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Research Article

Feasibility Study of Sugarcane-Haricot Bean Intercropping Under Different Sowing Dates at Wonji-Shoa, Metahara and Finchaa Sugar Estates

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Abstract

Feasibility study of Sugarcane-Haricot bean intercropping was conducted at Wonji-Shoa, Metahara and Finchaa sugar estates using split plot design with three replications. Planting dates were assigned to the main plots and a factorial combination of two cane varieties and two bean varieties with two rates of two fertilizer (100 kg DAP and 50 kg urea/ha as F1 and none fertilized one as F0) were arranged at sub-plot (34.8m^2) under the sowing dates. Data were collected both on bean and cane varieties for germination/ sprouting, tillering, plant height and population. Data for cane on sucrose % cane, cane and sugar yield were recorded. Similarly, for bean data were collected on number of pod per plant, seed per pod, and seed yield. The result indicated that the effect of intercropping cane with bean was not significant on any parameter of both crops. The intercropped cane performed equivalent to the sole cane treatment across the three sugar estates. However, the bean crop was challenged by poor germination under the irrigation system that was originally designed for sugarcane at Wonji-Shoa and Metahara; difficulty in using herbicides across the estates; abortion of flower and dropping of pod at Metahara owing to the weather condition that was intolerable for bean crop; and water logging or excess moisture due to rain, shattering and loss of seed quality during harvesting at Wonji-Shoa and Finchaa. Therefore, due to shortcomings mentioned herein that were particularly related to high temperature stress and specific culture operations and irrigation system, sugarcane haricot bean intercropping proved not feasible under existing conditions of Wonji-Shoa, Metahara, and Finchaa Sugarcane plantations.

Keywords: Feasibility; Study: Sugarcane-Haricot: Bean: Intercropping

Introduction

Intercropping is a process of growing two or more crops simultaneously on the same field. It aims using resources more efficiently while increasing production concurrently. Thus, crop intensification, in this case, comes both in time and space dimensions (Andrews and Kasim, 1976). On the other hand, traditionally, increasing food production and agricultural income boosting, in most cases, comes from putting more land under cultivation. Several crops cultivated in the tropics and subtropics areas are offer intercropping opportunity to the growers. However, it should not be forgotten that intercropping may lessen the yield of each component crop (Hailu Gebre, 1987). Yet, recent research indicates that intercropping systems can actually give more efficient total resource exploitation and greater overall production than sole crop (Niguse and Reddy, 1995). Similarly, intercropping is traditionally also practiced in many parts of Ethiopia (Andjei - Twumet, al, 1986). Plant cane, newly planted sugarcane crop, passes through a long juvenile period during which cane growth is slow where as weed infestation rate is high. During this stage, Wonji-Shoa, Metahara and Finchaa Sugar Estates were practicing growing haricot bean (*Phaseolus vulgaris*) inter-cropped with sugarcane. The haricot beans are one of the most important lowland grain legumes in most parts of Ethiopia. The crop is predominantly grown for cash in the central Rift Valley while for staple food in other parts of the country. The 1997/98 Ethiopian authorities for standardization indicated that total haricot beans exported were 32, 755 tons that valued US $ 13,265,613 foreign exchange. Almost all the production was collected from small farms of central rift valley. Haricot bean require optimum temperature of for growth (18 – 24 ^{0}C) where high temperature (<30^{0}C) retards growth, (Anonymous, 2002). However, the major haricot bean production season of the country, June-September, is not convenient for intercropping haricot bean with sugarcane as the indicated period is not planting season for sugarcane. When the, there Ethiopian sugar plantations directly embarked on commercial level intercropping of cane with beans, multitudes of problems emerged with the system. At Metahara it forced shifting from mechanical to manual operation of weed management, moulding operation, and created inconveniency of irrigating the two crops simultaneously (Bezuneh and Ambachew, 2006). However, there was no designed study with respect to the impact of intercropping sugar cane with haricot bean compared to that of sole cropping of sugarcane. Therefore, this experiment was conducted with the objective of studying technical and financial feasibility of sugarcane-haricot bean intercropping under different planting dates at Wonji-Shoa, Metahara and Finchaa Sugar Estates of Ethiopia. .

Materials and Methods

Description of study areas

The study was undertaken in Wonji-Shoa sugarcane plantation (8° 31' N; 39° 20' E; 1540 m.a.s.l.), Metahara (8° N; 39 52' E; 950 m.a.s.l) and Finchaa (9° 30 to 10° 00 'N; 37° 30' E; 1350 to 1600 m.a.s.l.). They receive mean annual min/maximum temperature and total annual rainfall 15.3/26.9, 17.5/32.6, 15/31 °C with 831, 554, and 1280 mm, respectively.

Methods

Split plot design with three replications was used where two planting dates (first weeks of February and March) were assigned to the main plot and factorial combination of two cane and two bean varieties with (100 kg DAP and 50 kg urea/ha and without fertilizers) were arranged as sub-plot under the sowing dates. The sub plot size was 4 rows spaced at 1.45m and 6m in length. The cane varieties were NCO334 and B41227 at Metahara, NCO334 and N14 at Wonji-Shoa and Finchaa. Two improved haricot bean varieties, Kranscop and Awash-Melka, were intercropped at all the sites. The recommended packages of haricot bean production includes 80-100 kg seed and 50 kg urea with 100 kg DAP ha^{-1}. The intercropped beans were planted at 50% reduced seed rate and fertilizer rate of sole bean production. After bean harvesting the entire crop residue was returned back to the respective plots and incorporated into the soil. Data were collected on stalk length, stalk population, sugar percent cane, and cane and sugar yield. Haricot bean data were collected on plant height, biomass, seed yield, and thousand seed weight. Soil samples were collected at 0-30cm depth composited at planting and per pots during harvesting at Metahara. All the collected data were subjected to statistical analysis using MSTATC computer software. Mean separation were computed based on the significance level using DMRT. Partial budgeting, which is a method of organizing experiments, was analyzed for this new cropping system as per the methodology of budget was analyzed as per the methodology of CIMMYT, (1998).

The partial budgeting was analyzed based on the following assumptions:

- Crop yields were reduced to 85% to avoid overestimation of yield in researcher managed trials (CIMMYT,1988); gross benefits were calculated based on the prices of sugar & bean seed: 3.37 & 5.00 birr per kg at Wonji-Shoa, 2.87 & 5.00 at Metahara, and 3.9 & 5.00 at Finchaa;
- The cost were taken at 275 birr per ha for bean planting at Wonji-Shoa, 297 at Metahara, and 270 at Finchaa;
- Costs of hand weeding (for intercropping) and manual herbicide application (for sole cane) were 275 and 26.54 birr per ha, respectively at all the estates;
- Purchasing costs were 70 birr per litre for 2, 4-D across the estates; for urea & DAP 610 & 680 birr per 100 kg at Wonji-Shoa, 561.85 & 71. 55 at Metahara, and 559.45 & 810.15 at Finchaa;
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- Cost of harvesting, threshing and bagging bean was 550 birr per 100 kg for all the estates; and cost of mechanical & manual moulding ware 123.36 & 843. 50 birr per ha at Wonji –Shoa; and 140 & 753 at Metahara; whereas not required at Finchaa. Additional costs associated with extra sugar gained due to intercropping were assumed to be negligible.

Finally, Land Equivalent Ratio (LER) was computed: LER = (Yij/Yii) + (Yji/Yjj); where Yij and Yii are intercrop and sole crop yields of component i; respectively while Yji and Yjj are intercrop and sole crop yield of component j, respectively.

Results and Discussion

The haricot bean component

Right from the beginning, through germination test, it was concluded that bean requires very precise level of moisture for optimum germination of seed. Complete germination failure was recorded if the bean seed was flooded even for a very short period of time. Similarly, field germination was failed due to excess moisture when bean seed was planted in the bottom of the furrow. Moreover, when the seed was planted on the top of ridge of 30 cm height, it remained dry or dry sooner after germination. At commercial level, the same problem of germination and failure in bean growth was reported at Metahara (Bezuneh and Ambachew, 2000). Statistically, planting date significantly affected only harvest index at Wonji-Shoa (Table 1); harvest index, and thousand weights at Finchaa (Tables 3a and 3b). However at Metahara, complete failure of haricot bean crop occurred for the later planting date due to high temperature. As a result only the first planting date (February) was included in this paper for Metahara. At Wonji-Shoa, effect of planting date was not significant on biomass, seed yield and thousand seed weight. Among the Sugar Estates, the highest biomass was recorded at Wonji-Shoa (3.35 t ha^{-1}) followed by Finchaa (2.65 and 3.94 t ha^{-1}). However, the mean seed yield was obtained at Finchaa (Table 1, 3a and 3b). This was mainly attributed to the suitability of sprinkler irrigation, which gradually moistens the soil, for the bean seed germination as compared to the furrow system, which flood bean seed, and that hampered bean germination at Wonji-Shoa and Metahara. Moreover, water logging condition affected yield at Wonji, while high temperature caused flower abortion and pod dropping at Metahara. Generally, at Wonji-Shoa, there was water logged condition almost on all soil type for haricot bean. Moreover occurrence of rain fall during bean maturity causes pod shattering and loss of seed quality at Wonji-Shoa. The later was also common problem for Finchaa where harvest quality loss was the major problem due to rainfall occurring at harvesting. At Metahara, insect pest was common for both planting time. The March planted bean completely failed due to high pressure of insect pest, and extremely high temperature for bean, that caused flower abortion, and pod dropping.

The effects of different combinations of intercropping treatments were significant on biomass and thousand seed weight at all the three sugar estates; and on seed yield at Metahara and Finchaa (Table 1, 2, 3a and 3b). At Wonji-Shoa, biomass yield was higher for fertilized sole planted bean over all the rests of combinations (Table 1). At Metahara, significantly the highest biomass was obtained from bean variety, Kranscop, in all combinations of the treatments (Table 2).

At Finchaa the fertilized combination of both bean varieties resulted in higher mean biomasses than the rests of treatment combinations (Table 3a and 3b). The seed yield was poor across the Estates except for Awash Melka (AM) at Finchaa which yielded 2.10 and 2.33 t ha^{-1} with-out and with fertilizer under sole bean production.

The highest thousand seed weight was generally obtained from Kranscop in all cases. This was mainly because of the varietal nature. Therefore, the result of this research exhibited the complexity of the bean growing in the environments and field managements originally designed for sugarcane production at Wonji-Shoa, and Metahara Sugar Estates. On contrary, the sprinkler irrigation was found more convenient for bean seed germination establishment and seed yield.

The sugarcane component

February and March planted sugar cane were not significantly varied in stalk length, stalk weight, cane yield, sucrose % cane and sugar yield at Wonji and Metahara (Tables 4 and 5). However, at Finchaa, for cane variety NCO334, only sugar % cane was not significantly affected by the planting dates (Table 6a). February planting resulted in higher stalk length, stalk

Table 1. Effect of intercropping on bean yield and related parameters of Haricot bean at Wonji-Shoa

Planting date	**Biomass yield (t ha^{-1})**	**Seed yield (t ha^{-1})**	**Harvest index %**	**1000 seed Weight(gm)**
February	3.44	1.23	36.21	370
March	3.25	1.10	31.05	360
Significance (P<1%, 5%)	NS	NS	*	NS
Treatment combinations				
NC * Kr * Fo	3.39 b	1.06	31.04	430 ab
NC * Kr * F1	4.59 a-b	1.29	28.03	550 a
NC * AM * Fo	3.59 b	1.29	34.58	240c
NC * AM * F1	6.06 a	2.29	38.37	260c
Nco334 * NB * Fo	-	-	-	-
Nco334 * Kr * Fo	3.36 b	1.76	41.93	500 a
Nco334 * Kr * F1	2.55 b	0.88	33.46	470 a
Nco334 * AM * Fo	3.25 b	1.20	37.06	250c
Nco334 * AM * F1	2.63 b	0.91	33.51	210c
N14 * NB * Fo	-	-	-	-
N14 * Kr * Fo	2.82 b	0.82	28.15	510 a
N14 * Kr * F1	2.70 b	0.82	29.43	460 a
N14 * AM * Fo	2.27 b	0.72	32.05	210 c
N14 * AM * F1	2.95 b	0.99	35.95	300 bc
Mean	3.35	1.17	34.93	360
CV%	43.96	74.74	59.35	23.68
Significance (P<1%, 5%)	**	NS	NS	**
LSD value	2.29	-	-	130.00

Table 2. Effect of intercropping on bean yield and related parameters of Haricot bean atMetahara (February planting)

Treatments	**Biomass yield(t ha^{-1})**	**Seed Yield (t ha^{-1})**	**Harvest Index (%)**	**1000 seed weight (kg)**
NC*Kr*F0	1.61ab	0.55bc	35.29	326.67ab
NC*Kr*F1	2.30a	0.88ab	39.78	356.67a
NC*AM*F0	1.00bc	0.35c	35.09	160.00bc
NC*AM*F1	2.33bc	0.99a	42.98	173.33bc
NCO334 - - -	NB	NB	NB	NB
NCO334*Kr*F0	0.92a-c	0.32c	37.56	278.33a-c
NCO334*Kr*F1	1.16ab	0.37c	30.72	336.67ab
NCO334*AM*F0	0.95bc	0.39c	41.69	175.00bc
NCO334*AM*F1	1.00bc	0.39c	35.64	176.67bc
B41227 - - -	NB	NB	NB	NB
B41227 * Kr * F0	0.64bc	0.13c	17.51	178.33bc
B41227 * Kr * F1	0.97ab	0.32c	35.45	336.67ab
B41227 * AM * F0	1.00a-c	0.47bc	47.70	186.67a-c
B41227 * AM * F1	0.95c	0.46bc	37.88	133.33c
Mean	1.23	0.47	36.44	234.86
CV%	41.33	50.14	30.31	28.55
Significance (P<1%,5%)	***	*	NS	**
LSD	0.18	0.40	-	154.30

Kr=Kranscop; AM= Awash Melkasa; F0 = No fertilizer; F1=fertilized; NB= No Bean; Kr=Kranskop

Table 3a. Effect of intercropping on **bean** yield and related parameters of Haricot bean varieties in Sugarcane **(in NCO334**) at Finchaa

Treatments	Biomass (t ha^{-1})	Seed Yield (t ha^{-1})	Harvest Index (%)	1000 seed weight (gm)
Planting dates				
February	2.61	1.88	41.87	291
March	2.70	1.32	32.84	319
Significance (P<1%, 5%)	NS	*	*	*
Combinations				
NC * Kr * F0	2.36 bc	1.22 d	34.08	382b
NC * K r* F1	3.08 ab	1.37 cd	30.79	376b
NC * AM * F0	2.86 a-c	2.10 ab	42.34	218c
NC * AM * F1	3.60 a	2.33 a	39.29	201c
Nco334 * NB * F0	NB	NB	NB	NB
Nco334 * Kr * F0	2.34 bc	1.05 d	30.97	421a
Nco334 * Kr * F1	2.38 bc	1.32 cd	35.68	435a
Nco334 * AM * F0	2.08 c	1.70 bc	44.97	203c
Nco334 * AM * F1	2.53 bc	1.69 bc	40.05	202c
Mean	2.65	1.60	37.65	15.25
CV%	24.52	24.24	24.71	11.28
Significance (P<1%, 5%)	**	**	NS	**
LSD	0.71	0.42	-	37

Kr=Kranscop; AM= Awash Melkasa; F0= No fertilizer; F1=fertilized; NB= No Bean; Kr=Kranskop

Table 3b. Effect of intercropping on **bean** yield and related parameters of Haricot bean varieties in Sugarcane **(in N14**) at Finchaa

Treatments	Biomass (t ha^{-1})	Seed Yield (t ha^{-1})	Harvest Index (%)	1000 seed weight (gm)
Planting dates				
February	4.06	1.67	41.96	286.89
March	3.82	1.32	34.69	308.18
Significance (P<1%, 5%)	NS	NS	*	*
Intercrop Combinations				
NC * Kr * F0	3.25 c	1.19c	36.04 bc	360.53 b
NC * K r* F1	3.8 bc	1.21c	34.48 bc	375.00 b
NC * AM * F0	4.78 ab	2.06ab	43.93 ab	204.53 c
NC * AM * F1	5.93 a	2.28a	38.88 a-c	202.37 c
N14 * NB * F0	NB	NB	NB	NB
N14 * Kr * F0	3.36 bc	0.97c	29.79ac	418. 4 a
N14 * Kr * F1	3.15 c	1.22c	38.49a-c	412.87 a
N14 * AM * F0	3.12 c	1.48c	47.93a	200.33 c
N14 * AM * F1	4.14 bc	1.57bc	37.09bc	206.23 c
Mean	3.94	1.5	38.33	297.53
CV%	21.56	22.65	20.48	7.54
Significance (P<1%, 5%)	**	**	*	**
	1.36	0.54	9.29	35.8

Kr=Kranscop; AM= Awash Melkasa; F0= No fertilizer; F1=fertilized; NB= No Bean; Kr=Kranskop

Table 4. Effect of intercropping Haricot bean varieties and sugarcane varieties under two fertilizer rates on sugar yield and related parameters at Wonji-Shoa

Treatments	Stalk length (m)	Stalk Weight (kg)	Cane Yield (t ha^{-1})	Sucrose % cane	Sugar yield (t ha^{-1})
Planting dates					
February	2.57	1.91	97.51	12.31	12.11
March	2.49	1.93	104.46	12.35	12.89
Significance (P<1%,5%)	NS	NS	NS	NS	NS
Combinations					
NCO334 * NB * F0	2.46	1.58 b	90.46 b	12.36	11.23 bc
NCO334 * Kr * F0	2.47	1.66 b	89.24 b	12.67	11.35 bc
NCO334 * Kr * F1	2.60	1.71 b	104.67ab	12.70	13.29 a-c
NCO334 * AM * F0	2.46	1.67 b	87.81 b	12.51	10.91 c
NCO334 * AM * F1	2.35	1.61 b	85.33 b	12.31	10.64 c
N14 * NB *F0	2.63	2.39 a	126.70 a	12.42	15.69 a
N14 * Kr * F0	2.69	2.35 a	129.01 a	11.93	15.38 ab
N14 * Kr * F1	2.38	2.02 ab	88.35 b	12.31	10.90 c
N14 * AM * F0	2.59	2.14 ab	92.05 b	12.00	11.58 a-c
N14 * AM * F1	2.70	2.07 ab	116.24 ab	12.05	14.01 a-c
Mean	2.53	1.92	100.98	12.33	12.50
CV%	15.73	24.09	24.55	4.12	25.59
Significance (P<1%,5%)	NS	*	*	NS	*
LSD	-	0.54	29.03	-	3.75

Table 5. Effect of intercropping Haricot bean varieties and sugarcane varieties under two fertilizer rates on sugar yield and related parameters at Metahara

Treatments	Stalk length (m)	Stalk Population (*1000 ha^{-1})	Cane yield (t ha^{-1})	Sucrose % cane	Sugar yield (t ha^{-1})
Planting date					
February	2.13	93.99	200.09	12.29	24.50
March	2.00	93.91	199.60	12.24	24.51
Significance P<1%,5%)	NS	NS	NS	NS	NS
Combinations					
Nco334 * NB *F0	2.13	124.90 a	214.11	12.03	25.66
Nco334 *Kr *F0	1.91	105.56 a	197.77	12.46	24.82
Nco334 * K * F1	2.12	121.65 a	178.23	12.92	22.95
Nco334 * AM * F0	1.94	115.90 a	187.55	12.54	23.50
Nco334 * AM * F1	2.00	113.50 a	181.22	11.99	21.82
B41227 * NB * F0	2.22	77.30 b	231.95	11.99	28.25
B41227 * Kr * F0	2.13	67.72 b	240.75	11.48	27.61
B41227 * Kr * F1	2.14	73.76 b	171.81	11.92	20.14
B41227 * AM * F0	2.01	69.83 b	194.25	12.69	24.57
B41227 * AM * F1	2.07	69.35 b	200.77	12.66	25.71
Mean	2.07	93.95	199.84	12.27	24.50
CV%	11.32	13.89	27.68	6.85	27.93
Significance P<1%,5%)	NS	**	NS	NS	NS
LSD	-	20.49	-	-	-

Table 6a. Effect of intercropping Haricot bean varieties and sugarcane varieties under two fertilizer rates on sugar yield and related parameters of NCO334 at Finchaa

Treatments	Stalk length (m)	Stalk Population (*1000 ha^{-1})	Cane yield (t ha^{-1})	Sugar % Cane	Sugar yield (t ha^{-1})
Planting dates					
February	2.38	151.27	189.34	13.90	22.15
March	2.17	150.61	166.29	12.22	20.36
Significance (P<1%, 5%)	**	NS	*	NS	*
Combinations					
NCO334*NB*F0	2.40 a	159.68	193.78 a	13.21	23.30 a
NCO334*Kr*F0	2.25 b	146.89	169.07 b	13.39	20.44 b
NCO334*Kr*F1	2.28ab	149.57	171.94 b	12.87	20.48 b
NCO334*AM*F0	2.25 b	147.80	175.43 ab	12.93	20.94 b
NCO334*AM*F1	2.20 b	150.77	178.85 ab	12.90	21.13 b
Mean	2.28	150.94	177.81	13.06	21.26
CV%	5.34	8.72	9.4	4.20	9.80
Significance (P<1%, 5%)	**	NS	**	NS	*
LSD	0.14	-	18.68	-	1.73

population, cane yield, sugar % cane and sugar yield on NCO334. However, at Finchaa, stalk length and sugar yield was significantly increased by planting early (in February) for both sugarcane varieties NCO334 and N14. Similarly, though statistically not significant, cane yield was also increased by earlier planting (Tables 6a and 6b).

At Wonji-Shoa, regardless of intercrop combinations, higher stalk weight was recorded for N14 over NCO334. However, fertilized Kranscop intercrop increased cane and sugar yield of NCO334 where as reducing that of N14 which is sprawling type cane variety (Table 4). This was mainly because Kranscop, the vigor growing bean, inhibited tillering in case of N14. Hailu Gebre (1987) also reported that inter cropping could lessen the yield of each component crop in other crops. At Metahara, the effect of intercrop combinations did not significant on parameters of sugarcane except plant population of the two sugarcane varieties which were significantly different mainly due to easily damageable buds of B41227. At Finchaa sole planted sugarcane gave the highest cane and sugar yield (Table 6a and 6b).

The amount of loss in sugar yield due to intercrop were 13.99% and 14.02% for NCO334 and N14, respectively at Finchaa. This was attributed to the vigorously grown bean at Finchaa that reduces light intensity reaching the base of the cane and suppresses early growth and tillering potential of the sugarcane. This was also in line of agreement with reports of Sundara (2000) that adequate light reaching the base of the sugarcane plant during the tillering period (45 - 120 days of the crop age) is the most important external factor influencing tillering. Therefore, on top of limiting chemical weed control in intercropped condition, bean shattering and seed quality loss at bean harvesting again makes intercropping system challenging at Finchaa. At Metahara, rather than the effects of treatment combination, stalk population varied only due to cane varieties (Table 5).

Result of comparison of soil chemical properties at Metahara indicated increasing trends in, pH**,** EC, Na, Ca, Mg, and OC while reducing in K during harvesting than at planting (Annex Table 7). However, statistically there was no significant difference among the effects of different intercrop combinations on the soil properties. Therefore, if economically viable, sugarcane haricot bean intercropping could be practiced without affecting the chemical properties of the soil. In Bread wheat field pea double cropping, in bale, also non significant effect of the system of the soil properties was reported (Feyissa et al., 1999).

Table 6b. Effect of intercropping Haricot bean varieties and sugarcane varieties under two fertilizer rates on sugar yield and related parameters of N14 at Finchaa

Treatments	Stalk length (m)	Stalk Population (*1000 ha⁻¹)	Cane yield (t ha⁻¹)	Sugar % Cane	Sugar yield (t ha⁻¹)
Planting dates					
February	250.75	141.80	199.10	11.74	23.33
March	221.24	136.17	171.61	12.33	21.08
Significance (P<1%,5%)	*	NS	NS	NS	*
Combinations					
N14*NB*F0	245.38	143.01	202.88a	11.87	24.06
N14*Kr*F0	234.72	142.91	177.49b	12.31	21.61
N14*Kr*F1	230.47	137.17	175.19b	12.10	21.10
N14*AM*F0	236.35	135.54	181.80b	12.18	22.02
N14*AM*F1	233.07	136.30	189.41ab	11.73	22.22
Mean	236.00	138.99	185.35	12.03	22.20
CV%	5.10	10.45	8.04	4.14	8.02
Significance (P<1%, 5%)	NS	NS	*	NS	NS
LSD	-	-	18.23	-	-

Table 7. Partial budget analysis for intercropping bean in sugarcane at Wonji-Shoa, Metahara, and Finchaa Sugar Estates of Ethiopia

Combinations of intercrops	Wonji-Shoa	Finchaa	Metahara
	Net benefit (Birr/ha	**Net benefit (Birr/ha**	**Net benefit (Birr/ha**
NC * Kr * Fo	2037	3074	(1553)
NC * Kr * F1	2029	2622	(2414)
NC * AM * Fo	3014	6814	(1638)
NC * AM * F1	**6279**	6702	**(2367)**
Average (Bean Sol)	**3340**	**4803**	**(1993)**
NCO334 (Sol)	31808	**77003**	62221
NCO334 *Kr *F0	37524	70110	**58144**
NCO334 * Kr * F1	**38356**	70300	52603
NCO334 * AM * F0	33883	74530	54954
NCO334 * AM * F1	30892	74028	49655
Average (Intercrop)	**34493**	**73,194**	**55556**
N14 (Sol)	44584	**79522**	**70003@**
N14 * Kr * F0	**45073**	**79522**	64870@
N14 * Kr * F1	31255	73649	45727@
N14 * AM * F0	33762	71931	57598@
N14 * AM * F1	40886	77176	59375@
Average (Intercrop)	**39112**	**75,332**	**59515@**

Economic aspects of intercropping

Net benefit obtained from sole sugarcane averaged across varieties, sugar estates and years was more than twelve folds than that of bean crop. The net benefit obtained from sole bean production at Metahara was negative. Bezuneh and Ambachew (2006) also reported, at Metahara commercial level haricot bean-sugarcane intercropping was carried out at loss due to low productivity of haricot bean and high expenses in its production. At each sugar estates, pooled net benefit of intercrop per sugarcane varieties was lower than that of sole crop of sugarcane except at Wonji-Shoa where intercropping NCO334 with Kranskop (Table 7). Therefore, at all the three Ethiopian sugar estates, owing to its incompatible cultural operations and the yield penalty on sugarcane, none of the intercrop combination could appear better than the sole sugarcane crop (Table 7).

Conclusions and recommendations

Based on actual sugar yield, the intercropped cane performed equivalent to the sole cane treatment except at Finchaa, where a loss of sugar yield due to intercropping reached 13.99%. Even at Wonji-Shoa and Metahara though additional bean yield could be harvested, there was no significant improvement in sugar yield. Moreover, the bean crop was challenged through all the growth stages including poor germination under the irrigation system that was originally designed for sugarcane at Wonji-Shoa and Metahara. Besides extremely high temperature of Metahara sugar estate during maturity period of bean, caused flower abortion, and pod dropping. Shattering and loss of seed quality was observed at Wonji-Shoa and Finchaa because of rainfall during bean maturity. The partial budgeting analysis indicated that sole sugarcane production was more beneficial than all the intercrop combinations except for intercropping NCo334 at Wonji-Shoa. In general, from the overall analysis, sugarcane-haricot bean intercropping was not feasible under existing conditions of Wonji-Shoa, Metahara, and Finchaa Sugarcane Plantations.

References

Adijei-Twum, D.C., Kidane Giorgis and Niguse T. Michael, 1986. Effect of Intercropping Sorghum with Crops. PP. 225-234. In: Proceedings of the 18th National Crop Improvement Conference, 24-26 April 1986, Nazareth, Ethiopia.

Andrews, D.J., and Kassam, A.H. 1976. The Importance of Multiple Cropping in Increasing world Food Supplies. In: Multiple Cropping. (R.I. Papedie, P.A. Sanchez, and G.B. Triplett, eds.), *Amer. Soc. Agro. Spec. Pub.* 27, PP, 1-10.

Anonymous 2002. Dry bean production manual. ARS-Grain Crops Institute, South Africa.

Bezuneh Assefa and Ambachew Dametie 2006. Potential and Constraints of Haricot Bean Production at Metahara Sugarcane Plantation. Metahara Sugar Factory, Merti.

CIMMYT. 1988. From Agronomic Data to Farmer Recommendations: An Economics Training Manual. Completely revised edition. Mexico, D.F.

Feyissa Tadesse, Tilahun Geleto, Kedir Nefo, and D. G. Tanner. 1999. On-farm evaluation of sequential double cropping with bread wheat in the Bale highlands of Ethiopia. In: African Crop Science Proceedings, Vol. 4. pp. 251 - 257

Hailu Gebre, 1987. Principles of Intercropping with Beans Towards Self-Sufficiency, *Proceedings of the Second Eastern, Central and Southern Africa Regional Maize Workshop, Harare*.

Niguse Tesfamichael and M.S. Reddy, 1995. Maize/Bean Intercropping Effects on component yield, Land Use Efficiency and Net Returns at Awasa and Melkassa. PP 51-55. In: *Proceedings of the first and Inaugural Conference of the Agronomy and Crop Physiology Society of Ethiopia*. 30-31 may 1995, Addis Ababa, Ethiopia.

Sundara B. 2000. *Sugarcane cultivation*. VIKAS Publishing House Pvt. Ltd. New Delhi.

Worku W. 2008. Evaluation of Common (*Phaseolus vulgaris* L.) genotypes of diverse growth habit under sole and intercropping with maize (*Zea mays* L.) in Southern Ethiopia. *J. Agron.*, 7:306-313.