ADOPTION OF OPTIMUM INTERCROPS AND THEIR EFFCTS ON YIELD AND ECONOMICS OF SUGARCANE CROP

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ABSTRACT

Under the current scenario of climate change and food security the uses of available resources efficiently are very important. A research experiment was planned at the farm area of Sugarcane Research Institute, Faisalabad. The experiment was replicated and laid out in a randomized complete block design. The treatments include sugarcane intercrops with one and two lines of Mung (*Vigna radiata*), Mash (*Vigna mungo*), Sunflower (*Helianthus annuus*) and canola (*Brassica napus* L.) with Sugarcane alone. It was determined from the study that higher cane yield (103.3 t ha^{-1}), sugar yield (13.12 t ha^{-1}) and more economic advantage of Rs. 345210/- ha^{-1} were obtained when intercropped with two lines of Canola. After canola, economic advantage of Pakistani Rs. 264,700/- ha^{-1} was obtained when intercropped with two lines of Mash.

Keyword: Intercrops, Vigna radiata, Vigna mungo, Helianthus annuus and canola

INTRODUCTION

Sugarcane (*Saccharum officinarum)* is an important cash crop of the Punjab province. It belongs to the family Poaceae and native of temperate humid to tropical regions of Asia. All sugarcane species interbreed and the major commercial cultivars are complex hybrids and products like table sugar, molasses and ethanol are directly obtained from sugarcane. The bagasse that remains after sugar cane crushing is burnt to provide heat and electricity (Rehman *et al.,* 2014). It is also utilized as raw material for paper, chipboard, and utensils, because of its high cellulose content. The sugarcane tops serve as fodder during scarcity of fodder period. The grower's economy and viability of sugar industry is based on this crop. Sugarcane crop plays a pivotal role in our domestic economy next to cotton as a cash crop. It has 0.7% share to Gross Domestic Product (GDP). In the Punjab, during 2017-18 sugarcane was grown on an acre of 859.88 thousand hectares with production of 55.1 million tones and average cane yield 695 mounds/acre. 1 % yield has been decreased as compared to last year (Annual Reports 2017-18). The Sugarcane Research Station was established in 1934, in Lyallpur. Later on, this section was upgraded as Sugarcane Research Institute; Faisalabad in 1978.The Research work was focused on the main objectives of the evolution of high cane and sugar yielding, disease and insect pest's resistant varieties besides, the development of improved production technology (Annual Reports 2017-18).

Intercropping supports diversification of crop production. There are many intercropping ways being experienced in Punjab, including, wheat, sunflower, maize fodder, canola, pulses, soybean, onion, garlic, potato, lentil, gram, turnip etc.

These Intercropping indicated a lot of advantages of higher yield, better the soil health, higher light interception and higher utilization rate of inputs, soil and farm resources (Cong *et al.* 2015).

Sugarcane grows slowly in initial growth stage and can accommodate easily the short-duration crops. Sugarcane crop takes early 120 days for canopy development in autumn plantation. Companion and multiple cropping produce and opportunity to best utilize the available space of 2-2.5 feet between cane rows. Cane growers may raise numerous short duration crops like cereals, pulses, vegetables, Oilseed crops and spices as intercrops to get interim return. Small sugarcane growers cannot wait until the harvest of the sole crop after 16 months to obtain financial benefits (Aggarwal *et al*., 1992). Organic matter and soil fertility have become principal concerns for sustainable agriculture and crop production. Leguminous have the opportunities to improve the crop productivity in sugarcane cropping system. It reduces the cost of production and improve soil fertility level on sustainable basis. Legume intercrops in cropping systems enrich soil fertility through the emission and release of amino acids into the rhizosphere of sugarcane. The legume intercrops fixed the nitrogen and makes it available to the associated sugarcane crop. In Pakistani agriculture, great potential exit in wider use of multiple cropping to increase crop production, more financial returns per unit land area and to improve resource use efficiency in the early slow crop growth period. Further, addition of the crop residues in soil with improve level of organic matter and soil fertility. Nitrogen doze required by sugarcane may possibly be decreased planting of legume intercrops (Chai *et al.,* 2005).

Results of research by Li et al., (2013) showed that dry weight of biomass and yield under sugarcane/soybean intercropping were increased by 35.44 and 30.57 % for sugarcane, and decreased by 16.12 and 9.53 % (100-grain weight) for soybean, respectively. The nitrogenase activity of intercropping soybean nodule was significantly increased by 57.4 % as compared with that in monoculture models. Intercropping improves the land use efficiency and boosts microbial activities in soil. The conventional method of planting cane does not permit the intercrops to grow well due to shading and competition effect. The use of leguminous intercrops in wider spaces sugarcane can help naturally to increase the available nitrogen in the soil, thereby reducing the use of inorganic fertilizers. Keeping in view the concept of sustainable crop production, a field experiment was designed to augment the intercropping system and to find out best suited for Farmer fields.

MATERIALS AND METHODS

The experiment was piloted at research and farm area of Sugarcane Research Institute, Faisalabad, Pakistan during autumn of the crop season 2018-19 to work out the feasibility and scope of suitable intercrop for sugarcane for increasing the cropping intensity and profitability and to determine the effect of different associated pulses and Oilseed crops on growth, yield and quality of autumn planted sugarcane. The net plot size was 10 m × 9.6 m a randomized complete block design with five replications. The four crops viz. Mung, Mash, Sunflower and Canola were selected as inter crops comprised with sugarcane alone as check. The sugarcane clone CPF-249 was used and seed was planted in September each year at the rate of 50,000 triple budded setts per hectare, on four feet apart double row strips. The treatments include sugarcane intercrops with one and two lines of Mung (*Vigna radiata*), Mash (*Vigna mungo*), Sunflower (*Helianthus annuus*) and canola (*Brassica napus* L.).

Half seed rate of intercrops was used. One and two lines of each intercrop were sown on ridges as per treatments. Intercrops were harvested at maturity while the sugarcane crop was harvested in the month of December each year. NPK Fertilizer was applied at the rate of 169, 112

and 112 kg per hectare respectively in the form of urea, DAP, SOP. Fifteen irrigations were applied at different intervals according to the crop need and weather conditions. Germination % and tillers were calculated at 45 and 90 days after sowing of experiment respectively. Number of canes was counted from the whole plot at crop harvesting and converted to number of canes per hectare. Crop was harvested at maturity from each plot and cane yield per hectare was valued. The data were put to Fisher's analysis of variance and treatment means were compared to find the differences by using LSD test at 0.05% probability (Steel and Torrie, 1997).

RESULTS

The data of experiment was abridged in Table-1, and found that all intercrops and sugarcane alone have no significant effects on crop germination. However, the highest germination of 52 % was achieved in one row of Mash and one row of Sunflower intercrop which was followed that of by 51 % in one row of Mung intercrop and 50% in two rows of sunflower and sugarcane alone. The lowest germination of 48 % was observed in two rows of mash and one line of canola. The number of tillers per plant counted at cane harvesting and found that higher number of tillers per stool (2.25) was formed in the plots where two rows of mash was used as intercropped followed by 2.20 tillers per plant in one row of Mung. The number of tillers plant^{-1} of sugarcane with intercrops varied statistically non-significantly. The data clearly presents that intercrop have competitive effects on sugarcane. Mash enhanced more tillers per plant. One row of Mash and two rows of canola produced 1.95 and 1.98 number of tillers per plant respectively and these are the lowest numbers of tillers per plant among all treatments.

Regarding the cane count it was observed that the highest cane count of 150 thousand ha^{-1} was recorded in one line of Mung intercrop. Two rows of Mash, one line of canola and two rows of canola produced 125, 120 and 115 thousand ha^{-1} number of millable canes respectively. This may be due to more tillers per plant in Mung intercropping in Sugarcane. The lowest numbers of cane count 67 thousand ha^{-1} were recorded in Sugarcane + two rows of sunflower. The statistical data in table-1 presents that Sugarcane mono-cropping and various inter crops in Sugarcane had highly significant effect on sugarcane yield. Two lines of canola produced the highest cane yield with the quantity of 103.3 t ha^{-1} when intercropped in sugarcane followed by 92 and 91 t ha^{-1} in one row of Mung and two rows of Mung respectively. The lowest crop yield of 45 t ha^{-1} was attained when two lines of sunflower was sown in sugarcane.

The means of sugar yield was also varied among all the treatments. The two lines of canola intercropped in sugarcane model out yielded in sugar quantity (13.12 t ha^{-1}) and then one row of Mung and two rows of Mung sugarcane crop system produce sugar quantity of 11.46 t ha^{-1} and 11.11 t ha^{-1} respectively. Two lines of canola also out yielded others in cane yield which ultimately leads to higher sugar yield. On the other hand, two rows sunflower-sugarcane model produced lowest sugar of 5.73 t ha^{-1}. Intercrops did not affect significantly sugarcane recovery. Maximum sugarcane recovery of 12.75% and 12.70% was achieved in one lines of canola and two rows of canola respectively.

The economics of the treatments were also calculated (table 2) were compared with the sugarcane mono-cropping system. The data discovered that h economic advantage of Rs. 345210/- ha^{-1} with benefit cost ratio of 1.93 was high and found in the treatments where two lines of canola sugarcane intercropping model was adopted because this intercrop maximizes the tonnage of sugarcane crop. Then economic advantage of Rs. 264700/- ha^{-1} was received in two rows of Mung Intercrop- Sugarcane model with BCR of 1.47. The lowest benefit of Rs. 80386/- ha^{-1} was produced where two lines of sunflower was sown as intercrop with minimum BCR of 0.44.

DISCUSSION

In this experiment, the highest germination of 52 % was achieved in one row of Mash and one row of Sunflower intercrop which was followed that of by 51 % in one row of Mung intercrop and 50% in two rows of sunflower and sugarcane alone. The lowest germination of 48 % was observed in two rows of mash and one line of canola. Because intercrops occupied the space between cane rows and suppress the weeds during critical period of competition. Tosti and Guiducci (2010) presents the same results and germination of sugarcane crop was not affected by sowing of intercrops. The number of tillers per plant counted at cane harvesting and found that higher number of tillers per stool (2.25) was formed in the plots where two rows of mash was used as intercropped followed by 2.20 tillers per plant in one row of Mung. The number of tillers plant^{-1} of sugarcane with intercrops varied statistically non-significantly. The data clearly presents that intercrop have competitive effects on sugarcane. Mash enhanced more tillers per plant. One row of Mash and two rows of canola produced 1.95 and 1.98 number of tillers per plant respectively and these are the lowest numbers of tillers per plant among all treatments. These results are opposed with of Shen *et al*., (2019), reported smothering and competitive effects of intercrops lowered tillers per plant.

Regarding the cane count it was observed that the highest cane count of 150 thousand ha^{-1} was recorded in one line of Mung intercrop. Two rows of Mash, one line of canola and two rows of canola produced 125, 120 and 115 thousand ha^{-1} number of millable canes respectively. This may be due to more tillers per plant in Mung intercropping in Sugarcane. The lowest numbers of cane count 67 thousand ha^{-1} were recorded in Sugarcane + two rows of sunflower and these results are same as of Sohu *et al*., (2008) because sunflower crop is an exhaustive crop and competes with main crops of nutrients. The statistical data in table-1 presents that Sugarcane mono-cropping and various inter crops in Sugarcane had highly significant effect on sugarcane yield. Two lines of canola produced the highest cane yield with the quantity of 103.3 t ha^{-1} when intercropped in sugarcane followed by 92 and 91 t ha^{-1} in one row of Mung and two rows of Mung respectively. This may be due to higher number of canes per ha and tillers per plant in one row of Mung and two lines of canola. The availability of sufficient soil nutrients especially Nitrogen by Mung crop being leguminous and restorative crop, improves the soil fertility and organic matter. The lowest crop yield of 45 t ha^{-1} was attained when two lines of sunflower was sown in sugarcane. These results are similar to Shukla *et al.,* (2017).

Legume crops excreted large number of amino acids into the rhizosphere. A further possibility of soil fertility improvement is through addition of crop residues, which on decomposition adds to the fertility of the soil and increased the organic matter in soil from 1.12% to 1.62% as presented in table-3. The nitrogen fixed by nitrogen fixing bacteria on the root nodules of lentil makes available to allied sugarcane crop and ultimately has positive impacts of yield contributing parameters. But sunflower crop competes with major crop and lowers yield. The means of sugar yield was also varied among all the treatments. The two lines of canola intercropped in sugarcane model out yielded in sugar quantity (13.12 t ha^{-1}) and then one row of Mung and two rows of Mung sugarcane crop system produce sugar quantity of 11.46 t ha^{-1} and 11.11 t ha^{-1} respectively. Two lines of canola also out yielded others in cane yield which ultimately leads to higher sugar yield. On the other hand, two rows sunflower-sugarcane model produced lowest sugar of 5.73 t ha^{-1}. This may lead to the support the recommendation that two lines of canola as intercrop in sugarcane will be better for the farmers to get maximum cane and sugar yield (5, 10). Intercrops did not affect significantly sugarcane recovery. Maximum sugarcane recovery of 12.75% and 12.70% was achieved in one lines of canola and two rows of

canola respectively. This highest sugarcane recovery in canola intercrops leads to maximum sugar yield. The economics of the treatments were also calculated (table 2) were compared with the sugarcane mono-cropping system. The data discovered that h economic advantage of Rs. 345210/- ha^{-1} with benefit cost ratio of 1.93 was high and found in the treatments where two lines of canola sugarcane intercropping model was adopted because this intercrop maximizes the tonnage of sugarcane crop. Then economic advantage of Rs. 264700/- ha^{-1} was received in two rows of Mung Intercrop- Sugarcane model with BCR of 1.47. The lowest benefit of Rs. 80386/- ha^{-1} was produced where two lines of sunflower was sown as intercrop with minimum BCR of 0.44. These results are in line with Solanki *et al.*, (2020), who stated that exhaustive inter crops decline cane yield and net benefit.

CONCLUSION

It was concluded from the study that higher cane yield (103.3 t ha^{-1}), sugar yield (13.12 t ha^{-1}) and more economic advantage of Rs. 345210/- ha^{-1} were obtained when intercropped with two lines of Canola. After canola, economic advantage of Rs. 264700/- ha^{-1} was obtained when intercropped with two lines of Mash. It is also suggested that a canola and Mash as intercrop will be more profitable for sugarcane growers to fetch short term benefit.

Table-1 Effect of Inter crops on Yield and quality of Sugarcane (*Saccharum officinarum*)

Sr. No.	Treatment	Germination (%)	Tillers/ plant	Cane account (000/ha)	Cane yield (t/ha)	Sugar recovery (%)	Sugar yield (t/ha)
1	T1 sugarcane alone	50	2.10	129 B	84 B	12.42	10.43 AB
2	T2 Sugarcane + 1 row of mong	51	2.20	150 A	92 A	12.47	11.48 A
3	T3 Sugarcane + 2 rows of mong	49	2.00	86 D	91 A	12.31	11.11 A
4	T4 Sugarcane + 1 row of mash	52	1.95	92 D	72 D	12.26	9.63 B
5	T5 Sugarcane + 2 r ows of mash	48	2.25	125 B	79 BC	12.13	9.58 B
6	T6 Sugarcane + 1 row of sunflower	52	2.08	100 C	74 CD	12.52	9.28 B
7	T7 sugarcane +2 rows of sunflower	50	2.05	67 E	45 E	12.74	5.73 C
8	T8 sugarcane +1 line of canola	48	2.00	120 B	79.4	12.75	10.12 B
9	T9 sugarcane +2 line of canola	49	1.98	115 B	103.3 A	12.70	13.12 A
	LSD 0.05	**N. S**	**N. S**	**7.8989**	**5.8425**	**N. S**	**1.2789**

Table-2 Effect of Inter crops on Sugarcane (*Saccharum officinarum*) Economics (In Pak Rs.)

Treatments	Yield (t/ha)	Intercrop yield (kg /ha)	s.cane Income	Intercrop Income	Total income	Cost of prod. s.cane	Cost of protect. Intercrop	Total cost	Net income	BCR
T1 Sugarcane alone	84	-	378000	-	378000	175000	-	175000	203000	1.16
T2 Sugarcane + 1 row of mong	92	234	414000	20592	434592	175000	5000	180000	254592	1.41
T3 Sugarcane + 2 rows of mong	91	400	409500	35200	444700	175000	5000	180000	264700	1.47
T4 Sugarcane + 1 row of mash	72	267	324000	24831	348831 0	175000	5500	180500	168331	0.93
T5 Sugarcane + 2 rows of mash	79	400	355500	52000	407500	175000	5500	180500	227000	1.26
T6 Sugarcane + 1 row of sunflower	74	1000	333000	57000	390000	175000	6000	181000	209000	1.15
T7 sugarcane +2 rows of sunflower	45	1033	202500	58881	361381	175000	6000	181000	80386	0.44
T8 sugarcane +1 line of canola	79	1.05	357300	59360	416660	175000	4000	179000	237660	1.33
T9 sugarcane +2 line of canola	103	1.05	464850	59360	524210	175000	4000	179000	345210	1.93

REFERENCES

Aggarwal PK, Garrity DP, Liboon SP, Morris RA (1992). Resource use and plant interactions in a rice-mungbean intercrop. Agron J 84:71–78.

Chai Q, Huang P, Huang GB (2005) Effect of intercropping on soil microbial and enzyme activity in the rhizosphere. Acta Pratacul Turae Sin 14(5):105–110.

Cong, W.F., E. Hoffland, L. Li, B.H. Janssen, and W. van der Werf. (2015). Intercropping affects the rate of decomposition of soil organic matter and root litter. Plant and Soil 391(1–2): 399–411.

Li, X., Mu, Y., and Cheng, Y. (2013). Effects of intercropping sugarcane and soybean on growth, rhizosphere soil microbes, nitrogen and phosphorus availability. Acta Physiol Plant 35, 1113–1119.

Rehman, A., A. Ali, Z. Iqbal, R. Qamar, S. Afghan and A. Majid. (2014). Maximum economic return through intercropping of different crops in September sown Sugarcane. P. Sugar. J. V.29 (2): 7-14.

Shen XF, Z.H. Zhao & Y. Chen. (2019). Effects of Intercropping with Peanut and Silicon Application on Sugarcane Growth, Yield and Quality. Sugar Tech. 21: 437–443.

Shukla S.K, K. K. Singh, A. D. Pathak, V. P. Jaiswal and S. Solomon. (2017). Crop Diversification Options Involving Pulses and Sugarcane for Improving Crop Productivity, Nutritional Security and Sustainability in India. Sugar Tech. 19:1–10.

Sohu, A. I., B. A. Abro and A. H. Memon. (2008). Effect of Intercropping Short Duration Crops on Sugarcane Production. Life Sci. Int. J, Vol. 2(3): 718-722.

Solanki M.K, F. Y. Wang, C. N. Li, Z. Wang, T. J. Lan, R. K. Singh, P. Singh, L. T. Yang and Y. R. Li. (2020). Impact of Sugarcane–Legume Intercropping on Diazotrophic Microbiome. Sugar Tech. 22: 52–64.

Steel, R.G.D. and J.H. Torrie. (1997). Principles and Procedures of Statistics. McGraw Hill Book Co. Inc. Singapore.

Tosti, G. and Guiducci M. (2010). Durum wheat-faba bean temporary intercropping: Effects on nitrogen supply and wheat quality. Europ. J. Agron.33: 157-165.