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Original Research

Influence of Cowpea and Soybean Intercropping Pattern and Time of Planting on Yield and Gross Monetary Value of Sorghum

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Abstract

The form of agriculture and cropping system found throughout the world are the results of variation in local climate, soil type, and a range of socio-economic and biological factor that are the main determinants of the physical ability of crops to grow and cropping system to exist. Field experiment was conducted at Mechara Agricultural Research Center during 2013; to determine the effect of cowpea and soybean intercropping pattern on Land Equivalent Ratio (LER) and Gross Monetary Value (GMV) on system productivity. The treatments included two legume crops (soybean and cowpea), their planting time (simultaneously and at first weeding of sorghum),three planting patterns of legumes (double alternate plants within sorghum plants, two rows in between two rows of sorghum and both double alternate plants and two rows in between two rows of sorghum) along with sole crops (sorghum, soybean and cowpea). The experiment was conducted in randomized complete block design with three replications. Intercropping of cowpea in sorghum depressed sorghum yield. There was a variable response yield of soybean and cowpea due to legume planting time, planting pattern and their interaction. However, grain yields of both the legumes were significantly (p<0.05) influenced by time of planting and planting pattern. Simultaneously planting proved significantly better than planting at first weeding of sorghum, while combination of double alternate plants within sorghum plants with two rows in between sorghum rows proved significantly better in enhancing the yield in case of both the legumes. Partial and total LER (1.55) was significantly higher in sorghum/soybean intercropping. Highest gross monetary benefit (20561Ethiopian birr) was accrued from planting two rows of cowpea with the first weeding of sorghum in between the two rows of sorghum however, it was at par with simultaneous planting of cowpea in double alternate plants within sorghum plants along with two rows of cowpea in between sorghum rows and two rows of soybean planted in between two rows of sorghum with first weeding in sorghum.

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INTRODUCTION

The current challenge of many developing countries is to produce and more and more necessities namely food, fodder, fuel and fiber forever-increasing human population. On the limited available land. Nearly 90% of the food requirements will have to come from land-based farming (Darshan, 2008).

One of the most important strategies to increases agricultural output is the development of new high intensity cropping systems, including intercropping system, which are resistant to biotic and abiotic stresses using soil building, protein containing and high yielder crops.

The cropping system is defined as the combination of crops grown on a given area within year. The form of agriculture and cropping system found throughout the world are the results of variation in local climate, soil type, and a range of socio-economic and biological factor that are the main determinants of the physical ability of crops to grow and cropping system to exist. Therefore, cropping system varies from location to location (Seran and Brintha, 2010).

Cropping system researcher is attracting worldwide attentions both in developed and in developing countries. Temporal and spatial intensification of crops constitutes the basic ingredients of national food production strategy. It helps to create varied income sources and labor use distribution. The economic return or monetary gain per unit area and time are the major considerations for adoptions of a certain cropping system and yield is the foremost agronomic parameter to compare the importance of component crops in any type of cropping system. Soil fertility, temperature, length of rainy season and pressure on the land influence the type of cropping systems used by smallholders.

In general, in designing alternative crop systems, the common approaches to be followed are crop intensification, crop diversification and cultivar options. However, the three approaches become inseparable and considered as a building block of a new system (Yadav *et al*., 1998).

Intercropping defined as the growing of two or more crops simultaneously in the same field, thus resulting in crop intensification in time and space. The main objective of intercropping has been to maximize use of resources, such as space, light and nutrients as well as to improve forage quality and quantity. Most researchers believe that intercropping system is especially beneficial to the smallholder farmers in the low-input and high-risk environments of the tropics (Rana *et al*., 2001). The principal reasons for smallholder farmers to intercrop are flexibility, profit maximization, risk minimization against total crop failure, soil conservation and improvement of soil fertility, weed management and balanced nutrition (Shetty *et al*., 1995). Intercrop can give higher yield than sole crop yields, greater yield stability, more efficient use of nutrients, better weed management, provision of insurance against total crop failure, improved quality by variety, also cereal as a sole crop requires a larger area to produce the same yield as cereal in an intercropping system (Jensen, 1996).

In Ethiopia, sorghum was cultivated on 1.78 million hectare with a production of 3.47 million metric tons and the average yield of 1.95 ton ha^{-1} during 2010-2011 (CSA, 2012). The livelihood millions of Ethiopians depends on this staple food crop. It remains to be primary source of food in Ethiopia (Asfaw, 2007). Besides, it has tremendous uses for the Ethiopia farmers and no parts of the plant are ignored. Sorghum is a major food crop grown in Western Hararghe, accounting for 59.3% followed by maize 32.8%, and tef 4.15% of the total cultivated areas (CSA, 2012).

In both West Hararghe and Eastern Hararghe chat/sorghum, chat/maize, chat/sweet potato, sorghum/ legumes and maize/legumes the common type intercropping system practiced by farmers. However, research on time of planting and planting pattern of soybean and cowpea on yield and gross monetary value of sorghum has not been carried out in West Hararghe. Therefore, the study was conducted with the following objectives: To determine the effect of cowpea and soybean intercropping pattern on Land Equivalent Ratio (LER) and Gross Monetary Value (GMV) on system productivity.

MATERIALS AND METHODS

Location of Study Area

The field experiment was conducted at Mechara Agricultural Research Center (McARC) during the 2013 cropping season. McARC is found at an Altitude of 1700 m.a.s.l at 40^o 19' North latitude and 08^o 35' East longitude. The major soil type of the center is sandy clay with reddish color (McARC, 2010). McARC is located at Daro Labu, which is one of the districts of West Hararghe Zone, Oromia Regional State of Ethiopia and 12% of its area lies in the high land, 44% in the mid-high land and 44% in the low land agro ecological zones. The rainfall in this area is usually erratic; there is also rainfall variability in the onset and cessation of the main rainfall. Farming systems of Daro Labu district constitute complex production units involving a diversity of interdependent mixed cropping and livestock activities. The area is predominantly cereal producing with sorghum and maize as staple food crops; the major annual crops grown include sorghum, maize, groundnuts, sweet potato, wheat, common beans and barley. In addition, the major cash crops, like chat and coffee, have a long-standing tradition in the district.

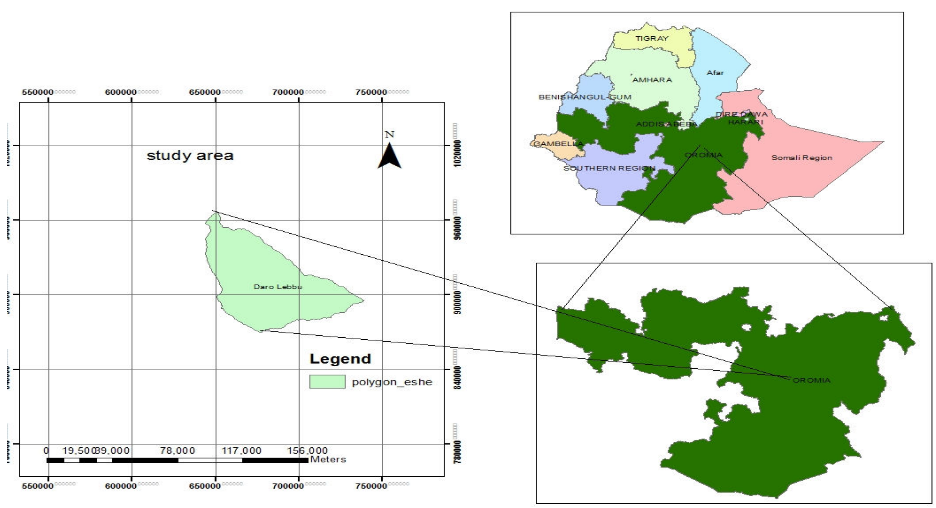

Figure 1: Map of the study area

Monthly data of total rainfall, maximum and minimum temperatures during the experimental season (June-November) showed a total rainfall of 757.6 mm out of which 35.1% was received during the month of August. Mean monthly maximum and minimum temperatures of the experimental season varied between 24.88^{o}C and 26.68^{o}C and 14.95^{o}C to 15.35^{o}C, respectively while the average temperature during the cropping season was 20.45^{o}C. In general, the average monthly maximum and minimum temperatures and rainfall distribution were suitable for sorghum production.

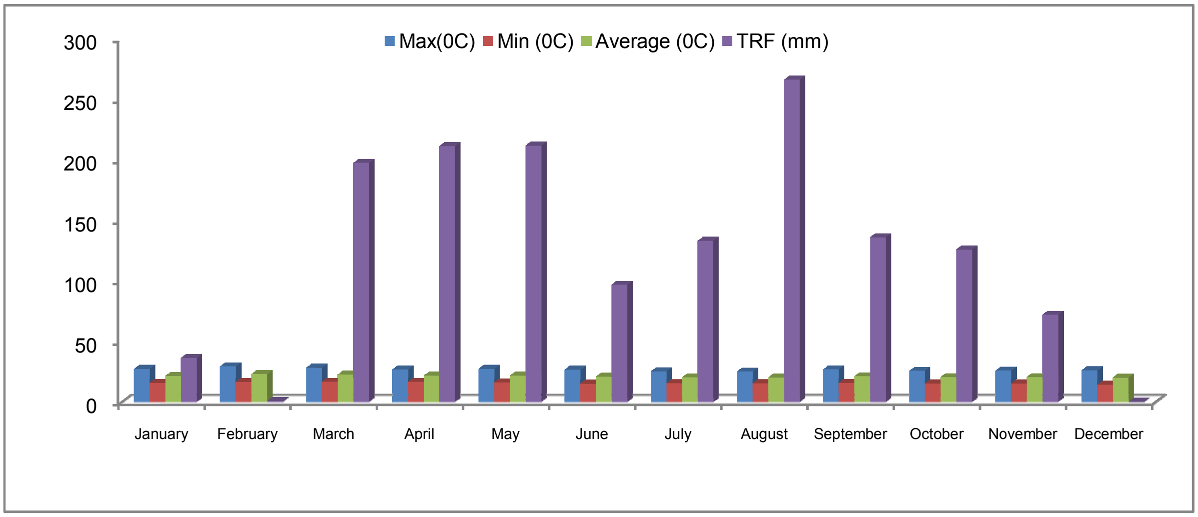

Figure 2: Weather data of 2013 cropping season (Source: Mechara weather station)

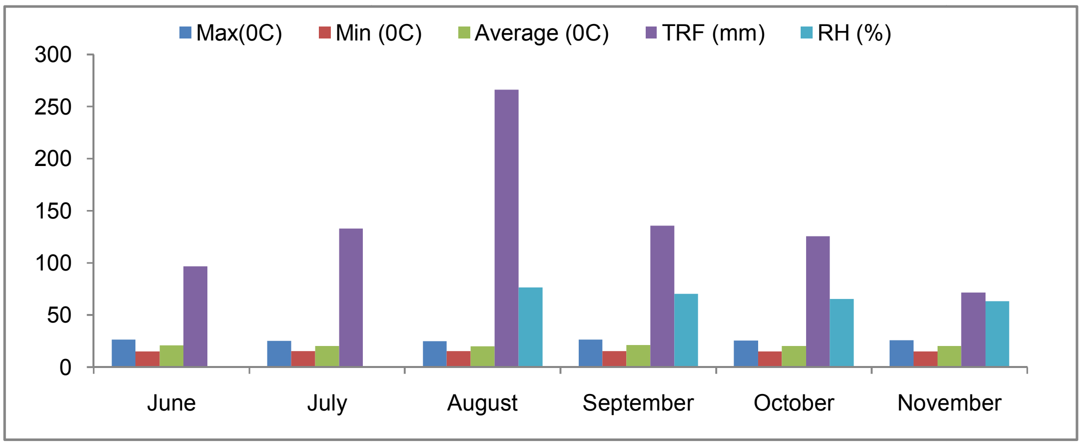

Figure 3: Weather data of experimental season

Experimental Materials

Sorghum variety Girana-1, cowpea variety ILRI11114-accession number and soybean variety Crowford were used for the study.

Treatments and Experimental Design

Cowpea and soybean were intercropped with sorghum in three planting patterns, i.e. inter rows (two rows each of cowpea and soybean in between two rows of sorghum) and intra-rows (two plants each of soybean and cowpea in between two sorghum plants) and the combination of both inter and intra rows. The legume intercrops were planted as per their planting pattern simultaneously with sorghum and at the time of first hand weeding sorghum. Thus, there were 12 treatment combinations (two legume crops x three planting patterns x two time of planting). Apart from these treatments, sole sorghum, sole cowpea and soybean were used for the study. The experiment was laid out in a randomized complete block design (RCBD) in a factorial arrangement with three replications. 1 m and each block with 1.5 m separated each plot. The plot size was 4.5 m x 3.0 m = 13.5 m^2. The net plot size was 3.0 m x1.8 m. The sole and intercropped sorghum were planted in spacing of 75 cm x 30 cm with a population density of 44,444 ha^{-1}. Sorghum seed was drilled in the rows and thinned to the recommended spacing at 30 cm between plants. Both cowpea and soybean were spaced at 18.75 cm from the sorghum rows with intra-row spacing of 10 cm and 5 cm for cowpea and soybean, respectively. The inter row spacing of 37.5 cm was between the rows of legume crops. The populations of cowpea and soybean were 2, 66, 666 and 5, 33,333 ha^{-1}, respectively. In intra, rows of sorghum two seeds of both soybean and cowpea were spaced 10 cm from each sorghum plant. The population of sole cowpea and soybean in combined inter- and intra-row planting pattern 33, 3332 and 59, 9999 ha^{-1}, respectively. The sole soybean and cowpea were planted at recommended spacing of 60 cm x 5 cm and 60 cm x 10 cm with a population of 3, 33,333 and 1, 66,666 ha^{-1}, respectively. Simultaneously planting of sorghum and legume crops was made on 24 June 2013 and the sowing of legume crop at first weeding of sorghum was done on 28 July 2013. After the crop emerged, thinning was carried out according to recommended population and spacing for all crops. Land Equivalent Ratio (LER) was calculated to determine the productivity of the system as proposed by Willey (1979).

$$LER = Yab / Yaa + Yba / Ybb$$

Where; Y is the yield per unit area, Yab and Yba are intercrop yields of the component crops a and b respectively and Yaa and Ybb are sole crop yields of a and b respectively. Gross Monetary Value (GMV) was determined to evaluate the economic advantage of intercropping system as compared to sole cropping (Willey, 1979). GMV was computed from the yield of sorghum, and soybean and cowpea component crops by multiplying the yields with their respective unit price. The total value obtained from the component crops were used to indicate the Gross Monetary Value. To estimate the GMV of component crops, sorghum grain yield was valued at an average open market price of 7.00 ETB kg^{-1}, soybean and cowpea each at 4 ETB kg^{-1} at the time of crop harvest in Daro Labu District, West Hararghe.

Data Analysis

The analysis of variance (ANOVA) was carried out using statistical packages and procedures out lined by Gomez and Gomez (1984) appropriate to Randomized Complete Block Deign using GenStat Computer Software version 13.3. Mean separations was carried out using least significant difference (LSD) at 5% probability level.

RESULTS

Soil Analysis : The soil analysis data indicated that the soil of the study area had low (0.2%) level of total nitrogen, (2.73%) medium level of organic carbon, (3.46-ppm) low level of available phosphorus, and medium CEC (21.6 meq/100g) (Table 1). The pH (H_2O) of the soil was 5.63 showing moderately acidic nature of the soil Thus, the pH of the experimental soil was within the range for productive soils. Soil textural analysis results indicated that the textural class of the experimental site was sandy clay.

Table 1: Selected physicochemical properties of experimental field soil before planting

Soil proprieties	Value
pH (1:2:5 H_2O)	5.63
Organic carbon (%)	2.73
Total nitrogen (%)	0.2
Available phosphorus (ppm)	3.46
Cation exchange capacity (meq/100g)	21.6
Particle size distribution	
Sand	51 %(very high level sand)
Clay	34% (Moderate level of clay)
Slit	15% (low Level of slit)

Grain Yield of Sorghum: Sorghum grain yield was significantly (p<0.05) influenced due to main effect of legume crops, time of planting, planting pattern and all interaction effects; except the interaction of legume crops with time of planting.

Cowpea Grain Yield: Grain yield of cowpea was highly and significantly (p<0.01) influenced by the main effect of time of planting and planting pattern. Interaction effect of time of planting and planting pattern was not significant.

Soybean Grain Yield: The analysis of variance showed that grain yield of soybean had highly significant (p<0.01) difference due to main effect of time of planting and planting pattern while their interaction had no significant difference (Table 2).

Table 2: Main effect of legume crops, time of planting and planting patterns on yield of sorghum, cowpea and soybean in sorghum intercropped with cowpea and soybean

Treatments	Sorghum yield kg ha^{-1}	Cowpea yield kg ha^{-1}	Soybean yield kg ha^{-1}
Legumes (L)			
Soybean	1787.1		
Cowpea	1401.8		
LSD (%)	**77.85**		
Time of planting (TP)			
Simultaneously	1436.1	1863.3	1169.0
First hand weeding	1752.8	1517.2	921.0
LSD (%)	**77.85**	**102.01**	**117.7**
Planting pattern (PP)			
Double alternate plant	1535.2	1505.4	735.0
Two rows of inter crops	1755.0	1764.6	1169
Two rows of inter crops + DAPs	1493.2	1800.9	1229
LSD (5%)	**95.37**	**124.93**	**144.2**
CV (%)	**7.1**	**5.7**	**10.7**
LXPP	*		
LXTP	NS		
TPXPP	*	NS	NS
LXPPXTP	*		

LSD= Least significant difference; CV= Coefficient of variation; NS= Not significant; *= significant at (p≤0.05) **= significant at (p≤ 0.01)

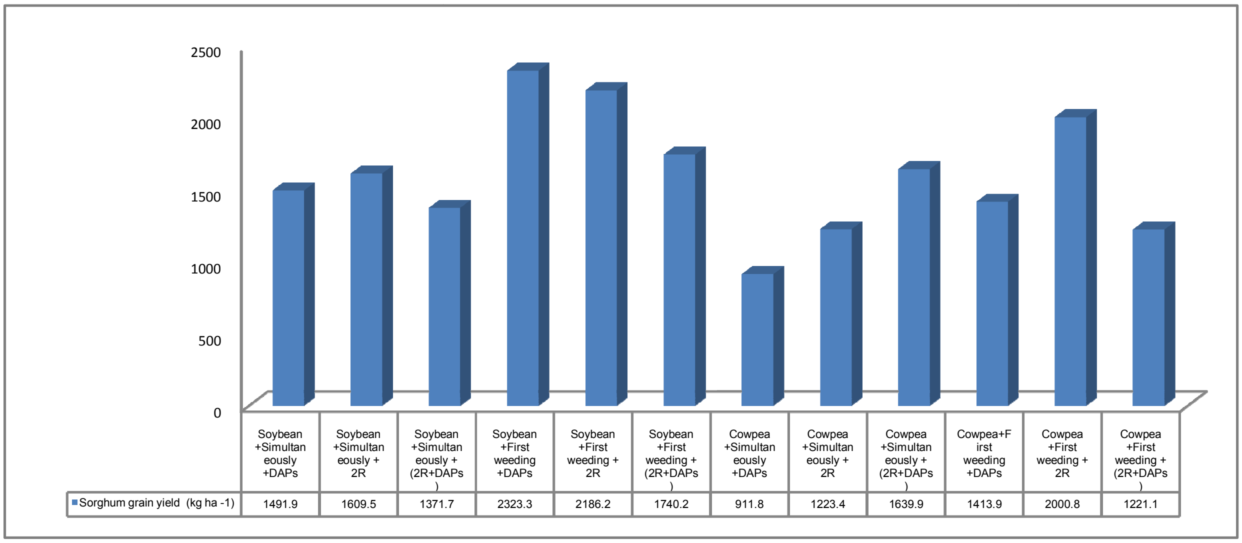

Figure 4. Grain yield of sorghum as affected by soybean and cowpea intercropping system

Table 3: Interaction effect of time of planting and planting pattern on grain yield of cowpea, in cowpea intercropped with sorghum

	Cowpea grain yield kg ha^{-1}		
Time of planting	**DAPs**	**2R**	**2R+DAPs**
Simultaneously	1720.2	1890.2	1979
First weeding	1290.5	1638.9	1622
LSD (5%)		**176.68**	
CV (%)		**5.70**	

LSD= Least significant difference, CV= Coefficient of variation

Table 4: Main effect of legume crops, time of planting and planting pattern on sorghum and legumes partial land equivalent ratios and total land equivalent ratio in sorghum intercropped with cowpea and soybean

Treatments	**Sorghum partial LER**	**Legumes partial LER**	**Total LER**
Legumes (L)			
Soybean	0.767	0.785	1.55
Cowpea	0.605	0.584	1.19
LSD (5%)	**0.072**	**0.0985**	**0.124**
Time of planting(TP)			
Simultaneously	0.609	0.753	1.36
First weeding	0.763	0.616	1.38
LSD (5%)	**0.072**	**0.0985**	**NS**
Planting pattern (PP)			
DAPs	0.655	0.709	1.21
2R	0.765	0.793	1.47
2R+DA	0.638	0.552	1.43
LSD (5%)	**0.0878**	**0.1207**	**0.151**
CV (%)	**15.1**	**20.8**	**13**
Cropping system			
Intercropped			1.37
Sole sorghum			1.00
Sole cowpea			1.00
Sole soybean			1.00
LSD (5%)			**0.366**
CV (%)			**21.3**
LXTP	NS	NS	NS
LXPP	*	NS	NS
TPXPP	**	NS	*
LXTPXPP	NS	NS	NS

LSD= Least significant difference; CV= Coefficient of variation; NS= Not significant;
*= significant at ($P \leq 0.05$) **= significant at ($P \leq 0.01$)

Land Equivalent Ratio (LER): The total land equivalent ratios (LER) were obtained by summing up the partial land equivalent ratios of sorghum and legume crops. Sorghum and legume partial land equivalent ratios were significantly ($p \leq 0.05$) affected due to main effect of legume crops, time of planting, planting pattern and the interaction of legumes with planting pattern (Table 5). In addition, sorghum partial LER was also influenced by legume planting patterns and time of planting. Partial land equivalent ratios for the crops in intercropping systems were less than one and unity.

Table 5: Main effect of legume crops, time of planting and planting patterns on GMV in sorghum intercropped with cowpea and soybean

Treatments	Sorghum (Birr ha^{-1})	Legumes (Birr ha^{-1})	GMV (Birr ha^{-1})
Legumes			
Soybean	12510	4178	16688
Cowpea	9813	6761	16574
LSD (5%)	**545.1**	**324.8**	**NS**
Time of planting			
Simultaneously	10053	6064	16117
First weeding	12270	4876	17146
LSD (5%)	**545.1**	**324.8**	**571.9**
Planting pattern			
DAPs	10747	4481	15228
2R	12285	5868	18153
2R+DAPs	10453	6060	16513
LSD (5%)	**667.6**	**397.8**	**700.4**
CV (%)	**7.1**	**8.6**	**5.0**
Cropping system			
Intercropped			16631
Sole sorghum			16440
Sole cowpea			11675
Sole soybean			5386
LSD (5%)			**2992**
CV (%)			**15.8**
LXTP	NS	NS	NS
LXPP	**	NS	**
TPXPP	**	NS	**
LXTPXPP	*	NS	*

LSD= Least significant difference; CV= Coefficient of variation; NS= Not significant; *= significant at ($P \leq 0.05$) **= significant at ($P \leq 0.01$)

Gross Monetary Value (GMV): GMV was also used to evaluate economic advantages of intercropping system. As result of economic analysis, intercropping of soybean and cowpea with sorghum was more advantageous than sole cropping sorghum. GMV was significantly ($p \leq 0.05$) affected due to main effect of time of planting and planting patterns but not due to the main of effect of legume crops (Table 6).

Table 6: Interaction effect of legume crops, time of planting and planting pattern on GMV of sorghum, in cowpea and soybean cropping system

		GMV		
		Planting pattern		
Legumes crops	**Time of planting**	**DAPs**	**2R**	**2R+DAPs**
Soybean with sorghum	Simultaneously	14086fg	16259de	17569cd
	First weeding	18503bc	19666ab	14046fg
Cowpea with sorghum	Simultaneously	13264g	16125e	19397ab
	First weeding	15059ef	20561a	15036ef
LSD (5%)			**1400.9**	
CV (%)			**5.00**	

LSD= Least significant difference; CV= Coefficient of variation

DISCUSSION

The interaction of three factors revealed that soybean DAPs at the time of sorghum first weeding resulted in the highest grain yield of sorghum; however, it did not show significant difference with soybean planted in 2R in between two sorghum rows at first weeding. The (911.8 kg ha $^{-1}$) lowest grain yield of sorghum was obtained when cowpea was intercropped in DAPs simultaneously with sorghum.

Soybean intercropped with sorghum resulted in significantly lower grain yield when planted simultaneously with sorghum than planting at first weeding of sorghum under all the planting patterns. On the other hand, cowpea-sorghum intercropping showed, a similar trend except cowpea planted with first weeding in sorghum in 2R+DAPs pattern, where in simultaneous planting in 2R+DAPs pattern gave significantly higher grain yield (Table 3). Myaka and Kabbissa (1996) and Champion *et al.* (1998) reported that variation in planting pattern could cause variation in nutrient uptake and the general performance of intercropping system.

Addo-Quaye (2011) found that time of introduction of soybean significantly affected maize grain yield and delayed soybean planting increased maize grain yield in maize/soybean cropping system. It was also reported that maize planted in alternate rows 28 days after soybean gave significantly higher grain yield than those planted in double rows of soybean. Similarly, Chemeda (1997) reported that delayed bean planting increased maize grain yield in maize / bean cropping systems. Fasil and Verkleij (2007) also reported that sorghum/ soybean-cropping system reduced sorghum yield by 27.5% while in system the magnitude of sorghum yield reduction was 55.6% sorghum/cowpea intercropping. Similarly, Oseni and Aliyu (2010) obtained a reduction of 69.7% in sorghum yield due to sorghum/cowpea intercropping. Further, they found that grain yield of sorghum was higher in sole cropping than intercropping mixtures. This was in agreement with the findings of Langat *et al*. (2006) who indicated that intercropping significantly affected the yield of sorghum in sorghum/ groundnut intercropping. Other studies revealed higher sorghum (Tamado and Eshetu, 2000) and maize (Chemeda, 1997) grain yield in sole cropping than intercropping. The interaction effect of legume, their planting time and planting pattern showed that planting of soybean in double alternate plants in between sorghum plants at the first weeding of sorghum resulted in a significant increase in sorghum yield over other interaction except the interaction of two soybean rows planted at the first weeding of sorghum in between two sorghum rows. Further, the latter interaction was statistically in parity with the interaction of two rows of cowpea planted at first weeding in sorghum. Simultaneous planting of double plants of cowpea in between the sorghum plants resulted in significant decrease in sorghum yield over other interactions.

Highest grain yield of soybean (1169 kg ha^{-1}) was recorded when soybean was planted simultaneously with sorghum, which was 26.9% higher than the yield obtained when soybean was planted with first weeding of sorghum. Sowing date is one of the most important agronomic factors affecting grain yield of soybean in intercropping system. Grain yield of soybean decreased with delayed sowing. Therefore, simultaneously planting with sorghum resulted in higher soybean grain yield. The reduction in grain yield of soybean by intercropping could be due to interspecific competition and depressive effect of sorghum, a C_4 species on soybean, a C_3 crop. Although the sorghum growth rate may be less than soybean at the initial stage (30-40) days after. Sowing, both crops attained the peak growth rate at 60-70 days after sowing. Due to the above reason, soybean yield decreased when planted at the first weeding of sorghum. This is in agreement with the findings of Chemeda (1997) who obtained higher haricot bean yield when the haricot bean cultivars were planted simultaneously with maize than common bean Nnoko and Doto (1980) reported that planting soybean before cereal gave significantly higher yield than planting soybean at the same time or after the cereal. Addo-Quaye *et al*. (2011) also showed that soybean planted before maize (maize planted 14 days after soybean, maize planted 28 days after soybean) recorded higher grain yield than soybean planted after maize. Different planting patterns of soybean intercropped with sorghum significantly the grain yield of soybean. A combination of two rows of soybean in between sorghum rows (2R) and double alternate plants within sorghum plants (DAPs) resulted in the highest soybean yield, which was statistically at par with the grain yield obtained in two rows of soybean intercropped in between sorghum rows. However, both these planting patterns resulted in significantly higher grain yield than double alternate soybean plants within sorghum plants. this yield increase was 67.2 and 59.0% respectively with two rows of soybean in between sorghum rows plus double alternate plants within sorghum plants (2R+DAPs) and two rows of soybean intercropped in between sorghum rows (2R) over double alternate soybean plants (DAPs) and two rows of soybean intercropped in between sorghum rows (2R) over double alternate soybean plants (DAPs) within sorghum plants. cropping system did not significant influence soybean grain yield in sorghum / soybean cropping system.

The highest cowpea yield (1979.5 kg ha^{-1}) was obtained when it was planted simultaneously with sorghum in two rows of cowpea in between sorghum rows along with double alternate plants of cowpea within sorghum plants (2R+DAPs). The yield obtained with this interaction was significantly higher than the other interactions except the interaction of simultaneous planting of cowpea in 2R pattern in between sorghum rows. The cowpea yield was significantly reduced when planted at the first weeding of sorghum under all the planting patterns compared to simultaneous planting of cowpea with sorghum. The data also showed that cowpea planted at the first weeding in DAPs resulted in significant reduction in yield compared to other interactions. This was in agreement with the findings of Gandebe *et al*. (2010) where reported that the time of introducing cowpea into maize significantly affected the yield of cowpea; simultaneous planting showed increasing cowpea yield when compared to introducing cowpea into maize when delayed by two or four weeks. When comparing the sole and intercropped cowpea yield, it was observed that sole cropping system gave 2918.3 kg ha-1 cowpea yield that was 72.6% higher than the intercropped cowpea yield. Similarly, Oseni and Aliyu (2010) reported a 55.3% cowpea yields reduction due to sorghum/ cowpea intercropping system. Oseni (2010) also found that grain yield of cowpea was higher in sole cropping than in intercropping mixtures. This was in agreement with the findings of Egbe *et al*. (2010) who found that cowpea grain yield was depressed by maize-cowpea intercropping systems. In this present study, not only the yield of cowpea was depressed by sorghum but cowpea also depressed the yield of sorghum.

Higher total LER (1.55) was obtained from sorghum/ soybean than to sorghum/cowpea (1.19) intercropping (Table 4), indicating 55% and 19% yield advantage respectively over sole crops. Though the yield of cowpea was higher than the Soybean in an intercropping system, the greater enhancement in sorghum yield intercropped with soybean was manifested by total higher LER of the system. The total LER in all cases was more than unity showing that intercropping of legumes with sorghum is advantageous in all instances rather than sole planting of sorghum. Higher LER in intercropping than sole cropping has also been reported in maize/soybean by Ullah *et al*. (2007). The yield advantage could be due to the efficient utilization of growth resources by the intercropped crops or the intercropping advantages of nitrogen fixation and increased light use efficiency (Willey, 1985; Reddy, 2000). Although, Yesuf (2003) reported that LER decreased with an increase in planting density, in this present experiment it was governed by time of planting of the legumes too. From this result, it can be concluded that additional yield can be produced by intercropping sorghum with a suitable legume at an appropriate time of planting and planting pattern. Sowing legume crops at first weeding of sorghum gave highest sorghum partial LER (0.763) and the least were obtained when sorghum was planted simultaneously with legumes (0.609). The highest sorghum partial LER (0.765) and the least (0.638) were obtained from 2R and DAPs+2R planting pattern, respectively. Planting soybean and cowpea at first weeding of sorghum resulted in higher monetary value than planting soybean and cowpea simultaneously with sorghum. From all interaction effect when cowpea was intercropped at first weeding or hoeing sorghum in 2R planting pattern gave highest GMV (20561 ETB ha^{-1}) and the lowest GMV(13264 ETB ha^{-1}) was recorded when cowpea intercropped with sorghum simultaneously in DAPs planting pattern. GMV was higher in intercropping system than sole cropping systems (Table 6). This is was in agreement with the findings of Wondimu (2013) and Alice (2007) obtained higher monetary returns from intercropping than sole maize, in maize soybean cropping system. Similarly, by Biruk (2007) reported that intercropping sorghum with common bean was more advantageous than sole cropping of either common bean or sorghum.

CONCLUSIONS

The most important strategy to increase agricultural output is the development of new high intensity cropping system, including intercropping system, which is tolerant to biotic and abiotic stresses. Sorghum grain yield was significantly affected due to main effect legumes crop, time of planting and planting pattern. The highest sorghum yield was recorded when sorghum intercropped with soybean, legume crops intercropped at first hand weeding sorghum at 2R planting pattern. The interaction effect of legume, their planting time and planting pattern showed that planting of soybean in double alternate plants in between sorghum plants at the first weeding of sorghum resulted in a significant increase in sorghum yield over other interaction except the interaction of two soybean rows planted at the first weeding of sorghum in between two sorghum rows. Further, the latter interaction was statistically in parity with the interaction of two rows of cowpea planted at first weeding in sorghum. Simultaneous planting of double plants of cowpea in between the sorghum plants resulted in significant decrease in sorghum yield over other interactions. Partial and total LER of sorghum was highest when intercropped with soybean. On the other hand, interaction of planting time and planting pattern revealed highest LER when legumes were planted at first weeding in sorghum in double row intercropping. However, it was found to be statistically in parity with simultaneously planted legumes in double alternate plants within sorghum plants plus two rows of legumes in between the sorghum rows. Highest gross monetary benefit was accrued from planting two rows of cowpea with the first weeding of sorghum in between the two rows of sorghum. However, it was at par with simultaneous planting of cowpea in double alternate plants within sorghum plants along with two rows of cowpea in between sorghum rows and two rows of soybean planted in between two rows of sorghum at first weeding in sorghum. The following are recommended from the study. The result clearly depicted that the role of legumes in increasing production per unit area. Under these scenarios also intercropping gave high yield advantage over sole cropping. In area where livestock and sorghum is the main source monetary income for farmers intercropping cowpea and soybean at first weeding of sorghum in 2R planting pattern were recommended. Legumes crop soybean and cowpea should involved in sorghum cropping either simultaneously planting or sowing at first weeding or hoeing of sorghum.

Conflict of Interest

Conflict of interest none declared.

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