*Journal of Agriculture and Food Sciences*
*Volume 21, Number 2, October 2023, p p 53 - 68*

# INFLUENCE OF DIFFERENT POPULATION DENSITIES OF BAMBARA GROUNDNUT INTERCROP AND WEEDING FREQUENCY ON MAIZE (*ZEA MAYS* L.) PERFORMANCE

**Nwagwu, F. A.*, Ekeruke, A. N., Umunnakwe, O. C. And Ukpong, O. E.**
*Department of Crop Science, Faculty of Agriculture, University of Calabar, Calabar, Nigeria*
*** Corresponding author's email**: salemgo2016@gmail.com

## ABSTRACT

*Effective weed management is essential for enhanced productivity of maize. A two-year field experiment was carried out at the Department of Crop Science Demonstration Farm, University of Calabar, Calabar, Nigeria (4.5-5.2$^0$ N, 8.0-8.3$^0$ E), in the 2019 and 2020 early planting seasons, to evaluate the influence of three population densities of Bambara groundnut [166,666 plants per hectare(B1), 100,000 plants per hectare (B2), 71,428 plants per hectare (B3)] and four hand weeding frequencies [weedy check (WC), one hand weeding (1HW), two hand weedings (2HW) and a weed free check (WFC)] on the performance of maize. The experiment consisted of three replications fitted into a Randomized Complete Block Design (RCBD). Data gathered on maize vegetative and yield characteristics were analysed using analysis of variance (ANOVA) procedures for RCBD (GenStat® statistical package, version 8.1). Significantly different means were compared at 5 % probability level using the Duncan's New Multiple Range Test (DNMRT). From the results, maize growth and yield performance were significantly ($P \leq 0.05$) affected by Bambara groundnut populations and the frequency of weeding. Leaving weeds unchecked all through the cultivation season hampered the vegetative and yield performance of maize, resulting in 47.54 % reduction in maize grain yield, compared with the weeded plots. Conclusively, intercropping maize with Bambara groundnut at 71,428 plants per hectare integrated with two hand weedings at 4 and 8 weeks after sowing (WAS), which optimized maize grain yield (3.87 t/ha on the two-year average) is recommended for farmers in the Calabar humid area and its environs.*

**Keywords**: Maize, Bambara groundnut, integrated weed management, intercropping, grain yield
https://dx.doi.org/10.4314/jafs.v21i2.4

## INTRODUCTION

Maize (*Zea mays* L.) is adapted to different agro-ecological environments of the globe (Erenstein, et al., 2022; Gbaraneh, 2018). Wheat, rice and maize are the three world most important cereal crops, in that order. The uses of maize are numerous, including human food, animal feed and as a raw material for different industrial commodities (Erenstein *et al.*, 2022). The United States of America, China, and Brazil are the highest three maize producers, accounting for about 79 % of the world's 717 million metric tonnes per annum (Mzyece *et al.*,

*Journal of Agriculture and Food Sciences*
*Volume 21, Number 2, October 2023, p p 53 - 68*

2023). In Africa, Nigeria ranks second to South Africa in maize production (FAO, 2022). The mean maize grain yield in Nigeria is however as low as 1.69 t/ha, contrasted with the world mean maize grain yield of 5.84 tonnes per hectare (USDA, 2019). The persisting low productivity of maize in Nigeria casts doubt on the sustainability of large scale maize production in the country. The factors contributing to low maize yield in Nigeria have been identified to include mainly, poor soil fertility, poor cultural practices and poor weed management (Omolaiye & Imoloame, 2017).

Uncontrolled weed growth accounts for 20–60 % grain yield reduction in maize (Agricdemy, 2020). In southeast Nigeria, full-season weed competition caused a grain yield loss of 53-71% compared to weeded treatments (Nwagwu et al., 2020). At least two hand weedings within the first six weeks after sowing are required to reduce weed competition and ensure enhanced maize yield in Nigeria (Amosun et al., 2016). However, the drudgery, high cost of labour and delay in initiation of hand weeding has resulted in shifts to integrating manual weeding with other eco-friendly, cost-effective weed management strategies, such as intercropping with compatible smother and food crops (Tijani-Eniola et al., 2003; Nwagwu & Udo, 2019; Michael et al., 2021). In addition, when cereal and grain legumes such as cowpea, soybean and groundnut are intercropped, soil fertility is improved because significant amount of nitrogen (80–350 kg /hectare) accumulate in the soil by the action of symbiotic bacteria inhabiting the root nodules of the legumes (Mobasser et al., 2014).

Reports indicated increased yield of maize intercropped with legumes such as Bambara groundnut (Godwin and Egbe, 2014), groundnut (Alom et al., 2009) and mungbean (Ogbueghu et al., 2018). Conversely, decrease in maize yield under intercrop has been reported (Huang, Liu, and Li, 2019; Shumba, Dhilwayo, and Mukoko, 1990). In another development, intercropping maize with soybean enhanced some yield characteristics of maize, including number of spikes/plant, ear grain number and 1000-grain weight; but grain yield/ha was depressed (Wei *et al.*, 2022). Intercropping ensures that the available growth resources are used more efficiently, thereby guaranteeing higher productivity compared with each sole crop of the mixture (Ibeawuchi *et al.*, 2007; Kumar et al., 2020). However, crop cultivars, production practices, competitiveness of the crops and the component crop densities can affect the performance of crops in intercropping systems (Maitraet al., 2021).

The maize crop is sensitive to the population density of an associated intercrop. Maize grain yield and yield components were reduced by intercropping with faba bean (Nurgi et al., 2023), whereas the highest density of pigeon pea (250,000 plants/ha) resulted in highest maize grain yield in an intercropping system (Merkeb, 2016). Also, peanut at 135,508 plants/ha intercropped with maize enhanced the yield of maize compared with sole-cropped maize (Zhao, Dong, and Han, 2022). Higher maize grain yield was attained at 25 % than at 50 % and 75 % of the recommended sole crop populations each of faba bean (Nurgi *et al.*, 2023) and soybean (Dangia et al., 2021) intercropped with maize. When maize is grown at the recommended sole crop population in additive intercropping, an adequate population of the intercrop must be determined to avoid excessive inter-specific competition that can adversely affect maize yield as the main or base crop (Maitra *et al.*, 2020). At the same time, the intercrop occupies niches which would have been available for weeds to thrive between the usually wide rows of maize, especially at the early slow growth stage of the crop.

Bambara groundnut, a neglected rich legume crop of West Africa (Effa et al., 2016), is usually grown by smallholder farmers in sole or intercrop with other food crops, including maize. However, there is a dearth of information on the sowing density of Bambara groundnut that is compatible with maize. As a broad objective, the present study set out to determine the performance of maize under Bambara groundnut intercrop integrated with different hand weeding regimes. Specifically, the research sought to establish the optimum population density of Bambara groundnut and hand weeding regime that would enhance the productivity of maize in a tropical humid agro-ecology.

## MATERIALS AND METHODS

### The study site

The two-year field experiment was conducted at the Department of Crop Science Demonstration Farm,University of Calabar, Calabar, Nigeria, in the early planting seasons (April–August) of 2019 and 2020. Calabar lies on the south-eastern rainforest agro-ecological zone of Nigeria, within latitude 4.5$^{o}$– 5.2$^{o}$ North and longitude 3.0$^{o}$– 8.6$^{o}$ East of the equator, with an elevation of about 39 m (Nwagwu, Manthy, Michael, Obok, and Ibrahim, 2022). Calabar is a coastal town depicted by two well-defined tropical moist climates – the rainy (March–November) and dry (November - February) seasons. A short break in rainfall in August normally separates the longer (early) from the shorter (late) cropping seasons. A 21-year (1991-2021) average climatic data of Calabar indicates rainfall of 3,306 mm/annum, temperature of 25.8 $^{0}$C, and humidity of 87% (Climate Data, 2023). The land was under a short fallow of about 12 months. Prior to land preparation, the predominant weeds on the land were *Chromolaena odorata* (L.) R. M. King & H. Robinson, *Panicum maximum* Jacq, *Commelina benghalensis* L., *Aspilia africana* (Pers.) C.D. Adams, *Calopogonium mucunoides* Desv., *Axonopus compressus* (Sw.) P. Beauv and *Cyperus esculentus* L.

### Land preparation and Treatments

The fallow vegetation was cleared with machete and the debris packed. The gross experimental area and treatment plots were mapped out according to the specified design. Raised seedbeds of 0.3 m high with fine tilth and levelled tops were made using spade. The dimensions of each treatment plot were 3 m x 2 m, with 1 m alleys left between experimental units and between blocks.

The experiment consisted of three replications fitted into a Randomized Complete Block Design. The 10 treatments were: Maize + Bambara groundnut at 166,666 stands/ha + one hand weeding

*Journal of Agriculture and Food Sciences*
*Volume 21, Number 2, October 2023, p p 53 - 68*

(M+B1+1HW); Maize + Bambara groundnut at 166,666 stands/ha + two hand weedings (M+B1+2HW); Maize + Bambara groundnut at 100,000 stands/ha + one hand weeding (M+ B2+ 1HW); Maize + Bambara groundnut at 100,000 stands/ha + two hand weedings (M+B2+2HW); Maize + Bambara groundnut at 71,428 stands/ha + one hand weeding (M+B3+1HW); Maize + Bambara groundnut at 71,428 stands/ha + two hand weedings (M+B3+2HW); Sole maize + one hand weeding (M+1HW); Sole maize + two hand weedings (M+2HW); Sole maize + weed free check (M+WFC); Sole maize + weedy check (M+WC). The first and second hand weddings were carried out at 4 WAS and 8 WAS respectively in designated plots using hand-held hoe.

**Planting materials and weed control**

An improved maize variety SAMMAZ-14, sourced from the State Agricultural Development Programme Headquarters, Calabar, Cross River State, Nigeria, was used for the study. The maize was manually sown at 75 cm between rows and 25 cm within rows. Two seeds were sown/stand and thinned to one at 2 WAS, to maintain a density of 53,333 plants/hectare. The Bambara groundnut (creamy white landrace, obtained from local farmers in Ogoja, Cross River State, Nigeria) was sown at three intra-row distances (15 cm, 25 cm, and 35 cm) x 40 cm inter-rows, giving densities of 166,666 plants/ha, 100,000 plants/ha, and 71,428 plants/ha, in that order.

**Data collection and statistical analyses**

An observational unit (225 cm × 25 cm) was earmarked within each treatment plot for the growth and yield assessment of maize. Eight (8) maize plants were randomly selected and tagged within each observational unit and the mean values obtained for each measured parameter were recorded. Growth data (plant height, stem girth, number of leaves, leaf area) were determined at 5 and 9 WAS, while the yield data (cob length, cob girth, seeds/cob) and grain yield estimates (t/ha) were assessed at crop harvest. The plant height, stem girth, cob length and cob girth were determined using flexible measuring tapes graduated in centimeter (cm), while visual counts were taken of the leaves/plant and seeds/cob. The leaf area (LA) was determined using the linear measurement method proposed by Musa and Usman (2016): LA = Lamina length x maximum width x 0.75 (correction factor). The leaf area index (LAI)

was subsequently determined with the formula: $\frac{\text{Total leaf area (cm}^2\text{)}}{\text{Plant spacing (cm}^2\text{)}}$

The grain yield was determined after drying the shelled maize grains to 12 % moisture content. The data obtained were analysed with GenStat® statistical package version 8.1, while the Duncan's New Multiple Range Test (DNMRT) was employed to compare the differences among means at 5% probability level.

## RESULTS

### Plant height and stem girth

Table 1 shows the effects of Bambara groundnut populations and the frequency of weeding on maize plant height and stem girth. Generally, maize plant height and stem girth increased over time, with statistical ($P \leq 0.05$) differences amid treatment means. At both periods of sampling in both years, significantly tallest maize plants were observed in M+B3+2HW, which tended to be statistically ($P \geq 0.05$) similar to sole maize weeded plots, while the shortest maize plants were obtained from M+WC (weedy check). However, the M+WC was statistically similar to M+B1+1HW at 5 WAS in both years and all intercropped plots except M+B3+2HW in maize plant height at 9 WAS in 2019. Similarly, M+B3+2HW produced the thickest maize stems which were statistically similar to all weeded sole maize plots in both years except M+1HW and M+WFC at 9 AWS in 2020. The thinnest maize stems were observed on M+WC plots, with statistical similarity to M+B1+1HW at all sampling periods in both years.

### Number of leaves per plant and leaf area index of maize

The effects of Bambara groundnut population density and frequency of weeding on the number of leaves/plant and leaf area index of maize are as presented (Table 2). The results indicated statistical ($P \leq 0.05$) variations in the number of leaves per plant and leaf area index across treatments over the sampling period. Generally, M+B3+2HW produced the highest number of leaves/maize plant, though statistically ($P \geq 0.05$) not superior to M+2HW and M+WFC at 9 WAS in 2019 and 5 WAS in 2020. The M+WC produced significantly the least number of leaves per maize plant, statistically similar to M+B1+1HW and M+B1+2HW at all sampling periods.

The LAI followed a comparable pattern as the number of leaves/plant. The highest LAI values were obtained from M+B3+2HW which, however, were statistically ($P \geq 0.05$) similar to M+2HW and M+WFC. The lowest LAI of maize was obtained from M+WC and M+B1+1HW in 2019 and 2020, respectively, with statistical similarity between both treatments except at 9 WAS in 2020.

### Yield components and grain yield

Table 3 shows the effect of integrating different population densities of Bambara groundnut with hand weeding frequencies on maize yield components and grain yield. The M+B3+2HW and M+WFC treatments yielded significantly ($P \leq 0.05$) the longest cobs, measuring 14.56 cm and 14.05 cm, respectively, on the two-year average. The weedy check (WC) plots yielded the shortest cobs (7.85 cm), followed by M+B1+1HW (9.09 cm), on the two-year average. Compared with sole maize weeded plots (M+1HW, M+2HW and M+WFC), cob length was statistically shorter ($P \leq 0.05$) under intercropping, in exception of M+B3+2HW. Cob length was statistically ($P \geq 0.05$) similar between the weedy check (M+WC) and M+B1+1HW. Significant ($P \geq 0.05$) differences were not found in cob girth among sole maize weeded plots and maize plots intercropped with Bambara groundnut at 100,000 and 71,428 stands/ha in the first year of cropping (2019). In the second cropping year (2020), maize cob girth was not significantly ($P \geq 0.05$) affected by intercropping and weeding frequency except the weedy control plots which produced the thinnest cobs. Averaged over both cropping years, maximal cob girth was obtained from M+B3+2HW plots, while the M+WC treatment had the least value.

The M+B3+2HW yielded the heaviest cobs (average: 153.61 g/cob), and next, the weed free sole maize (WFC), (average: 128.89 g/cob), while the weedy control (WC) produced the lightest cobs, (average: 59.17 g/cob), then, M+B1+1HW (79.34 g/cob), over the two years. Similarly, M+B3+2HW produced the maximal number of seeds/cob (average: 378.00), followed by M+2HW (average: 339.28), while the minimum values were obtained from the weedy check (mean: 149.34 seeds/cob), followed by M+B1+1HW (mean: 212.53 seeds/cob). Highest grain yields (3.73 tonnes per hectare and 4.01 tonnes per hectare in 2019 and 2020, respectively) were obtained from maize intercropped with Bambara groundnut at 71,428 stands/ha and weeded twice (M+B3+2HW). The M+WC (weedy check) had the least grain yields of 1.44 tonnes per hectare and 1.53 tonnes per hectare, in 2019 and 2020, respectively.

## DISCUSSION

### Vegetative performance of maize

The better growth performance of maize in treatments with Bambara groundnut intercrop at 71,428 stands/ha and two hand-weedings (M+B3+2HW) indicates minimized competition between the two different crops and hence, compatibility of maize with that population density of Bambara groundnut. This population of Bambara groundnut (71,428 stands/ha) corresponds with 43 % of the recommended sole crop rate of Bambara groundnut (166,666 plants/ha). There must have been better resource allocation to the maize crop at this 43 % intercrop population of Bambara groundnut, which could have been due to less inter-specific competition between the maize and the Bambara groundnut plants. This finding is in agreement with Jamshidi et al. (2013). These researchers noted that weeds were better controlled, and the vegetative performance of maize was not negatively impacted, when maize was intercropped with optimum density/spacing of legumes with short life span such as cowpea.

On the other hand, Bambara groundnut intercropped at 100 % of the recommended sole crop population (166,666plants/ha) or at 60 % (100,000 stands/ha) significantly depressed the growth attributes of maize compared with 43 % of the recommended population density of Bambara groundnut (71,428 plants/ha) attained at the intra-row spacing of 35 cm apart. This is attributable to severe competition between the maize and Bambara groundnut due to higher populations of the Bambara groundnut at closer intra-rows (15 and 25 cm). At these population densities (166,666 and 100,000 stands/ha) of Bambara groundnut, the demand for growth factors especially nutrients and water must have increased beyond the amounts readily available in the soil to satisfy the combined demands of the maize and Bambara groundnut crops, thereby resulting in competition and subsequent decline in maize growth performance in these plots. In accordance with this finding, Ogbueghu et al. (2018) reported decreased maize plant height when maize was intercropped with mungbean. According to Innis (1997), it is common knowledge to traditional farmers that, intercropping could depress the performance of one or more of the crops in the mixture due to inter-specific competition. Notwithstanding, the findings of the present study demonstrate that, weeds, if not adequately managed, also decrease crop growth and yield performance, as observed in the sole maize plots left weedy or weeded once. Thus, it seems preferable for local farmers to intercrop, rather than monocrop, as weeds would be better suppressed while compensatory yield is obtained from the companion crop.

The comparable growth performance of maize in sole plots of maize hand weeded two times to the ones kept weed free indicates that two hand weedings were sufficient to suppress weeds effectively in maize field in the Calabar humid zone. Thus, at least two well-timed hand weedings are necessary for enhanced maize vegetative growth, which supports the recommendations of Chicouene (2007). Further hand-weeding after the second could be counter-productive and uneconomical.

Intercropping maize with the highest population density of Bambara groundnut (166,666plants/ha) attained in the narrowest (15cm) intra-rows of Bambara groundnut significantly reduced the vegetative attributes of maize regardless of weeding frequency. This signals severe competition between the intercrops at that Bambara groundnut spacing and population. This finding collaborates the report of Ogbueghu et al. (2018), who observed variations in maize vegetative performance when interplanted with mungbean at different populations (125, 000 -250,000 plants/ha).

**Yield and yield components of maize**

Appropriate intercrop combination not only helps in weed suppression, but also enhances efficient utilization of resources and crop yield (Kadziuliene *et al*., 2009). In line with this, the higher maize grain yield attained in treatments interplanted with Bambara groundnut at 35 cm within the row and integrated with two hand weedings (M+B3+2HW), suggests the compatibility and complementarity of this intercrop combination at the specified population and weeding frequency. Integrating this low density of Bambara groundnut (71,428 plants/ha, equivalent to 43 % of its recommended population) with adequate (2 hand weedings) could have minimized inter-specific competition and enhanced the maize crop's access to more nutrients and water, thereby optimizing the vegetative and consequently grain yield of maize. Furthermore, maize might have benefited from possible increase in soil fertility due to nitrogen fixation by symbiotic bacteria in the root nodules of the leguminous Bambara groundnut. This observation is consistent with that of Ogbueghu et al. (2018). These researchers reported statistically higher maize grain yield when intercropped with optimum mungbean population, and ascribed this to the wide root system of maize and increased available nutrients in the soil due to nitrogen fixed by mungbean. Similarly, higher maize grain yield was attained at 25 % than at 50 % and 75 % of the recommended sole

*Journal of Agriculture and Food Sciences*
*Volume 21, Number 2, October 2023, p p* 53 - 68

crop populations each of faba bean (Nurgi *et al*., 2023) and soybean (Dangia et al., 2021) intercropped with maize.

The significant reduction in yield and yield characteristics of maize in plots intercropped with Bambara groundnut at 15 cm and 25 cm (full and 60 % of the population density of Bambara groundnut, respectively), could be attributed to superior competition from the component crop at high population density. Similarly, maize grain yield and yield components were reduced by intercropping with more than 25 % of the recommended sole faba bean population (Nurgi *et al.*, 2023). Mobasser *et al.* (2014) noted that intercrop species, crop cultivars, land and crop management strategies, as well as competitiveness of the crops contribute to the success or otherwise of an intercropping system. The finding of the present study reveals that the maize crop is sensitive to the population density of an intercrop. Farmers should therefore carefully strike a balance between intercropping for weed control and optimizing the yield of the maize crop, especially where maize is the primary crop of interest, through choice of an appropriate population of the component crop.

The similarity in the yield of weeded maize plots irrespective the hand weeding frequency suggests that, a minimum of one hand weeding is required to prevent economic yield losses due to weed interference, whereas, weeding more than twice is considered superfluous. This finding agrees with the recommendations of Omolaiye and Imolaeme (2017) and Amosun *et al*. (2016) that, two hand weedings are required in maize field to optimize the crop yield. The depressed maize grain yield from the weedy check plot might be due to reduction in the vegetative performance of maize as a result of unchecked weed competition. The season-long weed competition with maize resulted in depressed vegetative performance and less assimilate production, culminating in reduced grain yield of maize.

The present observation collaborates that of Nwagwu *et al*. (2020), who obtained 53.57 % reduction in maize grain yield due to uncontrolled weed growth in the same study area. Earlier, Akobundu and Ekeleme (2000) recorded yield reduction of 51 to 100 % in maize elsewhere in Western Nigeria, while Page *et al.* (2012) observed 65 % reduction in maize grain yield due to delayed weeding. These yield losses due to uncontrolled weed growth or inadequate weed management underpin the fact that farmers typically regard weeds as their enemies which must be effectively managed to avert economic yield losses in their crops.

The superior maize grain yield of 1.49 – 3.87 t/ha from this study, relative to that of Nwagwu and Effa (2018), (1.25-2.31 t/ha), on the two year-average in the same study area, could be ascribed to factors such higher yield potential of the present maize variety, cultural practices and fluctuating environmental conditions due to the changing climate.

## CONCLUSION

The findings of this study demonstrate that the growth and yield of maize could be sustained by integrating an appropriate population of Bambara groundnut intercrop with an adequate hand

*Journal of Agriculture and Food Sciences*
*Volume 21, Number 2, October 2023, p p 53 - 68*

weeding regime. Conclusively, intercropping maize with Bambara groundnut at 35 cm x 40 cm (71,428 plants/ha) integrated with two hand weedings enhanced maize vegetative performance and optimized maize grain yield, and is therefore recommended for farmers in the tropical humid agro-ecology. The yield from the Bambara groundnut would be an additional incentive to the farmers.

*Journal of Agriculture and Food Sciences*
*Volume 21, Number 2, October 2023, p p 53 - 68*

## REFERENCES

Agricdemy (2020). Maize farming in Nigeria. Retrieved 20 February, 2023, fromhttps:/agricdemy.com/post/maize-farming-nigeria.

Akobundu, I. O. & Ekeleme, F. E. (2000). Effect of method of *Imperata cylindrica*L. management on maize grain yield in the derived savannah of south western Nigeria. *Weed Research*, 40: 335-341.

Alom, M. S., Paul, N. K. & Quayyum, M. A. (2009). Performance of different hybrid maize (*Zea mays* L.) varieties under intercropping system with groundnut (*Arachis hypogeae* L.) *Bangladesh Journal of Agronomy Research*, 34(94): 585-595.

Amosun, J. O., Ayeni, A. O., Tijani-Eniola, H. & Majek, B. A. (2016). Influence of tillage on herbicide efficacy in maize in southwestern Nigeria. *Nigerian Journal of Weed Science*, 29: 41-55.

Chicouene, D. (2007). Mechanical destruction of weeds. A review: *Agronomy Sustenance and Development*, 27:19-27.

Climate Data (2023). Calabar Climate. Available online athttps://en.climate-data.org/africa/nigeria/cross-river/calabar-3023/#climate-graph.

Dangia, N., Jalata, Z., & Daba, G. (2021). Effects of varieties and population of soybeanintercropped maize on yield and yield components of associated crops. *Journal of Plant Sciences*, 9(4): 128-138.

Effa, E. B., Nwagwu, F. A., Osai, E. O. & Shiyam, J. O. (2016). Growth and yield response of Bambara groundnut (*Vigna subterranea* (L.) Verdc) to varying densities and Phosphate fertilizer rates in Calabar, South Eastern Nigeria. *Journal of Biology, Agriculture and Healthcare* 6(16): 14-20.

Erenstein, O., Jaleta, M., Sonder, K., Mottaleb, K. & Prasanna, B. M. (2022). Global maizeproduction, consumption and trade: trends and R & D implications. *Food Security*, 14:1295-1319. https://doi.org/10.1007/s12571-022-01288-7.

Godwin, A. A. & Egbe, O. M. (2014). Bambara groundnut/maize intercropping: Effects of planting densities in Southern Guinea Savanna of Nigeria. African Journal of Agricultural Research, 9(4): 479-486.

Gbaraneh, L. D. (2018). Growth and yield performances of maize/Egusi melon intercrop under different planting period on the Ultisols of Port Harcourt, Nigeria. *International Journal of Agriculture and Earth Science*, 4(4): 29-37.

Food and Agriculture Organization (FAO). (2022). *Crop Prospects and Food Situation* – Quarterly Global Report No. 4, December 2022. Rome. https://doi.org/10.4060/cc3233en

Huang, C., Liu, Q. & Li, X. (2019). Effect of intercropping on maize grain yield and yieldcomponents. *Journal of Integrative Agriculture*, 18(8):1690-1700.

Ibeawuchi I. I., Dialoke, S. A., Ogbede, K. O., Ihejirika, G. O., Nwokeji, E. M., Chigbundu, I. N., Adikuru, N. C. & Oyibo, P. O. (2007). Influence of yam/cassava based intercropping systems with legumes in weed suppression and disease/pest incidence reduction**.** *Journal of American Science*, 3, (1), 49-59.

Innis, W. H. (1997). Intercropping and the scientific basis of traditional agriculture. IntermediateTech. Publ. Ltd. London. https://doi.org/10.3362/9781780446158.

Jamshidi, K., Yousefi, A. R. & Oveisi, M. (2013). Effect of cowpea (*Vigna ungluiculata*).Intercropping on weed biomass and maize (*Zea mays*) yield, *New Zealand Journal of Crop and Horticultural Science*, 41(4): 180-188.

Kadziuliene, Z., Sarunaite, L., Dereikyte, I., Maiksteniene, S., Arlauskiene, A., Masilionyte, L., Cenuleviciene, R. & Zekaite, V. (2009). Quantitative effects of pea and spring cereals intercrop in the organic farming systems. *Agronomy Research*, 7(2): 606- 611.

Kumar, J. S., Nedunchezhiyan, M. & Sunitha S. (2020). Weed control approaches for tropical tuber crops - A review. *International Journal of Vegetable Science*, 27: 1-17. *https://doi.org/*10.1080/19315260.2020.1839156.

Maitra, S., Shankar, T., & Banerjee, P. (2020). Potential and Advantages of Maize-Legume Intercropping System. *Maize – Production and Use*. doi: 10.5772/intechopen.91722

Maitra, S., Hossain, A., Brestic, M., Skalicky, M., Ondrisik, P., Guitari, H., Brahmachari, K., Shankar, T. Bhadra, P., Palai, J., Jena, J., Bhattacharya, U., Duvvada, S., Lalichetti, S. & Sairam, M. (2021). Intercropping- a low input agricultural strategy for food and environmental security. *Agronomy*, 11, 343. http://doi.org/10.3390/agronomy 1102343.

Merkeb, F. (2016). Effect of population density and spatial arrangements of pigeon pea (*Cajanus cajan* L. Millsp) on productivity of maize-pigeon pea Intercropping. *World Scientific News*, 53(3): 216-229.

Michael, G. C. Tijani-Eniola, H., Nwagwu, F. A. & Olaniyi O. W. (2021). Weed floradynamics in maize (*Zea mays* L.) field as influenced by cover crop types and planting densities at Jalingo, Northeast, Nigeria. *International Journal of Plant & Soil Science, 33(19): 1-16.*

Mobasser, H. R., Vazirimehr, M. R., &Khashayar, R. K. (2014). Effect of intercropping on resources use, weed management and forage quality. *International Journal of Plant, Animal and Environmental Science,* 4: 706-713.

Mzyece, A., Shanoyan, A., Amanor-Boadu, V., Zereyesus, Y. A., Ross, K. & Ng'Ombe, J. N. (2023). How does who-you-sell-to affect your extent of market participation? evidence from smallholder maize farmers in Northern Ghana, Cogent Economics & Finance, 11:1, 2184062, DOI: 10.1080/23322039.2023.2184062.

Musa, U. T. & Hassan, U. T. (2016). Leaf area determination for maize (*Zea mays* L), okra (*Abelmoschusesculentus* L.) and cowpea (*Vignaunguiculata* L.) crops using linear measurements. *Journal of Biology, Agriculture and Healthcare,* 6(4): 103-111.

Nurgi, N., Tana, T., Dechassa, N., Alemayehu, Y.,& Tesso, B. (2023). Effects of planting density and variety on productivity of maize-faba bean intercropping system, *Heliyon*, 9(1) 2023, e12967.https://doi.org/10.1016/j.heliyon.2023.e12967.

Nwagwu, F. Manthy, A., Michael, G., Obok E. & Ibrahim, A. (2022). Weed control and cowpea yield under different tillage systems *Journal of Applied Biology & Biotechnology*, 10(4): 110-115. https://doi.org/10.7324/JABB.2022.100415.

Nwagwu, F., Okon, A. & Udoidiok, I. (2020). Weed suppressive effects of different organic mulches and their combinations in maize (*Zea mays* L.) field. *Discovery Agriculture*, 6(15): 18-94.

Nwagwu, F. A. & Effa, E. B. (2018). Maize response to varying intra-row spacing and types of nutrient sources. *Nigerian Journal of Crop Science,* 5(2): 12-17.

Nwagwu, F. A. & Udo, I. A. (2019). Effects of integrated weed management on tuber yieldof cassava (*Manihot esculenta* Crantz). *Journal of Research in Weed Science*, 2(1):1-15. https://doi.org/10.26655/JRWEEDSCI.2019.1.1

Ogbueghu, K. O., Agugo, B. C. & Onyeonagu, C. C. (2018). Effect of mungbean population on the productivity of mungbean (*Vigna radiata* L. Wilczek) maize (*Zea mays* L.) intercropping system in Umudike, Nigeria. *Nigerian Journal of Crop Science*, 5(2): 31-45.

Omolaiye, J. O. & Imoloame, E. O. (2017). Weed infestation, growth and yield of maize (*Zea mays* L.) as influenced by periods of weed interference. *Advanced Crop Science Technology*, 5: 267-273.

Page, E. R., Cerrudo, D., Westra, P., Loux, M., Smith, K., Foresman, C., Wright, H. & Swanton, C. J. (2012). Why early season weed control is important in maize.*Weed Science*, 60: 423-430.

Shumba, E. M., Dhilwayo, H. H., & Mukoko, O. Z. (1990). The potential of maize cowpea intercropping in low rainfall areas of Zimbabwe. Zum. *International Journal of Agricultural Research,* 28: 33-38.

Tijani-Eniola, H., Ndaeyo, N. U. Aiyelari O. P. &Nwagwu, F. A**.** (2003). Influence of crop density and delayed weeding on the performance (*Glycine max* (L). Merrill). *Nigerian Journal of Horticultural Science, 8(1)*: 53-60.

Udo, E. J., Ibia, T.O., Ogunwale, J. A., Ano, A. O. & Esu, I. E. (2009). Manual of soil, plant and water analyses. Lagos: Sibon Books Ltd., p. 183.

USDA (United States Department of Agriculture) (2019). World agricultural production. USDA Foreign Agricultural Service Circular Series WAP 2-19. Retrieved online at http://www.index mundi on March 15, 2019.

Wei, W., Liu, T., Shen, L., Wang, X., Zhang, S., & Zhang, W. (2022). Effect of Maize (Zeal mays) and Soybean (Glycine max) Intercropping on Yield and Root Development in Xinjiang, China. *Agriculture, 12*(7), 996. https://doi.org/10.3390/agriculture12070996

Zhao, X., Dong, Q., Han, Y., Zhang, K., Shi, X., Yang, X., Yuan, Y., Zhou, D., Wang, K., Wang, X., Jiang, C., Liu, X., Zhang, H., Zhang, Z., & Yu, H. (2022). Maize/peanut intercropping improves nutrient uptake of side-row maize and system microbial community diversity. *BMC Microbiology*, *22*(1). https://doi.org/10.1186/s12866-021-02425-6

*Journal of Agriculture and Food Sciences*
*Volume 21, Number 2, October 2023, p p 53 - 68*

**APPENDICES**

**Table 1: Response of maize plant height and stem girth to Bambara groundnut population and weeding frequency**

| | Maize plant height (cm) | | | | Maize stem girth (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | 2019 | | 2020 | | 2019 | | 2020 | |
| Treatments | 5 WAS | 9 WAS | 5 WAS | 9 WAS | 5 WAS | 9 WAS | 5 WAS | 9 WAS |
| M+B1+1HW | 60.17cd | 127.25bc | 95.22f | 144.11e | 3.66b | 4.78d | 4.02c | 4.78e |
| M+B1+2HW | 54.50d | 111.50c | 118.33bc | 153.66d | 3.88b | 4.50d | 4.68b | 4.96de |
| M+B2+1HW | 73.42ab | 125.00bc | 106.78de | 150.45de | 4.22ab | 5.20cd | 4.77b | 5.35d |
| M+B2+2HW | 63.92bc | 124.83bc | 103.22e | 154.33d | 3.75b | 5.05cd | 4.90b | 5.13de |
| M+B3+1HW | 65.00b | 126.42bc | 113.11cd | 172.22c | 3.94b | 5.30bc | 5.03b | 5.83c |
| M+B3+2HW | 76.50a | 163.50a | 136.44a | 199.22a | 5.02a | 6.43a | 6.12a | 7.05a |
| M+WC | 53.42d | 110.42c | 93.45f | 129.22f | 3.60b | 4.39d | 4.06c | 4.74e |
| M+1HW | 61.42bc | 131.42ab | 132.78a | 188.44b | 4.08ab | 6.08ab | 5.73a | 6.62b |
| M+2HW | 72.25ab | 151.00a | 124.46b | 194.00ab | 4.35ab | 6.40a | 5.70a | 6.70ab |
| M+WFC | 71.92ab | 161.42ab | 132.78a | 196.11a | 4.24ab | 6.42a | 5.97a | 6.64b |
| SE | 3.37 | 4.22 | 2.92 | 4.67 | 0.56 | 0.52 | 0.14 | 0.17 |
| CV (%) | 5.2 | 3.2 | 13.58 | 14.92 | 13.7 | 8.9 | 14.77 | 15.68 |

Means with the same letters in a column are not significantly different (P=0.05) (DNMRT). WAS, weeks after sowing; M, Maize; B1, Bambara groundnut at 166,666 stands/ha; B2, Bambara groundnut at 100,000 stands/ha; B3, Bambara groundnut at 71,428 stands/ha; WC, No weeding; 1HW, 1 Hand weeding; 2HW, 2 Hand weedings; WFC, Weed-free check.

**Table 2: Influence of Bambara groundnut population and weeding frequency on number of leaves per maize plant and leaf area index**

| Treatments | Number of leaves per plant | | | | Leaf area index | | | |
|---|---|---|---|---|---|---|---|---|
| | 2019 | | 2020 | | 2019 | | 2020 | |
| | 5 WAS | 9 WAS | 5 WAS | 9 WAS | 5 WAS | 9 WAS | 5 WAS | 9 WAS |
| M+B1+1HW | 5.42c | 8.92cd | 5.67c | 8.78ef | 0.07d | 0.15d | 0.11d | 0.16e |
| M+B1+2HW | 5.33c | 8.90cd | 5.78c | 9.11ef | 0.07d | 0.15d | 0.16b | 0.18d |
| M+B2+1HW | 6.08b | 9.58bc | 6.44b | 10.00cd | 0.10a | 0.17c | 0.14c | 0.18d |
| M+B2+2HW | 5.67c | 8.75d | 6.44b | 9.56cde | 0.09b | 0.16c | 0.15c | 0.18d |
| M+B3+1HW | 5.50c | 9.25bc | 6.78b | 9.44de | 0.08c | 0.18bc | 0.16b | 0.21c |
| M+B3+2HW | 7.08a | 11.33a | 7.56a | 11.89a | 0.10a | 0.20a | 0.21a | 0.29a |
| M+WC | 5.08c | 8.67d | 5.11c | 8.56f | 0.07d | 0.15d | 0.12d | 0.18d |
| M+1HW | 5.75c | 9.83b | 6.89b | 10.33bc | 0.08c | 0.15d | 0.20a | 0.26b |
| M+2HW | 6.17b | 11.33a | 7.56a | 10.89b | 0.10a | 0.20a | 0.22a | 0.29a |
| M+WFC | 6.00b | 11.25a | 7.56a | 11.11b | 0.10a | 0.19a | 0.21a | 0.30a |
| SE | 0.62 | 0.71 | 0.15 | 0.20 | 0.01 | 0.10 | 0.01 | 0.01 |
| CV (%) | 10.6 | 7.2 | 12.35 | 11.06 | 34.01 | 20.89 | 5.2 | 5.0 |

Means with the same letters in a column are not significantly different (P=0.05) (DNMRT). WAS, weeks after sowing; M, Maize; B1, Bambara groundnut at 166,666 stands/ha; B2, Bambara groundnut at 100,000 stands/ha; B3, Bambara groundnut at 71,428 stands/ha; WC, No weeding; 1HW, 1 Hand weeding; 2HW, 2 Hand weedings; WFC, Weed-free check.

*Journal of Agriculture and Food Sciences*
*Volume 21, Number 2, October 2023, p p 53 - 68*



**Table 3: Effect of Bambara groundnut population and weeding frequency on yield variables and grain yield of maize**

| Treatment | Cob length (cm) | | Cob girth (cm) | | Cob weight (g) | | Seeds per cob | | Grain yield (t/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| M+B1+1HW | 9.00de | 9.17ef | 11.30bc | 13.28ab | 78.67f | 80.00f | 209.50f | 215.55g | 1.78ef | 2.07de |
| M+B1+2HW | 9.80cd | 9.74de | 11.23bc | 13.93ab | 83.00ef | 85.55ef | 239.00e | 265.00f | 2.11de | 2.52cd |
| M+B2+1HW | 10.33bcd | 10.39cde | 11.62abc | 14.11a | 90.00e | 96.66de | 252.67d | 282.89e | 2.25de | 2.73bcd |
| M+B2+2HW | 10.87bc | 10.72cd | 12.02ab | 13.80ab | 92.33e | 90.00ef | 247.83d | 265.11f | 2.27de | 2.37cde |
| M+B3+1HW | 11.17bc | 12.44b | 12.03ab | 14.15a | 102.67d | 108.67cd | 287.83c | 339.56b | 2.56cd | 3.20abc |
| M+B3+2HW | 14.53a | 14.59a | 13.40a | 15.37a | 150.55a | 156.67a | 347.00a | 409.00a | 3.73a | 4.01a |
| M+WC | 7.73e | 7.96f | 10.08c | 11.79b | 58.33g | 60.00g | 137.50g | 161.18h | 1.44f | 1.53e |
| M+1HW | 11.85b | 11.37bc | 12.10ab | 14.59a | 110.50cd | 113.22c | 289.67c | 295.44d | 3.15abc | 3.23abc |
| M+2HW | 12.00b | 12.05b | 12.72ab | 15.08a | 114.50c | 120.00bc | 336.33b | 342.22b | 3.37ab | 3.54ab |
| M+WFC | 14.02a | 14.07a | 13.02ab | 15.26a | 126.67b | 131.11b | 290.67c | 314.22c | 3.00bc | 3.12bc |
| SE | 0.40 | 0.39 | 0.22 | 0.26 | 4.81 | 5.13 | 11.04 | 12.48 | 0.15 | 0.16 |
| CV (%) | 19.34 | 18.75 | 10.08 | 10.00 | 25.72 | 26.50 | 22.54 | 23.25 | 31.45 | 29.73 |

Means with the same letters in a column are not significantly different (P=0.05) (DNMRT). WAS, weeks after sowing; M, Maize; B1, Bambara groundnut at 166,666 stands/ha; B2, Bambara groundnut at 100,000 stands/ha; B3, Bambara groundnut at 71,428 stands/ha; WC, No weeding; 1HW, 1 Hand weeding; 2HW, 2 Hand weedings; WFC, Weed-free check.