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Evaluation of Different Maturity Groups of Soybean (*Glycine Max L. Merrill*) Grown Sole and Intercropped with Maize (*Zea Mays* L.) for Yield and Yield Components at Bako, Ethiopia

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Abstract

Different maturity of soybean genotypes interact differently either in sole or intercropping system. Therefore, screening of the genotypes under various environment is paramount important for variety recommendation. The experiment was conducted to evaluate different soybean genotypes in intercropping and sole cropping systems. Fifteen genotypes were evaluated in using randomized complete block design with three replications. The result revealed nodule number and plant height was significantly affected by genotypes variation in both systems. A total of 32-73% reduction in nodule number was recorded when compared with soles due to shading of maize. However, late and early types had higher number of nodules as opposed to medium type. Late type was generally taller than early and medium ones. Significant differences in grain yield were also recorded in both systems. But maize shading effect considerably reduced the yield though population difference is also another factor. Promoveria (3826 kg ha^{-1}), IAW-13-1(3747 kg ha^{-1}) and Pr-145-2-1 (3620 kg ha^{-1}) genotypes resulted the highest grain yield and productivity, while the lowest yield was obtained from Pr-145-2 (2144 kg ha^{-1}) when grown in soles. However, IAW-13-1 (690 kg ha^{-1}) and AGX-129-2 (672 kg ha^{-1}) produced the highest grain yield in intercropping systems. Comparing each maturity groups, significant variation both in nodule number and grain yield was also recorded. As general, most of the tested genotypes that were performed well in intercropping were not so far released. AGS-129-2 genotype was released recently in sole cropping systems, but now it is also well performed in intercropping systems. For unreleased pipelines it is important to consider as variety verification trial to confidently recommend for the end users.

Keywords: maturity groups, cropping systems, soybean genotypes

1. Introduction

Production of soybean in area coverage is increasing from time to time in Western Ethiopia. For instances, the area coverage by soybean increased from 19397 (2011) ha to 25320 (2012), and the productivity also increased up to 1.8 t ha^{-1} (Central Statistical Agency [CSA], 2012). Different maturity groups of soybean in intercropping systems interact differently, and hence compete with the associated crops differently. The early maturing groups, which take 90-120 days to mature, can be even used for double cropping in areas where rainfall distribution is not a problem. The medium maturing groups take 121-150 days, and the late maturing ones take 151-180 days to mature (Belay, 1988).

The grain yield of maize in maize/soybean mixed planting could be reduced though not significant, but this is partly compensated by the yield of soybean as well as by the higher protein content of the mixed crop (Muoneke, Ogwuche, & Kalu, 2007). The incidence of pests and diseases affecting soybean is often less in intercrops as compared to sole cropping. They also produce better yield in intercropping and compensate the lower yield they produce when grown sole compared to the late and medium maturing groups. The works of Belay (1988) and Bogale, *et al.* (2002) confirm that higher Land equivalent Ratio (LER) and even higher maize yield were recorded when some soybean varieties were intercropped with maize. But, these varieties do not perform well in sole cropping compared to others. The work of these researchers agrees with the findings of authors indicate that variety development for intercropping should be considered those performing well in the intercropping system (Andrighetto, Mosca, Cozzi, & Berzaghi, 2008; Sharma & Mehta, 1988). The yield difference in crop mixtures is influenced by not only the presence of other crops, but also by densities and spatial arrangements of crops and resource availability in the two systems. Maturity differences between intercropped species have to be quite large to obtain the benefits of temporal separation (Adenlyan & Ayoola, 2007).

Agronomic research works in the country are most commonly carried out on few crop varieties which are nationally or regionally released for sole cropping system. These varieties, when treated in intercropping system do not perform well as they do in sole cropping and the low yield obtained from companion crop hinders farmers to switch into the intercropping system. In recognizant of this fact, this study focused to identify maturity groups and varieties of soybean with better agronomic performance and higher grain yield when grown in maize intercropping and sole cropping.

2. Material and Methods

2.1 The Study Area

The experiment was conducted for two consecutive years (2010 and 2011) at Bako Agricultural Research Center in western Ethiopia located at latitude 9^{o} 6$^{'}$ N; longitude of 37^{o} 9$^{'}$ E and at an altitude of 1650 m above sea level. The site has a warm humid climate with annual mean minimum and maximum temperature of 13.5 and 29.7^{o}C, respectively. The area receives average annual rainfall of 1237 mm with maximum precipitation being received in the months of May to August. The soils at the experimental site are nitosols.

2.2 Treatment and Experimental Design

Soybean varieties which were categorized under three maturity groups with better agronomic performance in National variety trials and regional variety trials were selected and grown as intercropped with maize. The same genotypes were also grown under sole conditions. Five varieties of each maturity group early (Bossier-1, IAW-13-1, Jpb-144-8, Protona-2 and Maya-80), late (AGS-129-2, Ethio-yugozilavia, Pr-145-1, Pr-145-2, TGX-996- 28), medium (F-82-7629, Pr-145-2-1, Pr-149-81, Promoveria and V1-1), fifteen genotypes were arranged in RCBD and replicated three times. The physiological maturity period were 90-124, 130-145 and 145-154 days after planting for early, medium and late maturity groups, respectively. Late types were relatively high leaf canopy as compared to other groups and hence the spacing was different. Plot size was 15.3 m^2 (5.1 m x 3.0 m). Spacing for both intercropped and soil maize was 75cm x 30cm, whereas the spacing for intercropped soybean was 75 cm x 10 cm. A spacing of 40cm x 10cm for early and medium and 60cm x 10cm for late maturity types in sole cropping of soybeans were used as per recommendation. Soybean was intercropped in the center of maize rows. A maize variety called BH-543 was used in this experiment. Recommended 110/46 kg/ha N/P_2O_5 was applied for maize-soybean intercropping where as 46 kg/ha NP2O5 was applied for sole soybean at time of planting. All other management practices were uniformly applied both for sole and intercropped component crops.

2.3 Data Collection and Analysis

Main agronomic parameters for soybean components like plant height, pods per plant, nodule number and grain yield where as grain yield for maize and finally LER were collected. Gen stat discovery-15 was used for ANOVA and mean separation was used by LSD at P<0.005.

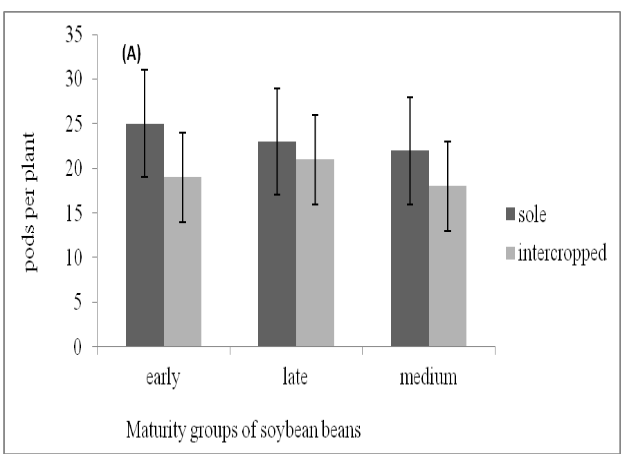
3. Results and Discussion

3.1 Nodule Number and Pods Number

The result of pooled of analysis of variance for two years revealed that there were significant differences in plant height of soybean either intercropped in maize or in soles across the years (2010-2011), but not nodule number. Significant variations were also observed on the same traits among genotypes either planted in maize or as soles. The highest number of nodules in sole cropped was recorded from V1-1 (65) followed by Bossier (63) and Pr-149-81(61) though not significant from each other. Similarly, V1-1 and Bossier gave the highest nodule number in intercropping systems while the lowest was obtained from Protona (12) and Maya-80. This result in agreement with the report of Otieno, Muthomi, Chemining'wa, and Nderitu (2009) indicated that significantly different nodule number in soybean varieties intercropped with maize, which may be attributed to variation in genetic characteristics and mutual association ability with effective indigenous *rhizobia*.

The effect of cropping systems drastically reduced nodules as compared to sole ones. It was noticed that 26%-73% reductions was recorded though the highest reduction was confirmed from JPB-144-81 genotype. This result is in agreement with other reports and might possibly be the shading effects of associated maize that significantly reduced light interception potential of the associated soybeans and reduced the photosynthetic assimilate (Ghosh *et al*., 2006)

Though medium types had higher number of nodules when grown in sole, lower number of nodule per plant was recorded when grown in maize as intercrops (Fig-1. A). Comparing within each maturity group, however, early type of the genotypes had significantly different number of nodules either intercropped or sole cropped. Bossier-1 significantly superior in terms of nodule number as compared to Protona-2 and maya-80 genotypes. Similar result was also noticed for medium maturity types. However, similar number of nodules for late maturity types was obtained either planted in sole or intercropped conditions though cropping systems significantly reduced nodules (Table-1 and Fig-1. A). The overall mean for each maturity types indicated that 47% to 59% nodule reduction was recorded due to the effect of cropping systems (Table-1).



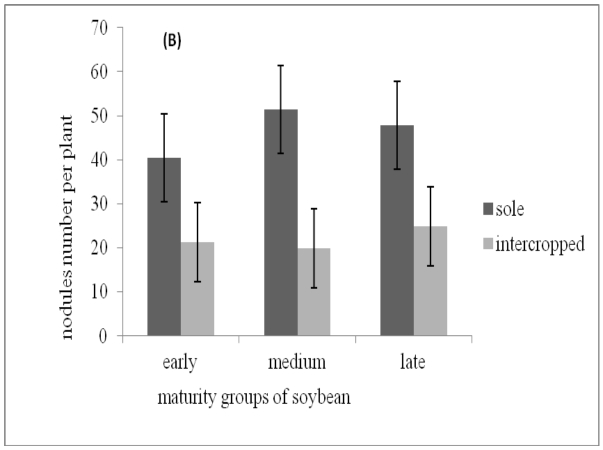


Fig-1. The effect of different maturity groups of soybeans on pods per plant (A) and nodule per plant (B) under sole and intercropping system

Table-1. Nodule number and plant height of soybean genotypes grown under sole and intercropping systems

		Nodule number per plant			**Plant height (cm)**		
Maturity groups	Genotypes	SC	IC	RDCS (%)	SC	IC	RDCS (%)
Early	Bossier-1	63	39	-38	58	46	-26
	IAW-13-1	52	18	-65	65	55	-18
	Jpb-144-81	33	24	-27	45	51	12
	Protona-2	32	12	-63	64	57	-12
	Maya-80	22	13	-41	42	53	21
Mean		40.4	21.2	-48	54.8	52.4	-5
Medium	F-82-7629-	62	25	-60	72	59	-22
	Pr-145-2-1	41	18	-56	67	61	-10
	Pr-149-81	61	16	-74	73	66	-11
	Promoveria	28	15	-46	71	58	-22
	V1-1	65	25	-62	56	47	-19
Mean		51.4	19.8	-61	97.8	58.2	-16
Late	AGS-129-2	36	24	-33	66	52	-27
	Ethio-yugo	58	28	-52	78	59	-32
	Pr-145-1	55	27	-51	77	67	-15
	Pr-145-2	44	22	-50	70	61	-15
	TGX-996- 28	46	23	-50	69	56	-23
Mean		47.8	24.8	-48	72	59	-22
LSD (P<0.05)		27	12	__	8	10	__
CV (%)		25	29	__	11	15	__
		Probability level (P<0.05)					
Year		*	*	-	*	*	-
Genotypes (early, late medium groups)		*	*	-	*	*	-

SC=sole cropping, IC=intercropping, RDCS=reduction due to cropping system*=significant

3.2 Pods per Plant

Even though number of pods per plant for sole planted genotypes were statistically different ($P<0.05$), similar number of pods for all genotypes were observed when intercropped in maize. AGS-129-2 produced the highest number of pods where as Pr-145-2 and Maya-80 was recorded the lowest pods when grown as sole. Pr-145-1 had numerically the highest number of pods when grown in maize. This considerable variation among genotypes may lead to genotypic variation that reacts differently at different environments. Similar result has been observed that in sole and intercropping system that the relative yield and yield traits of the individual crop are largely determined by the competitive ability of component crops (Panhwar, Hussain Memon, Kalhoro, & Ismail Soomro, 2004). Maize shading effect was significantly reduced pods number of each genotype as compared to their respective sole crops. This result (Fig-2) in agreement with other study indicated that a significant decrease in 4-48% was recorded when grown in maize, indicating that effect of maize shading may limit light transmission and other common resources that may contribute yield reduction (Addo-Quaye, Darkwa, & Ocloo, 2011).

Comparing based on their maturity types; early types had higher number of pods, though not significant, than late and medium types when grown in sole. But, similar number of pods for each maturity type was obtained in intercropping conditions. In agreement with the report of Onolemhemhen (2001), cropping systems significantly reduced pods of all genotypes ranging from 10%-32%, in which early type was highly affected than late type (Fig-1).

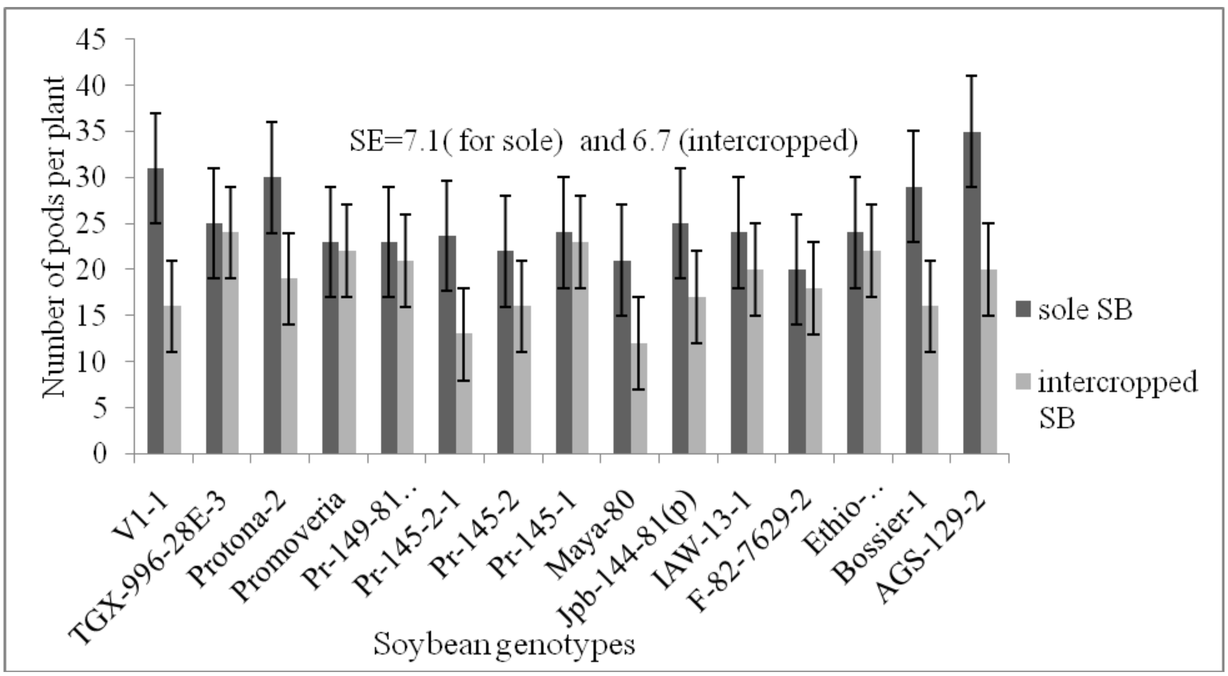


Fig-2. Pods per plant for soybean genotypes as grown under sole and intercropping systems

3.3 Plant Height

Like nodule number, highly significant variations were recorded in plant height among soybean genotypes either planted in intercropping or sole cropping. The largest plant height was recorded when Ethio-ugozilavia (78 cm) and Pr-145-1(77 cm) were planted as soles, where as Maya-80(45cm) and Bossier (58 cm) gave the lowest plant height (Table-1). However, genotype Pr-145-1(67cm) and Pr-149-81(66cm) showed the highest in height in intercropping, but Bossier-1 revealed the least. This result indicated that varietal difference may be the main reason that causes plant height differences under different environments. Cropping systems, however, considerably reduced plant height of the crops as compared to their respective sole crops. Reduction of 5-22% was recorded due to maize shading effect though JPb-144-81 and Maya-80 was not affected, which gave higher when planted in maize than in sole.

3.4 Yield and Yield Traits

Considerable variations in grain yield for soybean genotypes were recorded across the years, indicating that environmental variation and even management differences may cause the yield and yield trait variations. Genotypic differences also significantly resulted in grain yield difference among the genotypes of the crops (Table-2). Promoveria (3826 kg ha^{-1}), IAW-13-1(3747 kg ha^{-1}) and Pr-145-2-1 (3620 kg ha^{-1}) showed the highest grain yield though not significant among them, while the lowest yield was obtained from Pr-145-2 (2144 kg ha^{-1}) when grown in sole conditions. However, IAW-13-1 (690 kg ha^{-1}) and AGX-129-2 (672 kg ha^{-1}) produced the highest grain yield in intercropping systems than other genotypes. This indicates that additional yield from soybean component was obtained without affecting maize yield. However, the effect of cropping systems significantly reduced grain yield of soybeans (Muoneke *et al*.,2007) when compared to their respective sole crops though there were population difference that are also another factor (Table-2).

Table-2. Grain yield of soybean genotypes and Maize under different cropping systems (2010-2011)

		Soybean (kg ha^{-1})		**Maize yield (kg ha^{-1})**	**LER**
Maturity groups	Genotypes	SC	IC		
Early	Bossier-1	3167	442	6844	1
	IAW-13-1	3747	690	7098	1.1
	Jpb-144-81	3069	595	7987	1.19
	Protona-2	3249	434	7158	1.04
	Maya-80	2725	493	7004	1.04
Mean		3191	531	7218	1.07
Medium	F-82-7629-	2826	459	7279	1.07
	Pr-145-2-1	3620	436	7290	1.06
	Pr-149-81	2936	595	7768	1.17
	Promoveria	3826	480	6658	0.99
	V1-1	3376	592	8157	1.21
Mean		3317	512	7430	1.1
Late	AGS-129-2	2295	672	6724	1.05
	Ethio-yugo	2454	417	7457	1.08
	Pr-145-1	2757	417	7711	1.11
	Pr-145-2	2144	403	7342	1.06
	TGX-996-28	2630	477	7744	1.13
Mean		**2456**	**477**	**7396**	**1.09**
sole maize		__	__	7695	__
LSD (P<0.05)		916	137	NS	__
CV (%)		26	24	15	__
Year		*	*	*	-
Genotypes		*	*	*	-

SC=sole cropping, IC=intercropping, LER=land equivalent ratio

When the genotypes of each maturity crop were compared, early types genotypes were significantly different in yield potential both in sole and intercropping systems. For instance, a considerable yield of 3826 kg/ha was obtained when Promoveria was grown as soles where as Pr-149-81 gave the highest yield where as Pr-145-2-1 gave the lowest yield in intercropping systems. Similar results were also recorded for medium maturity groups of the genotypes. However, late genotypes did not show significant yield performance either in sole or intercrop system even if cropping systems markedly reduced in addition to population differences.

Pooled mean of each maturity type revealed that, late type of sole planted produced the lowest grain yield as compared to early one. The reduction in yield may be the variation of plant population for late type since its plant spacing was 60cmx10cm as compared to other maturity groups that were planted in 40cmx10cm. In an intercrop, early types had numerically higher grain yield (531 kg ha^{-1}) than medium (514 kg ha^{-1}) and late type (477 kg ha^{-1}). This result indicates that an early maturity group performs better than other types which might be its higher competitive value to the common sources or escape when the source, particularly moisture, is limited. Apart from this, cropping system had also considerably a contribution for yield reduction on each maturity group since other yield traits, like pods per plant and nodule per plant, were significantly reduced as compared to their respective sole crops (Fig-1, 2, 3).

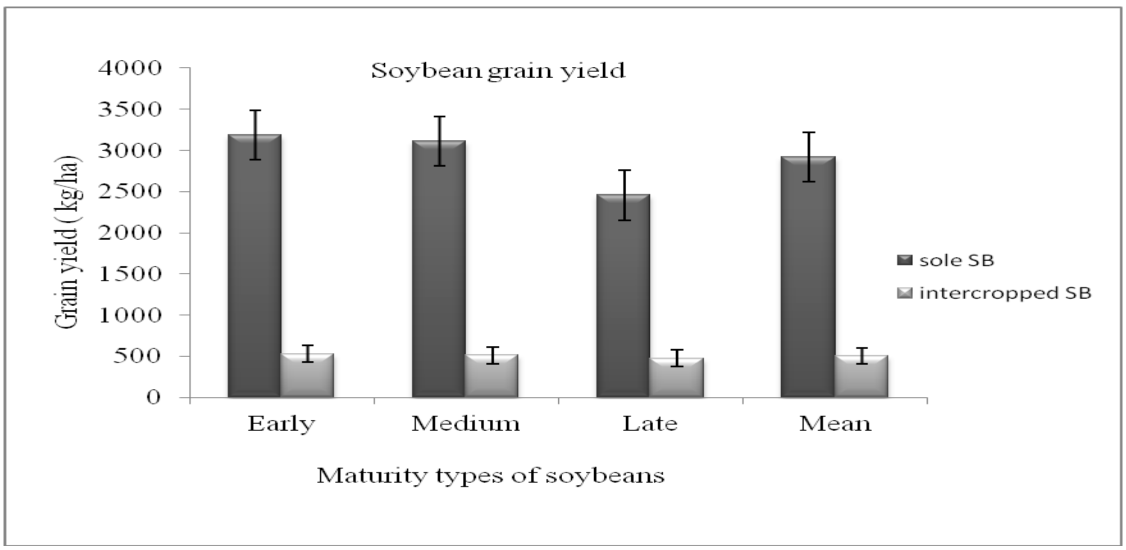


Fig-3. The effect of different maturity groups of soybeans on grain yield grown as sole and intercropping system

3.5 Maize Yield and Land Equivalent Ratio

Grain yield of maize was not significantly affected by genotypes though the highest yield was recorded when it was intercropped with V1-1 (8157 kg ha^{-1}) and Jpb-144-81 (7987 kg ha^{-1}) as compared to sole maize (7695 kg ha^{-1}), whereas the lowest was obtained when AGX-129-2 and Promoveria were associated with maize, which was reduced by 13% over the sole maize. The higher yield advantage of maize when associated with V1-1 and Jpb-144-81 might be higher nodulation potential or non coincident nutrient requirements with maize. Higher productivity was also obtained when V1-1(LER=1.21), Jpb-144-81 (1.19) and Pr-149-81 (LER=1.17) were intercropped in maize, which also increased yield of maize over the control. Similar result was also reported that the higher productivity of the intercrop system compared to the sole crop may have resulted from complementary and efficient use of growth resource by the component crops (Addo-Quaye *et al.*, 2011).However, uses of IAW-13-1 (690 kg ha^{-1}) and AGS-129-2 (672 kg ha^{-1}) in an intercrop gave higher grain yield as compared to other genotypes as their association with maize did not significantly reduce its yield. Apart from this, lower yield of maize and land productivity, though not significant, were recorded when early types were intercropped in the maize as compared with other crops (Fig-4).

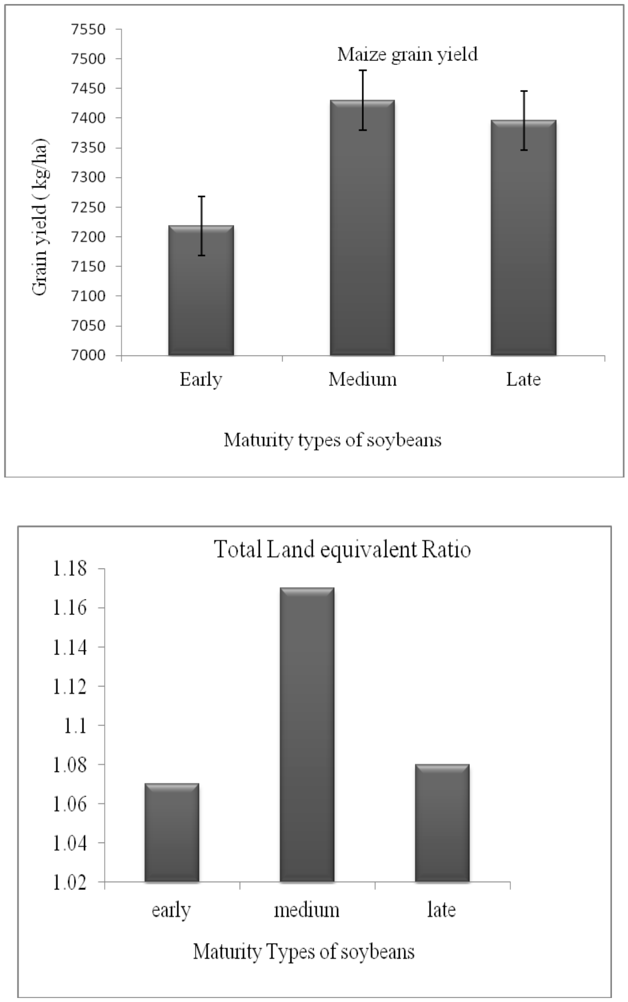


Fig-4. The effect of different maturity groups of soybeans on grain yield of maize grown as sole and intercropping system and Land equivalent ratio

As conclusion, IAW-13-1 (690 kg ha^{-1}) and AGX-129-2 (672 kg ha^{-1}) produced the highest grain yield in intercropping systems though higher productivity were obtained when V1-1(LER=1.21) and Jpb-144-81 (1.19) and Pr-149-81 (LER=1.17) were intercropped in maize, which increased yield of maize over the control. In other words, since maize yield reduction due to intercropping of different genotypes were not significant, uses of IAW-13-1 (690 kg ha^{-1}) and AGS-129-2 (672 kg ha^{-1}) gave higher grain yield of soybeans as compared to other ones. However, most of the tested genotypes (like IAW-13-1, V1-1 and Pr-149-81) were not so far released as variety in intercropping systems. AGS-129-2 genotype was released recently in sole cropping systems, but now it is also well performed in intercropping systems and thus advisable to use in intercropping systems. For unreleased pipelines it is important to consider as variety verification trial to confidently recommend for the end users.

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References

[1] Addo-Quaye, A. A., Darkwa, A. A., & Ocloo, G. K. (2011). Yield and productivity of component crops in a maize-soybean intercropping system as affected by time of planting and spatial arrangement. *ARPN Journal of Agricultural and Biological Science, 6*(9), 50-57.

[2] Adenlyan, O. N., & Ayoola, O. T. (2007). Evaluation of four improved soybean varieties under different planting date in relayed cropping system with maize under soybean/maize/cassava intercrop at Moor Plantation, Nigeria. *African Journal of Biotechnology, 6*(19), 2220-2224.

[3] Andrighetto, I., Mosca, G., Cozzi, G., & Berzaghi, P. (2008). Maize-soybean intercropping: Effect of different variety and sowing density of the legume on forage yield and silage quality. *Journal of Agronomy and Crop Science, 168*(5), 354–360

[4] Belay, A. (1988). *Progress and future prospects of soybean research in Ethiopia* (pp.252-265). Research Programs of IAR (Institute of Agricultural research). Proceedings of the Ninth National Crop Improvement Conference (NCIC), April 22-26, 1987, Addis Ababa, Ethiopia.

[5] Bogale, T., Debele, T., Gebeyehu, S., Tena, T., Geleta, N., & Warkayehu, T. (2002). Development of Appropriate cropping Systems for various maize producing Regions of Ethiopia. In M. Nigussie, D. Tanner, & S. Twumasi-Afriyie (Eds.), Enhancing the Contribution of Maize to Food Security in Ethiopia: Proceedings of the Second National Maize Workshop of Ethiopia: 12-16 November 2001, Addis Ababa, Ethiopia (pp.61-69).

[6] Central Statistical Agency. (2012). *Crop Production Forecast Sample Survey*. Federal Democratic Republic Of Ethiopia

[7] Ghosh, P. K., Manna, M. C., Bandyopadhyay, K. K., Ajay, Tripathi, A. K, Wanjari, R. H., . . . Rao, A. S. (2006). Interspecific Interaction and Nutrient Use in Soybean/Sorghum Intercropping System. *Bioresource Technology, 98*(4), 1097-1108.

[8] Muoneke, C. O., Ogwuche, M. A. O., & Kalu, B. A. (2007). Effect of maize planting density on the performance of maize/soybean intercropping system in a guinea savannah agroecosystem. *African Journal of Agricultural Research, 2*(12), 667-677.

[9] Onolemhemhen, P. O. (2001). Interaction between Maize and Soybean Sown Simultaneously and at Intervals in a Humid Tropical Environment. *Indian Journal of Agricultural Research, 35*(4), 238-242.

[10] Otieno, P. E., Muthomi, J. W., Chemining'wa, G. N., & Nderitu, J. H. (2009). Effect of rhizobia inoculation, farm yard manure and nitrogen fertilizer on nodulation and yield of food grain legumes. *Journal of Biological Science, 9*(4), 326-332.

[11] Panhwar, M. A., Hussain Memon, F., Kalhoro, M. A., & Ismail Soomro, M. (2004). Performance of maize in intercropping system with soybean under different patterns and nitrogen levels. *Journal of applied science, 4*(2), 201-204.

[12] Sharma, S. K., & Mehta, H. (1988). Effect of cropping System on Genetic variability and Component Crop analysis in soybean. Field Crop Research. 19:103-112.

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