Intercropping Soybean (Glycine max L.) with Sorghum [Sorghum bicolor (L.) Moench] in East Hararghe, Oromia

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ABSTRACT

Field experiments were done in 2018 and 2019 at Fedis and Erer to determine the effect of intercropping sorghum with soybean on grain yield. Seed yields were higher in the sole crops of sorghum and soybean than in the individual components of the intercrops. This is due to the crops' compete of nutrients, light, water, and other factors. The yields of the intercrop's component crops varied greatly depending on the variety. The sorghum/soybean 'Teshale/Awasa-95' intercrops were more productive than the sorghum/soybean 'Dhaqaba/Awasa-95' intercrops, which had an LER (land equivalent ratio) of 1.14. Intercropping sorghum 'Teshale' with soybean 'Awasa-95' resulted in maximum grain production and LER greater than one, showing that intercropping has an advantage over solely planting. As a result, intercropping sorghum and soybean is compatible, desirable, and more advantageous for increasing production than solely cropping under the same conditions.

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1. INTRODUCTION

Crop intensification is one of the strategies to increase productivity per unit area of land Bekele et al., 2016. Due to decreasing land units and decline in soil fertility integrating soybean in to the Sorghum production system is a viable option for increasing productivity and as well protein source. Sorghum [*Sorghum bicolor* (L.) Moench] was domesticated in Ethiopia about 5000 years ago. It is staple food and feed of eastern parties of the country particularly east Hararghe having 72.9%. Reports of persistence of high rate of acute malnutrition in certain specific areas of East Hararghe. Report of Sibhatu & Qaim, 2018 stated that although people had access to staple food groups the dietary diversity and therefore dietary quality was low. Furthermore, very low consumption of valuable protein sources (animal proteins such as meats, eggs, dairy products) implied low nutritional value of the diet (Phillips et al., 2015). Even though a high proportion of households had access to staple food, their knowledge on diversification of food remains limited. Hence, the essential nutritional value needed for each individual was not reached and poor nutritional status was expected to be found in households.

A general assumption in intercropping cereals with legume crops is that the legume, when associated with the specific Rhizobium, may have most of its N need supplied through fixation of atmospheric N, leaving the soil available N for the companion cereal (Saberi, 2018). There is evidence that leguminous plants can benefit the intercrop cereals in the same season through N excretion and nodule decomposition. Intercropping soybean (*Glycine max* L.) with sorghum (*Sorghum bicolor* L.) is common in the semiarid tropics (Ghosh et al., 2006). Sorghum and soybean are being intercropped in the tropics so that crops more effectively (Wahua & Miller, 1978) for utilize water, weed control, and soil fertility is improved. In view of the current situation of food security, particularly in developing countries, land availability for agricultural activities, fresh water resources, biotic and abiotic stresses, and low economic activity in agricultural sector Hossain et al., 2020 are factors that decrease in crop productivity.

Intercropping is influenced by factors such as rootstock or type, a lack of manure, plant growth stage, and irrigation management (Ouma & Jeruto, 2010). Because of the scarcity of land, resources, and risk management due to irregular rainfall, intercropping is a typical practice in the studied area (East Hararghe). Farmers' general methods include sorghum with common bean, sorghum with groundnut, and maize with common bean. Despite the fact that intercropping is widespread among east Hararghe farmers, soybean is a new crop for them, and intercropping sorghum with soybean is also new. As a result, the experiment was carried out in order to become acquainted with the technology and determine the commodity's compatibility.

2. METHOD

2.1 Description of the study Area

The field experiment was carried out in the East Hararghe zone, Fadis, and Babile districts' midland and lowland areas. Fadis district is located approximately 24 kilometers east of Harar, the capital of the East Hararhge Zone.

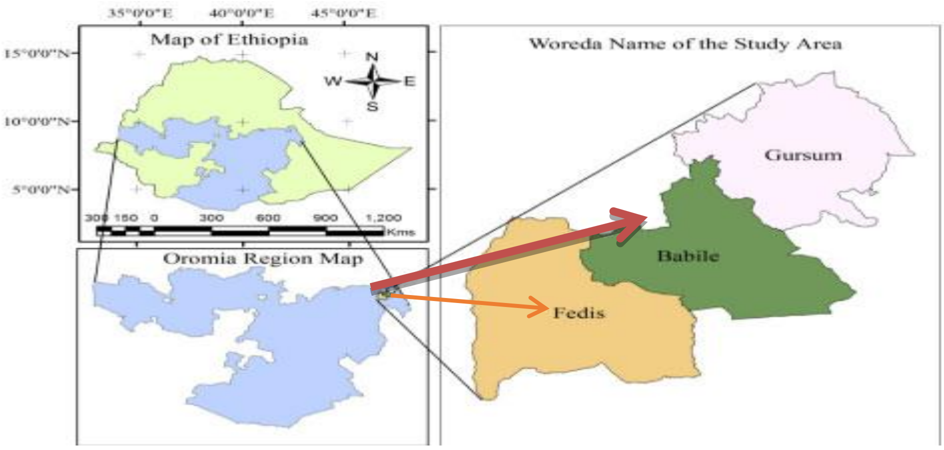

Figure 1. Map of study areas

The maximum and minimum annual temperatures are 28.23 degrees Celsius and 10.2 degrees Celsius, respectively. It is located at an elevation of approximately 1702 meters above sea level; the specific soil type of the site is Alfisols type soil and sandy clay loam in texture, with a pH value ranging from 8.1 to 8.6. Soil physical parameters include clay (48%), silt (29%), and sand (23%), and soil chemical properties include total nitrogen (0.167%), organic carbon (1.268%), and accessible phosphorus (2.61 ppm) (FARC, 2013). Babile is found in the East Hararghe zone of the Oromia region. It is located at 09°13′ N, 42°20′ E, and has an elevation of 1648 meters above sea level. The average rainfall in the experimental region is 749.9 mm. Rainfall is distributed bimodally, with strong rains from April to June and protracted and unpredictable showers from August to October.

2.2 Experimental materials

As a test crop, improved sorghum varieties Teshale and Dhaqaba, as well as two soybean varieties (Awasa-95 and Awasa-04), were used.

2.2.1 Treatments and experimental design

Soybean and sorghum were intercropped in a 1:1 ratio. In series, one row of sorghum and one row of soybean (1 sorghum: 1 soybean).

Teshale*Awasa-95
Teshale*Awasa-04
Dahaqaba*Awasa-95
Dhaqaba*Awasa-04

Teshale Sole
Dhaqaba Sole
Awasa-95 Sole
Awasa-04 Sole

2.2.2 Data Collection

The yield of sorghum and soybeans was collected. Commodity yield and yield-related components were collected. For Sorghum, measurements such as panicle length, panicle diameter, plant height, days to flowering, and days to maturity were taken. Soybean data including pod/plant, seed/pod, branches/plant, and plant height were also collected and analyzed.

2.3 Data Analysis

The analysis of variance (ANOVA) was carried out using statistical packages and procedures out lined by Gomez K. and Gomez A., 1984. Appropriate to Randomized Complete Block Deign using SAS Computer Software Version 9.0. Mean separations was carried out using least significant difference (LSD) at 5% probability level.

3. RESULTS AND DISCUSSION

3.1 Research results

The combined mean of the analysis of variance demonstrated that there was significant variation in yield and yield-related components for each crop commodity among the intercropping combinations. Panicle length, panicle diameter, and plant height all exhibit significant variance in sorghum output. Soybean grain yield, number of pods per plant, number of primary branches per plant, and plant height exhibited significant variance.

Table 1. The effect of intercropping sorghum and soybean on yield and yield components of sorghum

Treatments	PL	PH	PD	GY(qt/h)
Teshale sole	29a	184.3a	10.444a	37.67a
Teshale x Awasa-95	28.78a	164.8b	10.667a	27.70ab
Teshale x Awasa-04	27.33ab	171.8ab	9.444ab	24.20b
Dhaqaba sole	25.22ab	123c	9.333ab	32.96ab
Dhaqaba x Awasa-95	23.67bc	117c	8.667ab	23.00b
Dhaqaba x Awasa-04	22.78c	117.7c	8b	22.30b
LSD	3.57	16.44	2.12	10.35
CV	7.5	3.3	12.4	20.3

NB: PL=panicle length, PH=plant height, PD=panicle diameter, GY=Grain yield

The analysis of variance revealed that there was significant variation caused by intercropping among the treatments. As a result, for panicle length, the longest panicle was measured from Teshale intercropping with Awasa-95. Teshale was followed with Awasa-04, and the shortest panicle length was measured from Dhaqaba intercropping with Awasa-04. The wider diameter was obtained from the intercropping of Teshale with Awasa-95, followed by Teshale sole, and Teshale with Awasa-04. Grain yield showed significant variance as a result of intercropping. As a result, the highest grain yield was obtained from Teshale sole and Dhaqaba sole, followed by Teshale intercropping with Awasa-95.

Table 2. The effect of sorghum and soybean intercropping on soybean yield and yield components

Treatments	SPP	PPP	PH	NBPP	GY(qt/h)
Awasa-04 sole	2.67	24.89bc	65.00a	5.11ab	19.6a
Dhaqaba x Awasa-95	2.67	30.22abc	55.22bc	6.00ab	6.2b
Awasa-95 sole	2.44	38.33a	60.67ab	6.778a	14.0a
Dhaqaba x Awasa-04	2.44	18.89c	49.89c	4.00b	5.6b
Teshale x Awasa-04	2.44	24.00bc	50.67c	6.00ab	9.0b
Teshale x Awasa-95	2.33	36.67ab	57.56abc	5.56ab	13.8ab
LSD	NS	11.97	8.68	2.39	5.89
CV	10.19	5.37	3.89	11.07	12.64

NB: spp=seed/pod, ppp=pod/plant, PH=plant height, NBPP=Number of branches/plant and GY=Grain yield

The number of pods per plant, plant height, number of primary branches per plant, and grain seed results vary significantly when sorghum and soybean are intercropped. The highest number of pods per plant were counted from Awasa-95 sole, followed by intercropping of Teshale with Awasa-95 and Dhaqaba with Awasa-95. While intercropping Dhaqaba with Awasa-04 resulted in a minimal number of pods per plant. When compared to the intercropping, sole Awasa-95 and Awasa-04 have the highest plant height.

The number of primary branches per plant is significantly affected by intercropping. As a result, Awasa-95 had the highest number of primary branches per plant, followed by Dhaqaba with Awasa-95, Teshale with Awasa-04, and Teshale with Awasa-95. The smallest number of primary branches per plant was found by intercropping Dhaqaba with Awasa-04. Intercropping causes significant variation in seed yield. The maximum seed yield was obtained from sole Awasa-04, which was followed by sole Awasa-95 and intercropping of Teshale with Awasa-95.

Table 3. Effects of Sorghum and Soybean Intercropping on Sorghum and Soybean Yield

Treatments	Yield of Soybean(qt/h)	Yield of Sorghum (qt/h)
Awasa-04 X Dhaqaba	5.6b	22.3b
Awasa-95 X Dhaqaba	6.2b	23.0b
Awasa-04 X Teshale	6.0b	24.2b
Awasa-95 X Teshale	13.8a	27.7ab
Awasa-04 sole	19.6a	-
Awasa-95 sole	14.0a	-
Dhaqaba sole	-	32.9ab
Teshale sole	-	37.6a
LSD	5.89	10.35
CV	2.64	20.3

NB: CV=coefficient variation, LSD=least significant difference

The interaction effect of intercropping Soybean with Sorghum varies significantly among treatments. The highest seed yield was obtained by sole planting in both crops, followed by intercropping of Teshale ‘Sorghum’ and Awasa-95 ‘Soybean’ (Table 3). This suggests that intercropping surpasses sole cropping in terms of total yield. Similarly, Mohta & De, 1980 revealed that Sorghum intercropping with soybean treatment yielded 60% more than pure cultivation and that if each crop was seeded alone, the area required was equal to 1.6. According to Mortatha Ogee *et al*., 2019, the results show that soybean blended with sorghum had a better soil environment than the sole soybean treatment.

3.1.1 Land Equivalent Ratio (LER)

The land equivalent ratio (LER) was calculated to evaluate the effectiveness of intercropping for exploiting environmental resources to sole cropping (Dhima K, *et al*., 2007). When LER is more than one, intercropping benefits the species' growth and yield. When LER is less than one, intercropping has a negative impact on the growth and yield of plants cultivated in mixtures (Caballero R, 1995). The LER values were calculated as: LER = (LER Sorghum + LER Soybean), where LER Sorghum = (YSorSoy / YS), and LER Soybean = YSoySorg / YSoy, where YSor and YSoy are the yields of Sorghum and Soybean as sole crops, respectively, and YSoySorg and YSorSoy are the yields of Soybean and Sorghum as intercrops, respectively.

Table 4. Sorghum and soybean intercropping land equivalent ratio

		Teshale	Teshale	Dhaqaba	Dhaqaba
Sorghum	Sole	37.67	37.67	32.96	32.96
	Intercropping	24.2	27.7	22.3	23
	Partial LER	0.64	0.74	0.68	0.7
		Awasa-04	Awasa-95	Awasa-04	Awasa-95
Soybean	Sole	19.6	14.0	19.6	14
	Intercropping	6.0	13.8	5.6	6.2
	Partial LER	0.31	0.98	0.29	0.44
	LER	0.95	1.72	0.97	1.14

LER=land equivalent ratio

Total land equivalent ratios (LER) were calculated by adding the sorghum and soybean crops' partial land equivalent ratios. The main effect of sorghum intercropping with soybean had no significant (P>0.05) influence on sorghum partial land equivalent ration mean values. Even if no differences were detected in the analysis of variance, the higher total LER (1.72) was obtained from sorghum ‘Teshale’ and Soybean ‘Awasa-95’, followed by LER 1.14 Sorghum ‘Dhaqaba’ intercropping with Soybean ‘Awasa-95’, showing a 72% and 14% yield advantage over sole crops, respectively (Table 4). Intercrop yields of soybean and sorghum were lower than sole crop yields, even though land equivalent ratios favored intercropping.

Mean square analysis suggests that intercropping Sorghum and Soybean exhibits significant variation among treatments. Intercropping Sorghum 'Teshale' with Soybean 'Awasa-95' yielded the highest grain production. LER 1.72 indicates that approximately 72% of land is required to compensate for the yield obtained by intercropping Sorghum and Soybean. Similarly, Iqbal et al., 2019 found that intercropping soybean and maize offers the biggest yield advantages. When Sorghum 'Dhaqaba' and Soybean 'Awasa-95' were grown together, the land equivalent coefficient (LEC) was 1.27, which is more than 0.25.

4. CONCLUSION

According to the analysis of variance, intercropping of Sorghum and Soybean reveals significant diversity among the types. Intercropping Sorghum (Teshale) with Soybean (Awasa-95) yielded the highest grain production. LER 1.72 indicates that approximately 72% of land is required to achieve the yield attained by mono cropping of sorghum and soybean. Intercropping sorghum with soybean is therefore compatible, and maximum grain production was attained by intercropping sorghum (Teshale) with soybean (Awasa-95). Intercropping Sorghum and Soybean is generally acceptable and recommended.

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