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EFFECT OF INTERCROPPING CEREALS AND LENTIL IN SUGAR BEET ON YIELD AND MONETARY BENEFITS

M. U. USMANIKHAIL[1]*, S.D. TUNIO[1], G.H. JAMRO[1], F.C. OAD[1], SYED WASEEM UL HASSAN[1], Q.D.CHACHAR[1] AND M. ALI KHANZADA[1]

[1]*Sindh Agriculture University, Tandojam*
Corresponding author:musman_ari@yahoo.com

Abstract

Field trials were carried out at Sugarcane Section, Agriculture Research Institute, Tandojam, Pakistan during 2007-2008 and 2008-2009 to study the impact of intercropping sugar beet with wheat and barley (cereal crops) and lentil. For this purpose three sugar beet varieties *viz.,* Kaweterma, Aura and Pamela and four intercropping systems (sugar beet sole, sugar beet + wheat, sugar beet + barley, and sugar beet + lentil) were used. Sugar beet varieties planted as sole showed significantly higher values of all traits. Among the tested varieties, sole planting of sugar beet variety Kaweterma showed maximum leaf length, leaf area, leaves plant^{-1}, vertical diameter of beet, horizontal diameter of beet, beet root weight, beet yield, total dry matter, purity, Pol, brix, sugar recovery, N uptake and P uptake followed by Aura and Pamela when planted as sole. The intercropping of sugar beet with lentil produced second lowest values than sugar beet sole planting. However, wheat and barley intercropping produced minimum values of sugar beet. Maximum monetary benefits like higher gross revenue, input: output ratio, cost: benefit ratio and net returns were recorded when lentil crop was intercropped with sugar beet variety Kaweterma. It is concluded that sugar beet yields and consequently the monetary benefits were also higher in lentil intercropping as compared to cereals intercropping system.

Introduction

Farming systems in crop production can be defined as the cultivation of crop plants in time and space and the combination of applied inputs (fertilizers, irrigation water, pesticides etc.) believed to give maximum yield in specific socioeconomic, political and cultural conditions (Babar *et al.,* 2011). The instantaneous farming of different crops on the same piece of cultivated soil has been described interchangeably as mixed cropping or intercropping by Norman (1982). However, Ruthenberg (1980), differentiate mixed cropping and intercropping on the basis of the pattern of the intermixture. Temperate region alternates have been found good for the crops of tropical region. Oilseeds have greatly minimized the increasing requirement for groundnut oil, cotton has been dislocated to a considerable extent by artificial fibres; cane sugar has been replaced by sugar beet. In farming systems with low external inputs, intercropping became also appeared as an economically viable option for an integrated weed management (Schoofs & Entz, 2000; Jabbar *et al.* 2010; Teasdale, 1998). As an example of functional biodiversity, intercropping various major and minor crops with sugar beet (*Beta vulgaris* L.) produced number of extra positive affects like reduced level of pests infestation and weeds and an improved resource capture, while formal cropping practices were not hindered (Baumann *et al*., 2001). With intercropping various cereal and pulse crops, sugar beet has showed better weed suppression by the canopy due to improved light interception. The intercrop canopy captured the incoming radiation more effectively and thus less radiation was available for germination and growth of weeds. Moreover, the sturdy relative competitive ability of sugar beet in the intercropping system resulted in economic return (Baumann *et al*., 2001). Now-a-days, intercropping is becoming one of the important tools to increase crop productivity to meet food demands of an ever increasing population (Li *et al*., 1999). Intercropping, through effective use of inputs like water, nutrients, pesticides and solar energy, can significantly increase crop yields compared with monoculture cropping (Willey, 1990; Vandermeer, 1989). Mix cropping of cereals and lupins produced higher yield than either crop grown alone. This may happen not only due to increased availability of nitrogen to the cereal component, but also to other unknown causes (Morris & Garrity, 1993; Ahmad *et al*., 2007; Solangi *et al*., 2009). Altieri (1994) examined many combinations of crops as mixed or relay intercrops including sugar beets with sunflowers, sunflowers with lentils, cotton with pigeon pea, cotton with maize, wheat with flax, canola with flax and cotton with sesame.

Intercropping sugar beet is considered highly valuable in regards of net benefits from the same piece of land. Oil radish inclusion in the crop rotation significantly checked the population of major insect pest of sugar beet and significantly enhanced the beet yield. Sugar beet-mustard intercropping could provide more resistance to plant pathogenic nematodes and produce significantly high monetary returns (Krall *et al*., 1996). Sugar beet-sunflower combination considerably increase monetary returns and produced positive impacts on the soil health and nutrition for the next crop (Stoyanov *et al*., 1997). The intercropping system like sugar beet with cereals, sugar beet with oilseeds and or sugar beet with sugarcane could provide the farmer with high gross returns (Lal & Mukerji, 1998). Mustard and oil radish intercrops can suppress insect pest population considerably on sugar beet and oil radish reduces the nematode population (Banaszak *et al*., 1998). Intercropping of wheat with sugar beet, sugar beet or wheat in pure stands could turn out high monetary returns (Singh *et al*., 1999). The cultivation of sugar beet does not permit the land to develop hard pan and intercropping oilseeds of wheat reduced soil compaction (Gazdag, 2000); and stabilizes the situation regarding yields and economics returns from wheat, maize; correlation of yield averages and returns emphasize the need to improve yields (Osman & Haggag, 2000). Intercropping patterns of sugar beet + garlic or sugar beet + onion improves the yield of intercrops and other components of sugar beet (Toaima *et al*., 2000). Mixed1intercropping is common practiced when cereals, grain legumes, and root crops are grown together and when little or no tillage is required (Akinola & Agboola, 2000).

Although, root yields of sugar beet decrease with an increase in the number of rows of the intercrop, but no adverse effect sucrose yield; additionally yields of the intercrops adds remarkably high gross returns (Osman & Haggag, 2000). Badraoui *et al*., (2003) recommended sugar beet and sunflower as companion crops, who cultivated wheat-sugar beet or sunflower in the irrigated regions of Morocco and found them as most successful companion crops with overall net returns. El-Dessougi *et al*., (2003) grown sugar beet in oilseed rape and found that sugar beet intercropped with oilseeds produced higher monetary returns than other companion crops; however, Vos & Putten (2004) found sugar beet-oats and advocated that this could be a successful combination of crops as compared to sugar beet-wheat intercropping system. Sugar beet + potato, sugar beet + onion and sugar beet + coriander combinations may also be suggested for non mill zone area of Kashmir to get intervening benefit from the same piece of land (Azad & Alam, 2004). Moreover, the intercropping vegetables within the minor crops as well as with major crops are an old practice. Egg plant + beets is a general recommendation, while intercropping cucurbits with sugar beets also have been practiced (Sridhar *et al*., 2002). Present study has therefore, been carried out to examine the impact of intercropping cereal and pulse crops in sugar beet on crop productivities and monetary returns.

Materials and Methods

Field experiments were carried out at the experimental fields of Sugarcane Section, Agriculture Research Institute, Tandojam, Pakistan which is located at 25 o 25'60'N 68 o 31'60E. The experimental soil was clay loam, non-saline, low in organic matter ranging from 0.59-0.56%, available phosphorus (3.00-3.50 mg kg^{-1}) and high exchangeable potassium (168 mg kg^{-1}). The trail was laid out in randomized complete block design (RCBD) with four replications in factorial arrangement. Three sugar beet varieties i.e. Pamela, Aura and Kaweterma were tested against four intercropping arrangements i.e. Sugar beet sole, sugar beet with wheat, sugar beet with barley and sugar beet with lentil. Same land preparation operations were done for equal distribution of fertilizers and irrigation. Sowing of all crops was carried out on November 15, 2007-08. Sugar beet was grown on the raised beds of 90 cm. Each intercrop crop (barley, wheat and lentil) was sown between sugar beet raised beds in alternate row ratio of 1:1. After 20 days of sowing, first irrigation was applied and subsequent irrigations were applied as per requirement of the crop and soil. N-P fertilizer was applied at the @ 100-100 kg ha -1 in the form of urea and DAP, respectively. All P with half N were applied during the time of land preparation. The remaining half N was applied with 2nd, 3rd and 4th irrigations. Cost: benefit ratio (Cbr) was computed by the following formula as suggested by Siddiqui *et al*., (1983) i.e., Cbr = Nr ÷ Ge; where Nr=net returns and Ge=Gross expenditure.

Initially, two factors viz., intercrops and varieties and were set in RCBD factorial arrangement. Third factor (year was included during data record). Data were statistically analyzed by using MSTATC computer software. The LSD value for mean comparison was calculated only if the general treatment F test was significant at $p \leq 0.05$ (Gomez & Gomez, 1985).

Results and Discussion

Statistical analysis of variances for all crop traits as affected by intercrops, varieties and their interaction (intercropping x varieties) were significant (Tables 1-4). However, years and their interaction (years x intercropping, years x varieties, years x varieties x intercropping) were non significant. The non-significant interaction of years with other factors of variants could be predicted due to little variation in the weather in these years.

Varietal response: Sugar beet varieties showed significantly different response when intercropped with lentil and cereals (Table 1). Sugar beet variety Kaweterma had significantly maximum leaf length (52.25 cm), leaf area (834.0 cm), leaves $plant^{-1}$ (26.25), horizontal diameter of beet (12.96 cm), vertical diameter of beet (19.59 cm), beet root weight (1.77 kg/beetroot), beetroot yield (76.25 t ha^{-1}), total dry matter (3.92 t ha^{-1}), sugar recovery (11.40%), brix (21.77%), P uptake (18.6 kg ha^{-1}) and N uptake (88.1 kg ha^{-1}) and followed by Aura (Table 1). However, sugar beet variety Pamela showed higher Pol (15.21%), purity (77.04%) and maturity period of 160 days (Table 1).

In the present study Kaweterma showed its superiority in performance while Akinola & Agboola (2000) suggested that irrespective of varieties, sugar beet performed normally good under little or no tillage conditions when intercropped with cereals, grain legumes, and other root crops. It was observed that with intercropping sugar beet with cereals, the yield of intercrops was equal to those when sown as sole, and chemical analysis of sugar beet was improved (Toaima *et al*., 2000; Dessougi *et al*., 2003; Vos & Putten, 2004).

Effect of intercropping: The intercropping of sugar beet + cereals had significant effect ($p<0.05$) on beet traits (Table 2). Significantly maximum leaf length (54.50 cm), leaf area (915 cm), leaves $plant^{-1}$ (28.66), horizontal diameter of beet (15.32 cm), vertical diameter of beet (23.70 cm), beet root weight (1.69 kg), beet yield (76.50 t ha^{-1}), brix (21.93%), purity (83.11 %), total dry matter (3.96 t ha^{-1}), Pol (15.90%), sugar recovery (12.16%), P uptake (21.18 kg ha^{-1}) and N uptake (100.3 kg ha^{-1}) were recorded in sugar beet sole cropping system, followed by intercropping of sugar beet with lentil (Table 2). Sugar beet intercropping with cereals (wheat and barley) has revealed significantly lower values of beet traits (Table 2). Sridhar *et al*., (2002) advocated intercropping of cereals and sugar beet for improving soil organic matter without adverse effects on sugar beet yields. Similarly, Toaima *et al*., (2000) showed that intercropping sugar beet with cereals was highly beneficial as compared to those when cropped alone.

Table 1. Response of sugarbeet varieties planted in lentil and cereal intercropping system.

Plant traits	Varieties			SE	LSD (5%)
	Kaweterma	Aura	Pamela		
Days to maturity	147c	156b	160a	0.175	2.156
Leaves plant^{-1}	26.25a	24.00b	23.00c	0.161	0.461
Leaf length (cm)	52.25a	46.25b	45.00c	0.417	1.179
Leaf area (cm)	834a	769b	741c	2.97	8.40
Vertical diameter (cm)	19.59a	17.40b	16.71c	0.128	0.363
Horizontal diameter (cm)	12.96a	11.68b	11.12c	0.088	0.250
Single beet root weight (kg)	1.77a	1.26b	1.10c	0.020	0.056
Yield (t ha^{-1})	76.25a	72.62b	69.62c	0.360	1.018
Total dry matter (t ha^{-1})	3.92a	3.82b	3.75c	0.0147	0.0417
Brix (%)	21.77a	20.90b	19.53c	0.118	0.335
Purity (%)	75.95c	76.48b	77.04a	0.160	0.453
Pol (%)	14.92c	15.06b	15.21a	0.032	0.090
Sugar recovery (%)	11.40a	10.94b	10.60c	0.062	0.022
N content (%)	2.14	2.12	2.13	-	-
P content (%)	0.474	0.474	0.477	-	-
N uptake (kg ha^{-1})	88.1a	84.4b	83.8b	0.488	1.378
P uptake (kg ha^{-1})	18.6a	18.1b	17.9c	0.056	0.158

Value followed by same letters do not differ significantly at 0.05 probability level

Table 2. Sugar beet traits under the effect of cereal intercropping system.

Plant traits	Intercropping system					
	Sugar beet sole	Sugar beet + wheat	Sugar beet + barley	Sugar beet + lentil	SE	LSD (5%)
Days to maturity	157a	153b	152b	155ab	0.97	2.75
Leaves plant^{-1}	28.66a	22.16c	21.00d	25.83b	0.190	0.535
Leaf length (cm)	54.50a	44.33c	43.50c	49.00c	0.482	1.381
Leaf area (cm)	915a	716c	705d	790b	3.43	9.70
Vertical diameter (cm)	23.70a	15.50c	14.00d	18.41b	0.148	0.441
Horizontal diameter (cm)	15.32a	10.41c	9.75d	12.20b	0.102	0.289
Single beet root weight (kg)	1.69a	1.21c	1.20c	1.40b	0.023	0.065
Yield (t ha^{-1})	76.50a	70.33c	69.50c	75.00b	0.416	1.175
Total dry matter (t ha^{-1})	3.96a	3.74c	3.75c	3.85b	0.017	0.048
Brix (%)	21.93a	20.13c	20.10c	20.78b	0.137	0.387
Purity (%)	83.11a	73.01c	72.81c	77.03b	0.185	0.523
POL (%)	15.90a	14.75c	14.68c	14.93b	0.037	0.104
Sugar recovery (%)	12.16a	10.36c	10.20d	11.20b	0.025	0.071
N content (%)	2.48	1.95	1.93	2.15	-	-
P content (%)	0.535	0.446	0.441	0.478	-	-
N uptake (kg ha^{-1})	100.3a	75.7c	75.2c	90.7b	1.591	0.563
P uptake ((kg ha^{-1})	21.18a	16.69c	16.58c	18.40b	0.064	0.183

Value followed by same letters do not differ significantly at 0.05 probability level

Interaction of varieties x cereal intercropping: Interaction of cereal x varieties intercropping was significant ($p<0.05$) in all observed sugar beet traits except P uptake (21.18 kg ha^{-1}), days to maturity, N and P content (Table 3). Sugar beet varieties planted as sole yielded higher values in all traits. Among the tested varieties, sole planting of Kaweterma had maximum leaf length (60.50 cm), leaf area (1002 cm), leaves plant^{-1} (30.50), horizontal diameter of beet (16.25 cm), vertical diameter of beet (25.87 cm), beet root weight (2.28 kg), beet yield (80.50 t ha^{-1}), brix (23.8%), purity (83.5%), total dry matter (4.05 t ha^{-1}), Pol (15.9 5), sugar recovery (12.80%), P uptake (22 kg ha^{-1}) and N uptake (102 kg ha^{-1}) followed by Aura and Pamela when planted as sole (Table 3). Sugar beet with lentil intercropping was superior and showed second lowest values than sugar beet sole planting. However, minimum values of sugar beet were recorded in cropping system of wheat and barley intercropping (Table 3). Intercropping sugarbeet with cereals or oilseeds improve the soil structure and no marked variation in soil and crop profile due to different sugar beet varieties intercropped with cereals or oilseeds (Anon., 2000).

Table 3. Sugar beet agronomic traits as affected by interactive effect of varieties x intercropping system.

Varieties x intercropping system		Leaves plant^{-1}	Leaf length (cm)	Leaf area (cm)	Single beet root weight (kg)	Yield (t.ha^{-1})	Total dry matter (t.ha^{-1})
Sugar beet sole	Kaweterma	30.50a	60.50a	1002.50a	2.28a	80.50a	4.05a
	Aura	28.50b	52.50bc	902.50b	1.50c	74.00bc	3.95b
	Pamela	27.00c	50.50c	842.50c	1.30d	75.00b	3.90b
Sugarbeet + wheat	Kaweterma	24.50e	47.50d	751.50e	1.50c	73.50bcd	3.80c
	Aura	21.50g	43.50e	702.50g	1.15e	72.00cd	3.80c
	Pamela	20.50h	42.00e	695.00g	1.00f	65.50e	3.67de
Sugarbeet + barley	Kaweterma	23.00f	46.50d	731.50f	1.50c	72.50cd	3.90b
	Aura	20.50h	42.50e	695.00g	1.10ef	71.50e	3.75cd
	Pamela	19.50i	41.50e	690.00g	1.00f	64.50cd	3.62e
Sugarbeet + lentil	Kaweterma	27.00c	54.50b	852.50c	1.80b	78.50d	3.95b
	Aura	25.50d	46.50d	777.50d	1.30d	73.00d	3.80c
	Pamela	25.00e	46.00d	740.00e	1.10ef	73.50d	3.80c
SE		0.329	0.835	5.95	0.046	0.721	0.029
LSD 5 %		0.928	2.350	16.80	0.113	2.036	0.083

Table 4. Economics of various intercropping practices with sugarbeet.

Variables	Sugar beet yield t ha^{-1}	Intercrop tons ha^{-1}	Cost of production	Gross revenue	Net returns	Benefit cost ratio
Kawiterma	80.50	0.0	45056	119987	74931	1.66
Aura Sole	74.00	0.0	45056	110999	65943	1.46
Pamela Sole	75.00	0.0	45056	114000	68944	1.53
Kawiterma x Wheat	73.50	2.50	45844	135923	90079	1.96
Aura X wheat	72.00	2.47	45844	135257	89413	1.95
Pamela x Wheat	65.50	2.43	45844	125604	79761	1.74
Kawitarma x Barley	72.50	1.44	45353	126850	81498	1.80
Aura x Barley	71.50	1.43	45353	125126	79773	1.76
Pamela x Barley	64.50	1.41	45353	114429	69077	1.52
Kawitarma x lentil	78.50	0.40	45909	136295	90387	1.97
Aura x lentil	73.00	0.39	45909	127382	81473	1.77
Pamela x lentil	73.50	0.33	45909	125044	79136	1.72

Note: 1 USD = Rs.62.34 (Oct 07 – May 08), (SBP, 2008)

Monetary benefits

Beetroot yield (t ha^{-1}): Sugar beet variety Kaweterma intercropped with lentil yielded significantly highest beetroot yield of 78.50 t ha^{-1} against its yield of 80.50 t ha^{-1} under sole system (Table 4). Similarly, varieties Aura and Pamela yielded higher beetroot yield of 73.00, 73.50 t ha^{-1} when intercropped with lentil when compared with yields of 74.00 and 75.00 t ha^{-1}, respectively under sole cropping system (Table 4). Sugar beet varieties Kaweterma, Aura and Pamela produced beetroot of 73.50, 72.00, and 65 .50 t ha^{-1} when intercropped with wheat and produced 72 1.50, 71.50 and 64.50 t ha^{-1} when barley was used as companion crop, respectively (Table 4).

It was observed the with intercropping cereals and lentil with sugarbeet, the beetroot yield was slightly decreased but the overall production including beetroot and intercrop yields was markedly higher than sugar beet alone. Similar results have been reported by a number of researchers such as Gazdag (2000), Osman & Haggag (2000) and Badraoui *et al*., (2003) who reported no adverse effect of intercropping cereals in sugarbeet on production of main crop.

Yield of intercrops: Wheat yields were relatively more (2.50 tons ha^{-1}) when intercropped with sugar beet variety Kaweterma, while wheat grain yield was reduced to 2.47 tons ha^{-1} and 2.43 tons ha^{-1} when intercropped with Pamela and Aura. It means that sugar beet variety Pamela showed more adverse impact on yield of companion wheat crop than sugar beet varieties Kaweterma and Aura (Table 4). Similarly, lentil yields were 0.40, 0.39 and 0.33

tons ha^{-1} when Kaweterma, Aura and Pamela were used as companion sugar beet varieties, respectively; while barley produced 1.44, 1.43 and 1.41 tons ha^{-1} when intercropped with Kaweterma, Aura and Pamela sugar beet varieties, respectively (Table 4).

The yield of intercrops such as wheat and lentil was at par when compared with sole cultivation of these crops and these results are further supported by Toaima *et al*., (2000) and Dessougi *et al*., (2003) who observed that the yield of intercrops was nearly same when intercropped with sugar beet and higher overall productions were realized.

Cost of production: The cost of production was minimum in sole cropping system for all sugar beet varieties i.e., Rs. 45056 ha^{-1}, and production costs increased up to Rs. 45353 ha^{-1} when barley was intercropped with sugar beet varieties; while an expenditure of Rs. 45844 ha^{-1} was incurred when lentil was intercropped with sugar beet. However, the maximum cost of production (Rs. 45909 ha^{-1}) was observed when wheat was used as intercrop with different sugar beet varieties (Table 4). Among different intercrop treatments, intercropping barley with sugar beet was more economical in term of production cost, while production costs increased slightly in wheat + sugar beet.

Many researchers have observed that with intercropping, the cost of production is substantially reduced as compared to sole cropping (Gazdag, 2000; Osman & Haggag, 2000; Vos & Putten (2004) and findings of the present study are well comparable with their achievement.

Gross revenue: Table 4 showed remarkably higher gross revenues of Rs. 136295 ha^{-1} were attained when lentil was intercropped with sugar beet variety Kaweterma while the lower gross revenues of Rs. 114429, Rs. 114000 and Rs. 110999 ha^{-1} were obtained from the cropping systems where sugar beet varieties Pamela and Aura were grown as sole crops, and barley was intercropped with sugar beet variety Pamela, respectively (Table 4).

These findings are in concurrence with those of Badraoui *et al*., (2003) who found that intercropping cereals in sugarbeet improves revenue and decreases costs on these crops.

Net returns: Table 4 showed that net returns were in the lower side i.e. Rs. 81498, Rs. 79773, Rs. 69077, Rs. 68944 and Rs. 65943 ha^{-1} in case of barley intercropping with sugar beet varieties Kaweterma and Aura, sugar beet varieties Pamela and Aura grown as sole crop and barley intercropped with sugar beet variety Pamela, respectively (Table 4). However, net returns were remarkably highest (Rs. 90387 ha^{-1}) when lentil crop was intercropped with sugar beet variety Kaweterma; while the net returns were Rs. 90079, Rs. 81473 and Rs. 89413 ha^{-1} when wheat crop was intercropped with sugar beet variety Kaweterma or lentil intercropped with sugar beet variety Aura and wheat intercropped with sugar beet variety Aura, respectively (Table 4).

The Dessougi *et al*., (2003) have also reported similar results and reported that the economic returns were markedly higher under intercropped systems as compared to sole cropping. The comparative analysis of cropping systems showed that intercropping system was remarkably more profitable than the sole cropping system, irrespective of sugar beet varieties. It was also found that high net returns were received from sugar beet + lentil intercropping, followed by wheat + sugar beet; Kaweterma earned more net returns under intercropping systems as compared to other sugar beet varieties.

Input: output ratio: The results showed that lentil had significantly higher input: output ratios of 1:2.97, 1:2.77 and 1:2.72 when grown with sugar beet varieties Kaweterma, Aura and Pamela, respectively; and wheat as companion crop ranked second with input : output ratios of 1:2.96, 1:2.95 and 1:2.74 when sown with sugar beet varieties Kaweterma, Aura and Pamela, respectively (Table 4). Sugar beet under sole cropping system ranked third with input: output ratios of 1:2.66, 1:2.46 and 1:2.53 and simultaneous input: output ratios of 1:2.80, 1:2.76 and 1:2.52 were observed when barley sown as an intercrop with sugar beet varieties Kaweterma, Aura and Pamela, in descending order (Table 4).

Cost: benefit ratio: Cost: benefit ratio shows the net profit earned by a farmer on spending one rupee as capital cost and results indicate that cost : benefit ratios were noticeably higher 1:1.30, 1:1.19 and 1:1.18 under lentil intercropping with sugar beet varieties Kaweterma, Aura and Pamela, respectively (Table 4). Economically, lentil under intercropping system with sugar beet proved its superiority over wheat, barley and sole cropping systems (Table 4).

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