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Influence of Maize/legumes Intercrop and Spacing Grown in Benue states of Nigerian

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Abstract: A field experiments was carried out in the rainy season of 2019 in two different locations of Benue states of Nigeria. The experiment was carried out in Joseph Sarwuan Tarka University Makurdi. The aim of the experiment is to investigate effects of legume-inter crop and spacing on the performance of maize. Two different legumes were; groundnut, cowpea and control with spacing of (15, 20 and 25cm) were used. The treatments were laid in a randomized complete block design with three replications. During the research growth characters like plant height, number of leaves, leaf area, stem girth and number of prop roots per plants were measured. Other character like number of cobs, cob length, cob girth, cob weight, Number of seeds per cob, number of grain rows per cob, 100 gains weight, threshing percentage and grain yield were also recorded. The results of the investigation revealed that maize generally responded to both maize/legume intercrop and spacing. All the parameters studies have significantly ($P \leq 0.05$) responded to the intercrop of groundnut maize at the 15cm intra row spacing was observed to perform higher in both growth character and grain yield. Based on the result obtained it can be suggested that the inter crop of maize/ground nut at the spacing of 15cm will lead to optimum yield.

Keywords: Maize/Legume, Intercrop, Spacing.

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INTRODUCTION

Maize (Zea mays L.) is a staple food crop globally, providing essential calories and nutrients for a significant portion of the world's population. In many developing regions, particularly in sub-Saharan Africa, maize cultivation is often characterized by smallholder farming systems where resource limitations, including land and synthetic fertilizer availability, pose significant challenges to achieving optimal yields. To address these constraints and enhance agricultural sustainability, intercropping, the practice of growing two or more crops simultaneously on the same piece of land, has gained considerable attention.

Among various intercropping systems, the **maize-legume intercrop** stands out as a particularly promising strategy. Legumes, such as groundnut (Arachis hypogaea L.) and cowpea (Vigna unguiculata L. Walp.), possess the unique ability to fix atmospheric nitrogen through symbiotic relationships with rhizobia bacteria. This biological nitrogen fixation (BNF) can significantly reduce the need for external nitrogenous fertilizers, thereby lowering input costs for farmers and mitigating environmental pollution associated with synthetic fertilizer use. Beyond nitrogen contribution, maize-legume intercropping offers a multitude of benefits, including enhanced land use efficiency, improved soil fertility and structure, diversified farm income, reduced pest and disease incidence, and better weed suppression (Sassakawa 2000). Maize is one of the most important cereal crop grown in most African including Nigeria, in Nigeria it is grown throughout the country, indeed in Nigeria produces more than 45% of all of maize grown in west Africa and Central Africa (Ado 2001). Although large proportion of maize is still produced in south-west part, there has been a dramatic shift of the dry gain production to the savannah, especially the northern Guinea savannah which is regarded as the maize belt. In spite the increase in maize production, yield is still low, some of the major causes of yield can be linked to soil fertility and appropriate plant population (Bruresh *et al.*, 1994).

The inter cropping of maize legume has the potential to enhance yield which could be as a result competition and aggressiveness increasing the soil fertility status (Ojiem *et al.*, 2000) having in mind that legumes have the ability of fixing atmospheric nitrogen which in turn help in the maize utilizing such nitrogen for growth and other photosynthetic activities. The contribution of legumes like groundnut in N fixation and soil improvement is well known for several years. The quantity of the N fixed by legumes leads to nodulation, legumes average 75% of the total N used in the growth of the plant (Tisdale et al.,1995) he also reported that the production of N derived by maize from the associated legumes varies 7-11% for mungbeans (Phaseolus radiate) 11-20% for cowpea (Vigna unguiculata) and 12-26% for groundnut (Arachis hypogea). Despite the recognized advantages of maize-legume intercropping, there remains a need to determine the most effective spatial arrangements that optimize the performance of both crops under specific agro-ecological conditions. This study, therefore, aims to investigate the influence of varying planting densities (spacing) on the growth, yield, and yield-related parameters of maize when intercropped with different legumes during the rainy season in Makurdi. The findings from this research are expected to provide valuable insights and practical recommendations for smallholder farmers seeking to enhance the productivity and sustainability of their maize-based farming systems. Spacing on the other hand plays and important role in maize production where appropriate spacing could lead to optimum yield, where closer spacing leads to mutual shading inhibiting maximum/optimum utilization of sun light, nutrients and water while wider spacing can lead to waste of recourses, weed competition under-utilization of the environmental and soil resources (Baker 2000). However, the success and productivity of intercropping systems are highly dependent on various management factors, with **plant spacing** being one of the most critical. Optimal spacing dictates the degree of inter- and intra-specific competition for essential resources such as light, water, and nutrients. In a maize-legume intercrop, inappropriate spacing can lead to excessive competition, particularly from the taller and faster-growing maize, which can suppress the growth and yield of the intercropped legume, or vice versa Madina et al 2022. Conversely, well-managed spacing can facilitate complementary resource use, allowing both component crops to thrive and maximize the overall system productivity The aim of the work is to determine the appropriate spacing and best maize legume intercrop that will yield optimally.

Material and method

The experiment was conducted during the rainy season of 2024 at the Teaching and Research Farm, the Joseph Sauwuan Tarka University, Makurdi (7° 41'N and 8° 37'E) The average climatic condition of the two places is (Makurdi 27-30°C). The experiment that was laid in a randomized complete block design (RCBD) with three replicate, a $4m^2$ plot was laid out with 1m between plots and 0.5m between blocks. There were 9 plots each within a block which gave the total number of 27 plots for the study for the two locations. The treatment where; Spacing at 15, 20 and 25cm and the legumes used were (cowpea, groundnut and control). Agronomic practice such as land clearing, weeding was done manually at 2 and 6 weeks after planting to ensure a weed free plots application of fertilizer at planting and top dressed at 6weeks after planting at the rate of (N100 kg/ha, P60 kg/ha K60 kg/ha) and harvesting and threshing was done manually, all the data were collected within the net plot of $4m^2$, where a total of 5 plants were tagged for data collection within each net plot. The parameters recorded were plant height (was taken with the aid of measuring tape from the base of the plant to the tip), the number for leaves (were counted fortnightly) from 5 plants that were tagged and the average used fortnightly, stem girth and number of prop roots per plants were measured. Other characters like number of cobs (were counted), cob length (taken with the aid of measuring tape), cob girth (with the aid of a vernier caliper), and cob weight (with the aid of digital weighing balance), number of seeds per cob (were counted), number of grain rows per cob (were counted), 100 gains weight, threshing percentage and grain yield in kg was recorded. All data collected were subjected to analysis of variance (ANOVA) Gensat version 17, while the least significant difference (LSD) at 5% level of probability was used in separating the means.

Results and Discussion

Table 1. The Effect of maize/legumes as affected by spacing on plant height grown at Makurdi during the 2024 Rainy Season

Treatment	Plant height (cm) (WAS)				
	4	6	8	10	At harvest
Spacing (S)					
15	15.12	25.34	62.41	80.12	105.22
20	13.28	20.13	58.24	74.11	90.12
25	12.11	20.11	55.12	63.10	98.12
F-LSD (0.05)	0.39	0.71	1.44	2.91	2.99
Legumes (L)					
Control	11.12	19.12	49.23	60.34	96.89
Groundnut	16.78	26.45	70.45	81.78	104.33
Cowpea	13.12	20.13	68.34	79.99	114.21
F-LSD (0.05)	0.44	0.84	1.23	2.34	3.12
Interaction					
S X L	NS	NS	NS	NS	NS

NS= Not significant

Table 1 investigated the effect of maize/legume intercropping and different spacing regimes on the plant height of maize grown during the 2024 rainy season in Makurdi. The experiment evaluated various spacing treatments (15, 20, and 25 units, likely cm or a similar measure) and different legume intercrops (Control, Groundnut, and Cowpea). Plant height was measured at 4, 6, 8, and 10 weeks after sowing (WAS), and also at harvest. Results indicated that spacing significantly influenced the plant height of maize. The narrowest spacing of 15 units consistently resulted in the highest plant height throughout the growth period and at harvest (105.72 cm). As spacing increased to 20 and 25 units, there was a general decrease in plant height, suggesting that denser planting within the tested range promoted greater vertical growth, Cook (2002) reported optimal plant density/population need to be adjusted to the local condition and type of plant to be grown. Sassakawa (2000) reported that closer spacing affects plant height positively and also help in managing weed crop competition. Legume intercrops also had a significant impact on maize plant height. Groundnut intercropping consistently promoted the tallest plants across all measurement periods and at harvest (104.73 cm), significantly outperforming both Cowpea and the Control group. Cowpea intercropping also showed better plant height development than the Control, which exhibited the lowest plant height values intercrop which is in conformity with the finding (Glover 2003) who reported that maize/groundnut intercrop had higher plant which could be a result of its ability to fix atmospheric nitrogen more than other legumes Odiaka at al., 2025, this accession may be true due to its usage for a long time as a traditionally major legumes cultivated in Nigeria (Osun and Bala 2005). The F-LSD (Least Significant Differences at 5% Level of Probability) values confirmed that the observed differences due to both spacing and legume intercropping were statistically significant for plant height at all measured time points. These findings highlight the importance of optimizing both planting density and the choice of legume intercrop to enhance the vegetative growth and overall height of maize in intercropping systems in Makurdi.

Table 2. The Effect of maize/legumes as affected by spacing on Number of leaves grown at Makurdi during the 2024 Rainy Season

Treatment	Number of Leaves/Plant (WAS)				
	4	6	8	10	At harvest
Spacing (S)					
15	6.30	8.34	12.41	13.12	14.22
20	6.12	7.13	10.24	12.11	12.45
25	6.00	7.11	10.02	12.00	12.11
F-LSD (0.05)	0.11	0.14	0.14	0.15	0.19
Legumes (L)					
Control	4.12	6.12	8.23	10.34	12.11
Groundnut	6.78	8.45	11.45	12.78	14.33
Cowpea	5.12	8.13	10.34	11.99	12.89
F-LSD (0.05)	014	0.16	0.23	0.34	0.92
Interaction					
S X L	NS	NS	NS	NS	NS

Table 2 is the effect of maize/legume intercropping and different spacing regimes on the number of leaves per plant of maize grown during the 2024 rainy season in Makurdi. The experiment evaluated various spacing treatments (15, 20, and 25 units, likely cm or a similar measure) and different legume intercrops (Control, Groundnut, and Cowpea). The number of leaves per plant was measured at 4, 6, 8, and 10 weeks after sowing (WAS), and also at harvest. Results indicated that spacing significantly influenced the number of leaves per plant. The narrowest spacing of 15 units consistently resulted in the highest number of leaves per plant throughout the growth period and at harvest (14.77 leaves). As spacing increased to 20 and 25 units, there was a general decrease in the number of leaves, suggesting that denser planting within the tested range promoted greater leaf development. Legume intercrops also had a significant impact on the number of leaves per plant which is agreement with the finding of NRC (2000) which he attributed that to aggressiveness and competitive nature of the crops in consideration can lead to higher number of leave in plant. Higher number of leaves where recorded in groundnut/ maize inter crop when compared with cowpea/maize intercrop which could as the results of as complimentary effect on maize plant where the maize benefits more in the relation as reported by Ayub (2000). Groundnut intercropping consistently promoted the highest number of leaves per plant across all measurement periods and at harvest (14.33 leaves), significantly outperforming both Cowpea and the Control group. Cowpea intercropping also showed better leaf development than the Control, which exhibited the lowest number of leaves per plant. The F-LSD (Least Significant Differences at 5% Level of Probability) values confirmed that the observed differences due to both spacing and legume intercropping were statistically significant for the number of leaves per plant at all measured time points. These findings highlight the importance of optimizing both planting density and the choice of legume intercrop to enhance the vegetative growth and photosynthetic capacity of maize in intercropping systems in Makurdi (Iorlamen et al 2025)

Table 3. The Effect of maize/legumes inter crop as affected by spacing on Leaf Area grown at Makurdi during the 2024 Rainy Season

Treatment	Leaf Area (cm) (WAS)				
	4	6	8	10	At harvest
Spacing (S)					
15	125.12	245.34	362.41	380.12	395.22
20	120.28	201.13	308.24	344.11	350.12
25	112.11	200.11	255.12	290.10	331.12
F-LSD (0.05)	2.39	3.71	4.44	5.91	6.99
Legumes (L)					
Control	99.12	119.12	149.23	240.34	276.89

Groundnut	126.78	226.45	270.45	331.78	364.33
Cowpea	111.12	200.13	201.34	219.99	224.21
F-LSD (0.05)	2.44	3.84	4.23	5.34	6.12
Interaction					
S X L	NS	NS	NS	NS	NS

Table 3 is the effect of maize/legume intercropping and different spacing regimes on the leaf area of maize grown during the 2024 rainy season in Makurdi. The experiment evaluated various spacing treatments (15, 20, and 25 units, likely cm or a similar measure) and different legume intercrops (Control, Groundnut, and Cowpea). Leaf area was measured at 4, 6, 8, and 10 weeks after sowing (WAS), and also at harvest. Results indicated that spacing significantly influenced the leaf area of maize. The narrowest spacing of 15 units consistently resulted in the highest leaf area throughout the growth period and at harvest (395.22 cm2). As spacing increased to 20 and 25 units, there was a general decrease in leaf area, suggesting that denser planting within the tested range promoted greater leaf development. Legume intercrops also had a significant impact on maize leaf area This is in agreement with the finding Duncan (2000) who reported well-spaced plant utilize sunlight, moisture and nutrient and also to avoid mutual shedding which in return effect crop yield positively. Groundnut intercropping consistently promoted the largest leaf area across all measurement periods and at harvest (361.33 cm2), significantly outperforming both Cowpea and the Control group. Cowpea intercropping also showed better leaf area development than the Control, which exhibited the lowest leaf area values which could be as a result of competition and ability of the crop to fix atmospheric nitrogen more than other leguminous crop Bala (2005) and Madina 2023. The F-LSD (Least Significant Differences at 5% Level of Probability) values confirmed that the observed differences due to both spacing and legume intercropping were statistically significant for leaf area at all measured time points. These findings highlight the importance of optimizing both planting density and the choice of legume intercrop to enhance the photosynthetic capacity and overall vegetative growth of maize in intercropping systems in Makurdi.

Table 4. The Effect of maize/legumes inter crop as affected by spacing on stem Girth and Number of Pop roots of Maize grown Makurdi during the 2024 Rainy Season

Treatment	Stem Girth (cm) (WAS)				
	4	6	8	10	No.of poproots/plant
Spacing (S)					
15	3.11	5.11	5.41	4.62	4.22
20	3.12	4.13	4.24	4.61	3.42
25	3.28	4.43	4.12	5.45	3.12
F-LSD (0.05)	0.08	0.10	0.10	0.07	0.19
Legumes (L)					
Control	2.12	2.42	3.23	3.34	2.89
Groundnut	3.78	4.45	5.45	5.78	3.33
Cowpea	3.12	3.13	3.34	3.99	3.21
F-LSD (0.05)	0.04	0.06	0.07	0.10	0.18
Interaction					
S X L	NS	NS	NS	NS	NS

Table 4 is the effect of maize/legume intercropping and different spacing regimes on the stem girth and number of pop roots (likely referring to adventitious/prop roots or similar) of maize grown during the 2024 rainy season in Makurdi. The experiment evaluated various spacing treatments (15, 20, and 25 units, likely cm or a similar measure) and different legume intercrops (Control, Groundnut, and Cowpea). Stem girth was measured at 4, 6, 8, and 10 weeks after sowing (WAS), and the number of pop roots per plant was also recorded. Results indicated that spacing significantly influenced stem girth and the number of pop roots. A spacing of 25 units generally resulted in the largest stem girth at later stages (5.45 cm at 10 WAS), though 15 units showed slightly larger girth at 8 WAS. The number of pop roots per plant was highest at 15 units of spacing (4.22), decreasing with wider spacing, this collaborates with the work of Gargo (2000) who reported that closer spacing reduces land waste and increase assimilation of materials which in retune affect the stem girth. Legume intercrops also had a significant impact on both parameters. Groundnut intercropping consistently promoted the largest stem girth across all measurement periods, reaching 4.78 cm at 10 WAS, and also resulted in the highest number of pop roots per plant (3.31). Cowpea intercropping also showed better performance than the Control group, which exhibited the lowest values for both stem girth and pop roots which is in support of the finding of Hani el al. (2006) who reported bigger maize stem girth in maize/groundnut intercrop which he attributed it to ability of competitiveness, aggressiveness nitrogen fixation being more in groundnut than other leguminous crop .The F-LSD (Least Significant Differences at 5% Level of Probability) values confirmed that the observed differences due to both spacing and legume intercropping were statistically significant for all measured parameters. These findings suggest that both optimal planting density and the choice of legume intercrop are crucial for enhancing the vegetative development and root architecture of maize in intercropping systems in Makurdi. Iorlaman et al., 2025

Table 5. The Effect of maize/legumes inter crop as affected by spacing on Yield and Yield Related Parameters of Maize grown at Makurdi during the 2024 Rainy Season

Treatment	CW	NO.C	NO.R	No.G	S%	100GW	yield t/h
Spacing (S)							
15	913.11	2.11	12.41	64.62	84.22	456.91	5.67
20	823.12	1.13	10.24	54.61	75.42	401.21	4.23
25	773.28	1.03	9.12	50.45	73.12	320.11	3.65
F-LSD (0.05)	40.08	0.20	0.90	3.07	1.19	12.22	0.91
Legumes (L)							
Control	732.12	1.42	9.27	43.34	70.89	312.21	3.21
Groundnut	973.78	2.45	11.45	65.78	83.33	456.32	5.34
Cowpea	873.12	2.13	10.34	58.99	75.21	390.11	4.23
F-LSD (0.05)	50.04	0.16	0.07	4.10	1.18	`11.23	0.87
Interaction							
S X L	*	NS	NS	NS	*	*	*

CW= cob weigh, NO.C= number of cob, NO.R= number of rows, No.G= number of grains, S% = shelling percentage, 100GW= grain weight, t/h= tone per hectare.

Table 5 is the effect of maize/legume intercropping and different spacing regimes on the yield and yield-related parameters of maize grown during the 2024 rainy season in Makurdi. The experiment evaluated various spacing treatments (15, 20, and 25 units, likely cm or a similar measure) and different legume intercrops (Control, Groundnut, and Cowpea). Key parameters assessed included CW (likely cob weight or similar), NO.C (number of cobs), NO.R (number of rows), SVG (likely something related to vegetative growth), SG% (likely shelling percentage), 100GW (100-grain weight), and yield (t/h).Results indicated that spacing significantly influenced all measured parameters. A spacing of 15 units consistently resulted in the highest yield (5.67 t/h), 100-grain weight (456.91), and number of cobs (2.11). As spacing increased to 20 and 25 units, there was a general decrease in these parameters, suggesting that denser planting within the tested range was more beneficial for maize yield under intercropping conditions.Legume intercrops also had a significant impact on most parameters, except for the number of cobs. Groundnut intercropping demonstrated the highest yield (5.34 t/h) and 100-grain weight (456.37), outperforming both Cowpea and the Control group this finding is with agreement with Garba (2001) that closer spacing lead to higher number of plant per hectare which in return lead to higher yield when compare with wider spacing, Youdeowei *et al* (1999) reported that, closer spacing of crops is influential in crop yield. Cowpea intercropping also showed better performance than the Control in terms of yield (4.23 t/h vs. 3.21 t/h) which is in conformity with the findings of Kaleen (2000) who reported groundnut/maize inter crop having higher yield and yield related character which he attributed it to ability to fix atmospheric more than other legumes and also the competitive nature of the two crop in intercrop leading to general yield. The F-LSD (Least Significant Differences at 5% Level of Probability) values confirmed that the observed differences due to both spacing and legume intercropping were statistically significant for most parameters. These findings highlight the importance of optimizing both planting density and the choice of legume intercrop to enhance maize productivity in intercropping systems in Makurdi.

Table 6. Interaction Effect of maize/legumes inter crop as affected by spacing on some Yield and Yield Related Parameters of Maize grown at Makurdi during the 2024 Rainy Season.

Spacing	Legumes	CW	S%	100GW	yield t/h
15	Control	713.11	75.22	306.91	3.67
	Groundnut	923.12	85.42	401.21	5.23
	Cowpea	873.28	81.12	330.11	4.65
20	Control	692.12	70.89	312.21	3.21
	Groundnut	873.78	83.33	456.32	5.34
	Cowpea	773.12	78.21	390.11	4.23
25	Control	602.12	70.89	312.21	3.21
	Groundnut	773.78	82.33	456.32	5.04
	Cowpea	673.12	75.21	390.11	4.13
	F-LSD (0.05)	50.04	3.18	`10.13	0.57

CW= cob weigh, S% = shelling percentage, 100GW= grain weight, t/h= tone per hectare.

Table 6 is the interaction effect of maize/legume intercropping and different spacing regimes on key yield and yield-related parameters of maize grown during the 2024 rainy season in Makurdi. The experiment evaluated three spacing treatments (15, 20, and 25 units, likely cm or a similar measure) combined with three legume intercrops (Control, Groundnut, and Cowpea). Parameters assessed included cob weight (CW), shelling percentage(S%), 100-grain weight (100GW), and yield (t/h). Results indicated a significant interaction between spacing and legume intercrop for all measured parameters. At the narrowest spacing of 15 units, intercropping with Groundnut yielded the highest maize yield (5.23 t/h) and 100-grain weight (401.21), significantly outperforming both the Control and Cowpea intercrop at the same spacing. As spacing increased to 20 units, Groundnut intercrop continued to show the highest yield (5.34 t/h) and shelling percentage (83.33%). At the widest spacing of 25 units, Groundnut intercrop still maintained a strong performance in yield (5.04 t/h) and 100-grain weight (456.32), although the overall yield tended to decrease with wider spacing across all legume treatments this finding is in agreement with the report of Madina et al 2024 and Odiaka et al. 2025. The F-LSD (Least Significant Differences at 5% Level of Probability) values confirmed that the observed differences due to the interaction of spacing and legume intercropping were statistically significant for all parameters. These findings underscore the critical importance of selecting both an optimal planting density and a suitable legume intercrop combination to maximize maize productivity in intercropping systems in Makurdi. Specifically, Groundnut intercropping consistently demonstrated superior performance across various spacing, suggesting its strong compatibility with maize under these conditions

Conclusion

The finding came up with the following, All the parameters studies have significantly ($P \leq 0.05$) responded to the intercrop with groundnut/maize intercrop out performing followed by cowpea and 15cm intra row spacing was observed to perform higher in both growth character and grain yield followed by 20cm. Based on the result obtained it can be suggested that the inter crop of maize/ground nut at the spacing of 15cm will lead to optimum yield in Makurdi location .

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