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Research Paper

Response of maize crop to spatial arrangement and staggered interseeding of haricot bean

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Abstract. Field studies conducted to determine the effects of intercrop row arrangements and staggered intercropping of haricot bean (*Phaseolus vulgaris* L.) on the performances of maize (*Zea mays* L.) crop at Hallaba and Taba areas in 2013 cropping season, southern Ethiopia, revealed that there were significant effects of cropping patterns and staggered interseeding of the legume component on growth and yield components of maize crop. Significant interaction of row arrangement × intercropping time of haricot bean was observed with respect to leaf area index (LAI) of the maize crop. Increasing trends of LAI of maize crop were observed as interseeding of haricot bean was delayed for 3 weeks after maize (WAM) that stabilized during the 6 WAM interseeding time. Maize stover production was significantly high at 1:2 row ratio and delaying of the undersowing haricot bean in the already established maize crop for 6 weeks, 10.94 and 11.39 t ha^{-1}, respectively. Maize grain yield showed a significant variation with respect to the staggered sowing of haricot bean, whereby the highest (3.99 t ha^{-1}) being recorded when haricot bean intercropping was delayed for 21 days after maize planting. The data of this study revealed that the larger maize plant canopy providing larger photosynthetic area, attained when haricot bean interseeding was delayed, probably resulted in higher grain yield of maize.

Keywords: Grain yield, harvest index, leaf area index, kernel, row ratio, stover.

INTRODUCTION

Over the years, food requirements have increased while land availability has become less. Thus, the only way to increase agricultural production is to increase yield per unit area. Traditionally, intercropping is being used by small farmers to increase the density of their products and stability of their output. Complementarities in an intercropping situation can occur when the growth patterns of the component crops differ in time or when they make better use of resources in space. Row arrangement and planting date of the haricot bean are the two important management tools that could be explored to minimize competitive pressure created by a component crop in an intercropping system (Ofori and Stern, 1987; Maluleke et al., 2004).

Row arrangement, in contrast to arrangement of component crops within rows, may influence the productivity of an intercropping system (Oseni and Aliyu, 2010; Undies et al., 2012). The extent of competition-induced yield loss in intercropping is likely to depend on the special arrangement of the component crops. Choice of appropriate population density, therefore, seems relevant management options in improving the efficiency of intercropping by improving radiation interception through more complete ground cover (Heitholt et al., 2005). Arrangement of crops in mixture in the traditional farming systems of Hallaba and Taba areas, Southern Ethiopia is haphazard and without any sufficient attempt to pattern the crops for effective interception of essential resources. Spatial arrangement has an important influence on the degree of competition between crops. In intercropping studies conducted by Mohta and De (1980), the yields of the cereals were not affected by intercropping soybean in either single or double rows. Addo-Quaye et al. (2011) on the other hand reported that spatial arrangement of single rows of maize alternating with single rows of soybean gave the best yields.

The relative time of planting of the intercrop at the same time or after the main crop has both biological and practical

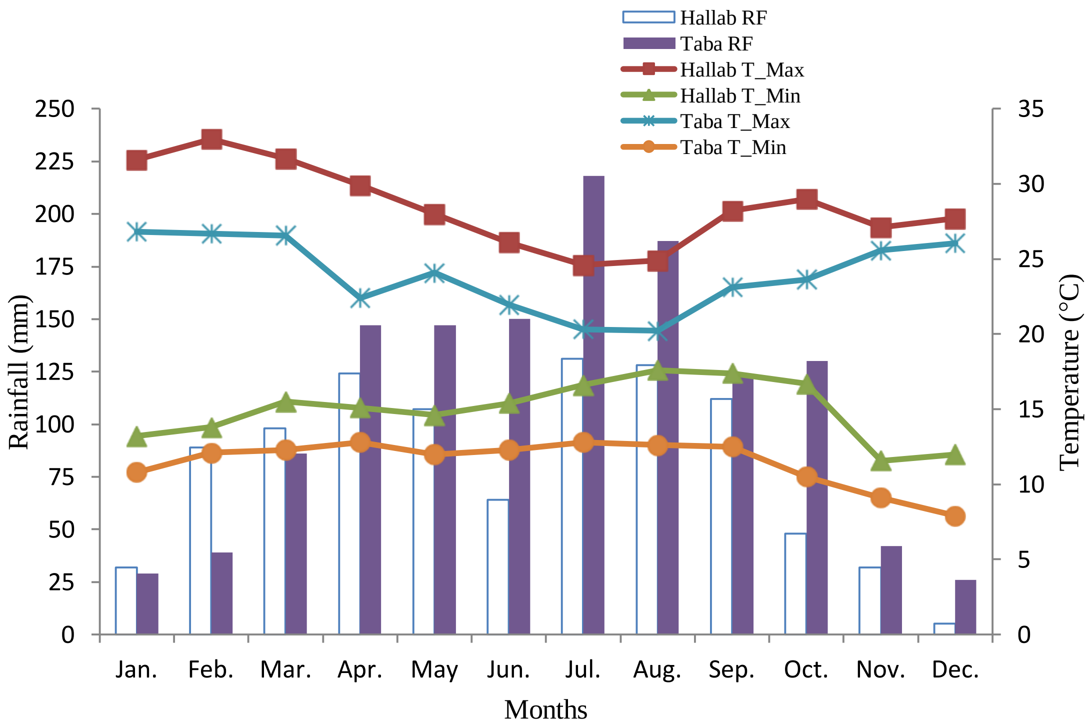

Figure 1. Monthly mean minimum and maximum temperature (°C) and rainfall (mm) data of Hallaba and Taba areas. RF = Rainfall; T = Temperature.

Table 1. Selected initial characteristics of the topsoil (0 to 20 cm) at the two trial sites.

Soil parameters	Hallaba	Taba
pH H_2O (1:2.5)	5.83	5.85
Organic C (%)	0.63	0.65
Total N (%)	0.22	0.22
Aval. P (mg/kg soil)	29.33	48
Exch. K (cmol(+)/kg soil)	0.64	0.56
CEC (cmol(+)/kg soil)	20.93	17.2
EC (ds/m)	0.18	0.16
Clay (%)	33	30
Silt (%)	37	36
Sand (%)	30	34

practical implications. In choosing the appropriate time to introduce legume crops into cereals, an important consideration is the objective of the farmer-whether to have a full cereal grain yield with some additional legume grain and fodder or balanced yield of both. Therefore, agronomic options where intercropping does not significantly reduce the main crop yield with some yield from the companion need to be determined experimentally.

In Ethiopia, information on the response of the main crop (maize) to relative planting time and intercrop row arrangement of haricot bean in additive series is scanty. The objective of this study was therefore to examine the effects of these factors on the yield and productivity of the maize crop in maize/haricot bean intercropping trials at Hallaba and Taba areas.

MATERIALS AND METHODS

Description of the study area

On farm studies were carried out in 2013 cropping season at Hallaba and Taba areas, southern Ethiopia, to determine the effects of population density and staggered intercropping of haricot bean crop on the productivity of maize crop. In the 2013 cropping season Hallaba and Taba, received annual rainfall of 970 and 1326 mm, respectively. The annual mean maximum temperatures of the two areas were 26.3 and 24.0°C while the mean minimum temperatures are 14.2 and 11.5°C, respectively (Figure 1). The soil of the study areas are clay loam in texture, acidic in reaction, low in organic matter, N and other essential nutrients (Table 1).

Description of the experimental treatments and field procedures

The experiments conducted at the two sites were arranged in a randomized complete block design comprising three maize: haricot bean row ratios and three intersowing dates of haricot bean crop plus the sole stands

Table 2. Effects of row proportion and staggered intercropping of haricot been on maize height and stover yield (pooled data of 2 sites).

Intercropping time (IT)	Maize: Haricot bean row proportion (RP)†			
	1:1	1:2	1:3	Mean*
	Plant height (m)			
Sole maize	-	-	-	2.19[ab]
Simultaneous	2.1	2.1	2.2	2.08[b]
3 WAM	2.2	2.2	2.3	2.21[a]
6 WAM	2.2	2.3	2.3	2.24[a]
Mean	2.18	2.18	2.16	
	RP	IT	RP × IT	
LSD (0.05)	NS	0.09	NS	
	Stover yield (t/ha)			
Sole maize	-	-	-	10.83[a]
Simultaneous	9.5	9.5	8.3	9.11[c]
3 WAM	9.8	10.8	10.2	10.27[b]
6 WAM	11.0	12.5	10.7	11.39[a]
Mean*	10.11[ab]	10.94[a]	9.72[b]	
	RP	IT	RP × IT	
LSD (0.05)	1.03	1.03	NS	

*Means within a row or a column followed by the same letter are not significantly different at the specified probability level. † IT = Intercropping time; NS = Non-significant; RP = Row proportion; WAM = Weeks after maize.

of the respective crops replicated three times. A uniform population of 50,000 plants ha^{-1} and a constant 80cm by 25cm inter and intra-row spacing, respectively, was maintained for maize in both cropping systems (sole and intercrop); because any variation in intercropped maize compared with sole cropping, would be attributed to the addition of beans between maize rows. In this study, a plant population of 333,333 plants ha^{-1} was considered as an optimum population for sole crop and the three different proportions of bean crop: 25% (83,333 plants ha^{-1}), 50% (166,666 plants ha^{-1}) and 75% (249,999 plants ha^{-1}). The three levels of bean population was interplanted with maize crop in an additive model were resulted into three maize: haricot bean row arrangements: 1:1, 1:2 and 1:3. Moreover, the three sowing dates of haricot bean crop relative to maize (simultaneously with maize, 3 weeks after maize (WAM) and 6 WAM) were also used to examine the staggered interseeding effect of haricot bean on the performance of the maize crop. Experimental plots used for this study were 19.6 m^2 (3.5 m × 5.6 m) size each. Maize and bean seeds were double seeded, which later thinned to obtain the required stand. Planting materials of maize and haricot bean used in this study were BH-540 and Hawasa-Dume varieties, respectively.

Data collection and analysis

To determine the response of maize crop to haricot bean intercropping, data were collected on growth parameters, yield and yield attributes, vis., plant height, LAI, cob length, number of cobs per m^2, kernel row cob^{-1}, kernels row^{-1}, 100 kernel weight, total stover yield, per plant and total grain yields.

Data collected over the two locations were subjected to analysis of variance (ANOVA) using the Statistical Analysis System (SAS). Differences between treatment means were separated using the least significant difference (LSD) test procedure at 95% confidence interval. Since the error variable was homogenous, instead of site wise data, pooled values were given for discussion and interpretation.

RESULTS AND DISCUSSION

Effect on growth and yield components of maize crop

Combined analysis of data over location revealed that there were significant differences in maize height due to varying intercropping time of the companion haricot bean crop. In this regard maize plots in which haricot bean was intercropped 6 weeks later than maize recorded the tallest plants; whereas simultaneous intercropping of maize with haricot bean produced the shortest plants (Table 2). The effect of row ratio of maize to haricot bean, however, was found non-significant on the height of maize crop.

Significant interaction of the row ratio and intercropping time of the haricot bean with maize was observed with

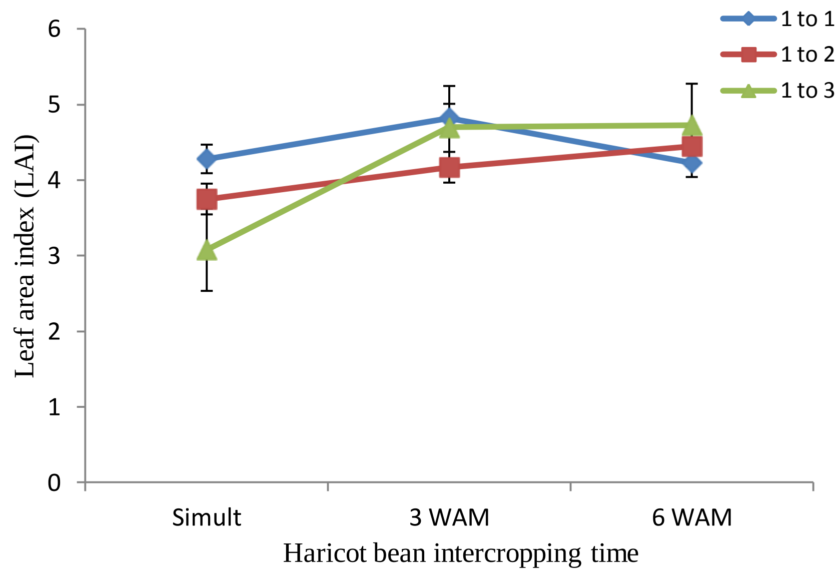

Figure 2. Interaction effect of row proportion and staggered intercropping of haricot bean on LAI of maize crop (pooled data of 2 sites). Vertical bars represent standard error of the means.

respect to LAI of the maize crop. Increasing trends of LAI were observed as interseeding of haricot bean was delayed, particularly in the 1:2 and 1:3 row combinations (Figure 2). Further delay of haricot bean interseeding beyond 3 WAM, however, resulted in the stabilization of the LAI of the maize crop, showing that the main crop could escape the competition and attain its climax LAI when the companion crop is delayed simply for 3 weeks.

Generally, this study demonstrated that differences in interplanting date of haricot bean influenced competitive ability of maize crop (measured as leaf area and plant height). Planting legumes and maize at the same time increased interspecies competition for growth limiting factors, resulting in reduced maize leaf area and maize height. Where the planting of maize and haricot bean was staggered, interspecies competition was reduced and maize attained higher leaf areas and height than with simultaneous planting. Similar observation was also made by Laurence et al. (2003), whereby growth (height and LAI) of maize crop was higher when the different green manure legumes were planted later in already established maize crop than planted simultaneously with maize.

In the present study, the overall maize stover production was significantly affected by the row proportion of haricot bean, whereby the highest (10.94 t ha^{-1}) being recorded at 1:2 row ratio, which was even higher than the sole maize, whereas the least was recorded from the highest population density (1:3 row ratio), attributable to increased interspecific competition. Table 2 shows that delaying of the undersowing time of haricot bean for 6 weeks into the already established maize crop produced the highest stover yield (11.39 t ha^{-1}), whereas simultaneously planting of the companion legume crop with maize resulted in inferior stover production, attributable to competition imposed from higher population of the companion crop since the early growth stages. Similar observations were also made by Prithiviraj et al. (2000) and Mburu et al. (2003) in which simultaneously seeded components caused decreases in stover yield and increased significantly with delayed planting time of the component.

Number of maize cobs produced on per m^2 basis was observed to be significantly affected by the intercropping time of haricot bean. The highest mean number of cobs, even higher than the sole maize, was recorded when interseeding was delayed for 3 weeks from maize; whereas the lowest number of cobs was recorded under simultaneous intercropping of the component crops (Table 3). Concomitant to present finding Amole et al. (2014) also reported that number of cobs from plot undersown by annual forage legumes at 4 WAP was similar and higher than the pure maize plot. The harvestable cob yield reduction due to simultaneous interplanting maize with other grain legumes is similar to previously reported works from other location (Tamiru, 2013).

Generally, in the present study stover yield and harvestable ears of maize crop were increased by about 8.2 and 12.3%, respectively, from simultaneous planting simply by delaying haricot bean planting for three weeks after maize. In agreement with this finding Saha et al. (2003) have reported significant increases in the number of harvestable ears (8%) and stover yield (39%) only after delaying the intercropping of velvet bean by four weeks. The effect of row proportion of the intercrops was, however,

Table 3. Effects of sown row proportion and staggered intercropping of haricot been on number of cobs m^{-2} and number of kernel rows/cob (pooled data of 2 sites).

Intercropping time (IT)	Maize: Haricot bean row proportion (RP)†			Mean*
	1:1	1:2	1:3	
	Number of cobs m^{-2}			
Sole maize	-	-	-	3.83^{ab}
Simultaneous	3.6	3.5	3.4	3.49^{c}
3 WAM	4.0	4.0	3.8	3.92^{a}
6 WAM	3.5	3.8	3.7	3.65^{bc}
Mean	3.68	3.75	3.63	
	RP	IT	RP × IT	
LSD(0.05)	NS	0.22	NS	
	Number of kernel rows cob^{-1}			
Sole maize	-	-	-	12.83
Simultaneous	15.5	12.7	12.8	13.00
3 WAM	12.8	12.8	13.0	12.88
6 WAM	13.2	13.0	12.8	13.00
Mean	13.16	12.83	12.89	
	RP	IT	RP × IT	
LSD (0.05)	NS	NS	NS	

*Means within a row or a column followed by the same letter are not significantly different at the specified probability level.† IT = Intercropping time; NS = Non-significant; RP = Row proportion; WAM = Weeks after maize.

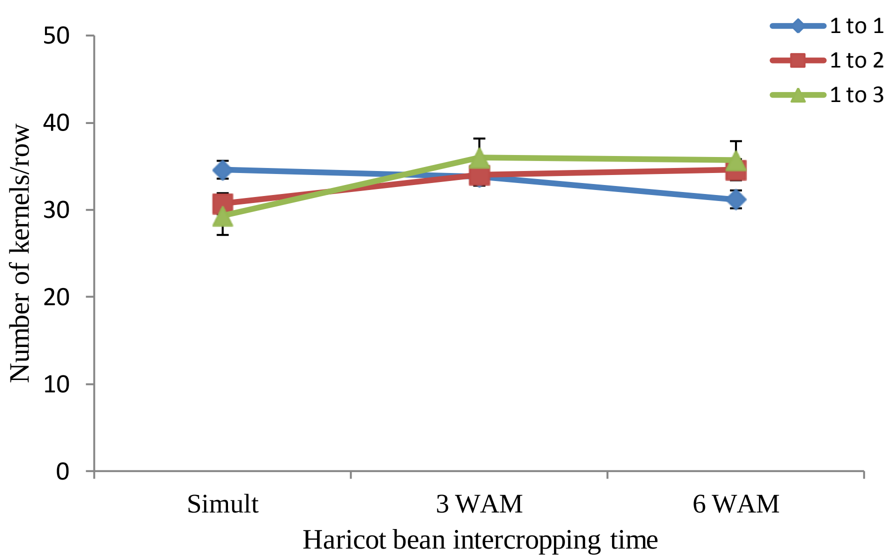

Figure 3. Interaction effect of sown row proportion and staggered intercropping of haricot bean on number of maize kernels per row. Vertical bars represent standard error of the means.

found non-significant. The number of maize kernel rows per cob was on the other hand observed to be unaffected by either of the studied variables.

Interaction effect of row proportion by intercropping time was observed highly significant with respect to number of maize kernels per row and cob length. In this regard increasing trends of kernels per cob rows and cob length were observed with decreasing number of haricot bean rows and delayed interseeding, which stabilized at 3 WAM (Figures 3 and 4). The differences in number of kernels and cob length were significant particularly at simultaneous intercropping of the intercrops, which recorded almost identical values for the 1:3 row proportion at 3 WAM planting level.

Effect on grain yield and production efficiency

A significant simple effect of intercrop row ratio by interplanting time was observed on the grain yield on per

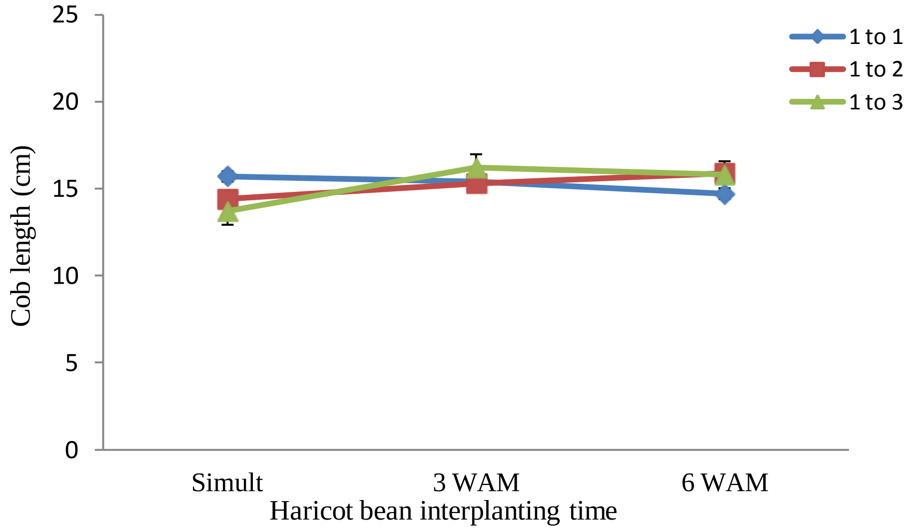

Figure 4. Interaction effect of sown row proportion and staggered intercropping of haricot bean on maize cob length (pooled data of 2 sites). Vertical bars represent standard error of the means.

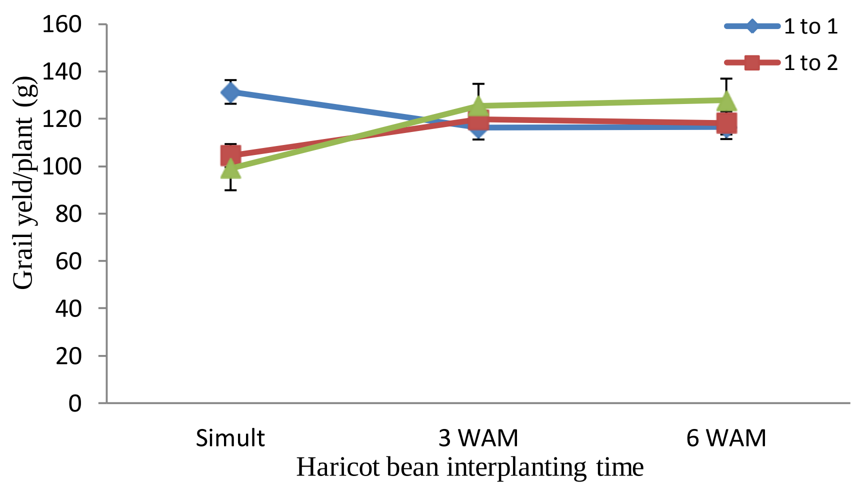

Figure 5. Interaction effect of row proportion and staggered intercropping of haricot bean on grain yield/plant of maize crop (pooled data of 2 sites). Vertical bars represent standard error of the means.

plant basis. In this regard varying trends of the different row ratios with respect to haricot bean planting dates were observed, whereby 1:2 and 1:3 maize to haricot bean ratios recorded increasing grain yield per plant as the intercropping of haricot bean delayed while the maize in 1:1 ratio with bean showed reducing trend (Figure 5).

Total grain yield of the maize crop in the present study showed that a significant variation with respect to the staggered sowing of the haricot bean crop, whereby the highest being recorded when haricot bean was delayed simply for 3 weeks after maize (3.99 t ha^{-1}), though statistically at par with maize sole cropped and interseeded 6 weeks later (Table 4). Simultaneous intercropping of maize with haricot bean, however, recorded the least grain yield, 21.1% lower yield than intercropped 3 WAM, attributable to aggravated interspecific completion starting right from emergence.

The yield boost under the later-planted haricot bean system could primarily be attributed to the better suppression of haricot bean vigour by the earlier-planted maize. Yield advantage in intercropping can arise when component crops have different growth patterns and make major demands on resources at different times (Harris et al., 1987; Putnam and Allan, 1992; Maluleke et al., 2004). In an intercropping system, a component crop can positively modify the growing environment for the benefit of the other crop, which can lead to an overall yield advantage relative to the sole crop (Vandermeer, 1992).

Table 4. Effects of sown row proportion and staggered intercropping of haricot bean on total grain yield and harvest index (HI) of maize crop (pooled data of 2 sites).

Intercropping time (IT)	Maize: Haricot bean row proportion (RP)†			Mean*
	1:1	1:2	1:3	
		Total grain yield (t/ha)		
Sole maize	-	-	-	3.68[a]
Simultaneous	3.49	3.01	2.95	3.15[b]
3 WAM	3.94	4.07	3.97	3.99[a]
6 WAM	3.36	3.83	3.86	3.68[a]
Mean	3.60	3.63	3.59	
	RP	IT	RP × IT	
LSD(0.05)	NS	0.33	NS	
		HI		
Sole maize	-	-	-	0.25[ab]
Simultaneous	0.27	0.24	0.26	0.26[a]
3 WAM	0.28	0.27	0.28	0.28[a]
6 WAM	0.23	0.24	0.27	0.24[b]
Mean	0.26	0.25	0.27	
	RP	IT	RP × IT	
LSD(0.05)	NS	0.02	NS	

*Means within a row or a column followed by the same letter are not significantly different at the specified probability level. † HI = Harvest index; IT = Intercropping time; HI = Harvest index; NS = Non-significant; RP = Row proportion; WAM = Weeks after maize.

In this study, the later planted haricot bean, though less competitive with maize, was observed to completely cover the soil late in the season, which could act to suppress weeds, create cooler soil conditions to possibly minimize moisture loss compared to the sole crop. These combined impacts would contribute to the enhanced yield of the later intercropped maize compared to sole maize crops.

In the present study, the effect of row ratio on the grain yield of maize was found non-significant showing that there is no adverse effect on maize grain yield by planting up to three haricot been rows between two maize rows. In agreement with this finding early works have reported that planting legumes at high densities do not appear to have any adverse effect on maize grain yield (Davis et al., 1987; Gitari et al., 2003; Addo-Quaye et al., 2011).

Harvest index (HI), the proportion of the mass of economic yield to total above ground biomass of maize crop was found in this study unaffected by sown proportion treatments. The HI of maize crop was however, found to be significantly affected by intercropping time of haricot bean crop (Table 4). Early associations (simultaneous and 3 WAM) gave higher proportion of economic yield, while delaying of intercropping favored the non-grain growth. This result was consistent with previous data from other location, whereby the mean HI of simultaneous intercropping of maize crop with four grain legumes was higher than later interseedings (Tamiru, 2013).

Significant effect of intercropping time was observed on partial land equivalent ratio of maize (LER_m), where values greater than one ($LER_m \geq 1$) were recorded in association of maize with haricot bean 3 and 6 weeks later; the highest partial LER value for maize being recorded when haricot bean was intercropped 3 WAM (Table 5). The LER_m = 1.09 value for the second interseeding shows that regardless of the additional grain yield from the haricot bean component, 9% more grain yield was obtained from the intercrop maize alone simply due to the association made at 3 WAM compared to the sole stand. This does mean on the other hand that 9% additional land is require by the sole stand to secure the yield obtained from maize interseeded by haricot bean 3 WAM. In the present study, the lowest mean partial LER of maize was on the other hand recorded when haricot bean was planted at the same time with maize (LER_m = 0.86). Chemeda (1997) also reported that partial LER for the crops from the relative planting dates in mixed intercropping varied significantly ($P < 0.05$). According to his report, the highest (0.93) and the lowest (0.65) partial maize LERs were registered when bean was planted 20 days after maize and 10 days before maize planting, respectively.

CONCLUSION

The results of this study demonstrate the importance of

Table 5. Effects of sown row proportion and staggered intercropping of haricot bean on partial land equivalent ratio of maize crop (LER_m) (pooled data of 2 sites).

Intercropping time (IT)	Maize: Haricot bean row proportion (RP)†			Mean*
	1:1	1:2	1:3	
Simultaneous	0.95	0.82	0.81	0.86[b]
3 WAM	1.07	1.10	1.08	1.09[a]
6 WAM	0.92	1.05	1.04	1.00[ab]
Mean	0.99	0.99	0.98	
	RP	IT	RP × IT	
LSD(0.05)	NS	0.09	NS	

*Means within a row or a column followed by the same letter are not significantly different at the specified probability level. † HI = Harvest index; IT = Intercropping time; LER = Land equivalent ratio; NS = Non-significant; RP = Row proportion; WAM = Weeks after maize.

sown row proportion and relative planting dates of maize and beans in an intercropping pattern. The precise decision on planting dates will depend on objectives to maximize total yield. According to the data of the present study, significant effect of interplanting time of haricot bean was observed on the total grain yield of the maize crop, whereby interseeding haricot bean 3 weeks later than maize favored the maize crop to produce 26.7% more grain yield than simultaneous planting of the components when averaged across locations and row proportion. The data of this study revealed that the larger maize plant canopy or LAI (providing larger photosynthetic area), attained by maize when introduction of haricot bean was delayed, probably resulted in higher grain yield of maize. When haricot bean was planted 21 days after maize, grain yield of the associated maize crop was similar to, even higher than the sole crop yield. Maize dry-matter accumulation at 1:2 row proportion with haricot bean was generally higher than the sole crop. Finally, the ultimate consideration for selection of best intercropping system is the advantages and production efficiency. Thus, on the basis of the results of this experiment, interseeding of haricot bean three weeks after maize planting in additive series may be recommended for the Halaba and Taba areas of southern Ethiopia.

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REFERENCES

Addo-Quaye AA, Darkwa AA, Ocloo GK (2011). Yield and productivity of component crops in a maize-soybean intercropping system as affected by time of planting and spatial arrangement. ARPN J. Agric. Biol. Sci. 6(9):50-57.

Amole TA, Ojo V, Dele PA, Idowu O, Adeoye A (2014). Influence of undersowing annual forage legumes in early-maturing maize on grain yield and quality of their forage mixtures, Afr. J. Range & Forage Sci. 31(1):59-64.

Chemeda F (1997). Effects of planting pattern, relative planting date and intra-row spacing on a haricot bean/maize intercrop. Afr. Crop Sci. J. 5(1):15-22.

Davis JHC, Roman A, Garcia S (1987). The effects of plant arrangement and density on intercropped beans (*Phaseolus vulgaris)* and maize: II. Comparison of relay intercropping and simultaneous planting. Field Crops Res. 16:117-128.

Gitari JN, Karumba SK, Mugendi DN, Kung’u J (2003). Effect of intercropping different densities of green manure legumes on maize performance in the central highlands of Kenya. In: J.G. Mureithi C.K.K Gachene, F.N. Muyekho, M. Onyango, L. Mose and O. Magenya (Eds.). Legume Research Network Projects. Kenya Agricultural Research Institute, Nairobi, Kenya. 10:7-11.

Harris D, Natarajan M, Willey RW (1987). Physiological basis for yield advantage in a sorghum/groundnut intercrop exposed to drought: 1. Dry matter production, yield and light interception. Field Crops Res. 17:259-272.

Heitholt JJ, Farr JB, Eason R (2005). Plant configuration and cultivar environments. Crop Sci. 45:1800-1808.

Laurence J, Chivinge OA, Mariga IK (2003). Effect of different green manure legumes and their time of planting on maize growth and witchweed *(Striga asiatica)* control: a preliminary evaluation. In: Waddington, S.R. (Ed.). Grain Legumes and Green Manures for Soil Fertility in Southern Africa: Taking Stock of Progress. Proceedings of a Conference held 8-11 October 2002 at the Leopard Rock Hotel, Vumba, Zimbabwe. Soil Fert Net and CIMMYT-Zimbabwe, Harare, Zimbabwe pp. 135-140.

Maluleke HM, Ayisi KK, Whitbread AM (2004). Lablab density and planting-date effects on growth and grain yield in maize–lablab intercrops. In: Anthony M. Whitbread and Bruce C. Pengelly (Eds.). Tropical Legumes for Sustainable Farming Systems in Southern Africa and Australia. Austr. Centre for Int. Agric. Res. Canberra pp. 99-105.

Mburu MW, Mureithi JG, Gachene CK (2003). Effects of mucuna planting density and time on water and light use in a maize - legume intercrop system. In: J.G. Mureithi, C.K.K Gachene, F.N. Muyekho, M. Onyango, L. Mose and O. Magenya (Eds.). Legume Research Network Projects. Kenya Agricultural Research Institute, Nairobi, Kenya. Issue No. 10:2-8.

Mohta NK, De R (1980). Intercropping maize and sorghum with soybeans. J. Agric. Sci. Camb. 95:117-122.

Ofori F, Stern WR (1987). Cereal-legume intercropping systems. Adv. Agron. 41:41-86.

Oseni TO, Aliyu IG (2010). Effect of row arrangements on sorghum-cowpea intercrops in the semi-arid savannah of Nigeria. Int. J. Agric. Biol. 12(1):137-140.

Prithiviraj B, Carruthers K, Fe Q, Cloutier D, Martin RC Smith DL (2000). Intercropping of corn with soybean and lupin for silage. effect of seeding date on yield and quality. J. Agron. Crop Sci. 185:129-160.

Putnam DH, Allan DL (1992). Mechanism for over yielding in sunflower/mustard intercrop. Agron. J. 84:188-195.

Saha HM, Wamocho LS, Lenga FK, Mureithi JG (2003). Effect of velvet bean (M*ucuna pruriens*) density and time of intercropping on the performance of maize in coastal lowland Kenya. In: J.G. Mureithi C.K.K Gachene, F.N. Muyekho, M. Onyango, L. Mose and O. Magenya (Eds.). Legume Research Network Projects. Kenya Agric. Res. Instit. Nairobi, Kenya 10:2-7.

Tamiru H (2013). Maize productivity as affected by intercropping date of companion legume crops. Peak J. Agric. Sci. 1(5):70-82.

Undies UL, Uwah DF, Attoe EE (2012). Effect of intercropping and crop arrangement on yield and productivity of late season maize/soybean mixtures in the humid environment of southern Nigeria. J. Agric. Sci. 4(4):37-50.

Vandermeer J (1992). The ecology of intercropping. Cambridge, UK, Cambridge, University Press.