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AGRONOMIC AND ECONOMIC EFFECT OF INTERCROPPING SUGARBEET WITH OILSEEDS AND LENTIL

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Abstract

In order to evaluate the effect of intercropping sugar beet with oilseeds (mustard and canola) and lentil, three sugar beet varieties *viz.,* Kaweterma, Aura and Pamela were tested against 4 intercropping systems (sugar beet sole, sugar beet + mustard, sugar beet + canola, and sugar beet + lentil). The study was carried out for two successive years and results showed that the sole plantation of sugar beet varieties showed significantly higher values for growth, yield and quality traits. Sole planting of sugar beet variety Kaweterma showed superiority over rest of intercropping treatments by recording maximum beet root weight, beet yield, leaves plant^{-1}, leaf length, leaf area, vertical diameter of beet, horizontal diameter of beet, total dry matter, Pol, sugar recovery, brix, purity, N uptake and P uptake. The minimum values of sugar beet varieties were observed in cropping system of canola and mustard. In this study sugar beet variety Kaweterma produced highest monetary benefits when planted as sole or with lentil. It is concluded that sugar beet varieties *viz*., Kaweterma, Aura and Pamela planted as sole had showed significantly better results and or intercropped with lentil. Among the sugar beet varieties, Kaweterma had excellent performance for growth, yield and quality traits. Sugar beet yields and monetary benefits were also maximum in lentil intercropping compared to cereals and oilseeds intercroppings. It is recommended that intercropping of sugar beet variety Kaweterma with lentil should be practised for higher qualitative, quantitative and monetary benefits.

Introduction

Intercropping is a widespread agronomic practice in the tropics because it reduces the losses caused by pests, diseases and weeds, as well as also guarantees better yield (Andrews, 1974). An agronomic advantage has been demonstrated of intercropping oilseeds like sesame and mustard with crops like sunflower with soybeans (Shivaramu & Shivashankar, 1992), maize (Olowe *et al*., 2003); pigeon pea (Singh & Singh, 1995) and other legumes (Robinson, 1984; Kandel *et al*., 1997). Various environmental and socioeconomic reasons have been suggested to explain the well-known concept of intercropping. Similarly, Banaszak *et al*., (1998) carried out intercropping experiments and found that new varieties of oil radish and white mustard as intercrops has reduced the *H. schachtii* infestation by about 20-40% in sugar beet crop. In view of lessening resources like irrigation water, arable land and energy, there is a dire requirement to devise and practiced new strategies and techniques of crop production to meet the expanding needs for food, feed and forage through sustainable utilization of available inputs (Jabbar *et al*. 2010). Usually, small farmers are incapable to meet their diversified domestic needs to sustain normal livings from their limited resources in cropping system (Jamil *et al*., 2007; Ahmad *et al*., 2007).

In agriculture, several studies on intercropping have been carried out to evaluate potential agronomic and economic benefits (Hauggaard *et al*., 2001). Importance of interactions among crop species in shaping the structure and dynamics of plant communities is widely acknowledged (Tilman, 1988). One of the potential benefits is that differences in the way crop species utilize resources. Intercropping systems can enhance crop produce. In some cases productivity is enhanced in intercrops (Fukai & Trenbath, 1993), but in the majority of studies intercrop yields are intermediate to the sole crops, or comparable to those of the highest yielding sole crop (Hauggaard *et al*., 2001; Jensen 1996). Krall *et al*., (1996) observed that intercropping of sugarbeet with mustard increased net returns as compared to the sole crop cultivation. Sugarbeet + mustard intercropping have less disease incidence and yield high economic returns. Tichy *et al*., (2001) found that sugarbeet+sunflower increased sunflower yield more than 5 tons ha^{-1} and sugarbeet -sunflower intercropping was appeared as most successful companion crops with net benefits.

However, in sugar beet + oilseed rape intercropping, the yield was strongly checked, probably due to competition for nutrients. Productivity analysis showed that sugar beet + oilseeds intercropped yielded higher monetary returns than other companion crops. In contradiction, intercropping studies conducted by Azad & Alam (2004) suggested that sugarbeet +mustard and sugarbeet + garlic intercropping system were found to be poorer in respect of yield, economic returns. It is revealed that sugarbeet + potato, sugarbeet +onion and sugarbeet + coriander combination showed better performance to get interim benefit from the same piece of land. In temperate regions of the world the interest in intercropping has increased in recent years (Connolly *et al*., 2001; Anil *et al*., 1998). The intercropping of legumes such as soybean with sugar crops may also be a feasible alternative (Carruthers *et al*., 1998; Ofori & Stern, 1987).

Different vegetative and yield parameters were potentially predisposed due to competition of plant with a second crop in an intercrop system and by contesting with other plants of the same species in monocrop systems, (Fortin & Pierce, 1996). Cereal + cowpea intercropping system in semiarid West Africa include more efficient use of environmental resources such as nutrients, light and water (Natarajan & Willey, 1986; Ofori & Stern, 1987; Rao *et al*., 1987; Willey, 1990), minimum risk (Ruthenberg, 1980; Tefera & Tana, 2002), higher monetary returns (Norman *et al*., 1982) and diversification of the food supply

(Francis, 1985). Stoyanov *et al*., (1997) observed that intercropping sugarbeet with oilseeds such as sugarbeet + sunflower combination was more advantageous under recommended nutrient application as compared with higher doses of the macro and micro nutrients. Thus investigation was therefore carried out to evaluate the impact of intercropping oilseed crops and lentil in sugar beet on yield traits and monetary returns.

Materials and Methods

The experiment was carried out in Randomized Complete Block Design (RCBD) with factorial arrangement in four replications. Three sugar beet varieties (Pamela Kaweterma and Aura) were kept as main plot factor, while five intercropping treatments (sugar beet sole, sugar beet + lentil, sugar beet + canola and sugar beet + mustard) were kept as sub plot factor.

Sugar beet crop was grown on the raised beds of 90 cm. Each intercrop (barley, wheat, mustard, lentil and canola) was drilled between sugar beet raised beds in alternate row ratio of 1:1. All P with half N fertilizer were applied during land preparation. In all plots, first irrigation was applied after 20 days of sowing and subsequent irrigations were applied as per requirement of the crop and soil. N-P fertilizer was applied at the rate of 100-100 kg ha-1in the form of urea and diammonium phosphate, respectively. The remaining half N was split applied with 2nd, 3rd and 4th irrigations. Besides agronomic and other economic observations, the cost:benefit ratio was also calculated. 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.

Statistical analysis: Data were statistically analyzed through MSTATC computer software. Initially, two factors *viz*. intercrops and varieties were set in RCBD factorial arrangement. Third factor (year was included during data record). The LSD value for mean comparison was calculated only if the general treatment F test was significant at a probability of ≤ 0.05 (Gomez & Gomez, 1985).

Results and Discussion

Varietal response: Sugar beet varieties showed significantly ($p<0.05$) varied response when grown with oil seeds (Table 1). Sugar beet variety Kaweterma had significantly maximum beet root weight (1.68 kg), beet yield (74.34 t ha^{-1}), total dry matter (3.93 t ha^{-1}), brix (19.75%), sugar recovery (10.81%), leaves $plant^{-1}$ (27.25), leaf length (49.00 cm), leaf area (788.12 cm), vertical diameter of beet (20.37 cm), horizontal diameter of beet (12.43 cm), N uptake (89.25 kg ha^{-1}) and P uptake (18.52 kg ha^{-1}) followed by Aura (Table 1). However, Pamela recorded higher maturity days (160), purity (81.81%) and POL (14.67) (Table 1).

Table 1. Response of sugar beet varieties planted in oilseed intercropping system.

Plant traits	Varieties			SE	LSD (5%)
	Pamela	Aura	Kaweterma		
Days to maturity	160a	156b	147c	0.173	2.160
Leaves $plant^{-1}$	23.62c	24.87b	27.25a	0.156	0.440
Leaf length (cm)	42.25c	44.12b	49.00a	0.303	0.856
Leaf area (cm)	680.00c	715.62b	788.12a	5.15	14.55
Vertical diameter (cm)	17.50c	18.25b	20.37a	0.063	0.180
Horizontal diameter (cm)	10.73c	11.06b	12.43a	0.075	0.213
Single beet root weight (kg)	1.17c	1.25b	1.68a	0.015	0.044
Yield (t ha^{-1})	67.90c	69.00b	74.34a	0.295	0.834
Total dry matter (t ha^{-1})	3.72b	3.78ab	3.93a	0.061	0.172
Brix (%)	18.03c	18.82b	19.75a	0.044	0.126
Purity (%)	81.81a	78.14b	74.06c	0.215	0.607
POL (%)	14.67a	14.55ab	14.47b	0.048	0.136
Sugar recovery (%)	9.98c	10.08b	10.81a	0.009	0.027
N content (%)	2.23	2.21	2.26	-	-
P content (%)	0.480	0.476	0.470	-	-
N uptake (kg ha^{-1})	83.37b	84.00b	89.25a	0.483	1.365
P uptake (kg ha^{-1})	17.85b	17.98b	18.52a	0.113	0.320

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

These findings are in concurrence with those of Singh and Singh (1995), Osman and Haggag (2000) who have suggested winter crops + sugarbeet intercropping with respect to suitable varieties. They also suggested intercropping as an agronomic advantage and intercropping of oilseeds with major crops were useful, while various socioeconomic and environmental reasons have been explained in favour of various intercropping systems. Similarly new varieties of sugarbeet showed positive response to productivity of intercrops and worked to suppress insect pests.

Effect of intercropping: Significantly ($p<0.05$) maximum beet root weight (1.83 kg), beet yield (75.83 t ha^{-1}), leaves $plant^{-1}$ (28.6), leaf length (53.33 cm), leaf area (905 83 cm), vertical diameter of beet (24.16 cm), horizontal diameter of beet (15.43 cm), total dry matter (4.00 t ha^{-1}), brix (21.79%), purity (83.54%), Pol (15.91%), sugar recovery (12.07%), N uptake (100.00 kg ha^{-1}) and P uptake (21.43 kg ha^{-1}) were observed in sugar beet sole cropping system, followed by intercropping of sugar beet with lentil (Table 2). Sugar beet intercropping with oil seed crops (mustard and canola) significantly had lower values of beet traits (Table 2).

Similar results have also been produced by Banaszak *et al*., (1998); Anonymous (2000); Osman & Haggag (2000); Usmanikhail (2012) who were of the experience that using intercrops in sugar be*et al*though slightly reduce the main crop yields, but overall productivity from the same piece of land was remarkably higher as compared to sole cropping.

Table 2. Sugar beet agronomic traits as affected by oilseed intercropping system.

Plant traits	Intercropping system					
	Sugar-beet sole	Sugar beet + lentil	Sugar beet + mustard	Sugar beet + canola	SE	LSD (5%)
Days to maturity	157	155b	151b	152b	0.95	2.70
Leaves $plant^{-1}$	28.66a	26.00b	23.00c	23.33c	0.18	0.508
Leaf length (cm)	53.33 a	50.00 b	38.16 c	39.00 c	0.35	0.989
Leaf area (cm)	905.83a	803.33b	595.00c	607.50c	5.95	10.80
Vertical diameter (cm)	24.16a	20.50b	14.83d	15.33c	0.07	0.208
Horizontal diameter (cm)	15.43a	12.96b	8.55c	8.70c	0.08	0.246
Single beet root weight (kg)	1.83a	1.43b	1.08c	1.13c	0.01	0.051
Yield (t ha^{-1})	75.83a	72.95b	65.87d	67.00c	0.34	0.963
Total dry matter (t ha^{-1})	4.00a	3.85ab	3.70b	3.70b	0.07	0.199
Brix (%)	21.79a	20.88b	16.45.c	16.45c	0.05	0.145
Purity (%)	73.55b	71.79c	83.13a	83.54a	0.24	0.701
POL (%)	15.91a	14.95b	13.66c	13.72c	0.05	0.157
Sugar recovery (%)	12.07a	10.91b	8.98d	9.19c	0.01	0.031
N content (%)	2.50	2.37	2.02	2.04	--	--
P content (%)	0.537	0.480	0.441	0.442	--	--
N uptake (kg ha^{-1})	100.00a	91.33b	75.00c	75.83c	0.55	0.13
P uptake ((kg ha^{-1})	21.43a	18.40b	16.26c	16.38c	1.57	0.36

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

Interactive effect of varieties x oilseed intercropping: Interactive effect of intercropping x varieties had significant ($p<0.05$) effect on all observed sugar beet traits except N and P content, days to maturity (Tables 3 & 4). Sugar beet varieties planted as sole has significantly ($p<0.05$) showed higher values of all traits. Among the tested varieties, sole planting of Kaweterma had maximum beet root weight (2.35 kg), beet yield (81.00 t ha^{-1}), leaves $plant^{-1}$ (31.00), leaf length (59.00 cm), leaf area (1000 cm), horizontal diameter of beet (16.25 cm),vertical diameter of beet (27.50 cm), total dry matter (4.15 t ha^{-1}), brix (23.0%), purity (69.56%), sugar recovery (12.96%), Pol (16.00), N uptake (102.50 kg ha^{-1}) and P uptake (22.55 kg ha^{-1}) followed by Aura and Pamela when planted as sole (Tables 3 & 4). Sugar beet + lentil intercropping was also better which produce second lowest values than sugar beet sole planting. However, minimum values of sugar beet were noted in cropping system of canola + mustard intercropping (Tables 3 & 4).

The interactive effect of main crop varieties and intercrops have been studied by many researchers including Singh & Singh (1995), Osman & Haggag (2000), Banaszak *et al*., (1998) and Anonymous (2000) and their findings coincide the results of the present study, suggesting that varietal evaluation is of significant importance for a main crop is used for intercropping minor crops.

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

Varieties x intercropping system		Leaves plant^{-1}	Leaf length (cm)	Leaf area (cm)	Single beet root weight (kg)	Yield (t ha^{-1})
Sugar beet sole	Kaweterma	31.00a	59.00a	1000.00a	2.35a	81.00a
	Aura	28.50b	51.50c	900.00b	1.65c	74.50c
	Pamela	26.50c	49.50d	817.50c	1.50d	72.00d
Sugarbeet + canola	Kaweterma	25.50d	41.50f	647.50f	1.35e	70.50de
	Aura	22.50f	39.00gh	595.00g	1.05h	65.50f
	Pamela	22.00f	36.50i	580.00g	1.00h	65.00f
Sugarbeet + mustard	Kaweterma	24.50e	40.00fg	632.50f	1.25fg	69.00e
	Aura	22.50f	38.00hi	580.00g	1.00h	64.50f
	Pamela	22.00f	36.50i	572.50g	1.00h	64.12f
Sugarbeet + lentil	Kaweterma	28.00b	55.50b	872.50b	1.80b	76.87b
	Aura	26.00cd	48.00de	787.50d	1.30ef	71.50d
	Pamela	24.00e	46.50e	750.00e	1.20g	70.50de
SE		0.311	0.606	10.31	0.031	0.591
LSD 5 %		0.880	1.71	29.1	0.089	1.669

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

Table 4. Sugar beet qualitative and chemical traits as affected by inter active effect of varieties x oilseed intercropping system.

Varieties x intercropping system		Brix (%)	Purity (%)	Pol (%)	Sugar recovery (%)	P content	N content	N uptake kg ha^{-1}	P uptake kg ha^{-1}
Sugar beet sole	Kaweterma	23.00a	69.56f	16.00a	12.96a	2.47ns	0.54ns	102.50a	22.550a
	Aura	22.05b	72.55e	16.00a	11.91b	2.52	0.53	99.50b	21.250b
	Pamela	20.05d	78.55c	15.75a	11.34d	2.51	0.52	98.00b	20.500c
Sugar beet + canola	Kaweterma	16.95f	79.34c	13.45d	9.48g	2.14	0.43	81.50d	16.600e
	Aura	16.15g	84.52b	13.65d	8.94j	1.98	0.43	73.50e	16.150e
	Pamela	16.25g	86.77a	14.08c	9.16i	2.00	0.45	72.50e	16.400e
Sugar beet + mustard	Kaweterma	16.95f	79.35c	13.45d	9.27h	2.09	0.43	80.50d	16.550e
	Aura	16.15g	83.90b	13.55d	8.74k	1.96	0.43	72.50e	16.100e
	Pamela	16.25g	86.16a	14.00c	8.94j	2.01	0.45	72.00e	16.150e
Sugar beet + lentil	Kaweterma	22.10b	68.00g	15.00b	11.53c	2.34	0.46	92.50c	18.400d
	Aura	20.95c	71.60e	15.00b	10.72e	2.38	0.49	90.50c	18.450d
	Pamela	19.60e	75.77d	14.85b	10.47f	2.39	0.48	91.000c	18.350d
SE		0.089	0.430	0.096	0.019	--	--	0.967	0.226
LSD 5 %		0.252	1.215	0.273	0.054	--	--	2.73	0.640

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

Monetary benefits

Beetroot yield (t ha^{-1}): Impact of intercropping different sugarbeet varieties with oilseeds and lentil was assessed by measuring the crop productivity and resultant impact on the net returns (Table 5). It was observed that among sole cropping sugarbeet, variety Kaweterma showed highest beetroot yield of 81.00 t ha^{-1}, followed by variety Aura with beetroot yield of 74.50 t ha^{-1}, while the minimum beetroot yield of 72.00 t ha^{-1} was recorded in variety Pamela (Table 5). The interaction of sugarbeet varieties when intercropped with other crops such as mustard, canola, and lentil showed that beetroot yield was significantly higher (76.87 t ha^{-1}) as reported under Kaweterma + Lentil, followed by interactions of variety Aura + Lentil (71.50 t ha^{-1}), Kaweterma + canola (70.50 t ha^{-1}) and Pamela + lentil (70. 50 t ha^{-1}) (Table 5).

The beet root yield was slightly decreased when some oilseed crops were intercropped (Azad & Alam, 2004; Tichy *et al*., 2001; Stoyanov *et al*., 1997; Krall *et al*., 1996); however, the overall crop productivity was remarkably higher under intercropping systems as compared to sole cropping.

Yield of intercrops: The yield of mustard, canola and lentil crops was recorded to determine the effect of intercropping. The data showed that the canola seed yield was highest (0.441 tons ha^{-1}) when canola was intercropped with sugarbeet variety Pamela, while intercropping of sugarbeet variety Kaweterma showed maximum reduction of canola yield that decreased to 0.32 tons ha^{-1} (Table 5). In mustard the highest seed yield of 0.44 tons ha-1was obtained when mustard was intercropped with sugarbeet variety Kaweterma, and was lowest 0.36 tons ha-1when intercropped with variety Aura (Table 5). The highest seed yield of lentil was 0.38 tons ha-1which was obtained when it was intercropped with sugarbeet variety Kaweterma, followed by lentil yield of 0.34 tons ha-1, when lentil was inetrcropped with variety Pamela, while it was lowest (0.29 tons ha-1) when intercropped with sugarbeet variety Aura (Table 5).

The findings from the past researches (Stoyanov *et al*., 1997; Azad & Alam, 2004; Krall *et al*., 1996; Usmanikhail, 2012) showed no significant decrease in the yields of intercrops when sown with sugar beet under good soil and crop management.

Table 5. Economics of various intercropping practices with sugarbeet.

Variables	Beet root yield (t ha^{-1})	Intercrop t/ha	Cost of Production	Gross Revenue	Net Return	Benefit cost ratio
Aura Sole	74.50	0.0	48753	111749	62997	1.29
Kawiterma	81.00	0.0	48753	121499	72746	1.49
Pamela Sole	72.00	0.0	48753	108000	59247	1.22
Aura X canola	65.50	0.36	48938	127161	78223	1.60
Kawiterma x canola	70.50	0.32	48938	131448	82510	1.69
Pamela x canola	65.00	0.44	48938	132836	83897	1.71
Aura x mustard	64.50	0.36	49000	127885	78885	1.61
Kawitarma x mustard	69.00	0.44	49000	141554	92554	1.89
Pamela x mustard	64.12	0.32	49000	123854	74854	1.53
Aura x Lentil	71.50	0.29	49605	121147	71541	1.44
Kawitarma x Lentil	76.87	0.38	49605	132904	83299	1.68
Pamela x Lentil	70.50	0.34	49605	121795	72190	1.46

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

Cost of production: It was observed that irrespective of sugarbeet varieties, the cost of sugarbeet (sole) production was Rs. 48753 ha-1against the production costs of Rs. 48938, 49000 and 49605 ha^{-1} when sugarbeet was intercropped with either canola, mustard or lentil, respectively (Table 5). In term of cost of production, a nominal difference was noted when sugarbeet was intercropped with lentil, mustard.

Intercropping sugarbeet with mustard resulted in reduced cost of production and improved overall returns over the sole crop cultivation (Tichy *et al*., 2001; Krall *et al*., 1996); this suggests that sugarbeet+mustard intercropping developed resistance against nematodes and produced noticeably higher overall productivity.

Gross revenue: Data exhibited in Table 5 reveals that gross revenues were significantly highest i.e., Rs. 141554 ha^{-1} interaction of sugarbeet variety Kaweterma+mustard, followed by sugarbeet variety Pamela+canola, Kaweterma +lentil and Kaweterma + canola with average gross returns of Rs. 132836, 132904 and 131448 ha^{-1}, respectively (Table 5). There was a significant reduction in gross returns i.e. Rs. 127885, 127161 and 123854 ha^{-1} recorded under intercropping combinations of sugarbeet variety Aura+ mustard, Aura + canola and Pamela + mustard, respectively (Table 5). Similarly interaction of variety Pamela + lentil ranked 8th with Rs. 121795 ha^{-1} gross revenue and sugarbeet variety as sole ranked 9th with gross revenue of Rs. 121499 ha^{-1}. Sugarbeet varieties Aura and Pamela when grown as sole crops produced lower revenue of Rs. 111749 and 108000 ha^{-1}, respectively (Table 5). Hence, the results suggested that for getting higher gross revenues, the intercropping of sugarbeet variety Kaweterma with mustard may prefer, followed by combinations of Pamela + canola and Kaweterma + lentil (Table 5).

The gross revenue has been universally reported markedly higher under intercropping systems under good management conditions as compared to sole cropping and sugar beet + winter oilseeds have proved to generate high revenues (Tichy *et al*., 2001; Krall *et al*., 1996).

Net returns, input: output ratio and cost: benefit ratio: The maximum net returns of Rs. 92554 ha^{-1} were obtained under combination of sugarbeet variety Kaweterma + mustard, followed by sugarbeet variety Pamela + canola, Kaweterma + lentil and Kaweterma + canola with average net returns of Rs. 83897, 83299 and 82510 ha$_{-1}$, respectively (Table 5). The net returns were decreased to Rs. 78885, 78223 and 74854 ha^{-1} under intercropping combinations of sugarbeet variety Aura + mustard, Aura + canola and Pamela + mustard, respectively. The net returns in sugarbeet variety Aura under sole cropping were Rs. 62997 and the minimum net returns of Rs. 59247 ha^{-1} were obtained from sole cropping of sugarbeet variety Pamela (Table 5). The results showed that for obtaining higher net returns, preference may be given to intercropped sugarbeet variety Kaweterma with mustard, while combinations of sugarbeet variety Pamela with canola and Kaweterma with lentil could also be practiced for reasonable net returns (Table 5).

The data indicated that maximum input: output ratio of 1:2.89 was obtained under combination of sugarbeet variety Kaweterma + mustard (Table 5). The input: output ratios were considerably reduced to 1:2.61, 1:2.60 and 1:2.53 with intercropping combinations of sugarbeet variety Aura x mustard, Aura x canola and Pamela x mustard, respectively (Table 5). However, the minimum input: output ratio of 1:2.22 was observed by sugarbeet variety Pamela in sole cropping (Table 5).

The data presented in Table 5 showed maximum cost: benefit ratio of 1:1.89 from interaction of sugarbeet variety Kaweterma + mustard, followed by cost: benefit ratios of 1:1.71, 1:1.68 and 1:1.69, respectively. The cost: benefit ratio’s decreased to 1:1.61, 1:1.60 and 1:1.53 under intercropping combinations of sugarbeet variety Aura + mustard, Aura + canola and Pamela + mustard, respectively. However, the lowest cost: benefit ratio of 1:1.22 was recorded from sugarbeet variety Pamela in sole cropping. For improved cost: benefit ratios, intercropping of sugarbeet variety Kaweterma + mustard, Pamela + canola and Kaweterma + lentil could be preferred (Table 5).

The net returns are varied with the production costs and revenue generated from a cropping system. Stoyanov *et al*., (1997), Azad & Alam (2004), Krall *et al*., (1996) indicated that intercropping sugar beet with winter oilseeds or some legume crops was found to be superior in respect of agronomic yield, monetary benefits and adjusted beet root yield. Studies conducted by Tefera & Tana (2002) have also advocated sugar beet intercropping with oilseeds for higher net returns.

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