constraints and management options can be produced. SCAMP has also been interfaced to CIS software, and risk and hazard maps can be produced for issues such as nutrient loss pathway and soH acidification risk. To obtain a qualitative assessment of the risk of off-site nutrient movement from different fertilizer management strategies (fertilizer form, rate, placement and time of application), SCAMP has been interfaced to the decision support tool, SafeGauge for Nutrients (SfN). SfN is a user-friendly package with an interactive front-end that utilises site-specific soil and rainfall information embedded in the package together with user-entered fertilizer management details to display visually the risk of off-site nitrogen (N) and phosphorus (P) movement to surface water (by runoff), groundwater (by drainage) and the atmosphere (by denitrification) over the crop cycle. A printed report on the risk of individual fertilizer management strategies is produced. A powerful application of SfN is in awareness building because different fertilizer management scenarios can be compared for their effects on qualitative risk of off-site nutrient movement. These two science-based tools provide the sugar industry with capacity-building packages and the capability to produce reports that demonstrate appropriate and responsible nutrient management at the block scale.

Seasonal concentrations of leaf nutrients in Florida sugarcane

J. M. McCray, S. Ji, G. Powell, G. Montes, R. Perdomo, and Y. Luo

Leaf nutrient analysis is a useful diagnostic to complement soil testing in a nutrient management program for sugarcane *(Saccharum* spp) and other crops. A survey of commercial sugarcane fields in Florida was conducted from 2004-2006 with the objective of evaluating leaf nutrient concentrations in representative fields for trends in relation to published optimum ranges and changes within and across growing seasons and cultivars. We collected 389 leaf samples from 205 commercial fields. Fields were representative of plant cane, first ratoon, and second ratoon crops, mineral and organic soils, and major cultivars. Nutrients with highest incidence of deficiency on mineral soils were Si, N, Mg, and Fe and on organic soils were Si and Mn. Ratoon crops had more leaf nutrient concentrations below optimum than plant cane. Leaf Fe and Mn concentrations increased in samples taken in July-August during the rainy season (June-October) compared to samples taken in April-May because of increased reducing conditions from increased soil moisture. Leaf sample collection in June-July in Florida will be most useful in terms of evaluating the impact of all nutrients on sugarcane production and being early enough during the grand growth period to collect samples before lodging occurs.

Life table analysis and intrinsic rate of natural increase of *Micromus igorotus* Bank (Neuroptera: Hemerobiidae), a predator of sugarcane woolly aphid, *Ceratovacuna lanigera* Zehntner (Hemiptera: Aphididae)

S. K. Singh, G. M. Tripathi, Omkar and G. Mishra

The brown lacewing, *Micromus igorotus* Bank, is one of the potential and commonly used predaceous natural enemies being commercially reared for controlling sugar cane woolly aphid (SWA). The reproductive attributes, such as, pre-oviposition, oviposition, and post-oviposition periods, fecundity, percent egg-viability and mean reproductive rate, along with age-specific fecundity, and natality based demographic parameters of *M. igorotus* were investigated, using sugarcane woolly aphid, *Ceratovacuna lanigera* Zehntner as prey. Each

female deposited an average of 1712.80 ± 467.07 eggs during its life span. Age-specific fecundity was found to be triangular in function. The net reproductive rate ($R_{,,}$), intrinsic rate of increase (r_m) and generation time was 856.05, 0.21 day^{1} and 32.57 days, respectively. The high values of R_0 and r_m are attributed to the high female-biased sex ratio of the offspring, high survival and high net fecundity. Such high values allow the mass-multiplication of *M. igorotus* in the laboratory and suggest the possible successful establishment of this predator in the habitats containing *C. lanigera* infestations This further strengthens the possibility of it , being utilized as a sugarcane woolly aphid biocontrol agent.

Genetic control of yield related stalk traits in sugarcane
K. S. Aitken, S. Hermann, K. Karno, G. D. Bonnett, L. C. Mclntyre and P. A. Jackson,

A major focus of sugarcane variety improvement programs is to increase sugar yield, which can be accomplished by either increasing the sugar content of the cane or by increasing cane yield, as the correlation between these traits is low. We used a cross between an Australian sugarcane variety Q165, and a *Saccharum offcinarum* accession, IJ76-514, to dissect the inheritance of yield-related traits in the complex polyploid sugarcane. A population of 227 individuals was grown in a replicated field trial and evaluated over 3 years for stalk weight, stalk diameter, stalk number, stalk length and total biomass. Over 1,000 AFLP and SSR markers were scored across the population and used to identify quantitative trait loci (QTL). In total, 27 regions were found that were significant at the 5% threshold using permutation tests with at least one trait; individually, they explained from 4 to 10% of the phenotypic variation and up to 46% were consistent across years. With the inclusion of digeneic interactions, from 28 to 60% of the variation was explained for these traits. The 27 genomic regions were located on 22 linkage groups (LGs) in six of the eight homology groups (HGs) indicating that a number of alleles or quantitative trait alleles (QTA) at each QTL contribute to the trait; from one to three alleles had an effect on the traits for each QTL identified. Alleles of a candidate gene, *TEOSINTE BRANCHED I* (TB/), the major gene controlling branching in maize, were mapped in this population using either an SSR or SNP markers. Two alleles showed some association with stalk number, but unlike maize, 78 / is not a major gene controlling branching in sugarcane but only has a minor and variable effect.

Registration of 'L 79-1002' sugarcane
K. P. Bischoff, K. A. Gravois, T. E. Reagan, J. W. Hoy, C. A. Kimbeng, C. M. LaBorde and G. L. Hawkins

L 79-1002 (Reg. No. CV-132, PI 651501) sugarcane (a complex hybrid of *Saccharum officinarum* L., S. spontoneum L., S. barberi Jeswiet, and S. s/nense Roxb. amend. Jeswiet) was released on 26 Apr. 2007 by the Louisiana State University Agricultural Center in cooperation with the USDA-ARS and the American Sugarcane League, Inc. The cross for L 79-1002, a F, hybrid, was made in 1974 using 'CP 52-68' as the female parent and Tainan, a *S. spontoneum* clone, as the male parent. Initial clonal selection was done in single stools. Testing was done from 1976 through 1983 in yield trials conducted in the traditional sugarcane growing area in south Louisiana and in the colder, non-sugarcane growing regions of north Louisiana. Yield testing was resumed in 2002 through 2005 as interest in biofuels research renewed. L 79-1002 was released for an emerging biofuels industry because of its high fiber content and biomass (cane yield) potential. Average fiber content for L 79-1002 is approximately 257 g kg. The new cultivar also has excellent vigor and ratooning ability.

Experiments conducted at Bossier City, Louisiana (32.1° N lat) indicated a broader range of adaptability than sugarcane cultivars grown for the production of sucrose.

Registration of 'CP 00-1 101' sugarcane
Robert A. Gilbert, Jack C. Comstock, Barry Glaz, Serge J. Edme, R. Wayne Davidson, Neil C. Glynn, Jimmy D. Miller and Peter Y. RTai

'CP 00-1 101' (Reg. No. CV-130, PI 651881) sugarcane (a complex hybrid of *Saccharum* spp.) was developed through cooperative research conducted by the USDA-ARS, the University of Florida, and the Florida Sugarcane League, Inc., and was released to growers in Florida in September 2007. CP 00-1 101 was selected from a putative self-cross of' CP 89-2143" made at Canal Point, FL, in January 1998. CP 89-2143 is a major sugar-cane cultivar in Florida. CP 00-1 101 was released because of its high plant cane and ratoon yields of cane and commercial recoverable sucrose on organic and sand soils, and its resistance to smut [caused by *Ustilago scitaminea* (Sydow & P. Sydow)], brown rust (caused by *Puccinia melanocephala* H. & P. Sydow), orange rust (caused by *Puccinia kuehnii* E.J. Butler), leaf scald (caused by *Xanthomonas albilineans* Ashby, Dowson), *Sugarcane mosaic virus* strain E (mosaic), and ratoon stunting disease (caused by *Clavibacter xyli* subsp. Xy// Davis) in Florida.

Evaluation of sugarcane *Saccharum spontaneum* progeny for biomass composition and yield components
Li-Ping Wang, Phillip A. Jackson, Xin Lua, Yuan-Hong Fan, John W. Foreman, Xue-Kuan Chen, Hai-Hua Deng, Cheng Fu, Li Ma and Karen S. Aitken

Saccharum spontaneum L. has contributed important traits to modern sugarcane (S. spp. L.) cultivars such as adaptation to environmental stress and ratooning ability. There is interest in further use of *S. spontaneum* in sugarcane improvement for sugar or energy-from-biomass production systems. In this study, parents and progeny from 43 biparental crosses between sugarcane and *S. spontaneum* clones were evaluated in field trials in China and Australia, along with several commercial cultivars. The *S. spontaneum* clones were from diverse geographic origins in China. Measurements were made on biomass composition (% dry matter, brix and pol in juice and cane, purity, fiber content) and yield components. Moderate to high (>0.7) broad-sense heritabilities and high genetic variances were observed for most traits. About half the total genetic variance was retained as among-family variance for the biomass composition traits, but this proportion was generally <25% for biomass yields. Midparent values in an independent trial predicted biomass composition traits reasonably well (generally, $r > 0.6$), but less so for cane and biomass yield ($0 < r < 0.4$). Genetic correlations between performances of families evaluated in different countries were strong, providing preliminary evidence that results in one country could be used for identifying elite families in the other. Strategies for efficient development and selection of elite clones from *S. spontaneum* are suggested.

Location contributions determined via GGE biplot analysis of multienvironment sugarcane genotype-performance trials
Barry Glaz, and Man Jit S. Kang

Selection for productive sugarcane *(Saccharum* spp.) cultivars in Florida has been more successful for organic than for sand soils. The objectives of this study were to assess the

contributions of a sand-soil location to the final stage of multienvironment testing of sugarcane genotypes in Florida, and to identify locations with organic soils that, if replaced with a sand-soil location, would be least likely to compromise superior cultivar selection for organic soils in Florida. Sixteen genotypes were harvested in two or three crop cycles from 2002 to 2005 at nine locations. Traits analyzed were cane and sucrose yields (t ha^{-1}) and theoretical recoverable sucrose (TRS) (g kg^{-1}). The sand-soil location, Lykes, was generally neither highly representative of locations nor highly discriminating of genotypes. Results revealed the desirability of replacing an organic-soil location with a sand-soil location in the final testing stage of this sugarcane breeding and selection program. Caution must be exercised, however, to ensure that such action would not compromise genotype discrimination for TRS and sucrose yield. Ability to identify productive cultivars on organic soils by the Florida sugarcane selection program would be least compromised by replacing either Osceola or Knight with a sand-soil location.

A comparison of growth and sucrose metabolism in sugarcane germplasm from Louisiana and Hawaii

Sarah E. Lingle, and Thomas L. Tew

Sugarcane (Sacchorum sp. hybrids) genotypes bred in Hawaii are selected for maximum tonnage in a 2-yr production cycle and contain *S. robustum* germplasm. Genotypes bred in Louisiana are selected for high early sucrose yield after a 9-month growing season, and contain *S. spontoneum* germplasm. We compared growth, sugar concentration, and enzymes of sucrose metabolism in four internodes of four Hawaii (HI) and two Louisiana (LA) genotypes during grand growth and ripening. On average, Sucrose concentrations were higher in LA than HI genotypes, especially at ripening. Fresh weight activities of soluble acid invertase (SAI) and neutral invertase (Nl) were not different among genotypes at either growth stage. Significant differences in activities of sucrose synthase (SuSy), sucrose-phosphate synthase (SPS), and cell wall acid invertase (CWIN) among genotypes were not consistent between types. Sucrose concentration, total sugar concentration, and sucrose: total sugar ratio in the internodes were negatively correlated with water content, SAI activity, and Nl activity, and positively correlated with the difference between SPS and SAI activity. These correlations seem to be a function of internode maturity. The consistent differences in sucrose content between LA and HI genotypes indicate the Louisiana and Hawaii breeding programs have produced very different genotypes, but these differences cannot be explained by differences in enzyme activities.

New role of phenylpropanoid compounds during sugarcane micropropagation in Temporary Immersion Bioreactors (TIBs)

Ariel D. Arencibia, Aydiloide Bernal, Liu Yang, Leidy Cortegaza, Elva R. Carmona, Alicia Perez, Chun-Jin Hu, Yang-Rui Li, Carlos M. Zayas, and Ignacio Santana

The genomic characterization of sugarcane plants has been achieved by suppressing key genes of the phenylpropanoid pathway; as a result, a new function of phenolic metabolites has been characterized during micropropagation in TIBs. Genes related to cell metabolism and development (10), plant defenses (9), phenyl-propanoids (7), methyl jasmonate response (5), ethylene (5), oxidative burst (3) and, auxins (3) pathways, among others (8) were found to be induced in sugarcane plants micropropagating in TIBs with phenolic metabolites, supporting that phenyl-propanoids might act as elicitor molecules of others biochemical pathways. During adaptation to natural conditions, plants micro-propagated in TIBs with highest levels of phenolics displayed an increased number of functional roots, a high growth

rate and, an early ability to be colonized by the natural sugarcane endophytic Gluconocetobocter diozotrophicus.

Gamma Irradiation of embryogenic callus cultures and in vitro selection for salt tolerance in sugarcane (*Sacchorum offfcinarum* L.)
Vikas Y Patade, P Suprasanna, and VA Bapata

Radiation induced mutagenesis followed by in vitro selection was employed for salt tolerance in popular Indian sugarcane (*Sacchorum officinarum* L.) cv. CoC-671. Embryogenic calli were gamma irradiated and exposed to different levels of NaCI (42.8,85.6, 128.3, 171.1, 213.9, 256.7, 299.5, or 342.2 mM). The relative growth rate (RGR) decreased progressively with increasing salt stress and was the least with a salt stress of 256.7 mM (0.25 ± 0.009), almost 10 fold lesser than the control. The RGR was significantly lower in 85.6 mM and higher salt stressed calli than the control. The survival percent also decreased, with an increase in NaCI concentration. In case of 10 and 20 Gy irradiated calli, regeneration was observed up to 85.6 mM NaCI selection, medium, whereas, higher treatments (128.3 mM and beyond) exhibited browning initially. However, in the subsequent subcultures, regeneration was obtained in the case of 10 and 20 Gy irradiated calli on 128.3 and 171.1 mM NaCI selections. Higher dose of gamma irradiation (40 Gy) also showed regeneration, but only with 85.6 mM NaCI selection. The unirradiated calli regenerated the highest number of plantlets followed by 10 and 20 Gy irradiated calli on salt selection. A total of 147 plantlets were selected from different salt levels. The salt selected plants are being tested for their field performance.

Effect of exogenous arginine on sugarcane *(Saccharum* sp.) somatic embryogenesis, free polyamines and the contents of the soluble proteins and proline
N. Nieves, F. Sagarra, R. Gonzalez, Y. Lezcano, M. Cid, M. A. Blanco and R. Castillo

The aim of this study was to evaluate the effect of arginine on sugarcane (Saccharum sp.) somatic embryogenesis, free polyamines and other nitrogenous compounds contents. Segments of leaves were used as explants to establish embryo-genie cultures on media with 0 and 50.0 mg I" I arginine. Somatic embryos formation and free polyamines, free proline and total soluble proteins contents were compared. Arginine significantly induced sugarcane somatic embryogenesis. Free proline and protein levels determined in embryogenic cell masses during embryo differentiation-maturation, showed an arginine-induced promotion associated to the enhancement of the embryogenic process. In addition, free putrescine and, in a minor extent, spermidine and spermine contents were enhanced by arginine.

Regulation of photosynthesis by sugars in sugarcane leaves
Alistair James McCormick, Michael D. Cramer, and Derek A. Watt

In sugarcane, increased sink demand has previously been shown to result in increased photosynthetic rates that are correlated with a reduction in leaf hexose concentrations. To establish whether sink limitation of photosynthesis is a result of sugar accumulation in the leaf, excision and cold-girdling techniques were used to modify leaf sugar concentrations in pot-grown sugarcane In excised leaves that were preincubated in darkness for 3h, sucrose accumulation was reduced but accumulated again upon transfer to the light, while hexose concentrations remained lower than in controls (7.7 |omol mg'^{1} FW versus 18.6 ^mol mgol mg^{-1} FW versus 18.6 fimol mg^{-1} FW hexose in controls). These results were associated with a

66% and 59% increase in photosynthetic assimilation (A) and electron transport rate (ETR), respectively, compared to controls maintained in the light. Similar increases in photosynthesis were observed when dark-treated leaves were supplied with 5 mM sorbitol, but not when supplied with 5 mM sucrose. Further analyses of ^{14}C-labeled sugars indicated rapid turnover between sucrose and hexose. Cold-girdling (5°C) increased sucrose and hexose levels and resulted in a decline of photosynthetic rates over 5d (48% and 35% decline in assimilation rate and ETR, respectively). These sugar-induced changes in photosynthesis were independent of changes in stomatal conductance. This study demonstrates that the down-regulation of photosynthesis in response to culm sugar accumulation reported previously could be due to the knock-on effect of accumulation of sugar in leaf tissue, and supports the contention that hexose, rather than sucrose, is responsible for the modulation of photosynthetic activity.

Culm sucrose accumulation promotes physiological decline of mature leaves in ripening sugarcane

A. J. McCormick M. D. Cramer, and D. A. Watt

Photosynthetic activity in C^4 sugarcane has been suggested to be regulated by the demand for photoassimilate from sink tissues, including culm storage of sucrose and other components of the plant (e.g. roots and shoot primordia). This study examined the extent to which sink-demand influences leaf photosynthetic activity and controls leaf turnover in field-grown sugarcane. To increase sink-demand on selected leaves, plants were defoliated apart from the immature leaf before the first fully expanded leaf (2nd leaf) and the mature 8th leaf. Changes in leaf gas exchange and fluorescence characteristics were recorded for both leaves over a 28d period. Variations in leaf and culm sucrose and hexose concentrations and allocation of ^{14}C-labelled photosynthate were also measured. A decrease in culm internodal sucrose concentrations in partially defoliated plants was associated with significant increases in assimilation (A) and electron transport rates (ETR) for both leaves 2 and 8. Conversely, accumulation of sucrose in the culms of control plants was related to a decline in photosynthetic rates in leaf 8 during the treatment period. Leaves 2 and 8 of defoliated plants (27 d) were characterised by an increase in partitioning of ^{14}C to mature and immature internodes, respectively, compared to control plants. In addition, hexose levels in leaves of defoliated plants decreased significantly (36% and 48% decrease in leaves 2 and 8, respectively) compared to corresponding leaves of untreated controls over the duration of the experiment, indicating that the signaling mechanisms regulating the decline in leaf photosynthetic activity are likely hexose-mediated. It was concluded that leaf physiological ageing in sugarcane was promoted by sucrose accumulation during culm maturation as a consequence of decreased sink-demand for photosynthate.

Sugarcane phosphoribosyl pyrophosphate synthetase: molecular characterization of a phosphate-independent PRS

Susana Andrea Sculaccio, Hamilton Barbosa Napolitano, Leila Maria Beltramini, Glaucius Oliva, Emanuel Carrilho and Otavio Henrique Thiemann

Phosphoribosyl pyrophosphate synthetase (PRS-EQ2.7.6.1) is an important enzyme present in several metabolic pathways, thus forming a complex family of isoenzymes. However, plant PRS enzymes have not been extensively investigated. In this study, a sugarcane prs gene has been characterized from the Sugar Cane Expressed Sequence Tag Genome Project. This gene contains a 984-bp open reading frame encoding a 328-amino acid protein. The predicted amino acid sequence has 77% and 78% amino acid sequence identity to *Arabidopsis*

thaliana and Sp/'nocio *oleracea* PRS4, respectively. The assignment of sugarcane PRS as a phosphate-independent PRS isoenzyme (Class II PRS) is verified following enzyme assay and phylogenetic reconstruction of PRS homologues. To gain further insight into the structural framework of the phosphate independence of sugarcane PRS, a molecular model is described. This model reveals the formation of two conserved domains elucidating the structural features involved in sugarcane PRS phosphate independence. The recombinant PRS retains secondary structure elements and a quaternary arrangement consistent with known PRS homologues, based on circular dichroism measurements.

Estimating sugarcane root length density through root mapping and orientation modelling

Jean-Louis Chopart, Silvia Rosa Rodrigues, Mateus Carvalho de Azevedo and Cristiane de Conti Medina

Root length density (RLD) is a key factor in crop functioning. A field method was developed to quantify RLD of sugarcane from root intersection density (RID) taking root orientations into account. RIDs were observed on three perpendicular soil planes and RLD was measured for the enclosed volume. RID and RLD of thick and fine roots were measured separately. These measurements were replicated at different ages and sites to test models describing RLD according to RID. Fine roots were nearly isotropic and thick roots had a preferential orientation, i.e. horizontal near the surface and becoming progressively vertical in deeper horizons. Relationships in thick roots were modelled according to CO_t: $RLD_t = RID_t . CO_t$ (CO_t: root orientation coefficient, ranged from 1.3 to 4.9 for thick roots). For fine roots ($_f$), CO_f=2.This theoretical model led to differences between measured and calculated RLD.The ratio between measured and calculated RLD_f (CE_f) increased from I to 3 with RID_f. CEj was introduced as an additional coefficient in the model: RLD_f=2. Nl_f. CEf. Intermediate results were obtained for all (a) roots: CO_a and CEa were both dependent on RID_a, therefore: $RLD_a = Nl_a . CO_a . CE_a$. The models were validated with independent datasets from Brazil and France. These allowed a more robust prediction of RLD than direct regressions between RID and RLD. They may estimate RLD from RID in soil profiles by root mapping while taking RLD spatial variability into account.

The reduction of starch accumulation in trans-genic sugarcane cell suspension culture lines

Stephanus J. Ferreira, Jens Kossmann, James R. Lloyd, Jan-Hendrik Groenewald,

Starch only occurs in small amounts in sugarcane, but is, nevertheless an unwanted product because it reduces the amount of sucrose that can be crystallized from molasses. In an attempt to reduce the starch content of sugarcane, the activities of ADP-glucose pyrophos-phorylase (AGPase) and (3-amylase were manipulated using trans-genic approaches. Transformation vectors to reduce AGPase activity and to increase plastidial p-amylase activity were constructed and used for the transformation of sugarcane calli. The results of the manipulations were analyzed in suspension cultures. AGPase activity was reduced down to between 14 and 54% of the wild-type control. This led to a reduction in starch concentration down to 38% of the levels of the wild-type control. (5-Amylase activity was increased in the transgenic lines by 1.5-2 times that of the wild-type control. This increase in activity led to a reduction in starch amounts by 90% compared to wild-type control cells. In both experiments, the changes in starch concentrations could be correlated with the change in enzyme activity. There were no significant effects on sucrose concentrations in either experiment, indicating that these approaches might be useful to engineer regenerated

sugarcane for optimized sucrose production 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 1*2%* if a resistant variety is grown.

Re-evaluation of sugarcane borer (Lepidoptera: Crambidae) bioeconomics in Louisiana
Effects of entomopathogenic bacterium *Photorhabdus* temperate infection on the intestinal microbiota of the sugarcane stalk borer *Diatraea saccharalis* (Lepidoptera: Crambidae)

Ci'ntia N.B. Carneiro, Renato A. DaMatta, Richard I. Samuels and Carlos *P.* Silva
W. H. White, R. R Viator, E.G. Dufrene, C.D. Dalley, E.R Richard Jr. and T. L Tew

The sugarcane borer, *Diatraea saccharalis* (F.) (Lepidoptera: Crambidae), is the key insect pest of sugarcane, *Saccharum* 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 yield sugar 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 Photorhabdus temperata is an entomopathogenic bacterium that is associated with nematodes of the Heterorhabditidae family in a symbiotic relationship. This study investigated the effects of *P. temperata* infection on the intestinal microbiota of the sugarcane stalk borer *Diatraea saccharalis.* Histopathology of the infection was also investigated using scanning electron microscopy. Groups of 20 larvae were infected by injection of approximately 50 bacterial cells directly into the hemocoel. After different periods of infection, larvae were dissected and different tissues were used for bacterial cell quantification. *P. temperata* was highly virulent with an LD_{50} of 16.2 bacterial cells at 48 h post-infection. Infected larvae started dying as soon as 30 h post-infection with a LT_{SO} value of 33.8 h (confidence limits 32.2-35.6) and an LT90 value of 44.8 h (CL 40.8-51.4). Following death of the larvae, bacteria from the midgut did not invade the hemocoel. In the midgut epithelium, *P. temperata* occupied the space underneath the basal lamina. The cultivable intestinal bacterial populations decreased as soon as I h post-infection and at 48 h post-infection, 90% of the gut microbiota had died. The role of *P. temperata* in control of the midgut microbiota was discussed.

Production of a His-tagged canecystatin in transgenic sugarcane and subsequent purification

Carolina W. Ribeiro, Andrea Soares-Costa, Maria Cristina Falco, Sabrina M. Chabregas, Eugenio C. Ulian, Simone S. Cotrin, Adriana K. Carmona, Lucimeire A. Santana, Maria Luiza V. Oliva, Flavio Henrique-Silva

Transgenic plants have been used widely as expression systems of recombinant proteins in recent years. This process can be an efficient alternative for the large-scale production of proteins. In this work, we present the establishment of transgenic sugarcane expressing a His-tagged canecystatin under the control of the maize ubiquitin promoter. A number of studies have demonstrated that cystatins, which are natural inhibitors of cysteine proteinases, can be used for protection against insect attacks. A transformed sugarcane plant that presented high levels of $_{HB}$CaneCPI-l expression, was selected for the purification of this protein through affinity chro-matography in a nickel column. This purified $_{H/s}$CaneCPI-l was immunodetected using a polyclonal antibody, which was also able to detect the $_{HK}$CaneCPI-l in a crude extract from transgenic plant leaves. Assays of inhibitory activity performed with the purified $_{H/s}$CaneCPI-1 revealed its ability to inhibit the catalytic activity of midgut cysteine proteinase partially purified from the sugarcane weevil *Sphenophorus levis* and human cathepsin L in nanomolar order. These studies demonstrate that sugarcane is a viable expression system for recombinant protein production.

Verifying an Fl screen for identification and quantification of rare *Bacillus thuringiensis* resistance alleles in field populations of the sugarcane borer

Bisong Yue, Fangneng Huang, B. Rogers Leonard, Steven Moore, Roy Parker, David A. Andow, Don Cook, Karla Emfinger and Donna R. Lee

Using an FI screen, 352 feral individuals of the sugarcane borer, *Diatraea saccharalis* (F.) (Lepidoptera: Crambidae), were examined for the presence of *Bacillus thuringiensis* (Bt)-resistance alleles. These insects represented four geographical populations collected in central and northeastern Louisiana, USA, and one field population from the Gulf Coast area of Texas, USA, during 2006.The F! screen used various crosses between field-collected insects and a laboratory strain of Cry I Ab-resistant *D. saccharalis*, including both reciprocal crosses and group mating. FI neonates of the crosses were screened for Bt resistance on Bt maize leaf tissue. One field-collected individual of *D. saccharalis* was shown to have a Bt-resistance allele. Based on Bayesian analysis procedures, the Bt-resistance allele frequency in the five populations of *D. saccharalis* was 0.0028 with a 95% confidence interval of 0.0003-0.0079. The successful identification of a resistance allele in a field collection of insects suggests that the FI screening technique could be an effective tool for detecting and monitoring rare Bt-resistance alleles in field populations of *D. saccharalis.*

Identification of three genotypes of sugarcane *yellow leaf virus* causing yellow leaf disease from India and their molecular characterization

R. Viswanathan, M. Balamuralikrishnan and R. Karuppaiah

Sugarcane yellow leaf virus (SCYLV) that causes yellow leaf disease (YLD) in sugarcane (recently reported in India) belongs to *Polerovirus.* Detailed studies were conducted to characterize the virus based on partial open reading frames (ORFs) I and 2 and complete ORFs 3 and 4 sequences in their genome. Reverse-transcriptase polymerase chain reaction (RT-PCR) was performed on 48 sugarcane leaf samples to detect the virus using a specific set of primers. Of the 48 samples, 36 samples (field samples with and without foliar symptoms)

including 10 meristem culture derived plants were found to be positive to SCYLV infection. Additionally, an aphid colony collected from symptomatic sugarcane in the field was also found to be SCYLV positive. The amplicons from 22 samples were cloned, sequenced and acronymed as SCYLV-CB isolates. The nucleotide (nt) and amino acid (aa) sequence comparison showed a significant variation between SCYLV-CB and the database sequences at nt (3.7-5.1%) and aa (3.2-5.3%) sequence level in the CP coding region. However, the database sequences comprising isolates of three reported genotypes, viz., BRA, PER and RED, were observed with least nt and aa sequence dissimilarities (0.0-1.6%). The phylogenetic analyses of the overlapping ORFs (ORF 3 and ORF 4) of SCYLV encoding CP and MP determined in this study and additional sequences of 26 other isolates including an Indian isolate (SCYLV-IND) available from GenBank were distributed in four phylogenetic clusters. The SCYLV-CB isolates from this study lineated in two clusters (CI and C2) and all the other isolates from the worldwide locations into another two clusters (C3 and C4). The sequence variation of the isolates in this study with the database isolates, even in the least variable region of the SCYLV genome, showed that the population existing in India is significantly different from rest of the world. Further, comparison of partial sequences encoding for ORFs I and 2 revealed that YLD in sugarcane in India is caused by at least three genotypes, viz., CUB, IND and BRA-PER, of which a majority of the samples were found infected with Cuban genotype (CUB) and lesser by IND and BRAPER genotypes. The genotype IND was identified as a new genotype from this study, and this was found to have significant variation with the reported genotypes.

Evolutionary relationship between defensins in the Poaceae family strengthened by the characterization of new sugarcane defensins

V. S. De-Paula, G. Razzera, L Medeiros, C. A. Miyamoto, M. S. Almeida, E. Kurtenbach, F. C. L. Almeida and A. *P.* Valente

Plant defensins are small (45-54 amino acids), highly basic, cysteine-rich peptides structurally related to defensins of other organisms, including insects and mammals. Small putative proteins (MW < 10 kDa) containing eight cysteines were screened based on the sugarcane expressed sequence tag (EST) database. We selected ORFs that exhibited 25-100% similarity in primary sequence with other defensins in the NCBI database and that contained eight cysteines. This similarity is sufficient for folding prediction, but not enough for biological activity inference. Six putative defensins (Sd I -6) were selected, and activity assays showed that recombinant Sd I, Sd3 and SdS are active against fungi, but not against bacteria. Structural characterization, based on circular dichroism (CD) and nuclear magnetic resonance (NMR) spectroscopy showed that the structures of these Sds were compatible with cx/P proteins, a feature expected for plant defensins. Phylogenetic analysis revealed that sugarcane defensins could clearly be grouped within defensins from Poaceae family and Andropogoneae tribe. Our work demonstrates that defensins show strong conservation in the Poaceae family and may indicate that the same conservation occurs in other families. We suggest that evolutionary relationships within plant families can be used as a procedure to predict and annotate new defensins in genomes and group them in evolutionary classes to help in the investigation of their biological function.

Sugarcane glycoproteins bind to surface, specific ligands and modify cytoskeleton arrangement of *Ustilago scitaminea* teliospores

Ana-Mara Millanes; Carlos Vicente and Mara-Estrella Legaz

Inoculation of sugarcane plants, cv. Jaronu 60-5, with teliospores of *Ustilago scitaminea* increased the production of sugarcane glycoproteins of high molecular mass (HMMG) and decreased the amount of those of mid-molecular mass (MMMG) recovered from stalks cell-free extracts. Whereas sugarcane glycoprotein of healthy plants totally inhibited the production of fungal mycelium from teliospores, mycelium growth was slightly affected by MMMG, and drastically diminished by HMMG obtained from inoculated plants. The adhesion of sugarcane glycoproteins to fungal teliospores produced cell aggregation. This effect was clearly reduced by incubating teliospores in buffer containing HMMG or MMMG previously digested with invertase. Sugarcane arginase associated to MMMG was retained by teliospores, whereas the enzymatic activity associated to HMMG from inoculated plants increased. Chitinase was not significantly retained by teliospores. Only HMMG and MMMG obtained from healthy plants were able to inhibit cell polarity in some extent. Smut induced changes in the composition of HMMG and MMMG. Some of these new glycoproteins are able to inhibit cell polarity. Since receptors, isolated from the cell wall of smut teliospores, were eluted from activated agarose beads by N-acetyl-D-glucosamine, we concluded that the peptide fraction of HMMG and MMMG bind to this amino sugar in the polysaccharide moiety of smut ligands.

Influence of nonoptimal ripener applications and post harvest residue retention on sugar-cane second ratoon yields

Ryan P. Viator, Richard M. Johnson, Edward P. Richard, Jr. Herman L. Waguespack and Windell Jackson

Retention of sugarcane (interspecific hybrids of *Saccharum* spp.) post harvest residue and certain glyphosate ripener application regimes may independently reduce yields of the subsequent ratoon crop in wet climates. The objective of this experiment was to determine the effects of ripener application and ripener treatment to harvest intervals (THI) on yields of the treated first ratoon, and the combined effects of these treatments and postharvest residue retention on the subsequent second ratoon. Whole plots consisted of either a nontreated control or 0.21 kg a.e. ha^{-1} glyphosate applied to the first ratoon of cultivar LCP 85-384. Split-plots consisted of THI of 40,50, and 60 d for all plots. Split-split plot treatments consisted of partial removal of post harvest residue or complete retention for second ratoon. Averaged across all this for the first ratoon, glyphosate increased sucrose yield by 300 kg ha^{-1} compared with the control. The 60 d THI reduced second ratoon cane and sucrose yields by 5.4 Mg ha^{-1} and 900 kg ha^{-1}, respectively, compared with the means of the 40 and 50THI and sucrose yields by 300 kg ha~' compared with the control. Full residue retention reduced second ratoon cane and sucrose yield by 2.3 Mg ha^{-1} and 300 kg ha^{-1}, respectively, compared with partial removal. Residue retention and glyphosate application were not negatively synergistic. Producers should remove postharvest residue from the row top and harvest ripener-treated cane at a THI of 40 to 50 d to maximize sucrose yields in the first ratoon while also preventing yield losses in the subsequent second ratoon.

Sugarcane response to nitrogen fertilization on a Histosol with shallow water table and periodic flooding

B. Glaz, ST. Reed and J. RAIbano

In sugarcane juice or raw sugar, ash refers to soluble inorganic salts. The ratio of ash/impurity is important because high levels reduce sucrose extraction in sugar mills and the market value of raw sugar. The aim of research reported here was to examine, through a series Sugarcane *(Saccharum* spp.) is increasingly exposed to periodic floods and shallow

water tables on Histosols in Florida's Everglades Agricultural Area (EAA). In the past, when these soils were usually well drained, they provided excess N for sugarcane through microbial oxidation. It is not known if supplemental N would now improve yields because microbial oxidation is reduced by shallow water tables and periodic floods. The purpose of this study was to evaluate the effects of N fertilizer rates on two sugarcane cultivars exposed to a 25-cm water-table depth with and without repeated 2-day floods. Two studies were planted in containers in 2001 and 2002 with two sugarcane cultivars and five equally spaced rates of N fertilizer from 0 to 200 kg ha^{-1}. Leaf, stalk and root weights were reduced by periodic flooding and the magnitude of the reduction sometimes differed between cultivars. Plant weights, leaf chlorophyll content (SPAD) and leaf N content were often highest near an N rate of 100 kg t/ha. Usually, N fertilizer rate did not interact with water treatment. Nitrogen fertilization may be useful for sugarcane exposed to water-table depths of 25 cm with and without 2-day repeated floods on EAA Histosols.