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Research article

Influence of time of sowing and stand density of soybean (*Glycine max* [L.] Merrill) varieties in maize (*Zea mays* L.) on the growth of component crops in Northern Guinea Savannah Agro-Ecological Zone of Nigeria

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Field trials were conducted at the Teaching and Research Farm of the Federal College of Education (Technical), Gusau local government area (LGA) on latitude 12º 9' 46.25" N and longitude 6º 40' 28.22" E and at an altitude of about 495.98 m above sea level (asl) and Gidan Dawa Yandoto Tsafe LGA on latitude 12º 57' 27.45" N and longitude 6º 55' 14.27" E and at an altitude of about 574.87 m asl, Zamfara State in the northern Guinea Savannah agro-ecological zone of Nigeria. The experiment consisted of two varieties of soybean (TGX 1448-2E and TGX1904), four (4) times of sowing soybean (soybean 14 days after maize, soybean 14 days before maize, soybean simultaneously with maize and soybean simultaneously with maize weedy check), three (3) soybean stand densities (one, two and three plants stand^{-1}). The treatments were laid out in a split plot design with three replications. Time of sowing and stand density were allocated to the main plot while variety was assigned to the sub-plot. Data were collected on stand establishment count of maize and soybean, plant and ear height of maize, leaf area index of maize, canopy height, spread, and number of leaves of soybean. Data were analyzed using the procedure outlined for ANOVA and the means for the main effect of the three factors were separated using Duncan New Multiple Range Test (DNMRT) and least significance difference (LSD) for the three factors interactions. The result showed significant difference ($P<0.05$) among time of sowing on stand establishment count of maize, plant height and ear height of maize, leaf area index, stand establishment count of soybean at FCET, canopy height, spread, number of leaves. Also on stand density there was significant difference on canopy height, spread, and number of leaves of soybean. The results also showed significant ($P<0.05$) differences among time × variety interactions on canopy height of soybean at 8 WAS at Gidan Dawa, time × density interactions on ear height of maize at Gidan Dawa, number of leaves at 8 and 12 WAS at Gidan Dawa and at FCET respectively, time × density × variety interactions on stand establishment count of maize at FCET, number of leaves of soybean at 8 WAS at Gidan Dawa. Therefore, it can be concluded that for growth improvement of maize farmers in the study area can adopt sowing maize 14 days before Soybean irrespective of soybean variety and its stand density.

Keywords: time of sowing, stand density, variety, maize, soybean

Introduction

The importance of maize to food security has led the government and agricultural research scientists to take keen interest in increasing maize production and introducing high yielding varieties and best management practices such as efficient weeds control and soil fertility management (Khaliq *et al.*, 2004). In Nigeria, soil fertility, prices of chemical fertilizers and weed infestation are the most important yield affecting factors that result in low maize yield. Intercropping, (i.e. growing of more than one species simultaneously in the same field) is a cropping strategy, which causes more stable yield, often results in a more efficient utilization of recourses; and a method to reduce weeds related problems, minimize nitrogen losses and lessen plant pathogens pressure. Intercropping also encourages efficient utilization of the environmental resources (Egbe and Adeyemo, 2007); thus the growth of weeds is decreased, depending on the availability of environmental resources.

If the crops grown together differ in the way they utilize environmental resources, they can complement each other and make better combined use of resources than when they are grown separately (Ghanbari- Bonjar, 2000).

Leguminous cover crops have been extensively used in the tropics for soil conservation and for maintaining soil fertility. Fast growing legumes are potentially good for suppressing many unwanted weeds that normally dominates farmlands especially after crop harvest (Akobundu, 1987). The intercropping system is included in efforts to diversify agriculture that can be done on maize and soybean plants. This intercropping is possible because maize is included in C_4 plants that prefer direct sunlight (Kiswanto and Putra, 2012) and require nitrogen in relatively high amounts (Clément *et al*., 1992). Soybeans are included in C_3 plants, which are quite tolerant of shade (Turmudi, 2002); besides that, soybean roots can fix nitrogen through symbiosis with Rhizobium japonicum bacteria (Adu-Gyamfi *et al*., 2007). The intercropping system of maize with soybean had a positive influence on maize production (Undie *et al*., 2012). Based on the results obtained by Hadirochmat (2008) it can be seen that the intercropping system of soybean and maize is more efficient compared to the intercropping system of soybean and upland rice. An increase of one more row from 3 to 4 rows significantly decreases the weight of maize cobs (3.5-folds), pods (2.3-folds), and 1000 seeds (1-folds). One row of maize plant density, which was beginning three rows to 4 rows, causes a decrease in the weight of dry root biomass and shoot of maize and soybean plants (Astiko *et al*., 2021). Cereal-legume intercropping presents solution to obtain higher yields per unit area, diversified food and reduced risk of crop failure under rain fed conditions. Cereal-legume intercropping systems play significant role in efficient utilization of the available recourses. The main theme in intercropping is to augment the total productivity per unit area and time, besides judicious and equitable utilization of land resources and farming input including labour etc. (Marer *et al.,* 2007).

In the savannah ecology of Nigeria farmers intercrop legumes with maize after the emergence and at a later stage of growth of the cereal at their own convenient times. This implies that there is no uniform time of intercropping the legumes with maize for growth improvement. Time of planting legumes in cereal could also affect the weed problems as well as increase grain yield of cereal and the extent could vary with changes in stand density of the legumes. Iwuagwu *et al*. (2020) reported that growth and yield of cocoyam and the cowpea genotypes increased significantly when either of the component crops was planted earlier than the other. Intercropping reduced significantly cocoyam yield by 0.7-74% in IT97K-499-35 and 22-80% in Akidienu. Sowing the cowpea genotypes the same day or before cocoyam resulted in over-yielding of cowpea, whereas sowing Akidienu and IT97K-499-35 after cocoyam caused pod yield reductions of 64%-73% and 32%-59% on average, respectively. Cocoyam planted two weeks before IT97K-499-35 produced more satisfactory yields of the intercrops than the other planting schedules with LER, LEC and ATER of 2.15, 1.03 and 1.57, respectively.

Planting date among other factors including plant architecture, plant geometry, growth habit, density, spatial arrangement, and soil fertility management, affects the efficiency of resources (light, water and nutrients) used in an intercrop mixture (Singh and Ajeigbe, 2003; Petu-Ibikumle *et al*., 2010), hence the productivity of the system. Research findings have suggested varied times to intercrop legumes in mixtures to ensure maximum yield of the component crops. Studies conducted by Okpara (2000) on cowpea/maize mixture showed that plant height, leaf area index, dry matter and pod yields in vegetable cowpea, as well as seed yield in maize, were significantly decreased due to delay in the introduction of either crop in the mixture, whereas best results were obtained when maize and vegetable cowpea were sown same day. Sarkodie-Addo and Abdul-Rahaman (2012) reported optimum yields when maize and soybean were sown simultaneously. On the contrary, Osang *et al*. (2014) suggested the sowing of maize two weeks after planting soybean as this planting schedule gave higher advantages (Land equivalent ratio) than other planting schedules. Therefore, determining the appropriate time to plant a component crop in any mixture is important in maximizing the yield of both crops.

There are no documented reports on the best time to introduce soybean in maize/ soybean intercrop. Therefore, this research was undertaken to ascertain the most suitable time to introduce component crop (soybean)

variety and its stand density in maize/soybean intercropping for increase on growth of component crops.

Materials and Methods

Field trials were conducted at the Teaching and Research Farm of the Federal College of Education (Technical), Gusau LGA on latitude 12º 9' 46.25" N and longitude 6º 40' 28.22" E and at an altitude of about 495.98 m above sea level (asl) and Gidan Dawa Yandoto Tsafe LGA on latitude 12º 57' 27.45" N and longitude 6º 55' 14.27" E and at an altitude of about 574.87 m asl, Zamfara State in the northern Guinea Savannah agro-ecological zone of Nigeria. The experiment consisted of two varieties of soybean (TGX 1448-2E and TGX1904), four (4) times of sowing soybean (soybean 14 days after maize, soybean 14 days before maize, soybean simultaneously with maize and soybean simultaneously with maize weedy check), three (3) soybean stand densities (one, two and three plants stand^{-1}). The treatments were laid out in a split plot design with three replications. Time of sowing and stand density were allocated to the main plot while variety was assigned to the sub-plot.

The land was ploughed, harrowed and ridged at 75 cm apart to obtain a fine tilt and then marked out into required plot sizes with 1.0 m spacing between replications and 0.50 m spacing between plots. The gross and net plot sizes were 3 m × 4.5 m (13.5 m^2) and 2.5 m × 3 m (7.5 m^2), respectively, constituting 6 ridges in the gross plots and 4 ridges in the net plots respectively.

The seeds were dressed with Apron- star at the rate of 10 g of the chemical per 2.0 kg of seed before sowing, in order to protect the seeds from soil borne diseases and pests. At Gidan dawa, sowing was done on 10th and 24th June 2021 while at FCET sowing was done on 11th and 25th June 2021 at an intra and inter row spacing of 25 cm × 75 cm. Two seeds of maize were sown hill^{-1} and thinned to 1 plant stand^{-1} at two weeks after sowing (WAS). Six seeds of soybean were sown hill^{-1} and thinned to 1, 2 and 3 plants stand^{-1} respectively at 2 WAS according to the treatments.

Compound fertilizer (NPK 15:15:15) was applied to maize only by side placement at the rate of 250 kg ha^{-1} at 2 WAS and Urea at the rate of 125 kg ha^{-1} at 6 WAS to supply total nutrients of 95.0 N; 37.5 P_2O_5; 37.5 K_2O kg ha^{-1}.

Weeds were controlled manually by hoe weeding twice at 3 and 6 weeks after sowing maize.

Pest and disease were controlled based on standard practices.

The maize crop was harvested when the cobs matured, when husk has turned yellow and grains have harden enough and when black layers at the point of attachment to the cob is formed. The ears from the net plots were manually removed and de-husked. The cobs were sun-dried, weighed and later shelled and winnowed to obtain clean grains. The pods of soybean crop were harvested by cutting the entire plant at the base, sun-dried, threshed, winnowed and weighed.

Data were collected on stand establishment count of maize and soybean, plant and ear height of maize, leaf area index of maize, canopy height, spread, and number of leaves of soybean. . Data were analysed using the procedure outlined for ANOVA and the means for the main effect of the three factors were separated using Duncan New Multiple Range Test (DNMRT) and least significance difference (LSD) for the factors' interactions.

Results and Discussion

Maize growth parameters

Stands establishment count

Effect of time of sowing and stand density of soybean varieties on stands establishment count at 14 days after sowing (DAS) is presented in Table 1. Time of sowing had significantly ($P<0.05$) influenced stands count of maize at 14 DAS at both locations. The highest (53333.3 and 52666.7) stands count were recorded on plots of soybean 14 days before maize at both locations comparable with all the other treatments except soybean simultaneously with maize at FCET and comparable with soybean 14 days after maize at Gidan Dawa. The least (51703.7 and 50518.5) stand count were recorded from soybean simultaneously with maize and soybean simultaneously with maize weedy check at FCET and Gidan Dawa respectively which is comparable with simultaneously with maize weedy check at FCET and all the other treatments except 14 days after Soybean at Gidan Dawa. This might be as a result of differences in heat units and rainfall distribution between the two locations.

Stand density and variety did not significantly ($P>0.05$) influenced stand count of maize at 14 DAS.

Table 1: Effect of time of sowing and stand density of soybean varieties on stand establishment count (ha^{-1}) of maize at FCET and Gidan Dawa in the Northern Guinea Savannah Agro-ecological Zone of Nigeria during 2021 rainy season

Treatment	FCET	GIDAN DAWA
Time of sowing (TS)		
Soybean 14 days before maize	53333.3a	52666.7a
Soybean 14 days after maize	52963.0a	51629.6ab
Soybean simultaneously with maize	51703.7b	50963.0b
Soybean simultaneously with maize weedy check	52740.7ab	50518.5b
Significance level	*	**
SE (±)	372.887	367.497
Stand density (SD)		
1 plant	52888.9	51777.8
2 plants	52944.4	51055.6
3 plants	52222.2	51500.0
Significance level	NS	NS
SE (±)	322.930	318.262
Variety (V)		
TGX1448-2E	52555.6	51444.4
TGX1904	52814.8	51444.4
Significance level	NS	NS
SE (±)	267.078	419.844
Mean	52685.19	51444.44
CV (%)	3.04	4.90
Interaction		
Significance level (TS×SD)	NS	NS
SE (TS×SD) (±)	645.859	636.524
Significance level (TS×V)	NS	NS
SE (TS×V) (±)	534.156	839.688
Significance level (SD×V)	NS	NS
SE (SD×V) (±)	462.5924	727.1909
Significance level (TS×SD×V)	**	NS
SE (TS×SD×V) (±)	925.185	1454.382

Means in a column under each factor followed by the same letter(s) are not significantly different at P=0.05 using Duncan's new multiple range test (DNMRT), *, **** represent significant at P≤0.05, P≤0.01, ns = not significant at P>0.05, DAS = days after sowing, WAS = weeks after sowing

None of the interactions was found to be significant on stand count of maize at 14 DAS except interactions of time of sowing × stand density × variety (Table 1b).

Plant and ear height of maize (cm)

Effect of time of sowing and stand density of soybean varieties on plant and ear height is presented in Table 2. Time of sowing had significantly (P<0.05) influenced plant height at all sampling period and ear height at both locations. The highest (2.14, 2.26, 95.04, 1.72, 2.20 and 86.57) plant and ear height were recorded on plots of soybean 14 days after maize at both locations comparable with soybean simultaneously with maize at both locations and soybean simultaneously with maize weedy check on plant height at 12 WAS and ear height at FCET. The least (1.27, 1.95, 77.27, 1.08, 1.88 and 74.13) plant and ear height were recorded from soybean 14 days before maize. This indicated better growth.

Table 1b: Interaction of time of sowing × stand density × variety on stand establishment count of maize at FCET in the Northern Guinea Savannah Agro-ecological Zone of Nigeria during 2021 rainy season

		Variety	
Time of sowing	Stand density	TGX1448-2E	TGX1904
Soybean 14 days before maize	1 plant	53333.33a	53333.33a
Soybean 14 days after maize	1 plant	52888.89a	52888.89a
Soybean simultaneously with maize	1 plant	52444.44a	53333.33a
Soybean simultaneously with maize weedy check	1 plant	53333.33a	51555.56a
Soybean 14 days before maize	2 plants	53333.33a	53333.33a
Soybean 14 days after maize	2 plants	53333.33a	52888.89a
Soybean simultaneously with maize	2 plants	53333.33a	51555.56a
Soybean simultaneously with maize weedy check	2 plants	52444.44a	53333.33a
Soybean 14 days before maize	3 plants	53333.33a	53333.33a
Soybean 14 days after maize	3 plants	53333.33a	52444.44a
Soybean simultaneously with maize	3 plants	46222.22b	53333.33a
Soybean simultaneously with maize weedy check	3 plants	53333.33a	52444.44a
LSD (0.05)	2700.56		

Means followed by similar letter(s) across rows and columns do not differ significantly at 5% level of significance using least significant difference (LSD)

Table 2: Effect of time of sowing and stand density of soybean varieties on plant and ear height (cm) of maize at FCET and Gidan Dawa in the Northern Guinea Savannah Agro-ecological Zone of Nigeria during 2021 rainy season

Treatment	FCET			GIDAN DAWA		
	Plant height		Ear height	Plant height		Ear height
	8 WAS	12 WAS		8 WAS	12 WAS	
Time of sowing (TS)						
Soybean 14 days before maize	1.27c	1.95b	77.27b	1.08c	1.88b	74.13c
Soybean 14 days after maize	2.14a	2.26a	95.04a	1.72a	2.20a	86.57a
Soybean simultaneously with maize	1.99ab	2.22a	91.85a	1.65a	2.11a	81.93ab
Soybean simultaneously with maize weedy check	1.84b	2.05ab	87.04a	1.36b	1.89b	76.44bc
Significance level	***	*	***	***	***	***
SE (±)	0.061	0.070	2.701	0.050	0.035	1.970
Stand density (SD)						
1 plant	1.80	2.08	88.12	1.49	2.05	80.23
2 plants	1.80	2.14	85.32	1.48	2.02	79.06
3 plants	1.83	2.14	89.97	1.39	1.99	80.02
Significance level	NS	NS	NS	NS	NS	NS
SE (±)	0.053	0.061	2.339	0.043	0.030	1.706
Variety (V)						
TGX1448-2E	1.81	2.15	87.41	1.43	2.03	78.79
TGX1904	1.81	2.09	88.19	1.47	2.01	80.74
Significance level	NS	NS	NS	NS	NS	NS
SE (±)	0.037	0.051	1.443	0.034	0.032	1.534
Mean	1.81	2.12	87.80	1.45	2.02	79.77
CV (%)	12.24	14.32	9.86	13.95	9.63	11.54
Interaction						
Significance level (TS×SD)	NS	NS	NS	NS	NS	*
SE (TS×SD) (±)	0.106	0.122	4.678	0.086	0.060	3.412
Significance level (TS×V)	NS	NS	NS	NS	NS	NS
SE (TS×V) (±)	0.074	0.101	2.887	0.068	0.065	3.068
Significance level (SD×V)	NS	NS	NS	NS	NS	NS
SE (SD×V) (±)	0.064	0.088	2.500	0.059	0.056	2.657
Significance level (TS×SD×V)	NS	NS	NS	NS	NS	NS
SE (TS×SD×V) (±)	0.128	0.175	5.000	0.117	0.112	5.313

Means in a column under each factor followed by the same letter(s) are not significantly different at P=0.05 using Duncan's new multiple range test (DNMRT), *, *** represent significant at P≤0.05, P≤0.001, ns = not significant at P>0.05, DAS = days after sowing, WAS = weeks after sowing

None of the interactions was found to be significant except interactions of time of sowing × stand density on ear height at Gidan Dawa that showed significant (P<0.05) different effect Table 2b. The interaction revealed that at stand density 1 plant and 2 plants, soybean 14 days after maize recorded the highest (83.47 and 95.33 cm) ear height comparable with the other time of sowing on stand density 1 plant except soybean 14 days before maize that recorded the least (73.43 cm) ear height but different with the other time of sowing. At stand density 3 plants, soybean simultaneously with maize recorded the highest (86.63 cm) ear height comparable with soybean 14 days after maize while soybean 14 days before maize (75.17 cm) and Soybean simultaneously with maize weedy check (77.37cm) recorded the least ear height.

Table 2b: Interaction effect of time of sowing × stand density on ear height of maize at Gidan Dawa in the Northern Guinea Savannah Agro-ecological Zone of Nigeria during 2021 rainy season

	Stand density		
Time of sowing	1 plant	2 plants	3 plants
Soybean 14 days before maize	73.43b	73.80b	75.17b
Soybean 14 days after maize	83.47a	95.33a	80.90a
Soybean simultaneously with maize	82.83a	76.33b	86.63a
Soybean simultaneously with maize weedy check	81.20a	70.77b	77.37b
LSD (0.05)	15.51		

Means followed by similar letter(s) across rows and columns do not differ significantly at 5% level of significance using least significant difference (LSD)

Leaf area index

Effect of time of sowing and stand density of soybean varieties on leaf area index is presented in Table 3. Time of sowing had significantly (P<0.05) influenced leaf area index at all sampling period and at both locations. The highest (4.75, 2.91 and 3.54) leaf area index were recorded on plots of soybean 14 days after maize at all sampling period at FCET and at 8 WAS at Gidan Dawa comparable with soybean simultaneously with maize at all sampling period and at both locations. The least (1.32, 2.06, 1.16 and 1.50) leaf area index were recorded from soybean 14 days before maize at all sampling period at FCET, at 8 WAS at Gidan Dawa and soybean simultaneously with maize weedy check at Gidan Dawa respectively. The highest plant height, ear height and leaf area index recorded on plots of soybean 14 days after maize might be attributed to healthy condition of the plants devoid of competition at initial stage of growth and does not stress. This condition allows the absorption of nutrients by plants prioritized to develop organs on the above ground, such as leaves, stems, flowers, and seeds, so that they grow better (Hooper and Vitousek, 1997).

Stand density and variety did not significantly (P>0.05) influenced leaf area at both locations.

None of the interactions was found to be significant on leaf area at all sampling period and at both locations.

Table 3: Effect of time of sowing and stand density of soybean varieties on leaf area index of maize at FCET and Gidan Dawa in the Northern Guinea Savannah Agro-ecological Zone of Nigeria during 2021 rainy season

Treatment	FCET		GIDAN DAWA	
	8 WAS	**12 WAS**	**8 WAS**	**12 WAS**
Time of sowing (TS)				
Soybean 14 days before maize	1.32c	2.06b	1.16c	1.93bc
Soybean 14 days after maize	4.75a	2.91a	3.54a	2.72a
Soybean simultaneously with maize	4.30a	2.61a	3.32a	2.37ab
Soybean simultaneously with maize weedy check	3.25b	2.14b	2.42b	1.50c
Significance level	***	**	***	***
SE (±)	0.220	0.157	0.144	0.154
Stand density (SD)				
1 plant	3.48	2.42	2.82	2.11
2 plants	3.40	2.45	2.49	2.10
3 plants	3.34	2.43	2.53	2.18
Significance level	NS	NS	NS	NS
SE (±)	0.190	0.136	0.125	0.133
Variety (V)				
TGX1448-2E	3.44	2.44	2.62	2.21
TGX1904	3.37	2.42	2.60	2.05
Significance level	NS	NS	NS	NS
SE (±)	0.132	0.086	0.104	0.075
Mean	3.41	2.43	2.61	2.13
CV (%)	23.26	21.14	23.91	21.10
Interaction				
Significance level (TS×SD)	NS	NS	NS	NS
SE (TS×SD) (±)	0.381	0.271	0.250	0.267
Significance level (TS×V)	NS	NS	NS	NS
SE (TS×V) (±)	0.264	0.171	0.208	0.150
Significance level (SD×V)	NS	NS	NS	NS
SE (SD×V) (±)	0.229	0.148	0.180	0.130
Significance level (TS×SD×V)	NS	NS	NS	NS
SE (TS×SD×V) (±)	0.457	0.297	0.360	0.259

Means in a column under each factor followed by the same letter(s) are not significantly different at P=0.05 using Duncan's new multiple range test (DNMRT), ****,** *** represent significant at P≤0.01 P≤0.001, ns = not significant at P>0.05, DAS = days after sowing, WAS = weeks after sowing.

Soybean growth parameters

Stand establishment count

Effect of time of sowing and stand density of soybean varieties on stand establishment count 14 days after sowing (DAS) is presented in Table 4. Time of sowing had significantly (P<0.05) influenced stand count of soybean at 14 DAS at FCET only. The highest (53629.6) stand count were recorded on plots of soybean simultaneously with maize comparable with all the other treatments except soybean 14 days before maize that recorded the least (52222.2) stand count. This is possibly because during this time, there was low soil moisture, soybean suffered moisture stress and therefore was not able to germinate. Density and variety did not significantly (P>0.05) influenced stand count of soybean at 14 DAS. None of the interactions was found to be significant on stand count of soybean at 14 DAS.

Table 4: Effect of time of sowing and stand density of soybean varieties on stand establishment count (ha^{-1}) of soybean at FCET and Gidan Dawa in the Northern Guinea Savannah Agro-ecological Zone of Nigeria during 2021 rainy season

Treatment	FCET	GIDAN DAWA
Time of sowing (TS)		
Soybean 14 days before maize	52222.2b	49852
Soybean 14 days after maize	52666.7ab	50963
Soybean simultaneously with maize	53629.6a	51852
Soybean simultaneously with maize weedy check	53629.6a	48889
Significance level	*	NS
SE (±)	375.885	841.542
Stand density (SD)		
1 plant	52722.2	49500
2 plants	53611.1	51389
3 plants	52777.8	50278
Significance level	NS	NS
SE (±)	325.526	728.797
Variety (V)		
TGX1448-2E	53259.3	51111.1
TGX1904	52814.8	49666.7
Significance level	NS	NS
SE (±)	265.791	690.420
Mean	53037.04	50388.89
CV (%)	3.01	8.22
Interaction		
Significance level (TS×SD)	NS	NS
SE (TS×SD) (±)	651.052	1457.594
Significance level (TS×V)	NS	NS
SE (TS×V) (±)	531.582	1380.841
Significance level (SD×V)	NS	NS
SE (SD×V) (±)	460.363	1195.843
Significance level (TS×SD×V)	NS	NS
SE (TS×SD×V) (±)	920.726	2391.687

Means in a column under each factor followed by the same letter(s) are not significantly different at P=0.05 using Duncan's new multiple range test (DNMRT), *, represent significant at P≤0.05, ns = not significant at P>0.05, DAS = days after sowing, WAS = weeks after sowing

Canopy height (cm)

Effect of time of sowing and stand density of soybean varieties on canopy height is presented in Table 5. Time of sowing had significantly (P<0.05) influenced canopy height at all sampling period and at both locations except at Gidan Dawa at 12 WAS. At 8 WAS, at FCET, the highest (91.76 cm) canopy height was recorded on plots of soybean simultaneously with maize weedy check comparable with soybean simultaneously with maize. At 12 WAS and 8 WAS at FCET and Gidan Dawa respectively, Soybean simultaneously with maize recorded the highest (112.52 and 74.51 cm) canopy height comparable with Soybean simultaneously with maize weedy check. The least (55.38, 91.86 and 54.73 cm) canopy height were recorded from soybean 14 days after maize at 12 WAS and 8 WAS at FCET and Gidan Dawa respectively. The reduction in height by soybean 14 days after maize could be due to interspecific competition and depressive effect of maize, a C_4 species on soybean, a C_3 crop. Crops with C_4 photosynthetic pathways such as maize have been known to be dominant when intercropped with C_3 crops like soybean (Hiebsch, *et al*., 1995). Also, the reduction in height by soybean 14 days after maize could be due to shading by the taller maize plants. Olufajo (1992) and O' Callaghan *et al*. (1994) reported that shading by the taller plants in mixture could reduce the photosynthetic rate of the lower growing plants and thereby reduce their growth and yields.

Stand density had significantly (P<0.05) influenced canopy height at both sampling period at FCET. Stand density 3 plants recorded the highest (83.04 and 108.23 cm) canopy height at 8 and 12 WAS respectively comparable with 2 plants.

The least (75.12 and 97.83 cm) canopy height were recorded from density 1 plant at 8 and 12 WAS respectively. From this research, maize growth aggressively occurred at a density of 1 plant of soybean that impacted maize and soybean depression because of less photosynthesis in plant leaves.

Variety did not significantly (P>0.05) influenced canopy height at all sampling period and at both locations

Table 5: Effect of time of sowing and stand density of soybean varieties on canopy height (cm) of soybean at FCET and Gidan Dawa in the Northern Guinea Savannah Agro-ecological Zone of Nigeria during 2021 rainy season

Treatment	FCET		GIDAN DAWA	
	8 WAS	12 WAS	8 WAS	12 WAS
Time of sowing (TS)				
Soybean 14 days before maize	82.11b	99.14b	68.39b	102.14
Soybean 14 days after maize	55.38c	91.86c	54.73c	101.20
Soybean simultaneously with maize	88.76a	112.52a	74.51a	106.56
Soybean simultaneously with maize weedy check	91.76a	110.80a	71.96ab	103.81
Significance level	***	***	***	NS
SE (±)	1.714	1.924	1.874	2.225
Stand density (SD)				
1 plant	75.12b	97.83b	65.80	101.66
2 plants	80.34a	104.68a	68.61	104.13
3 plants	83.04a	108.23a	67.78	104.50
Significance level	**	***	NS	NS
SE (±)	1.485	1.666	1.623	1.927
Variety (V)				
TGX1448-2E	79.14	104.54	66.77	104.93
TGX1904	79.86	102.62	68.03	101.92
Significance level	NS	NS	NS	NS
SE (±)	0.955	1.477	0.756	1.329
Mean	79.50	103.58	67.40	103.43
CV (%)	7.21	8.55	6.73	7.71
Interaction				
Significance level (TS×SD)	NS	NS	NS	NS
SE (TS×SD) (±)	2.969	3.332	3.245	3.853
Significance level (TS×V)	NS	NS	*	NS
SE (TS×V) (±)	1.911	2.953	1.512	2.659
Significance level (SD×V)	NS	NS	NS	NS
SE (SD×V) (±)	1.655	2.558	1.309	2.302
Significance level (TS×SD×V)	NS	NS	NS	NS
SE (TS×SD×V) (±)	3.310	5.116	2.619	4.605

Means in a column under each factor followed by the same letter(s) are not significantly different at P=0.05 using Duncan's new multiple range test (DNMRT), *, **, *** represent significant at P≤0.05, P≤0.01 P≤0.001, ns = not significant at P>0.05, DAS = days after sowing, WAS = weeks after sowing.

None of the interactions was found to be significant on canopy height at all sampling period and at both locations except time of sowing × variety at 8 WAS at FCET that showed significant (P<0.05) different effect Table 5b. The interaction revealed that variety TGX1448-2E recorded the highest (75.24 cm) canopy height at soybean simultaneously with maize comparable with soybean simultaneously with maize weedy check. Similarly, TGX1904 recorded the highest (73.78 cm) canopy height at soybean simultaneously with maize comparable with all the other time of sowing except soybean 14 days after maize that recorded the least (51.96 and 57.51 cm) canopy height across the varieties indicating that it is advisable to intercrop maize with soybean 14 days after maize.

Table 5b: Interaction effect of time of sowing × variety on canopy height of soybean at 8 WAS at Gidan Dawa in the Northern Guinea Savannah Agro-ecological Zone of Nigeria during 2021 rainy season

	Variety	
Time of sowing	TGX1448-2E	TGX1904
Soybean 14 days before maize	66.78b	70.00a
Soybean 14 days after maize	51.96c	57.51c
Soybean simultaneously with maize	75.24a	73.78a
Soybean simultaneously with maize weedy check	73.09a	70.82a
LSD (0.05)	7.64	

Means followed by similar letter(s) across rows and columns do not differ significantly at 5% level of significance using least significant difference (LSD)

Canopy spread

Effect of time of sowing and stand density of soybean varieties on canopy spread is presented in Table 6. Time of sowing had significantly ($P<0.05$) influenced canopy spread at all sampling period and at both locations. The highest (56.47, 66.49, 51.64 and 69.68 cm) canopy spread was recorded on plots of soybean 14 days before maize. The least (35.94, 50.92, 37.23 and 50.50 cm) canopy spread were recorded from soybean 14 days after maize at FCET and at 8 WAS at Gidan Dawa, and at 12 WAS at Gidan Dawa respectively. The least canopy height and spread recorded from soybean 14 days after maize might be due to interspecific competition and depressive effect of maize, as a C_4 species at early stage of growth on soybean, as a C_3 crop. Crop plants with C_4 photosynthetic pathways such as maize have been known to be dominant when intercropped with C_3 crop plants like soybean (Hiebsch, *et al*., 1995). Similarly, the decrease in canopy height could be due to shading by the taller maize plants. Olufajo (1992) and O' Callaghan *et al*. (1994) reported that shading by the taller plants in mixture could decrease the photosynthetic rate of the lower growing plants and thereby decrease their growth. From the findings of this research, aggressive growth of soybean occurred at a soybean 14 days before maize that obstructed maize and soybean depression because of less photosynthesis in plant leaves.

Stand density had significantly ($P<0.05$) influenced canopy spread at all sampling period and at both locations except at 12 WAS at Gidan Dawa. Stand density 3 plants recorded the highest (47.49 cm) canopy spread at 8 WAS at FCET. While density 2 plants recorded the highest (59.78 and 44.23 cm) canopy spread at 12 WAS at FCET and 8 WAS at Gidan Dawa respectively. This might be due to greater competition for growth factors such as nutrients, light moisture and space thereby enabling the plants to express their growth in both direction to make use of the available resources.

Variety did not significantly (>0.05) influenced canopy spread at all sampling period and at both locations.

None of the interactions was found to be significant on canopy spread at all sampling period and at both locations.

Number of leaves

Effect of time of sowing and stand density of soybean varieties on number of leaves is presented in Table 7. Time of sowing had significantly ($P<0.05$) influenced number of leaves at all sampling period and at both locations. The highest (29.23, 36.02, 29.83 and 46.70) number of leaves were recorded on plots of soybean 14 days before maize different from the other time of sowing. At 8 WAS, the least (7.18 and 8.16) number of leaves were recorded from soybean 14 days after maize and at 12 WAS, the least (19.35 and 20.03) number of leaves were recorded from soybean simultaneously with maize weedy check. The highest number of leaves recorded on plots of soybean 14 days before maize might be ascribed to release N from soybean by fixation reaction from the air.

Table 6: Effect of time of sowing and stand density of soybean varieties on canopy spread of soybean at FCET and Gidan Dawa in the Northern Guinea Savannah Agro-ecological Zone of Nigeria during 2021 rainy season

Treatment	FCET		GIDAN DAWA	
	8 WAS	12 WAS	8 WAS	12 WAS
Time of sowing (TS)				
Soybean 14 days before maize	56.47a	66.49a	51.64a	69.68a
Soybean 14 days after maize	35.94c	50.92c	37.23c	55.23bc
Soybean simultaneously with maize	45.61b	59.14b	41.02b	60.10b
Soybean simultaneously with maize weedy check	41.50b	54.71c	37.41c	50.50c
Significance level	***	***	***	***
SE (±)	1.675	1.458	1.023	1.691
Stand density (SD)				
1 plant	41.93b	54.83b	38.09b	57.13
2 plants	45.23ab	59.78a	44.23a	60.05
3 plants	47.49a	58.84a	43.16a	59.46
Significance level	*	*	***	NS
SE (±)	1.451	1.263	0.886	1.465
Variety (V)				
TGX1448-2E	45.50	56.80	42.30	59.37
TGX1904	44.26	58.83	41.36	58.39
Significance level	NS	NS	NS	NS
SE (±)	1.214	1.065	0.714	1.229
Mean	44.88	57.82	41.83	58.88
CV (%)	16.23	11.05	10.24	12.52
Interaction				
Significance level (TS×SD)	NS	NS	NS	NS
SE (TS×SD) (±)	2.901	2.525	1.771	2.930
Significance level (TS×V)	NS	NS	NS	NS
SE (TS×V) (±)	2.429	2.130	1.428	2.457
Significance level (SD×V)	NS	NS	NS	NS
SE (SD×V) (±)	2.103	1.845	1.237	2.128
Significance level (TS×SD×V)	NS	NS	NS	NS
SE (TS×SD×V) (±)	4.207	3.689	2.473	4.256

Means in a column under each factor followed by the same letter(s) are not significantly different at P=0.05 using Duncan's new multiple range test (DNMRT), *, *** represent significant at P≤0.05, P≤0.001, ns = not significant at P>0.05, DAS = days after sowing, WAS = weeks after sowing.

As anticipated, soybean plants can release a large amount of N with Rhizobium bacteria in the soil, so encouraged plant growth (Ariel, 2013). Enhancement of soil N nutrients due to the N-binding bacteria that can fix N directly from the air in the affected soybean plants, causing the growth of roots and shoot of plants to be useful (Forrester and Ashman, 2018).

Stand density had significantly (P<0.05) influenced number of leaves at 12 WAS at FCET and 8 WAS at Gidan Dawa. Stand density 2 plants recorded the highest (27.18) number of leaves at 12 WAS at FCET. While density 1 plant recorded the highest (17.37) number of leaves 8 WAS at Gidan Dawa. Density 3 plants recorded the least (14.38 and 23.32) number of leaves at both locations. This might be due to greater availability of growth factors such as nutrients, light moisture and space. There was also less competition for these factors at the lower stand density thereby enabling the plants to grow and express their full potential. Similar reports were made by Daudawa (2007); Salau and Makinde (2014).

Variety did not significantly (>0.05) influenced number of leaves at all sampling period and at both locations.

Table 7: Effect of time of sowing and stand density of soybean varieties on number of leaves plant^{-1} of soybean at FCET and Gidan Dawa in the Northern Guinea Savannah Agro-ecological Zone of Nigeria during 2021 rainy season

Treatment	FCET		GIDAN DAWA	
	8 WAS	12 WAS	8 WAS	12 WAS
Time of sowing (TS)				
Soybean 14 days before maize	29.23a	36.02a	29.83a	46.70a
Soybean 14 days after maize	7.18d	20.26c	8.16c	24.08bc
Soybean simultaneously with maize	16.51b	26.27b	16.29b	30.66b
Soybean simultaneously with maize weedy check	12.53c	19.35c	10.30c	20.03c
Significance level	***	***	***	***
SE (±)	1.047	1.183	0.801	2.418
Stand Density (SD)				
1 plant	18.02a	25.93ab	17.37a	32.14
2 plants	15.32a	27.18a	16.69a	28.23
3 plants	15.75a	23.32b	14.38b	30.73
Significance level	NS	*	*	NS
SE (±)	0.907	1.024	0.694	2.094
Variety (V)				
TGX1448-2E	16.80	25.95	15.89	32.64
TGX1904	15.92	25.00	16.40	28.09
Significance level	NS	NS	NS	NS
SE (±)	0.791	0.965	0.721	1.669
Mean	16.36	25.48	16.14	30.37
CV (%)	28.99	22.72	26.81	32.99
Interaction				
Significance level (TS×SD)	NS	**	*	NS
SE (TS×SD) (±)	1.814	2.049	1.388	4.188
Significance level (TS×V)	NS	NS	NS	NS
SE (TS×V) (±)	1.581	1.930	1.443	3.339
Significance level (SD×V)	NS	NS	NS	NS
SE (SD×V) (±)	1.369	1.671	1.249	2.892
Significance level (TS×SD×V)	NS	NS	*	NS
SE (TS×SD×V) (±)	2.739	3.342	2.499	5.783

Means in a column under each factor followed by the same letter(s) are not significantly different at P=0.05 using Duncan's new multiple range test (DNMRT), *, **, *** represent significant at P≤0.05, P≤0.01 P≤0.001, ns = not significant at P>0.05, DAS = days after sowing, WAS = weeks after sowing.

Interactions of time of sowing × stand density at 12 WAS at FCET (Table 7bi), 8 WAS at Gidan Dawa (Table 7bii) and time of sowing × stand density × variety at 8 WAS at Gidan Dawa (Table 7biii) were found to be significant (<0.05) on number of leaves. The result showed significant (P<0.05) different effect of time of sowing × stand density on number of leaves at 12 WAS at FCET Table 7bi. The interaction revealed that soybean 14 days before maize recorded the highest (40.25, 41.43 and 26.38) number of leaves across the different stand density. The least (16.86 and 19.65) number of leaves were recorded from soybean simultaneously with maize weedy check at density 1 plant and 3 plants while soybean 14 days after maize recorded the least (20.08) number of leaves at density 2 plants.

Table 7bi: Interaction effect of time of sowing × density on number of leaves plant^{-1} of soybean at 12 WAS at FCET in the Northern Guinea Savannah Agro-ecological Zone of Nigeria during 2021 rainy season

	Stand density		
Time of sowing	1 plant	2 plants	3 plants
Soybean 14 days before maize	40.25a	41.43a	26.38b
Soybean 14 days after maize	19.78b	20.08b	20.91b
Soybean simultaneously with maize	26.84b	25.64b	26.33b
Soybean simultaneously with maize weedy check	16.86c	21.56b	19.65b
LSD (0.05)	9.76		

Means followed by similar letter(s) across rows and columns do not differ significantly at 5% level of significance using least significant difference (LSD).

The result showed significant (P<0.05) different effect of time of sowing × stand density on number of leaves at 8 WAS Gidan Dawa Table 7bii. The interaction revealed that soybean 14 days before maize recorded the highest (34.63, 29.77 and 25.10) number of leaves while the least (8.47, 8.27 and 7.73) number of leaves were recorded from soybean 14 days after maize across the different stand density. This could be attributed to no competition experience by the soybean and shading from the maize plant at early stage. Sowing soybean before maize provide adequate time for the plants to grow and express their full growth potentials in terms of more number of leaves in the presence of necessary mineral nutrients and other growth factors. Elemo *et al*. (2006) reported that, better utilization of light enhances canopy structure of the intercrops making up the crop mixture.

Table 7bii: Interaction effect of time of sowing × stand density on number of leaves plant^{-1} of soybean at 8 WAS at Gidan Dawa in the Northern Guinea Savannah Agro-ecological Zone of Nigeria during 2021 rainy season

	Stand density		
Time of sowing	1 plant	2 plants	3 plants
Soybean 14 days before maize	34.63a	29.77a	25.10b
Soybean 14 days after maize	8.47d	8.27d	7.73d
Soybean simultaneously with maize	16.03c	17.633c	15.20c
Soybean simultaneously with maize weedy check	10.33d	11.10c	9.47d
LSD	7.29		

Means followed by similar letter(s) across rows and columns do not differ significantly at 5% level of significance using least significant difference (LSD)

The result showed significant (P<0.05) different effect of time of sowing × stand density × variety on number of leaves at 8 WAS at Gidan Dawa Table 7biii. The interaction revealed that soybean 14 days before maize with 1 plant density of soybean recorded the highest (37.40) number of leaves of TGX1448-2E at par with 2 plants density and comparable with variety TGX1904 at the 1 plant density. The least (7.06 and 7.87) number of leaves were recorded from soybean 14 days after maize 3 plants density across the different varieties.

Table 7biii: Interaction effect of time of sowing × stand density× variety on number of leaves plant^{-1} of soybean at 8 WAS at Gidan Dawa in the Northern Guinea Savannah Agro-ecological Zone of Nigeria during 2021 rainy season

		Variety	
Time of sowing	Stand density	TGX1448-2E	TGX1904
Soybean 14 days before maize	1 plant	37.40a	31.87a
Soybean 14 days after maize	1 plant	8.40d	8.53d
Soybean simultaneously with maize	1 plant	16.33c	15.73c
Soybean simultaneously with maize weedy check	1 plant	9.93d	10.73d
Soybean 14 days before maize	2 plants	24.13b	35.40a
Soybean 14 days after maize	2 plants	8.20d	8.33d
Soybean simultaneously with maize	2 plants	18.60c	16.67c
Soybean simultaneously with maize weedy check	2 plants	10.67d	11.53d
Soybean 14 days before maize	3 plants	29.40b	20.80c
Soybean 14 days after maize	3 plants	7.60d	7.87d
Soybean simultaneously with maize	3 plants	12.13d	18.27c
Soybean simultaneously with maize weedy check	3 plants	7.87d	11.07d
LSD (0.05)	7.29		

Means followed by similar letter(s) across rows and columns do not differ significantly at 5% level of significance using least significant difference (LSD)

Conclusion

The results also showed significant ($P<0.05$) differences among time × variety interactions on canopy height of soybean at 8 WAS at Gidan Dawa, time × density interactions on ear height of maize at Gidan Dawa, number of leaves at 8 and 12 WAS at Gidan Dawa and FCET respectively, time × density × variety interactions on stand establishment count of maize at FCET, number of leaves of soybean at 8 WAS at Gidan Dawa. Therefore, it can be concluded that for growth improvement of maize farmers in the study area can adopt sowing soybean 14 days after maize irrespective of soybean variety and its stand density.

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