EFFECT OF DIFFERENT INTERCROPS ON YIELD, QUALITY AND ECONOMICS OF SUGARCANE

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ABSTRACT
Sugarcane is of great value in the world as it provides sugar to more than half of global population. Cultivated land in the world is decreasing very rapidly due to urbanization, road construction and land deterioration. While the world population is increasing day by day. This world scenario demands maximum economic returns per acre to feed world population. Intercropping in sugarcane is very important in this regard and may become popular among farmers due to long duration and late return from sugarcane crop. Intercropping in sugarcane has potential to provide farmers with maximum economic returns per acre per annum. In a field experiment, different intercrops were sown in autumn planted sugarcane at research area of Sugarcane Research Institute, Faisalabad, Pakistan during the crop season 2015-16. The intercropping systems comprised of SC + lentil, SC + linseed, SC + canola, SC + onion and check with alone SC. The experiment was laid out in a randomized complete block design with three replications. The results revealed that SC +lentil gave higher cane (138.44 t ha^{-1}) and sugar (16.56 t ha^{-1}) yield with maximum economic benefits as compared with others.

Keywords: Sugarcane, Intercropping, Economic Return, Cost Benefit Ratio.
Abbreviations: SC = Sugarcane; BCR = Cost Benefit Ratio

INTRODUCTION

Sugarcane is an important cash-cum-industrial crop of Pakistan. It is the main source of revenue in Pakistan after cotton and rice. It is a source of providing raw material to many allied industries and employment (Akbar *et al*., 2011). Sugarcane contributes 3.4% to the value added products in agriculture and 0.7% to gross domestic production. Currently, the area under sugarcane is 1.21 million hectares and total production is 73.6 million tons with an average yield of 60.42 ton ha^{-1} (Anonymous, 2016-17).

Sustainable agriculture seeks, at least in principle, to use nature as the model for designing agricultural systems. Since nature consistently integrates her plants and animals into a diverse landscape, a major tenet of sustainable agriculture is to create and maintain diversity. Intercropping offers farmers the opportunity to engage nature's principle of diversity on their farms. Spatial arrangements of plants, planting rates, and maturity dates must be considered when planning intercrops. Intercrops can be more productive than growing pure stands (Preston, 2003). Intercropping efficiently maximizes land and productivity per unit of area per season (Oad *et al.* 2001) and owner can obtain more added benefits with low added costs. Therefore, it is important to investigate the added benefits of intercropping through economic analysis.

Cane is planted in wider rows, and takes several months to canopy, during which time the soil, solar energy and much of the rainfall between the rows goes to waste. Any inter-row crop must therefore mature and be harvested within 90-120 days before the cane canopies (Rathore *et al.,* 1999).
Day-by day, the population is rapidly increasing which decreasing the area under crop production. The prerequisite is to increase the production and income per unit area. This may be possible by intercropping (Rehman *et al.,* 2014). 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 can help naturally to increase the available nitrogen in the soil, thereby reducing the use of inorganic fertilizers (Tosti and Guiducci, 2010).The intercrops were also used in the South African sugarcane industry to manage nematodes on small scale grower farms (Berry *et al*., 2009).

Autumn-planted sugarcane occupies the land for more than one year and hence the farmers have no chance to taken other crop in both the winter and summer season. The growth rate is very slow during the winter and early spring due to prevalence of low temperature. This period can safely be utilized for raising suitable winter intercrops maturing up to the end of April without doing much damage to the associated cane crop (Dhima *et al*., 2007).

Pakistan being the subtropical country with best growing conditions can easily exploit the potential of growing more than two crops in a year through intercropping. This may increase production per unit land area with suitable farm management practices. Consequently the present study was designed to explore the feasibility and scope of different intercrops in sugarcane and their economics and assess their effects on growth, yield and quality of cane.

MATERIALS AND METHODS

The study was conducted at research area of Sugarcane Research Institute, Faisalabad, Pakistan during the crop season 2015-16. The experiment was laid out in a randomized complete block design with three replications. The net plot size was 9.6 m × 5 m. The treatments comprised of SC + Lentil, SC + Linseed, SC + Canola, SC + Onion and SC alone as check. The sugarcane clone S2008-FD-19 with seed rate of 75,000 double budded setts per hectare was planted in September 2015 in 120 cm apart double row strips. Trenches were made with the help of tractor drawn ridger.

Lentil, linseed, canola were sown in the month of October 2015 and onion nursery was transplanted in the month of December 2015. Half of the recommended seed rate of intercrops was used i.e. Lentil 20 kg, Linseed 20 kg and Canola 5 kg per ha. Onion was sown by using nursery. Two lines of each intercrop were sown in between sugarcane. Intercrops were harvested at maturity during the month of April 2016 while the sugarcane crop was harvested in the month of December 2016. Fertilizer was applied at the rate of 175, 115 and 115 kg NPK per hectare. Sixteen irrigations were applied at different intervals according to the crop need and climate.

Data recording

Emergence and tillers per plot was counted at 45 days and 90 days after planting respectively. Number of canes was counted from the two strips in each plot at final harvest and was converted to canes per hectare. Crop was harvested at maturity by taking an area of two strips from each plot and cane yield per hectare was estimated.

Net return was determined by subtracting the total cost of production from the gross income of each treatment (CIMMYT, 1988).

Net income = Gross income – Cost of production

Benefit cost ratio was calculated by dividing the gross income with the total cost of production.

BCR = Gross income / Total cost

Statistical analysis

The data collected were subjected to Fisher's analysis of variance technique and LSD test at 0.05% was used to compare the differences among treatment means (Steel & Torrie, 1984).

RESULTS AND DISCUSSION

Emergence

It is explicit from the data that emergence has non significant results in all treatments. But the maximum germination of 49.60 % was attained in SC+ lentil which was followed that of by 49.48 % in SC + canola. The lowest emergence of 49.25 % was attained in sole SC. The results are in line with those of Sain, *et al*. (2003) who

reported no significant affect of sole sugarcane and different intercrops on emergence.

Tillers per plant

The summarized observations in Table 1 regarding average number of tillers per plant recorded at the time of harvesting revealed that significantly more number of tillers per stool (2.20) was produced in the plots where lentil was intercropped in sugarcane crop which was followed that of by 2.15 in SC + onion. The difference in number of tillers per plant of sugarcane with intercrops showed statistically non-significant results. The data clearly manifested that intercrops did show no competitive effect on sugarcane but lentil improve more tillers per plant. Tillers per plant are at par in case of canola, onion intercrops and sole sugarcane. The lowest numbers of tillers per plant (2.02) were attained in SC + linseed. These results are in contradict with the findings of Sain, *et al*. (2003) who reported smothering and competitive affects of intercrops on tillers per plant of sugarcane.

Cane count (000 ha^{-1})

Regarding the cane count it was observed that the highest cane count of 140.33 thousand ha^{-1} was recorded in SC + lentil which was at par with SC + onion with cane count of 139.07 thousand ha^{-1}. This may be due to more tillers per plant in lentil intercropping in SC. The lowest numbers of cane count 121.51 thousand ha^{-1} was recorded in SC + linseed and these results are in line with Bajwa *et al.,* (1992).

Cane Yield (t ha^{-1})

A perusal of data in Table 1 showed that Sole SC and different intercrops in SC had a significant impact on cane yield. SC + lentil produced the highest cane yield with the quantity of 138. 44 t ha^{-1} which was followed that of by 135.55 t ha^{-1} in SC + onion crop system. The significantly higher sugarcane yield in SC + lentil is due to higher cane count per ha and more tillers per plant and availability of sufficient soil nutrients as lentil is a leguminous and restorative nature crop. The lowest crop yield of 117.16 t ha^{-1} was attained when linseed was sown in sugarcane. These results are similar to Sain *et al.,* (2003).

Sugar yield (t ha^{-1})

It is clear from the data in Table 1 that sugar yield was significantly affected by all the treatments. The maximum sugar yield of 16. 56 t ha^{-1} was recorded where lentil was intercropped in sugarcane which was followed that of by 15.61 t ha^{-1} in sugarcane + onion and 15.46 t ha^{-1} in sugarcane + canola crop system. The lowest sugar yield of 14.02 t ha^{-1} was attained when linseed was sown in sugarcane. On the basis of these results, it may be inferred that lentil intercropping in cane will be economical and better for the farmers to get maximum sugar yield. Our results are supported the findings of Rehman *et al.,* (2014), Sharma *et al.,* (1993) and Rana *et al.,* (2006) who confirmed that lentil + SC produced higher number of tillers, millable canes and cane yield which ultimately leads to highest sugar yield.

Economic analysis:

The economics of intercropping and sole sugarcane was worked out in table 2. The economic benefits got from different intercrops planted in sugarcane were compared with the sole sugarcane. The data revealed that high economic advantage of Rs. 542810/- ha^{-1} with benefit cost ratio of 3.51 was recorded in the treatment where lentil was intercropped in sugarcane. Lentil is a legume intercrop enhances soil fertility through the excretion of amino acids into the rhizosphere. The nitrogen fixed by the legume intercrop may be available to the associated sugarcane in the current season itself, as sugarcane remains in the field for over nine months after the harvest of the legumes. Since considerable addition of nutrient to soil was result in more cane and sugar yield per hectare which ultimately leads to more economic benefits than others. The lowest net benefit of Rs. 422275/- ha^{-1} was attained in sole SC. Our results are in line with Rehman *et al.,* (2014).

CONCLUSION

It was concluded from the results of the study that sugarcane crop produced higher cane and sugar yield of 138.44 t ha^{-1} and 16.56 t ha^{-1} respectively when

intercropped with lentil. It gave high economic advantage of Rs. 542810/-ha^{-1}with benefit cost ratio of 3.51 than other intercrop systems. Economic analysis suggested that a sugarcane-lentil crop system is more profitable than sole sugarcane and other intercrops.

Table-1 Yield and quality parameters

Treatments	Emergence (%)	Tillers/ plant	Cane count (000 ha^{-1})	Cane yield (t ha^{-1})	CCS%	Sugar Yield (t ha^{-1})
SC + Lentil	49.60	2.20 a	140.33 a	138.44 a	12.76 a	16.56 a
SC + Linseed	49.45	2.02 c	121.57 e	117.16 e	12.25 b	14.02 d
SC + Canola	49.48	2.09 bc	134.51 c	129.83 c	12.74 a	15.46 b
SC + Onion	49.28	2.15 ab	139.07 b	135.55 b	12.74 a	15.61 b
Sugarcane Sole	49.25	2.08 bc	130.46 d	127.30 d	12.35 b	14.77 c
LSD @ 0.05	NS	0.0832	0.6036	1.1252	0.1509	0.2324

Table-2 Economic analysis

Treatments	Cane yield (t-ha^{-1})	Inter-crops yield (kg/ha)	Income sugarcane (Rs.)	Income Intercrop (Rs.)	Total income (Rs.)	Cost of production sugarcane (Rs.)	Cost intercrop (Rs.)	Net income/ ha (Rs.)	Cost benefit ratio (BCR)
SC + Lentil	138.44	496.03	622980	74405	697385	150575	4000	542810	3.51
SC + Linseed	117.16	535.72	527220	53572	580792	150575	3250	426967	2.78
SC + Canola	129.83	376.97	584235	20733	604968	150575	3200	451193	2.93
SC + Onion	135.55	1295.33	609975	27202	637177	150575	27500	459102	2.58
Sugarcane Sole	127.3	0	572850	0	572850	150575	0	422275	2.80

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