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Productivity and economics of sugarcane (*Saccharum officinarum*)-based production systems in subtropical India

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ABSTRACT

A field experiment was conducted at the Indian Institute of Sugarcane Research, Lucknow, during 1996–98 and 1998–2000 with 3 cropping systems, viz. wheat *(Triticum aestivum* L. emend. Fiori & Paol.)–sugarcane (*Saccharum officinarum* L.), sunflower (*Helianthus annuus* L.) + sugarcane and sunflower–sugarcane, and 3 planting materials for sugarcane (conventional 3-bud setts; setts obtained from 750 ppm a.i. ethephon sprayed solution in seed cane 10 days before planting and polythene bag-raised settlings–PBS). The highest number of millable canes (158,700/ha), cane yield (116.9 tonnes/ha) and cane-equivalent yield (145.9 tonnes/ha) were obtained when sugarcane (ethephon sprayed) was planted with spring sunflower. Sugarcane intercropping with sunflower increased 41.43% cane yield (111 tonnes/ha) over sunflower–sugarcane system. Sunflower + sugarcane (CP) system produced taller cane (214 cm) than other systems. Use of polythene bag-raised settlings increased the cane yield by 17% in wheat–sugarcane system. The variation in cane yield was observed due to variation in date of planting under different systems. Sugarcane + sunflower (ethephon sprayed) system also produced the highest number of millable canes (159,000) and cane yield (72.9 tonnes/ha) in subsequent ratoon. Sugarcane (ethephon sprayed) + sunflower system fetched highest net return (Rs 78,000/ha) and benefit : cost ratio (3.27). However, for late planting conditions in wheat–cane system the use of polythene bag-raised settlings was found quite remunerative (Rs 69,596/ha net return and benefit : cost ratio 3.16)

Key words : Sugarcane with sunflower, Wheat–sugarcane, Sugarcane-equivalent yield, Ratoon yield

A drastic reduction in sugarcane yield ranging from 30 to 50% is a common feature when the sugarcane is planted in summer after the harvest of wheat crop. High to very high temperature at time of planting and germination, low humidity, over-matured seed cane, little time for tillering, heavy infestation of weeds and insect-pests are the major factors responsible for poor cane yield of summer-planted cane (Shahi, 2001).

Tillering is an important growth phase in sugarcane influenced by environmental factors like light, temperature as well as management practices, i.e. application of fertilizers and growth-regulating chemicals (Yadav and Prasad, 1987). Use of plant growth-regulators, viz. etherel (2 chloro ethyl phosphoric acid) improved sprouting of sugarcane setts and tillering. Use of polythene bag-raised settlings encounters the effect of late sugarcane planting (Kumar and Lal, 1993). The problem could, however, be tackled either by advancing the planting time of sugarcane coinciding with sowing of spring sunflower or by using polythene bag-raised settlings. This could also be achieved by accelerating the bud sprouting in seed cane through chemical treatment.

MATERIALS AND METHODS

A field experiment was conducted at the Indian Institute of Sugarcane Research, Lucknow, during 1996–98 and 1998–2000 with 3 cropping systems, viz. wheat–sugarcane, sunflower + sugarcane and sunflower–sugarcane, and 3 planting materials for sugarcane (conventional 3-bud setts, setts obtained from ethephon @ 750 ppm ai solution-sprayed seed cane - 10 days before planting and polythene bag-raised settlings–PBS). In all, 8 treatments were evaluated in randomized block design with 4 replications. The investigation aimed at advancing the growth phase of sugarcane in different cropping systems necessitated under late planting conditions. The fertilizer schedules included N, P_2O_5, K_2O@150, 60, 60 for sugarcane; 80, 40, 40 for sunflower and 120, 60, 60 kg/ha for wheat. The soil was loamy in texture with low available N (190 kg/ha), and medium in phosphorus (12.6 kg P/ha) and potassium content (220 kg K/ha), with pH 7.60.

Polythene bag-raised settlings of 1 month age were transplanted as per the treatments. Sugarcane was planted in February (sugarcane + sunflower system), April (wheat–sugarcane system) and first week of June (sun-

flower–sugarcane system) under respective cropping systems. The row spacings of sugarcane (var. 'CoLK 8102'), sunflower (cv. 'Jwalamukhi') and wheat (cv. 'HD 2285') were kept at 60, 60 and 23 cm, respectively, in sole stand. In spring season, sugarcane and sunflower were planted in 1:1 row arrangement. Harvesting of sugarcane plant crop was done on 12 March 1998 during the first and second season respectively. Ratoon of sugarcane was also raised (1999–2000) after the second crop cycle with recommended package of practices. A dose of 187.5 kg N/ha was applied to ratoon crop. The ratoon crop was harvested on 15 December 2000. Cane-equivalent yield was calculated based on market price of sugarcane (Rs 74 and 80/q during the first and second cropping seasons respectively), sunflower (Rs 1,500/q during both the seasons) and wheat (Rs 475 and 550/q during first and second cropping seasons respectively).

RESULTS AND DISCUSSION

Plant cane

Spring (February) planting resulted in the highest number of millable canes (158,700) in sugarcane + sunflower (ethephon-sprayed seed cane) cropping system (Table 1). This was at par with sugarcane conventional planting (CP) + sunflower. There was an increase of 9.96% millable canes when sugarcane was grown in association with sunflower compared to its succession due to maximum period available for tillering in former case. Highest cane yield was obtained when ethephon-sprayed cane was planted with sunflower in February which increased the cane yield by 20.57% over wheat–sugarcane (PBS) system indicating that use of polythene bag-raised settlings under late planting situations could not compensate the yield loss. However, the cane yield improvement in sunflower + sugarcane (CP) system was only 8.4%. On the other hand, spraying of ethephon increased cane yield by 11.2%. Sugarcane intercropping with sunflower increased 41.43% cane yield (111 tonnes/ha) over sunflower–sugarcane system. In wheat–sugarcane system, polythene bag-raised settlings improved the cane yield by 17% over conventional planting, whereas ethephon spraying in seed cane could increase the yield only by 9.4%.

Pole per cent juice did not differ significantly due to different treatments (Table 1). Sugarcane requires a wide range of temperature (10–15°C), low relative humidity (50–60%) with bright sunshine for better sucrose synthesis (Srivastava, 2000). Thus the effect of planting season could be adhered on sucrose content. It was due to its temperature dependent phenomenon. Early planting in different cropping systems produced vigorous cane. Sunflower + sugarcane (CP) system produced taller cane (214 cm) than the other systems, but cane diameter (2.45 cm) was the highest with ethephon-sprayed seed cane intercropped with sunflower. It was due to longer period of growth under sunflower + sugarcane system compared to other systems. These results are in close conformity with the find-

Table 1. Mean growth, yield and juice quality of sugarcane as influenced by different treatments (pooled data of 1996–98 and 1997–99)

Treatment	Mean shoot population ('000/ha)				Millable canes ('000/ha)	Pol (%) juice	Cane length (cm)	Cane diameter (cm)	Cane weight (g)	Wheat yield (q/ha)	Sunflower yield (q/ha)	Cane yield (tonnes/ha)	Cane equivalent yield (tonnes/ha)
	June	July	Aug	Sep									
Wheat–sugarcane (CP)	181.9	254.7	263.9	282.3	144.2	19.5	201	2.06	642	53.4		82.8	108.2
Sunflower–sugarcane (CP)		185.6	271.0	250.7	138.2	19.6	195	2.01	517		15.1	86.6	96.1
Sugarcane + sunflower (CP)	128.7	264.4	291.3	264.6	153.6	19.2	213	2.23	767		14.6	105.1	133.6
Wheat–sugarcane (ethephon sprayed)	271.3	273.9	308.5	292.4	147.9	19.5	204	2.16	650	48.1		90.6	122.6
Sunflower–sugarcane (ethephon sprayed)		164.0	259.4	240.5	141.3	19.6	200	2.06	542		15.8	69.7	100.5
Sugarcane + sunflower (ethephon sprayed)	135.4	276.6	303.8	274	158.7	19.3	185	2.45	855		14.9	116.9	145.9
Wheat–sugarcane (PBS)	283.6	335.1	325.7	284.5	151.6	19.8	167	2.01	600	52.9		96.9	132.3
Sunflower–sugarcane (PBS)		219.6	286.3	323.8	146.5	19.4	159	1.91	535		15.7	79.1	97.6
CD (P=0.05)	21.40	23.50	18.50	16.40	6.50	NS	8.70	0.19	53.78	NS	NS	11.39	9.70

CP, Conventional planting; PBS, polythene bag-raised settlings

ings of Verma *et al.* (1996). Cane weight was also followed the similar trend. This indicates higher contribution of cane diameter to cane weight than cane length.

Wheat yield did not differ significantly under different treatments. There were no significant differences in the yield of sunflower grown in sequential (15.51 q/ha) and intercropping (14.79 q/ha) systems. This indicates that sugarcane crop did not exert an adverse effect on growth and productivity of sunflower.

Highest cane-equivalent yield was obtained when ethephon-sprayed seed cane was planted with sunflower in February. It was followed by sugarcane (CP) + sunflower system. Cane-equivalent yield of wheat–sugarcane (PBS) system was found at par with sugarcane (CP) + sunflower system. It showed that use of polythene bag-raised settlings was beneficial during late planting conditions (Ravi Kumar and Lal, 1993). Higher cane growth under polythene bag-raised settlings was due to assured plant population and longer period available for tillering and elongation phases of sugarcane. This shows the possibility of compensating the productivity of late-planted cane by the use of polythene bag-raised settlings. In spring (timely) planting, the net return could be maximized by application of ethephon in seed cane.

Tiller population in sugarcane plant and ratoon crops indicated that the magnitude of difference among the treatments in plant crop was greater compared to ratoon which was an outcome of variation in planting materials, periods and treatments applied (Tables 1, 2). Intercropping of sunflower with spring cane produced higher number of tillers to its sequential cropping. However, the significant differences in number of tillers were not observed with wheat–sugarcane system. In the July and August, higher number of tillers was recorded under wheat–sugarcane sequential system. Intercropping of sunflower reduced the tillers at early stages but later on compensation occurred and differences were non-significant. Sugarcane + sunflower system produced higher number of tillers than sunflower–sugarcane system. It was due to longer period of higher temperature and lower humidity available in former system than latter which encouraged higher tiller production. The mean maximum and minimum temperature of 25.1°C and 9.4°C, respectively, in February which rose to 29.15°C and 14°C in March favoured germination of cane under sunflower + cane system. After that higher temperature (33.5°C, 38.8°C and 38.8°C in April, May and June respectively) and lower humidity (65, 60 and 66%) favoured tiller production. Thus higher number of primary and secondary tillers maximized number of millable canes, cane length and diameter. In other cropping systems such as wheat–sugarcane and sunflower–sugarcane, the tillering period was reduced which ultimately decreased cane yield. The use of polythene bag-raised settlings increased the tiller production owing to longer period available and better establishment even under adverse (hot weather) conditions. Spraying of ethephon increased the tillering in different cropping systems. Solomon *et al.* (1993) also observed positive effect of ethephon on tillering of sugarcane.

Ratoon cane

Ratoon crop produced maximum number of millable canes (159,000/ha) when sugarcane was planted with spring sunflower using setts obtained from ethephon-

Table 2. Influence of different treatments on growth, yield and quality of sugarcane ratoon (1999–2000)

Treatment	Cane length (cm)	Cane girth (cm)	Cane weight (g)	Millable canes	Pol (%) juice	Cane yield (tonnes/ha)	Mean shoot population ('000/ha)					CCS (tonnes/ ha)
							May	June	July	Aug	Sep	
Wheat–sugarcane (C.P.)	179	2.25	695	152.4	16.6	63.9	229.5	253.8	349.3	344.8	323.9	7.22
Sunflower–sugarcane (C.P.)	156	1.95	615	143.2	16.9	53.1	220.1	244.1	333.3	322.2	311.1	6.07
Sugarcane + sunflower (C.P.)	192	2.45	210	157.3	16.8	69.8	235.8	263.9	360.1	352.5	334.4	7.93
Wheat–sugarcane (ethephen sprayed)	186	2.32	725	154.9	16.4	66.7	233	257.9	354.2	349.3	329.5	7.35
Sunflower-sugarcane (ethephen sprayed)	165	2.10	660	147.6	16.5	55.9	229.9	246.5	338.9	330.9	315.6	6.22
Sugarcane + sunflower (ethephon sprayed)	206	2.50	790	159.0	16.3	72.9	240.3	274	366.3	361.1	341.7	8.34
Wheat–sugarcane (PBS)	170	2.15	685	150.0	16.9	60.4	225.7	249.3	343.7	336.5	320.5	7.14
Sunflower–sugarcane (PBS)	147	1.97	585	140.3	16.9	43.7	216.7	241.5	328.1	317.3	301.4	4.84
CD (P=0.05)	5.64	0.15	70.1	2.00	NS	4.87	14.50	16.83	13.89	17.40	17.40	0.86

CP, Conventional planting; PBS, polythene bag-raised settlings
Ethephon sprayed, 750 ppm a.i. solution in seed cane

sprayed seed cane (Table 2). Number of millable canes in ratoon crop was higher with February planting (in case of plant crop) compared to late planting. Taller cane with greater diameter and weight were observed in ratoon of sugarcane + sunflower (ethephon sprayed) system. This clearly indicated that the good sugarcane plant crop raised by spraying of ethephon also produced good ratoon. Highest ratoon yield (72.9 tonnes/ha) was observed in sugarcane + sunflower (ethephon sprayed) cropping system. The commercial cane sugar also showed similar trend. Superiority of wheat–sugarcane system was observed to sunflower–sugarcane system but sugarcane + sunflower produced higher ratoon yield (71.4 tonnes/ha). Juice quality was not significantly influenced by different treatments.

Tiller population in ratoon (Table 2) was not influenced tangibly by different cropping systems. Ratoon initiated from ethephon-sprayed cane showed higher number of tillers over conventional crop in all the cropping systems. Higher numbers of tillers were observed up to July. Thereafter mortality of tillers started which continued up to September. High humidity (87–96%) along with high temperature (31.7°C–34.1°C during July – October 1999) brought forth cane elongation in rainy season. These environmental variations caused mortality of late tillers due to competition for moisture, nutrient and light.

Economics

Sunflower–sugarcane (ethephon sprayed) system registered the highest cost of production (Rs 39,404/ha) for both the crop components (Table 3). Highest gross return (Rs 112,328/ha) was obtained when ethephon-sprayed seed cane was planted with sunflower. This was followed by sugarcane (CP) + sunflower and wheat–sugarcane (PBS). Net return was also highest in sugarcane (ethephon sprayed) + sunflower system. Lower cost of production in wheat–sugarcane (PBS) system compared to cane (CP) + sunflower system increased the net return. The benefit : cost ratio was also highest (3.27) in sugarcane (ethephon sprayed) + sunflower system.

Table 3. Economics of sugarcane-based production systems

Treatment	Cost of production (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	Benefit : cost ratio
Wheat–sugarcane (CP)	36,401	83,314	46,913	2.29
Sunflower–sugarcane (CP)	38,943	73,997	35,049	1.90
Sugarcane+sunflower (CP)	33,872	102,849	68,977	3.04
Wheat–sugarcane (ethephon sprayed)	36,857	94,417	57,560	2.56
Sunflower–sugarcane (ethephon sprayed)	39,404	77,362	37,958	1.96
Cane + sunflower (ethephon sprayed)	34,328	112,328	78,000	3.27
Wheat–sugarcane (PBS)	32,267	101,863	69,596	3.16
Sunflower–sugarcane (PBS)	34,814	75,121	40,307	216

On the basis of economic evaluation of different treatments, adoption of sugarcane (ethephon sprayed) + sunflower system and/or use of PBS under late planting conditions in wheat–cane sequential system found quite remunerative.

REFERENCES

Kumar, Ravi and Lal, Asharfi. 1993. *Annual Report* 1992–93, Indian Institue of Sugarcane, Lucknow, Uttar Pradesh.

Shahi, H.N. 2001. Technology for maximizing sugarcane production in India. Technical Bulletin no. 43, pp. 33–34.

Solomon S., Madan, V.K. and Srivastava, K.K. 1993. Studies on some biochemical changes during sprouting and tillering of sugarcane. *Indian Journal of Sugarcane Technology* **8**(1) : 41–49.

Srivastava, Arun K. 2000. Sugarcane : Climate and weather relationships. (In) *50 years of Sugarcane Research in India,* Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh.

Verma, R.S., Shukla, S.K., Singh, G.B. and Verma, Lal Jee. 1996. Agro techniques to enhance sugar productivity of mid late varieties for early crushing. *Indian Journal of Sugarcane Technology* **11**(1) : 38–41.

Yadav, R.L. and Prasad, S.R. 1987. Hormonal effect on tillering and yield of late planted sugarcane. *Indian Journal of Sugarcane Technology* **4**(1) : 53–56.