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Research Paper

Intercropping of medicinal and high value crops in autumn sugarcane (*Saccharum* spp. hybrid) for higher productivity and profitability

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ABSTRACT

A field experiment was conducted during autumn season of 2006-07, 2007-08 and 2008-09 at sugarcane experimental area (Ladhowal), Punjab Agricultural University, Ludhiana to assess the profitability of intercropping of medicinal and high value crops in autumn planted sugarcane(*Saccharum* spp. hybrid). Gobhi sarson *(Brassica napus* L*.)*, canola type 'GSC 5' and 'GSC 6' and non canola type varieties 'GSL 2', celery *(Apium graveolens* L*.)* 'local', barley (*Hordeum vulgare* L*.)* 'VJM 201' and radish (*Raphanus sativus* L*.)* 'Punjab Pasand' for seed purpose were evaluated as intercrops. Out of 9 combinations of intercropping, sugarcane+ gobhi sarson 'GSL 2' (1: 1) recorded the highest cane equivalent yield of 87.95 t/ha, which was 22 % higher than that of sole crop of sugarcane. The economic analysis also indicated that sugarcane+gobhi sarson 'GSL 2' (1: 1) recorded the highest net profit of ₹ 80,894/ha, followed by intercropping of sugarcane + celery (1:2) and sugarcane + gobhi sarson 'GSC 5' (1:2) + with 29.0%, 26.9% and 22.2% higher net returns over sole crop of sugarcane, respectively. However, different intercrops did not show any significant effect on cane quality in terms of pol % juice and commercial cane sugar (CCS %).

Key words **:** Celery, Cane equivalent yield, Gobhi sarson, Intercropping, Radish, Sugarcane

Sugarcane (*Saccharum* spp. hybrid) offers unique possibilities for intercropping. Autumn planted sugarcane being widely spaced row (90 cm or >90 cm) crop with planting time from mid September to mid October under Indo-Gangetic plains, is more suitable for growing intercrops as its growth slows down because of low temperature from November to February. During these months the conditions are favourable for growth of short duration *rabi* crops, which can be grown successfully in the inter-row spaces of sugarcane for efficient utilization of incident solar energy, rainfall and other resources. The crops selected for intercropping must mature, and be harvested, before the spread of cane canopies at three to four months after planting. In addition to high productivity of the intercropping system, selection of suitable intercrops also assure greater importance in minimizing the adverse effects on cane yield by utilizing the inter row space thereby reducing the weed infestation. The objective of intercropping in sugarcane is intensification of productivity per unit area per unit time. Intercropping of different crops in autumn sugarcane has been reported both in Punjab (Kanwar *et al.,* 1987; Singh and Mehra, 1995 and Singh *et al.,* 1999) and other parts of country (Sharma *et al.,* 1997). The companion cropping of sugarcane with high value medicinal, oilseeds and vegetable for seed purpose were found remunerative rather than growing the sole crop of sugarcane. Rehman *et al*., (2014) and Li *et al*., (2013) have also established the yield advantages of intercropping of sugarcane with vegetable and oilseed crops.

Celery is an important crop of Punjab mainly cultivated in Gurdaspur and Amritsar district. About 90% of country's celery production comes from Punjab (Buttar *et al.* 2012) and sugarcane is the main crop of this area. Celery seed and products are exported from India as its essential oil has many medicinal properties. Canola type gobhi sarson is another high value oilseed crop. The characteristics of canola include higher yield with less than 2% erucic acid and less than 30 micromoles glucosinolates per gram of defatted meal (PAU, 2013-14), due to which its oil demand for human consumption and as livestock feed is increasing. Therefore, short duration intercrops can be a successful practice as it offers income during early stage and increases the total productivity without affecting the main crop. The present study was therefore carried out to

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assess the relative performance of celery, canola and non canola type gobhi sarson, barley suitable for brewing industry and radish for seed purpose as inter crops in autumn planted sugarcane.

MATERIALS AND METHODS

The present investigations were carried out at sugarcane experimental area (Ladhowal) at Punjab Agricultural University, Ludhiana during the autumn seasons of 2006–07, 2007–08 and 2008–09 using sugarcane variety 'CoJ 83'. Ludhiana is situated in trans-gangetic agro-climatic zone, representing the Indo-Gangetic alluvial plains at (30° 56' N, 75° 52' E and 247 m above mean sea-level). The average annual rainfall is 705 mm, about 80% of which is received during south-west monsoon (July to September). In winter month, rains are scanty but a few showers of rains are received during December-January or late spring. The soil of the experimental field was sandy loam tested low in organic carbon (0.36 %), medium in P_2O_5 (18.5 kg/ha) and high in available K (305 kg/ha). Gobhi sarson, canola type and non canola type, celery, barley and radish for seed purpose were evaluated as intercrops. The experiment comprised of 10 treatments, *viz.* sole sugarcane, sugarcane + gobhi sarson 'GSC 5' (1:1), sugarcane + gobhi sarson 'GSC 5' (1:2), sugarcane + gobhi sarson 'GSC 6' (1:1), sugarcane + gobhi sarson 'GSC 6' (1:2), sugarcane + gobhi sarson 'GSL 2' (1:1), sugarcane + celery (1:1), sugarcane + celery (1:2), sugarcane + barley 'VJM 201' (1:2), sugarcane + radish for seed (1:1), laid out in randomized block design with 3 replications. Three budded setts of sugarcane 'CoJ 83' were planted at row to row spacing of 90 cm using seed rate of 1,50,000 buds per ha during autumn season (mid October). The recommended dose of 150 kg N/ha was applied in 3 equal splits at planting, end March and in end April, whereas 30 kg P_2O_5/ha was applied as basal dose. Two varieties of canola type gobhi sarson 'GSC 5', 'GSC 6', non canola type gobhi sarson 'GSL 2' were sown as intercrop during 3rd week of October during all the seasons under experimentation. Barley 'VJM 201' was sown during last week of October every year. Sixty days old seedlings of celery raised separately through nursery were transplanted in 3rd week of December during all the years. Upper 3/4th part of 45 days old radish, raised separately, was transplanted as intercrop for seed production during last week of November every year. The additional doses of fertilizer i.e. 50 kg N and 15 kg P_2O_5 to gobhi sarson, 50 kg N and 20 kg P_2O_5 to celery, 30 kg N and 15 kg P_2O_5 to barley and 40 kg N and 10 kg P_2O_5/ha to radish crop was also applied to meet the nutritional requirements. All other recommended package and practices of PAU Ludhiana were followed in raising the intercrops. The potassium in the experimental soil was high therefore, it was not applied. The weeds in all the treatments were managed through two manual weeding. The data on sugarcane germination was recorded 45 days after planting whereas tillers and millable canes were recorded in the month of June and November every year. Sugarcane crop was harvested in the end of November every year. The harvesting of barley and canola type gobhi sarson ('GSC 5 and GSC 6') was done during last week of March. Gobhi sarson (GSL 2) and radish were harvested during mid of April, whereas celery was harvested in the last week of May every year. The yields of various intercrops were converted into cane yield using existing market price in the respective year and equivalent cane yield was calculated. Gross returns were calculated by multiplying equivalent cane yield with cane price of respective year thereafter, the mean of three years was calculated. Net returns were calculated by deducting the expenditure incurred on raising sugarcane as well as intercrops from gross returns and finally percent increase in net returns over sole crop of sugarcane was calculated. The quality parameters of sugarcane, viz. Pol percent juice (Pol %) and commercial cane sugar percent (CCS %), a representative sample of 10 stalks in each replication were crushed with vertical three roller laboratory cane crusher to extract the juice. The juice was analyzed by standard method as described by Chen (1985). Commercial cane sugar percent (CCS %) was calculated using Winter's formula (Chen 1985).

RESULTS AND DISCUSSION

Germination and growth parameters

The data presented in Table 1 showed that sugarcane germination varies from 33.1 to 35.5%. However, the differences among the treatments were non significant and the crop had uniform plant stand which indicated that there was no competition and adverse effect on sugarcane during early stages of different intercrops. However, at later stages, different intercrops caused considerable reduction in sugarcane tillering. The highest number of tillers 1,44,500/ha were recorded in sole crop of sugarcane where as the lowest (1,09,300/ha) in case of intercropping of barley showing the maximum adverse effect on sugarcane tillering to the tune of 24.4%. Vigorous growth and shading effect of barley may have attributed adverse effect on sugarcane tillering. However, intercropping of gobhi sarson, celery and radish did not cause significant reduction on sugarcane tillering which may be due their lesser canopy spread and leaf senescence during reproductive phase which in turn reduced the competition with the main crop.

Intercropping of different crops also showed significant effect on number of millable canes. The least effect, 3.2%

reduction, was observed in case of intercropping of one row of gobhi sarson (GSC 5) where as the maximum reduction (21.1 %) was recorded in case of barley. Intercropping of celery and radish for seed production did not show any significant effect on number of millable canes. The adverse effect of barley on sugarcane tillering might be probable reason of lower number of millable canes. Singh *et al.* (2007) have also reported adverse effect of barley on millable canes.

Productivity and quality of sugarcane

Pooled analysis of 3 years data showed that the reduction in cane yield with intercropping of different crop varied from 1.7% in case of celery to 19.86% in case of barley however, the cane yield under all the intercropping system, except for barley was statistically at par with the cane yield obtained under sole crop of sugarcane. Further, the additional yield obtained with intercropping could have contributed to the significantly higher equivalent cane yield than that of sugarcane alone. The highest equivalent cane yield of 87.95 t/ha was recorded with intercropping of one row of gobhi sarson 'GSL 2' which was 22% higher than that of sole crop of sugarcane. It was closely followed by intercropping of 2 rows of celery with 21.4% higher equivalent cane yield. Inter cropping of 2 rows of canola type gobhi sarson, viz. 'GSC 5' and 'GSC 6' also recorded 19.8 and 17.5% higher equivalent cane yield respectively, compared to that of sole sugarcane. Singh *et al.* (2007) have also reported similar findings with intercropping of gobhi sarson. Intercropping of 2 rows of gobhi sarson (GSC 5 and GSC 6) and celery recorded higher system productivity than 1 row of these crops. The equivalent cane yield was also increased by 13.8% with intercropping of one row of radish for seed purpose. Saini *et al.* (2003) have also reported higher equivalent cane yield with intercropping of vegetable crops in autumn planted sugarcane. The lowest equivalent cane yield of 74.58 t/ha was recorded with intercropping of barley as it reduced the cane yield to 57.77 t/ha against the 72.09 t/ha under sole crop of sugarcane. The higher

Table 1. Effect of different intercrops on germination growth, yield and quality of sugarcane (pooled mean of 3 years)

Treatment	Germination (%)	Tillers (000/ha)	Millable cane (000/ha)	Cane yield (t/ha)	Yield of intercrop (t/ha)	Equivalent cane yield (t/ha)	Pol% juice	CCS%
Sole sugarcane	33.1	144.5	91.4	72.09	-	72.09	18.0	12.4
Sugarcane + gobhi sarson 'GSC 5' (1:1)	34.5	133.5	88.5	70.86	0.97	82.03	18.6	12.9
Sugarcane + gobhi sarson 'GSC 5' (1:2)	34.7	125.1	83.8	69.03	1.25	86.36	18.7	13.0
Sugarcane + gobhi sarson 'GSC 6' (1:1)	33.5	137.2	85.8	69.52	0.89	79.64	17.8	12.2
Sugarcane + gobhi sarson 'GSC' 6 (1:2)	34.2	123.5	83.4	68.59	1.20	84.69	18.5	12.7
Sugarcane + gobhi sarson 'GSL 2' (1:1)	35.5	130.0	85.5	69.52	1.52	87.95	18.4	12.8
Sugarcane + celery (1:1)	34.1	135.5	88.1	70.88	0.38	81.83	18.7	13.0
Sugarcane + celery (1:2)	34.6	128.3	86.2	69.67	0.60	87.49	18.6	12.8
Sugarcane + barley (1:2)	34.2	109.3	72.2	57.77	2.95	74.58	18.5	12.8
Sugarcane + radish for seed purpose (1:1)	35.1	132.3	87.7	68.62	0.36	82.05	18.3	12.6
SEm±	1.49	3.87	2.62	1.69	-	1.54	0.15	0.07
CD(0.05)	NS	8.1	5.51	3.54	-	3.24	NS	NS

Table 2. Economics of different intercrops in sugarcane (Pooled mean of 3 years)

Treatment	Gross returns ($\times 10^3$ ₹/ha)	Net returns ($\times 10^3$ ₹/ha)	% increase/decrease in net returns over sole crop
Sole sugarcane	116.0	61.4	-
Sugarcane + gobhi sarson 'GSC 5' (1:1)	131.8	71.3	16.2
Sugarcane + gobhi sarson 'GSC 5' (1:2)	139.4	77.9	26.9
Sugarcane + gobhi sarson 'GSC 6' (1:1)	128.1	67.6	10.1
Sugarcane + gobhi sarson 'GSC 6' (1:2)	136.5	75.0	22.2
Sugarcane + gobhi sarson 'GSL 2' (1:1)	141.4	80.9	31.8
Sugarcane + celery (1:1)	131.9	71.3	16.1
Sugarcane + celery (1:2)	141.4	79.2	29.0
Sugarcane + Barley (1:2)	119.9	60.9	-0.9
Sugarcane + radish for seed purpose (1:1)	132.2	71.3	16.2

The market price (₹/tonne) of celery, barley, gobhi sarson, radish seed and sugarcane during 2006–07, 2007–08 and 2008–09 was ₹40,000, 40,000, 60,000; 8,500, 9,500, 8,500; 17,500, 25,000, 22,000; 40,000, 45,000, 60,000; 1,320, 1,650 and 1,850 respectively

grain yield of barley (2.95 t/ha) and its smothering effect on tillering and millable canes might have reduced the equivalent cane yield. Intercropping of different crops did not show any significant adverse effect on cane quality in terms of Pol % juice and commercial cane sugar (CCS %). This might be due to the fact that quality parameters are inherent character of the crop and variety.

Economics

The economic analysis of different intercrops (Table 2) indicated that one row of gobhi sarson 'GSL 2' recorded the highest net profit of ₹80,894/ha which was 31.8% higher than that of sole crop of sugarcane. The higher yield potential of 'GSL 2', which increased the equivalent cane yield attributed the higher net returns. It was followed by intercropping of 2 rows of celery (29.0 %), 2 rows of canola type gobhi sarson 'GSC 5' (26.9 %) and 'GSC 6' (22.2%). Additional yields from these crops, without significant adverse effect on sugarcane yield, might have increased the net returns over sole crop of sugarcane. Intercropping of radish for seed purpose had also recorded 16.2% increase in net return over sole crop, which indicated that it can be grown in areas having demand of seed. Intercropping of barley was not found profitable as it has shown net return of ₹60,850 against ₹61,378/ha obtained with sole crop of sugarcane which was 0.90% lesser. Further, the data has shown that intercropping of 2 rows of gobhi sarson (GSC 5, GSC 6) and celery were more profitable compared to one row of these crops between two rows of sugarcane. This may be attributed to considerable higher yield with dual row intercropping of these crops with negligible adverse effect on cane yield.

Intercropping of medicinal and high value *rabi* crops like celery, gobhi sarson (both canola and non-canola type) and radish for seed purpose in sugarcane was found profitable as the net returns increased over the range of 10.1 to 31.8% compared to sole crop of sugarcane. This practice not only increased the productivity but also ensure sustained income to the sugarcane farmers. Under the present scenario, it encourages more area under autumn planted sugarcane while having the scope of cultivating *rabi* crops at the same time.

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