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Effect of intercropping maize (*Zea mays* L.) and soybean (*Glycine max* (L.) Merril and blended NPS rate on yield and yield component of the crops at Bako, western Oromia

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Abstract
The field experiment was carried out at Bako Agriculture Research Center, during 2017 with the objectives of evaluating the effect of maize-soybean intercropping and blended NPS on yields and yield traits of the component crops. The experiment was laid out in RCBD with three replication in factorial combination of three planting densities of soybean (25%, 50% and 75%) and four fertilizer rate (0, 50, 100 and 150 kg/ha). BH 546 (maize) and Didesa (soybean) varieties used. Interaction effect of the intercropped maize significantly ($P<0.05$) affected number of ears per plant, hundred kernel weight and GY of maize. The highest hundred kernel weight (33.67g) was obtained for 50% soybean population with 100kg NPS-rate. The highest LAI (72.75) was obtained from 50% soybean population and all plant population except 25% produced more than one ear per plant. Grain yield (tha-1) of maize was significantly affected by soybean populations and fertilizers and highly significantly affected by interaction effect. The highest grain yield (1.77) was obtained for 0kgNPS-rate and 25% soybean populations. Grain yield (t ha-1) of soybean was highly significantly affected by main effect of plant population, interaction effect. The highest (0.164) grain yield was recorded for 150kg NPS-rate with 50% soybean population. Considering experimental findings 25% soybean population and 50 kg NPS ha-1 was recommended for the study area.

Keywords: Glycine max, intercropping, plant populations, sole cropping, Zea mays

1. Introduction

Increasing pressures on agricultural land have resulted in much higher nutrient depletion and the subsequent breakdown of many traditional soil fertility maintenance strategies, such as fallowing land, intercropping, mixed crop-livestock farming, and opening new lands (Sanchez *et al.*, 1997) [15]. Continued population pressure has reduced farm sizes to the point where farms can only provide adequate living for their families if the land is cultivated very intensively and if there is off-farm income (Sanchez *et al.*, 1997) [15]. Maize (*Zea mays L.)* is one of important food crops in Ethiopia. It is also the most important cereal crop in terms of area coverage, production, and economic importance in Ethiopia (Legesse *et al.*, 2011) [9]. One of the major constraints affecting maize production and productivity is declining soil fertility and inadequate crop management. Soybean (*Glycine max* (L.) Merril.) is one of the pre-eminent crop in providing cheap and inexpensive protein (40%) and oil (20%) determines the economic worth of the crop on the globe (Thomas and Erostus, 2008) [19]. The N-fixing ability of soybean has long been hypothesized as an explanation for the soybean N credit. Currently, the cost of inorganic fertilizer is increasing and the resource poor farmers are forced to use below recommended rate or null.

Farmers do not use fertilizer due to different reasons. The two major reasons are unable to afford the cost of fertilizer and undependability of moisture in the area during the cropping season. At present the use of blended NPS is being recommended for maize production. There is shortage of information in the study area on site specific rate of blended NPS and the potential of maize and soybean intercropping. Therefore, the objective of the study was to evaluate the effect of maize-soybean intercropping and blended NPS on yields and yield traits of the component crops.

Some of the problems associated with the soil for cultivation of maize in Ethiopia are deficiencies of N, P and S due to leaching, continuous cropping, oil spillage and exploration. Thus there is need to carry out a systematic research on these three nutrient elements in order to develop comprehensive information regarding N, P and S.

Materials and Methods

Site Description

The experiment was conducted at BARC during 2017 cropping season. The experimental site is located at Bako in the Western part of the country in the Oromia National Regional State. Bako is located at 250 km far from Addis Ababa city. The soils at the experimental site are nitosols. The Center is located between 37^{o}1'00''E to 37^{o}3'40"E and 9^{o}4'20''N to 9^{o}7'20''N (Fig. 1). Annual minimum and maximum temperature is 13.5^{0}C and 29.7^{0}C respectively and receives average annual rainfall of 1237mm with maximum precipitation being received in the months of May to August (Bako Agricultural office profile).

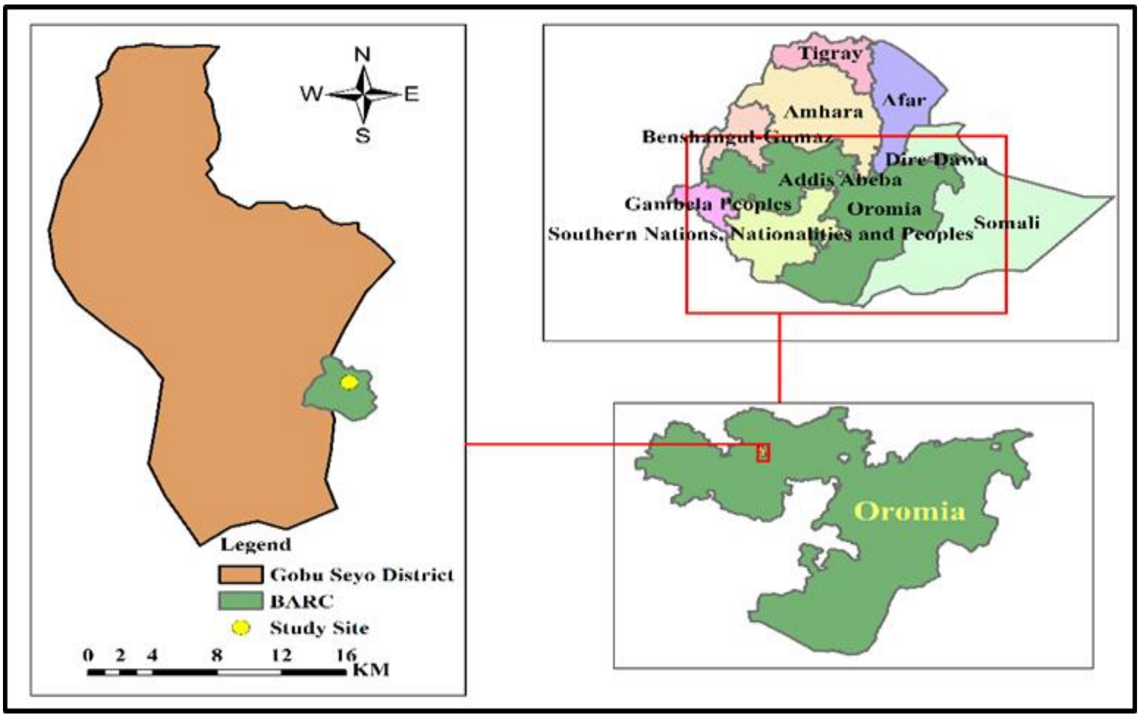

Fig 1: Description of the study area

Soil Sampling and Analysis

Composite soil samples were randomly collected from the field at a depth of 0-30 cm before from randomly selected places which represent the whole field and from 14 sampling spots after the onset of experiment to represent the experiments effect. However, during post soil sampling soil samples were taken at the bases of five plants taken randomly from each plot and between the maize and soybean rows in the intercrops. The analytical results indicated that the textural class of the experimental site was mainly of Silt soil with a proportion of 10 % sand, 16 % clay and 74% silt (Table 1). Thus, the textural class of the experimental soil is ideal for maize production (Onwueme and Sinha, 1991).

Table 1: Selected physico-chemical properties of experimental soil

Soil characteristic	Value
Total nitrogen (%)	0.13
Available phosphorus (ppm)	2.97
Sulphur (ppm)	29.12
pH-H_20	5.21
Particle Size distribution (%)	
Sand	10
Silt	74
Clay	16
Textural class	Silty

Experimental Materials and Treatments

The soybean variety Didesa, maize variety BH 546 and the newly introduced blended NPS fertilizer with 19% nitrogen, 38% P_2O_5 and 7% sulfur were used. The soybean variety, Didesa was released by BARC, yellow in color, adapted to an altitude of 1200-1900m above sea level and late maturing variety (137-145 days to maturity). It has a yield potential of 3.3t ha^{-1} at research center. The maize variety, BH 546 was released by CIMMYT, white in color, good husk cover and better reaction to known diseases of the area.

The treatments consisted of three planting densities of soybean (25%, 50% and 75%) and four NPS fertilizer rate (0, 50, 100 and 150 kg ha^{-1}). The NPS treatments are based on national recommendation of 100 kg ha^{-1} for maize by

Ministry of Agriculture (MoA). The experiment consisted of two factors, namely four fertilizer rates and three soybean plant populations with twelve treatments. The treatment combinations were sole maize, maize + soybean and sole soybean. The experiment was laid out in randomized complete block design (RCBD) with three replications (Table 2).

Table 2: Details of treatment combination of the experiment

R. No	Treatment Description
1	Maize + 25% soybean + 0 kg NPS ha^{-1}
2	Maize + 25% soybean + 50 kg NPS ha^{-1}
3	Maize + 25% soybean + 100 kg NPS ha^{-1}
4	Maize + 25% soybean + 150 kg NPS ha^{-1}
5	Maize + 50% soybean +0 kg NPS ha^{-1}
6	Maize + 50% soybean +50 kg NPS ha^{-1}
7	Maize + 50% soybean +100 kg NPS ha^{-1}
8	Maize + 50% soybean +150 kg NPS ha^{-1}
9	Maize + 75% soybean + 0 kg NPS ha^{-1}
10	Maize + 75% soybean+50 kg NPS ha^{-1}
11	Maize + 75% soybean +100 kg NPS ha^{-1}
12	Maize + 75% soybean +150 kg NPS ha^{-1}
13	Sole Maize +100 kg NPS ha^{-1}
14	Sole soybean +100 kg NPS ha^{-1}

Management of the Experiments

The experimental field was ploughed with tractor three times to a fine tilth before sowing. The plots were leveled manually. The seeds were planted by hand at a specified spacing by placing two seeds per hill and thinning was done to one plant at each specific intra-row spacing two weeks after seedling emergence. The gross plot size for maize was 5 rows of each 3 m length at spacing of 75 cm×30 cm (3 m × 3.75 m = 11.25 m²). The gross plot size for sole soybean was 9 rows of each 3 m at spacing of 40 cm x10cm (3 m × 3.6 m =10.8 m²). The net plot was the middle 3 rows of maize (3 m x 2.25 m =6.75 m²) and the middle 7 rows of sole soybean (3 m x 2.8 m = 8.4m²). Fertilizer was applied at the time of planting to all plots. . For sole soybean 109 kg urea ha^{-1} and 100 kg NPS ha^{-1}, for 0 kg NPS ha^{-1} = 150 kg urea ha^{-1}, for 50 kg NPS ha^{-1} = 129 kg urea ha^{-1}, for100 kg NPS ha^{-1} = 105kg urea ha^{-1}, for 150 kg NPS ha^{-1} = 88kg urea ha^{-1} and for sole maize 100 kg urea ha^{-1} = 100 kg NPS ha^{-1} to uniformly treat all plots. The two outer most rows (one row from each side) of each plot were considered as border rows for soybean. Soybean variety was sown in rows which are 40 cm apart. Within rows, plant seeds at 5cm apart from each other (1 seed per stand). The soybean was harvested when the first pod of the plants fully matured and dried. Maize seeds were sown in rows with 75cm inter-row spacing and 30cm intra-row spacing in cropping system and for intercrops there were three planting patterns used: 8.75cm apart 1row between the two maize rows, 8.75cm apart 2 rows between the two maize rows and 5.66cm apart 2 rows between the two maize rows for 25%, 50% and 75%, respectively.

Fertilizer application was done in two splits for urea that are by side placement and of NPS (19% N, 38% P 2 O 5 and 7% S) applied three weeks after sowing or at knee height stage of the maize and DAP applied only at planting time. The four NPS levels (0 kg NPS ha^{-1}, 50 kg NPS ha^{-1}, 100 kg NPS ha^{-1}, and 150 kg NPS ha^{-1}) used in maize/soybean intercropping and urea. The sole maize received 100 kg NPS ha^{-1} and Sole soybean received 108 kg NPS ha^{-1} and 118 kg urea. The rate used for the sole crops was as recommended for production of each crop.

Data Collection and Analysis

Data on maize yield components such as number of ears per plant, ear length, hundred kernel weight, grain yield and soybean number of pods per plant,100 seed weight (g), grain yield (kg ha^{-1}) and harvest index (%) were collected. Analysis of variance was carried out using General Linear Model of ANOVA using SAS version 9.0 software's (SAS Institute Inc., 2002). Mean separation was carried out using Least Significance Difference (LSD) test at 5% probability level.

Results and Discussion

Post-harvest soil analysis

The soil analysis for the samples collected after harvesting revealed that there was variation in total nitrogen due to variation in NPS application and cropping systems. All cropping systems increased total nitrogen compared to total nitrogen of the site before planting (Table 3). The reason for the increment of total nitrogen could be due to ability of N fixation of soybean and NPS added soil nutrients and even if most of the soil nitrogen was removed through grains and other plant parts of both crops. In contrast with this result Wondimu *et al.*, (2016) [22] was reported that, all cropping systems reduced total nitrogen compared to total nitrogen of the site before planting (Table 3).

Table 3: Total nitrogen, available phosphorus, Sulphur and pH before planting and after harvest in response to the treatments

Treatments	Total Nitrogen (%)	Available Phosphorus (ppm)	Sulphur (ppm)	pH
Before planting	0.13	2.97	29.12	5.21
Maize + 25% soybean + 0 kg NPS ha^{-1}	0.15	3.53	30.88	5.32
Maize + 25% soybean + 50 kg NPS ha^{-1}	0.14	3.34	22.61	5.37
Maize + 25% soybean + 100kg NPSha^{-1}	0.14	3.54	24.30	5.30
Maize + 25% soybean + 150kg NPS ha^{-1}	0.15	3.54	23.38	5.39
Maize + 50% soybean +0 kg NPS ha^{-1}	0.14	3.37	22.99	5.29

Maize + 50% soybean +50 kg NPSha^{-1}	0.15	3.54	23.47	5.37
Maize + 50% soybean +100 kg NPS ha^{-1}	0.15	3.50	26.09	5.26
Maize + 50% soybean +150 kg NPS ha^{-1}	0.14	3.49	25.63	5.24
Maize + 75% soybean +0 kg NPS ha^{-1}	0.15	3.31	24.57	5.24
Maize + 75% soybean +50 kg NPS ha^{-1}	0.14	3.67	24.55	5.28
Maize + 75% soybean +100 kg NPS ha^{-1}	0.12	3.52	24.88	5.23
Maize + 75% soybean +150 kg NPS ha^{-1}	0.15	3.97	26.14	5.25
Sole Maize +100 kg NPS ha^{-1}	0.14	3.63	25.15	5.29
Sole soybean +100 kg NPS ha^{-1}	0.159	3.28	24.50	5.27

Maize Component, Yield and yield components

Number of ears per plant

The number of ear per plant was highly significantly (P<0.05) affected by NPS rate and soybean population, and significantly (P<0.05) affected by interaction effect (Table 4). All plant population except 25% population at 50 kg NPS ha^{-1} produced more than one ear per plant.

Table 4: Interaction effect of the intercropped NPS-rates and Soybean populations on number of ears per plant of maize in maize/soybean intercropping

Soybean population per ha	NPS rates (kg ha^{-1})			
	0	50	100	150
(25%) 125, 000	2a	1c	2a	2a
(50%) 250, 000	2a	2a	2a	2a
(75%) 375, 000	1.67ab	1.67ab	1.33bc	1.67ab
Intercropping mean			1.68B	
Sole mean			1.87A	
	NPS rates x soybean population		Cropping system	
LSD (P<0.05)	0.56		1.55	
CV (%)	18.75		24.68	

Means within the same column followed by the same letter or by no letters of each factor do not differ significantly at 5% probability level; LSD = Least Significant Difference (P< 0.05); CV = Coefficient of Variation

Ear length

The ear length was highly significantly (P<0.05) affected by NPS fertilizers rate, soybean population, however was non-significantly affected by cropping systems and interaction effect. The longest ear length was recorded due to 75% soybean population, while the shortest was recorded due to 25% soybean population. In terms of NPS rate, the highest ear length was recorded by 100 kg NPS ha^{-1} while the lowest was recorded by 0 kg NPS ha^{-1}. In general there was significant difference among soybean population and NPS rate (Table 5). Indicating that, 50% soybean density and 100 kg NPS ha^{-1} increased ear length. Wondimu (2016) [22] reported that the reduction in number of ears per plant and ear length in intercropped maize might be due to the reduction in the ear leaf photosynthesis due to competition with soybean that lowers the number of ears per plant.

Table 5: Main effects of the intercropped NPS rates and Soybean populations on ear length of maize in maize/soybean intercropping

Treatments	Ear length
Soybean densities	
(25%) 125, 000	36.47c
(50%) 250, 000	38.01a
(75%) 375, 000	36.99b
LSD(P<0.05)	0.72
NPS rate (kg ha^{-1})	
0	31.93d
50	34.40c
100	39.67a
150	37.50b
LSD(P<0.05)	2.05
CV (%)	5.74
Cropping system	
Sole maize	36.95A
Intercropped maize	36.83A
LSD(P<0.05)	NS
CV (%)	2.88

Means with the same letter (S) in the same column are not significantly different at P<0.05; NS = Non-significant; LSD = least significant difference; CV = coefficient of variation

Hundred kernel weight

Hundred kernel weight (HK) was highly significantly (P<0.05) affected by fertilizer rate, soybean population and interaction effect, however no significant effect due to cropping system. Highest hundred kernel weights (33.67g) was obtained due to 50% soybean population with 100 kg NPS ha^{-1}, while the lowest (21.00g) was obtained due to 25% soybean population and 100 kg NPS ha^{-1} (Table 11). Biruk

(2007) [5] reported that 25% common bean: 100% sorghum planting density gave the highest mean 1000 kernel weight of the sorghum component. In contrast, Tilahun (2002) [20] and Tolera (2003) [21] reported that planting density of beans had no significant effect on 100 kernel weight of the associated maize.

Table 6: Interaction effect of the intercropped NPS rates and Soybean populations on hundred kernel weights (g) of maize in maize/soybean intercropping

Soybean population per ha	NPS rates (kg ha^{-1})			
	0	50	100	150
(25%) 125, 000	22f	27.67cd	21.67f	29.33c
(50%) 250, 000	25.67e	33.33ab	33.67a	27.67cd
(75%) 375, 000	29.33c	28cd	27de	31.67b
Intercropping mean			28.08A	
Sole mean			31A	
	NPS rates x soybean population		Cropping system	
LSD (P <0.05)	1.95		NS	
CV (%)	4.11		2.42	

Means within the same column followed by the same letter or by no letters of each factor do not differ significantly at 5% probability level; LSD = Least Significant Difference (P< 0.05); CV = Coefficient of Variation

Grain yield

Grain yield (tha^{-1}) was significantly (p<0.05) affected by soybean populations and NPS rate and highly significantly (p<0.05) affected by interaction effect. The highest grain yield (1.87 t ha^{-1}) was obtained for 50 kg NPS ha^{-1} and 25% soybean populations, while the lowest (1.21 t ha^{-1}) obtained for 50 kg NPS ha^{-1}and 75% soybean population, and non-significantly affected by cropping system (Table 7). This might be due to reduction in competition for growth resources due to its early maturity of the intercropped variety. The grain yield reduction of the intercropped maize might be associated with interspecific competition between the intercrop components for growth resources (light, water, nutrients etc.) and depressive effects of soybean on maize at early growth stage because both crops were planted simultaneously and soybean was emerged earlier than maize.

Table 7: Interaction effect of the intercropped NPS rates and Soybean populations on Grain yield (tha^{-1}) of maize in maize/soybean intercropping

Soybean population per ha	NPS rates (kg ha^{-1})			
	0	50	100	150
(25%) 125, 000	1.59a	1.87a	1.72a	1.84bc
(50%) 250, 000	1.29cd	1.27cd	1.34bcd	1.56ab
(75%) 375, 000	1.25cd	1.21d	1.41bcd	1.36bcd
Intercropping mean			1.12A	
Sole mean			1.34A	
	NPS rates x soybean population		Cropping system	
LSD (P < 0.05)	0.23		1.58	
CV (%)	9.35		36.50	

Means within the same column followed by the same letter or by no letters of each factor do not differ significantly at 5% probability level; LSD = Least Significant Difference (P< 0.05); CV = Coefficient of Variation

Soybean components, Yield and yield Components

Number of nodules per plant

Number of nodules per plant was significantly (P<0.05) affected NPS rate and highly significantly (P<0.05) by the soybean population, interaction effect and cropping system. Significantly highest (76.73) due to 0 kg NPS ha^{-1} and 75% soybean population, due to 100 kg NPS ha^{-1} and 75% soybean population. The significantly highest(76.73) and the significantly lowest (32.6) number of nodules per plant were obtained from 0 kg NPS ha^{-1} with 75% soybean population and 100 kg NPS ha^{-1} with 25% soybean population and 100kg NPS ha with 75% soybean population, respectively (Table 8). The result of this study was also in agreement with Muoneke *et al.* (2007) [13] and Otieno *et al.* (2009) who reported significantly different nodule number in soybean fertilizers with intercropped maize. The finding also revealed that nodulation potential of legume crops in intercropping systems are enhanced under the influence of strong competition between companion crops for limited nutrient sources. Higher number of nodules per plant (56.79) was recorded from intercropped soybean than sole (52.20) soybean (Table 8). This might be due to the fact that intercropping enhanced nodule and maintained the majority of soil fertility properties for at least three to four years, especially at suitable P application rates.

Table 8: Interaction effect of the intercropped NPS rates and Soybean populations on number of nodules per plant of soybean in maize/soybean intercropping

Soybean population per ha	NPS rates (kgha^{-1})			
	0	50	100	150
(25%) 125, 000	61cd	69.6b	76.73a	66.4cd
(50%) 250, 000	69.6b	45.47g	66bc	46.27fg
(75%) 375, 000	76.73a	66bc	32.6h	52.47ef
Intercropping mean			56.79A	
Sole mean			52.20B	
	NPS rates x soybean population		Cropping system	
LSD (P< 0.05)	6.24		33.13	
CV (%)	6.52		14.13	

Means within the same column followed by the same letter or by no letters of each factor do not differ significantly at 5% probability level; LSD = Least Significant Difference (P< 0.05); CV = Coefficient of Variation

Number of pods per plant

The analysis of variance showed that number of pods per plant was significantly (P<0.05) affected by NPS rate and highly significantly (P<0.05) affected by soybean population, interaction effect and cropping system. The highest number of pods per plant (35.33) was recorded from 100 kg NPS ha^{-1} with 25% soybean population while the lowest (22.87) was obtained from 50 kg NPS ha^{-1} with 50% soybean population (Table 9). Decrease in number of pods per plant at higher plant density could be due to increased inter and intra-specific competition for growth resources, which might have led to reduced number of effective branches. The higher pods per plant at 25% soybean population might also be due to the lower soybean population and the lower maize competition due to the greater distance between soybean plants that might have provided a better soil resource condition with higher light availability for soybean plants. This result was in agreement with Biruk (2007) [5] who reported in sorghum/common bean intercropping the number of pods per plant decreased with the increase in planting density.

Table 9: Interaction effect of the intercropped NPS rates and Soybean populations on number of pods per plant of soybean in maize/soybean intercropping

Soybean population per ha	NPS rates (kg ha^{-1})			
	0	50	100	150
(25%) 125, 000	25.5de	33.47a	35.33a	28.33bc
(50%) 250, 000	34.2a	22.87e	33.87a	24.93de
(75%) 375, 000	32.97a	33.87a	25.93de	29.35b
Intercropping mean			29.40B	
Sole mean			48.40A	
	NPS rates x soybean population		Cropping system	
LSD (P< 0.05)	2.59		22.78	
CV (%)	5.23		13.61	

Means within the same column followed by the same letter or by no letters of each factor do not differ significantly at 5% probability level; LSD = Least Significant Difference (P< 0.05); CV = Coefficient of Variation

Hundred seed weight

Hundred seed weight (HSW) of the soybean was highly significantly (P<0.05) affected by main effect of soybean population, interaction effect and cropping system, and was significantly (P<0.05) affected by NPS rates. The highest HSW (17.67g) was recorded for 75% soybean population with 50 and 100 kg NPS ha^{-1} with 50% soybean population while the lowest (13.67g) was recorded for 0 and 50 kg NPS ha^{-1} with 25% soybean population. In general, HSW increased due to the highest soybean population with all but 150 NPS rate (Table 10).

Table 10: Interaction effect of the intercropped NPS rates and Soybean populations on hundred seed weight (g) of soybean in maize/soybean intercropping

Soybean population per ha	NPS rates (kg ha^{-1})			
	0	50	100	150
(25%) 125, 000	15.67cd	13.67e	16.67abc	15.67c
(50%) 250, 000	15.33d	15.33d	17.00ab	16.67abc
(75%) 375, 000	16.67abc	17.67a	17.67a	16.33bcd
Intercropping mean			16.19A	
Sole mean			15.33B	
	NPS rates x soybean population		Cropping system	
LSD (P< 0.05)	1.16		0.67	
CV (%)	4.24		6.65	

Means within the same column followed by the same letter or by no letters of each factor do not differ significantly at 5% probability level; LSD = Least Significant Difference (P< 0.05); CV = Coefficient of Variation

Number of seeds per plant

The number of seeds per plant was highly significantly (P<0.05) affected by the main effects of soybean population, NPS rate, interaction effect and cropping system. The highest (70.33) and the lowest (41.6) number of seeds per plant were recorded for 150kgNPSha^{-1} with 75% soybean population and for 0 kg NPS ha^{-1} with 50% soybean population, respectively (Table 11). In terms of cropping system, sole soybean had higher (82.47) number of seeds per plant than intercropped (52.54) with maize (Table 11). This result was in agreement with Sisay (2004) on sorghum/green gram intercropping and with Dechasa (2005) on sorghum/bean intercropping where planting density had non-significant effect on number of seeds per plant of the legume components.

Table 11: Interaction effect of the intercropped NPS rates and soybean populations on number of seeds per plant soybean in maize/soybean intercropping

Soybean population per ha	NPS rates (kg ha^{-1})			
	0	50	100	150
(25%) 125, 000	51.13c	50.13c	56.93b	60.53b
(50%) 250, 000	41.6d	43.47d	50.53c	44.6d
(75%) 375, 000	60.07b	56.93b	44.2d	70.33a
Intercropping mean			52.54B	
Sole mean			82.47A	
NPS rates x soybean population			Cropping system	
LSD (P< 0.05)	4.26		3.18	
CV (%)	4.81		1.34	

Means within the same column followed by the same letter or by no letters of each factor do not differ significantly at 5% probability level; LSD = Least Significant Difference (P< 0.05); CV = Coefficient of Variation

Grain yield

Grain yield (tha^{-1}) was highly significantly (P<0.05) affected by interaction effect. Non-significantly affected by NPS rate and cropping system. As it is affected by soybean population and interaction effect, the highest (0.164) and the lowest (0.047) grain yield was recorded for 150 kg NPS ha^{-1} with 50% soybean population and for 150 kg NPS ha^{-1} with 25% soybean population, respectively (Table 12). For that of cropping system, sole cropped was high yielder (0.363) than intercropped (0.343) with maize. This result could indicate that the maize can compete for the resources since it is heavy feeder.

Table 12: Interaction effect of the intercropped NPS rates and Soybean populations on Grain Yield (t ha^{-1}) of soybean in maize/soybean intercropping

Soybean population per ha	NPS rates (kg ha^{-1})			
	0	50	100	150
(25%) 125, 000	0.083e	0.094e	0.089e	0.047f
(50%) 250, 000	0.124c	0.109d	0.158ab	0.164a
(75%) 375, 000	0.161a	0.161a	0.147b	0.152ab
Intercropping mean			0.343A	
Sole mean			0.363A	
NPS rates x soybean population			Cropping system	
LSD (P< 0.05)	0.11		0. 23	
CV (%)	6.28		2.00	

Means within the same column followed by the same letter or by no letters of each factor do not differ significantly at 5% probability level; LSD = Least Significant Difference (P< 0.05); CV = Coefficient of Variation

Above ground dry biomass

There was highly significant (P<0.05) effect due to cropping system on above ground dry biomass of soybean, however no significant effect due to NPS-rate, soybean population and their interaction. Similarly, Zerihun, (2011) [23] reported no significant difference on dry biomass of the intercropped maize due to the associated soybean varieties. On the other hand, cropping system had highly significant (P<0.05) effect on soybean biomass where significantly higher biomass of soybean (9.00 t ha^{-1}) was produced from sole cropped soybean than that of intercropped soybean with maize (8.67 t ha^{-1}) (Table 13). The lower biomass yield produced from intercropped soybean might be due to interspecific competition between component crops. In line with this result, Shehu *et al.* (1999) [17] reported significantly higher sorghum stalk yield for sole crop compared with different mixed cropping treatments. Likewise, Luiz and Robert (2003) [10] reported that intercropping as compared with sole cropping decreased biomass yield of maize under intercropping with common bean.

Harvest index

Harvest index was highly significantly (P<0.05) affected by plant population, NPS rate and cropping system while non-significantly affected by their interaction. The highest soybean harvest index (21.94%) was obtained from 25% soybean population and the lowest soybean harvest index (20.41%) was obtained from 75% population of soybean (Table 13). The highest HI recorded for 50 kg NPS ha^{-1} was (23.33) intercropped with maize might be due to the high grain yield to biomass obtained by the high NPS-rate as a result of high partitioning of dry matter to the grain. The sole has higher (20.88) than that of inter cropped (20.39) this might be due to the high nutrient was released to the intercropped one rather than that of the sole cropped.

Table 13: Main effects of NPS rates and plant population of the intercropped soybean with maize on above ground dry biomass and Harvest index of the soybean component

Treatments	Above ground dry biomass	Harvest index
Soybean densities		
25%	8.66	21.94ab
50%	8.67	21.34b
75%	8.77	20.41c
LSD(p<0.05)	NS	0.46
NPS rate (kg ha^{-1})		
0	8.56	19.86c
50	9.00	23.33a
100	8.89	21.37ab
150	8.67	22.84ab
LSD(p<0.05)	NS	0.23
CV (%)	4.94	1.56
Cropping system		
Sole maize	9.00A	20.88A
Intercropped maize	8.67B	20.39B
LSD(P<0.05)	0.09	0.55
CV (%)	0.21	1.09

Means within the same column followed by the same letter or by no letters of each factor do not differ significantly at 5% probability level; LSD = Least Significant Difference (P< 0.05); CV =Coefficient of variation; NS =Non-Significant

Summary and Conclusion

The results revealed that the number of ear per plant was highly significantly (P<0.01) affected by fertilizers and soybean population and significantly affected by interaction effect. All produced more than one ear per plant except soybean population of 25% with 50 kg NPS ha^{-1}. Hundred kernel weight (HKW) was highly significantly (P<0.05) affected by NPS rate and soybean population, as well as cropping system, but significantly (P<0.05) by interaction effect. The highest HKW (33.67) was obtained for 50% soybean population with 100 kg NPS ha^{-1}, while the lowest (21.67) was obtained for 25% soybean population with 100 kg NPS ha^{-1}. Grain yield (tha^{-1}) of maize was significantly (P<0.05) affected by soybean populations and fertilizers and highly significantly (P<0.05) affected by interaction effect. The highest grain yield (1.77tha^{-1}) was obtained for 0 kg NPS ha^{-1} with 25% soybean populations, while the lowest (1.21) obtained for 50 kg NPS ha^{-1} with 75% soybean population. In soybean, the main effect of plant population and interaction of NPS ha^{-1} and population showed significant effect on days to physiological maturity. The 0 kg NPS ha^{-1} with 25% soybean population delayed (161.67) days to 90% maturity and 50 kg NPS ha^{-1} with 75% soybean population hastened (159.67) days to 90% maturity of soybean. The analysis of variance revealed that days to 50% flowering was significantly (P<0.05) varied for the soybean populations and non-significantly by NPS rate and interaction effect. Whereas all growth parameter of soybean were significantly (P<0.05) affected by the interaction effect of fertilizers and soybean population except plant height.

The significantly tallest (83.80cm) plants were recorded for 100% plant population and the shortest (79.57cm) for 25% soybean population. Cropping system also affect significantly (p<0.05) the plant height of soybean. Stand count was highly significantly affected soybean population, NPS rate and interaction effect. The highest(362) stand count was due to 150 kg NPS ha^{-1} and 75% soybean population recorded and the 50 kg NPS ha^{-1} with 25% soybean population recorded the lowest(146) stand count. The number of primary branches was highly significantly (P<0.05) affected by plant populations, and interaction effect but significantly (P<0.05) by NPS rate. The highest number of primary branches (5.37) was recorded from 50 kg NPS ha^{-1} with 25% soybean population while the lowest (2.87) was from 50 kg NPS ha^{-1} with 75% soybean population. Sole cropped had significantly higher (4.80) branches than intercropped (3.70). Number of nodules per plant was highly significantly (P<0.01) affected by the soybean population, and interaction effect and significantly (P<0.05) affected by the fertilizer rate. The highest(76.73) and the lowest number of nodules per plant (32.6.) were obtained from 0 kg NPS ha^{-1} with 75% soybean population,100 kg NPS ha^{-1} with 25%, respectively. Significantly higher number of nodules per plant (56.79) was recorded from intercropped soybean than sole (52.20) soybean.

The number of pods per plant was highly significantly (P<0.01) affected by main effect of fertilizer rate, plant population and by interaction effect. It was significantly (P<0.05). The highest number of pods per plant (35.33) was recorded from 100 kg NPS ha^{-1} with 25% soybean population while the lowest number of pods per plant (22.87) was obtained from 50 kg NPS ha^{-1}with 50% soybean population. Sole cropped developed significantly higher (48.40) pods per plant than intercropped soybean (29.40). Hundred seed weight (HSW) of soybean was highly significantly (P<0.01) affected by main effect of plant population, interaction effect and cropping system, but was significantly (P<0.05) affected by NPS-rates. The highest (17.67g) and lowest (13.67g) HSW was recorded for 100 kg NPS ha^{-1} with 75% soybean population and for 100 kg NPS ha^{-1} with 50% population, respectively. The number of seeds per plant was highly significantly (P<0.01) affected by the main effects of soybean population, fertilizer rate, interaction effect and cropping system. The highest (70.33) and the lowest (41.6) were recorded for 150 kg NPS ha^{-1} with 75% population and for 0 kg NPS ha^{-1} with 50%, respectively. Sole soybean had significantly higher (82.47) number of seeds per plant than intercropped (52.54). Grain yield (tha^{-1}) was highly significantly (P<0.01) affected by main effect of plant population and interaction effect. Non-significantly by NPS rate and cropping system. The highest (0.164) grain yield was recorded for 150 kg NPS ha^{-1} with 50% and lowest (0.047) was recorded for 150 kg NPS ha^{-1} with 25% soybean population. Thus, the result remarks that proper decision should be given while practicing intercropping of maize/soybean. In this regard 25% soybean population was the best in intercropping system to maximize the productivity and 50 kg NPS ha^{-1} was the best compatible rate in intercropping. To reach better conclusive recommendation, it needs further investigation on the selection of additional best compatible NPS-rates, plant proportion and repetition of this study on more locations and seasons.

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