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Research Article

Crop yield, efficiency and economics of autumn and spring sown single bud sugarcane intercropped with pulse crops

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ABSTRACT : The low plant population albeit of high seed rate in sugarcane (*Saccharum officinarum*) coupled with shrinking net cultivable land in Punjab, necessitates the generation of an innovative technique that aims at enhancing plant population and maximization of land-use. In this context, a single-bud sowing technique in sugarcane might be a convincing option for reducing seed rate and furthermore, being long duration and widely spaced crop it offers considerable scope for intercropping for maximization of land-use. The present investigation was, therefore conducted during 2009-10 to assess the potential of single-bud planted autumn (*var.* CoJ-64) and spring sugarcane (*var.* CoH-119) intercropped with pulses (gram/lentil/summer moong/summer mash) at farmers' field in sub-tropics of Roop-nagar (Punjab). During the study period, 94-97 per cent bud germination was observed in single-bud planted cane plots as opposed to 76-84 per cent in three-bud planted plots. The intercropping of spring and autumn planted sugarcane with pulses exerted a synergistic effect on sugarcane in terms of enhanced yield and improved production and economic efficiency. The autumn cane yield increased by 3.97 and 2.48 per cent, respectively with intercropping of gram and lentil over sole cane. The highest cane yield (125.6 t ha^{-1}) was obtained when sugarcane was intercropped with gram followed by intercropping with lentil (123.8 t ha^{-1}) and sole cane (120.8 t ha^{-1}). The economic analysis demarcates autumn sugarcane + gram as most profitable intercropping system that gave the highest net returns (Rs. 178042.5 ha^{-1}) and the highest B-C ratio (1.84) as compared to autumn sugarcane + lentil and sole cane. Maximum production efficiency (356.9 kg ha^{-1} day^{-1}) and economic efficiency (Rs. 462.4 ha^{-1} day^{-1}) values in sugarcane + gram intercropping system also reflected the same. Likewise, the cane yield increased by 3.2 and 2.2 per cent, respectively with intercropping of summer moong and summer mash over sole spring cane. However, highest cane yield (121.6 t ha^{-1}) was obtained with intercropping of sugarcane with summer moong followed by intercropping with summer mash (120.4 t ha^{-1}) and sole cane (117.8 t ha^{-1}). Economically, sugarcane + summer moong intercropping system gave highest net returns (Rs. 177607.9 ha^{-1}), production efficiency (404.2 kg ha^{-1} day^{-1}) and economic efficiency (Rs. 530.2 ha^{-1} day^{-1}) than sugarcane + summer mash and sole cane. Thus, it can be concluded that single-bud technique in spring and autumn sugarcane intercropped with pulses, has immense scope in subtropical areas.

KEY WORDS : Single-bud technique, Production efficiency, Economic efficiency, Intercropping

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INTRODUCTION

Sugarcane (*Saccharum officinarum*)is an important and assured crop in tropical and subtropical India. Sugarcane production in India during the last decade has been reported to fluctuate between 233 and 355 Mt, in contrast to its productivity at the farm level which is as low as 40 t ha^{-1} (Gujja *et al*., 2009). However, the low plant population owing to the low germination rate (35-40%) albeit of high seed rate (6.0 t ha^{-1}) in sugarcane (*Saccharum officinarum*) (Singh *et al*., 2011) has been recognized as major culprit for lower cane production. Owing to the high seed rate of sugarcane, the profit margins of farmers are dwindling since the planting material costs 22 to 25 per cent of the total production cost (Srivastava *et al*., 1981).

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The 50-60 per cent tiller mortality in sugarcane (Kapur *et al*., 2011) causing heavy reduction in crop yield also cannot be neglected. The present day agriculture with rapidly shrinking net cultivable land, deteriorating natural resources necessitates the generation of an innovative technique in sugarcane cultivation that aims at enhancing plant population and maximization of land-use. In order to increase sugarcane and sugar productivity, the only alternative is to increase the sugarcane productivity per unit area. Suryavanshi *et al*. (2010) compared different plant geometry strategies *viz.,* tissue culture plant lets, ploy bag settlings, two eye bud, single eye bud in sugarcane (var. Co-94012), and concluded the later three technologies as economical for sugarcane cultivation. The single-bud sowing technique might be a convincing option for reducing seed rate and furthermore, being long duration and widely spaced crop it offers considerable scope for intercropping for maximization of land-use. Under sustainable sugarcane initiative (SSI), the farmers have been able to reduce cost of cultivation by about 21 per cent and increased yield by 24 per cent to 30 per cent apart from extra income from inter crops (NRMC, 2011). Intercropping has been reported to be the most efficient and profitable production system especially for small farmers with limited land and inputs resources (Nazir *et al*., 1988; Bajwa *et al*., 1992). Earlier research on economics, production and feasibility of intercropping in sugarcane focused primarily on the sowing of multi-bud sets (Khakwani *et al*., 2001; Shafi Nazir *et al*., 2002; Gana and Busari, 2003; Saini *et al.,* 2003; Bhullar *et al.,* 2006; Singh *et al.,* 2007). Further since, India is still not self reliant in pulse production, therefore, the un-planted space between two sugarcane rows can be exploited for pulse production. The only few studies carried for assessing the scope of pulse intercropping in sugarcane are confined only in traditionally (multi-bud sets) sown sugarcane. The studies on single-bud planted sugarcane intercropped with pulse crops are still lacking. Therefore, there was need to prepare a balance sheet to assess the production feasibility and economic profitability of intercropping pulse crops in single-bud planted sugarcane.

EXPERIMENTAL METHODS

Description of study area and important soil properties:

The study area is located in village-Paprali, Block-Majri, S.A.S. Nagar (Mohali), Punjab. The climate of the experimental site is sub-tropical characterized by hot summer with mean maximum temperature of $42^0 \pm 5^0$C during June and cool winter with mean minimum temperature of $4^0 \pm 2^0$C during December. The average annual rainfall (AAR) in the study area varied from 650-1300 mm of which ~75-80 per cent is received during summer season extending from July to September and rest during the winter season. The relative humidity in the district varies from 36.3-93.7 per cent demarcating a peak during July-August, the days when 'monsoon' in the area is on full swing. The surface (0-15 cm) soil pH =7.83, electrical conductivity (E.C.)=0.256 dS m^{-1}, soil organic carbon (SOC)=4.35 g kg^{-1}, available-P=17.3 kg ha^{-1}, available-K=166.5 kg ha^{-1} and was sandy loam in texture. Soil reaction (pH) and E.C. were determined by using 1:2 soil: water (w/v basis) ratio (Jackson, 1967). Soil organic carbon content was determined by method of Walkley and Black (1934). The Available-P (Olsen-P) content in the soil sample was determined as described by Olsen *et al.* (1954). Available-K was determined using 1N, CH_3COONH_4 (pH=7.0) followed by flame photometric estimation.

Crop sowing and fertilizer treatments:

The field study was conducted during 2009-11 at farmer field to assess the potential of single-bud planted autumn sugarcane (var. Co.J-64) and spring sugarcane (var. Co.H-119) intercropped with pulses (Gram, Lentil, Summer Moong and Summer Mash) practiced in sub-tropics of Punjab (District Roop-nagar). In autumn, Co. J-64 variety was sown in third week of September and in spring, Co.H-119 variety was sown in second week of March 2010, during both the years. Single buds of sugarcane were planted on 80 cm wide raised beds made in east-west direction with 40 cm wide furrows for irrigation. Single buds were planted on southern side of the bed keeping bud direction towards outer-side. This helps in better germination. Before planting, selection of buds was done to remove unhealthy and diseased buds. Buds were planted by keeping bud to bud distance of 60 cm and row-to-row distance of 120 cm. In autumn cane two rows of gram (var. PBG-5) and lentil (local variety) were sown on bed top having 30 cm row to row spacing in the first fortnight of October. The bed top was intercropped two rows of summer moong (var. SML-668) and summer mash (Mash-1008) in case of spring sugarcane. For planting one hectare, 13,500 buds (10-11.25 q) were being used. At the time of planting 37.5 kg K_2O and 115 kg P_2O_5 ha^{-1} were applied before making beds. Nitrogen @ 172.5 kg ha^{-1} was applied through urea in six splits. No separate fertilizers were applied for intercrops. Plant protection measures were followed as and when required. Weed control was done manually. Irrigation was applied as and when required depending upon soil type and rainfall. More frequent irrigations were applied in hot summer months. On the other hand, three bud sugarcane was planted using a seed rate @ 87.5 q ha^{-1} at row spacing of 75 cm spring (third week of march) and at 90 cm in autumn (first week of October) sown sugarcane. The fertilizer dose was same for three bud set planted cane as described for single-bud planted sugarcane. To evaluate the profitability of intercropping system, the economics was worked out from the gross return calculated by taking normal market prices of the produce and total expenditure. The cane equivalent yield was calculated based on the average selling price of the crops used in the study.

Statistical analysis:

The production efficiency of crops as influenced by fertilizer application at differential rate was worked out by as described by (Tomar and Tiwari, 1990). The economic efficiency (EE) of fertilizer application was calculated from the average net-returns on unit area basis and average crop duration. The production efficiency (PE) of fertilizer application was worked out by dividing crop yield on unit area basis by average crop duration.

EXPERIMENTAL RESULTS AND ANALYSIS

The results obtained from the present study have been discussed in detail under following heads :

Per cent bud germination:

The per cent bud germination of autumn and spring planted sugarcane was observed for only alone sugarcane for both single-bud and three bud planted sugarcane plots (Fig. 1). The results revealed that bud germination of single-bud planted autumn sugarcane was 94 and 96 per cent, respectively during 2009 and 2010. However, the bud germination of three-bud sets planted autumn sugarcane was 83 and 76 per cent, respectively during 2009 and 2010. The average of two years thus showed 19.5 per cent higher bud germination in single-bud planted than three-bud set planted autumn sugarcane. Likewise, the bud germination of single-bud planted spring sugarcane was 95 and 97 per cent during 2010 and 2011, respectively in contrast to the bud germination of three-bud sets planted spring sugarcane that was 79 and 84 per cent, respectively during 2009 and 2010 (Fig. 1). Thus, it can be concluded that single-bud sugarcane planting results in achieving 18 to 20 per cent higher bud germination, owing to the selection of healthy bud for sowing.

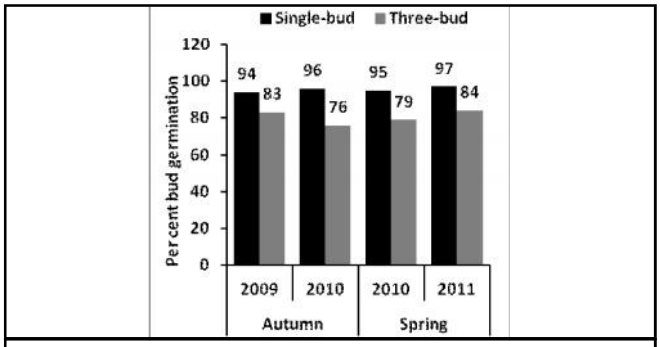

Fig. 1 : Per cent bud germination during two years

Yield and economics of three-bud and single-bud sown autumn sugarcane intercropped with pulses:

The autumn sown single-bud sugarcane (var. Co.J.-64) intercropped with gram (*Cicer arietinum* L., var. PBG-5) and lentil (*Lens culinaris*, local) was compared for the yield and economics with alone single-bud sugarcane during two consecutive years (2009-11). The results revealed ~28.2 per cent higher cane yield in single-bud planted plots over three-bud planted plots, owing to better germination in the single-bud planted cane plots (Table 1 and Fig. 1). The average (mean of 2 years) single-bud sugarcane yield was 120.8 t ha^{-1}, that increased to 125.6 t ha^{-1} (4.0%) with intercropping of gram. However, there was non-significant (p=0.05) yield difference among single-bud sugarcane yield form plots intercropped with gram and lentil during the two years of study period (Table 1). The average gram and lentil yield was 0.9 t ha^{-1} and 0.4 t ha^{-1}, sown as intercropped crops between single-bud sugarcane rows. The intercropping thus resulted in single-bud sugarcane equivalent yield of 137.1 and 130.0 t ha^{-1}, respectively form plots intercropped with gram and lentil, which exhibited an increase in sugarcane yield by 13.5 and 7.6 per cent. Present results corroborate the findings of earlier research by Singh *et al*. (2007), who also reported higher cane equivalent yield from plots intercropped with gram. The average cost of cultivation

Table 1 : Crop yield and economics of different sugarcane based intercropping systems (pooled data of two years)

Intercropping system	Yield (t ha^{-1})	Equivalent cane yield (t ha^{-1})	Average cost of cultivation (Rs. ha^{-1})	Average gross returns (Rs. ha^{-1})*	Average net returns (Rs. ha^{-1})	B-C ratio
Autumn sugarcane (Co. J.-64)						
Three-bud sugarcane alone	94.2	--	90,386.0	1,88,400.0	98,014.0	1.08
Single-bud sugarcane alone	120.8	--	88,292.5	2,41,600.0	1,53,307.5	1.73
Single-bud sugarcane + Gram	125.6+0.9	137.1	96,667.5	2,74,710.0	1,78,042.5	1.84
Single-bud sugarcane + Lentil	123.8+0.4	130.0	93,458.2	2,60,000.0	1,66,541.8	1.78
Spring sugarcane (Co. H.-119)						
Three-bud sugarcane alone	91.4	--	88,654.5	1,82,800.0	94,145.5	1.06
Single-bud sugarcane alone	117.8	--	85,458.5	2,35,600.0	1,50,141.5	1.76
Single-bud sugarcane + Summer Moong	121.6+0.8	135.4	93,192.5	2,70,800.4	1,77,607.9	1.91
Single-bud sugarcane + Summer Mash	120.4+0.7	131.1	93,667.5	2,62,200.5	1,68,533.0	1.80

*Average gross returns were worked out by considering minimum support price (MSP) for different crops during two study years

for alone autumn sown single-bud sugarcane crop was Rs. 88,292.5 ha^{-1} as compared to Rs. 96,667.5/- and Rs. 93,458.2 ha^{-1}, respectively for plots having sugarcane intercropped with gram and lentil, respectively (Table 1). The variation in average gross returns *viz.*, Rs. 2,41,600/-, Rs. 2,74,710/-, and Rs. 2,60,000/-ha^{-1}, respectively for single-bud sugarcane alone, single-bud sugarcane intercropped with gram and single-bud sugarcane intercropped with lentil, was due the variation in minimum support price for different crops during study period under consideration. Likewise, the average net-returns were highest (Rs. 1,78,042.5 ha^{-1}) from plots where single-bud sugarcane was intercropped with gram, followed by plots intercropped with lentil (Rs. 1,66,541.8 ha^{-1}) and lowest (Rs. 1,53,307.5 ha^{-1}) for alone single-bud sugarcane planted plots (Table 1). The results revealed that, although pulse intercropping in single-bud sugarcane has increased the cost of cultivation, but the practice was economical since the benefit-cost (B-C) ratio was higher for plots having single-bud sugarcane intercropped with pulses than alone single-bud sugarcane planted plots. However, the monetary returns worked out from average gross returns and B-C ratios were higher from autumn single-bud sugarcane intercropped with gram as compared to single-bud sugarcane intercropped with lentil. Earlier, Saini *et al*. (2003) while evaluating relative profitability of intercropping vegetable crops in autumn planted three-bud sugarcane reported 5.1 to 11.5 per cent decline in cane yield from plots intercropped with radish, turnip and palak in contrast to plots intercropped with peas-a leguminous crop where there was no difference in cane yield from intercropped and non-intercropped plots. In contrast, however, although Singh *et al*. (2007) reported 3.5 per cent cane yield loss when intercropped with gram as compared to sole sugarcane crop grown in South-western Punjab, the cropping has been the most profitable with highest average net returns. At Faisalabad (Pakistan), Shafi Nazir *et al*. (2002) reported higher gross returns (Rs. 1,50,125.0 ha^{-1}) and net returns (Rs. 96,207.0 ha^{-1}) in plots with autumn sugarcane intercropped with gram as compared to sole sugarcane crop with Rs. 1,31,197.5 ha^{-1} and Rs. 81,048.0 ha^{-1}, as gross and net returns, respectively. While comparing sugarcane intercropped with gram with sole sugarcane crop, Singh *et al*. (2007) reported ~2.0 per cent yield augmentation with intercropping of gram. On the other hand, Saini *et al*. (2003) reported 5.1 to 11.5 per cent yield increase with intercropping of sugarcane over sole.

Yield and economics of three-bud and single-bud sown spring sugarcane intercropped with pulses:

The yield and economics of spring sown single-bud sugarcane (var. Co.H.-119) intercropped with summer moong (*Phaseolus aureus* L., var. SML-668) and summer mash (*Vigna mungo*, var. Mash-1008) worked out for study period has been shown in Table 1. The three bud planted sugarcane yielded ~29.0per cent lower cane yield than single-bud planted plots. The average (mean of 2 years) spring sown single-bud sugarcane yield was 117.8 t ha^{-1} that increased to 120.4 t ha^{-1} (2.2%) with intercropping of summer mash and to 121.6 t ha^{-1} (3.2%) with intercropping of summer moong. However, there was non-significant (p=0.05) yield difference among sugarcane yield form plots intercropped with summer moong and mash during the two years of study period (Table 1). The average summer moong and mash yield was 0.8 t ha^{-1} and 0.7 t ha^{-1}, sown as intercropped crops between single-bud sugarcane rows during summer season. The intercropping thus resulted in single-bud sugarcane equivalent yield of 135.4 and 131.1 t ha^{-1}, respectively form plots intercropped with summer moong and summer mash, which exhibited an increase in sugarcane yield by 14.9 and 11.3 per cent. The average cost of cultivation for alone spring sown single-bud sugarcane crop was Rs. 85, 458.5 ha^{-1} as compared to Rs. 93,192.5/- and Rs. 93,667.5 ha-^{1}, respectively for plots having single-bud sugarcane intercropped with summer moong and summer mash, respectively (Table 1). The variation in average gross returns *viz.*, Rs. 2,35,600.0/-, Rs. 2,70,800.4/-, and Rs. 2,62,200.5/- ha^{-1}, respectively for single-bud sugarcane alone, single-bud sugarcane intercropped with summer moong and single-bud

Table 2 : Production and economic efficiency of different sugarcane based intercropping systems (pooled data of two years)

Intercropping system	Production efficiency (kg day^{-1} ha^{1})	Economic efficiency (Rs.day^{-1} ha^{-1})
Autumn sugarcane (Co. J.-64)		
Three-bud sugarcane alone	251.2	259.3
Single-bud sugarcane alone	313.8	398.2
Single-bud sugarcane + Gram	356.9	462.4
Single-bud sugarcane + Lentil	337.7	432.6
Spring sugarcane (Co. H.-119)		
Three-bud sugarcane alone	240.5	336.2
Single-bud sugarcane alone	351.6	448.2
Single-bud sugarcane + Summer Moong	404.2	530.2
Single-bud sugarcane + Summer Mash	391.3	503.1

sugarcane intercropped with summer mash, was due the variation in minimum support price for different crops during study period under consideration. Likewise, the average net-returns were highest (Rs. 1,77,607.9 ha^{-1}) from plots where single-bud sugarcane was intercropped with summer moong, followed by plots intercropped with summer mash (Rs. 1,68,533.0 ha^{-1}) and lowest (Rs. 1,50,141.5 ha^{-1}) for alone single-bud sugarcane planted plots (Table 1). The results revealed that, although intercropping in single-bud sugarcane with summer sown pulses has increased the cost of cultivation, but the practice was economical since the benefit-cost (B-C) ratio was higher for plots having single-bud sugarcane intercropped with pulses than alone sugarcane planted plots. However, the monetary returns worked out from average gross returns and B-C ratios were higher from spring single-bud sugarcane intercropped with summer moong as compared to sugarcane intercropped with summer mash. The economics revealed lowest B-C ratio of sugarcane production using three-bud sets, owing to increased cost of cultivation and reduced average cane yield during both the seasons (Table 1). Present results corroborate the findings of Kanwar *et al.* (1992) who reported higher profitability of intercropping in autumn planted sugarcane than spring planted sugarcane because of slow growth of sugarcane owing to low temperature during peak autumn season (November to February). By comparing different intercropping strategies in sugarcane, Singh *et al.* (2007) reported highest cane equivalent yield from plots intercropped with gram and hence highest profitability in terms of net returns and B-C ratio

Efficiency of three-bud and single-bud sugarcane intercropped with pulses:

The crop efficiency of autumn planted single-bud sugarcane, sown either alone or intercropped with pulses (gram/ lentil) was assessed through production and economic efficiency (Table 2). The production efficiency of single-bud planted alone autumn sugarcane was 313.8 kg day^{-1} ha^{-1} that increased to 356.9 kg day^{-1} ha^{-1} and 337.8 kg day^{-1} ha^{-1}, respectively for sugarcane intercropped with gram and lentil. In comparison, however, the production efficiency of spring planted single-bud sugarcane was 351.6 kg day^{-1} ha^{-1} that increased to 404.2 kg day^{-1} ha^{-1} for sugarcane intercropped with summer moong and to 391.3 kg day^{-1} ha^{-1} for sugarcane intercropped with summer mash (Table 2). The economic efficiency of single-bud planted autumn sugarcane was Rs. 398.2 day^{-1} ha^{-1}. However, autumn sown single bud sugarcane when intercropped with gram and lentil exhibited an increase in economic efficiency by Rs. 64.2 day^{-1} ha^{-1} (16.1%) and Rs. 34.4 day^{-1} ha^{-1} (8.6%) over alone single-bud sugarcane. The economic efficiency of spring planted single-bud sugarcane also exhibited an increase with intercropping of pulse crops (summer moong/mash) (Table 2). However, the highest economic efficiency (Rs. 530.0 day^{-1} ha^{-1}) was observed in single-bud sugarcane intercropped with summer moong followed by Rs. 503.1 day^{-1} ha^{-1} in plots intercropped with summer mash and lowest (Rs. 448.2.0 day^{-1} ha^{-1}) in alone single bud sugarcane plots (Table 2). The comparison demarcates lower production and economic efficiency of sugarcane planted by using three-bud sets as compared to single-bud planted sugarcane during both autumn and spring season. The highest relative profitability of intercropping in sugarcane has also been reported earlier by Saini *et al.* (2003).

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