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EVALUATING ORGANIC AND INORGANIC FERTILIZERS FOR SUSTAINABLE SUNFLOWER CULTIVATION IN THE DERIVED SAVANNAH

Chukwuemeka Ifeanyi Nwankwo
Department of Crop Science, Faculty of Agriculture, University of Nigeria, Nsukka 410001, Nigeria

Abstract:
A field experiment was conducted during the 2016 and 2017 cropping seasons at the University of Nigeria, Nsukka, to assess the effects of poultry manure and NPK 20:10:10 fertilizer on the growth and seed yield of sunflower (Helianthus annuus L.) in the derived savannah. The experiment followed a 4 × 4 factorial layout in a randomized complete block design (RCBD) with three replications. Poultry manure was applied at 0, 5, 10, and 15 t ha^{-1}, while NPK 20:10:10 was applied at 0, 100, 200, and 300 kg ha^{-1}. Results showed significant improvements ($p < 0.05$) in growth and yield parameters—such as plant height, head diameter, seed weight, and flowering duration—under increasing levels of both fertilizer types. The highest seed yield was achieved with 300 kg ha^{-1} of NPK and 15 t ha^{-1} of poultry manure, though no significant interaction between the inputs was observed. While combined application gave the best results, sole use of either poultry manure at 15 t ha^{-1} or NPK 20:10:10 at 300 kg ha^{-1} is also effective for optimal sunflower productivity in southeastern Nigeria.

Keywords: *Sunflower, Poultry manure, NPK fertilizer, Seed yield*

INTRODUCTION

Sunflower (Helianthus annuus L.) stands as a key global oil crop. Originating from North and Central America, the sunflower belongs to the Helianthus genus and is notably recognized for its round head, which, when combined with its ligules, resembles the sun (Putt, 1997; Schilling and Edward, 2006). This and other varieties, particularly Jerusalem artichoke (H. tuberosus), are grown in temperate and certain tropical areas. They serve as food crops for humans, cattle, and poultry, and are also cultivated for ornamental purposes (Balogh, 2008). Sunflowers belong to the Asteraceae family, the largest plant family with nearly 1,550 genera and around 24,000 species. The Helianthus genus, within this family, consists of 51 species, comprising 14 annual and 37 perennial varieties.

The productivity of sunflowers is subject to the interplay of various factors, as highlighted by Kaleem et al. (2011). Cultural practices, including sowing timing and fertilizer application, along with environ- mental factors such as temperature and rainfall, play pivotal roles in shaping the growth and develop- ment of sunflowers. Sunflower species can reach heights of 300 cm or more. Each "flower" is essentially a disc composed of tiny flowers, creating a larger false flower to enhance attraction to pollinators (Sommerlad, 2022). The cultivated sunflower holds a significant position alongside soybean, rapeseed, and peanut as one of the

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four major annual crops worldwide cultivated for edible oil. Its leaves serve as fodder, while the sunflower oil cake is utilized in livestock feed. The extracted oil finds applications in soap, paints, and as a lubricant. Sunflower seeds, whether dried, roasted, or ground into nut butter, are commonly included in birdseed mixes (Pilorgé, 2020).

The development of a sunflower is predominantly influenced by its genetic composition and origin. Moreover, the timing of its planting exerts notable effects on its growth. The species H. annuus generally thrives during the summer, reaching its peak growth phase in mid-summer (Dorling, 2008). The ideal sowing time for sunflowers can vary across locations due to diverse climatic factors. Research conducted in Nigeria revealed that the timing of sowing (late July to mid-August) significantly impacted various yield parameters and the overall growth of sunflowers (Ali *et al.*, 2014). Sunflowers, known for their affinity to sunlight, thrive best in locations receiving six to eight hours of direct sun daily. Planting sunflower seeds is optimal when the soil temperature reaches at least 60 °C at a depth not exceeding one inch. These plants possess extensive tap roots that extend several feet into the ground, making them prefer loose, well-drained soil with a somewhat alkaline pH ranging from 6.5 to 7.5 (Vasyl, 2023). The growth of sunflowers undergoes distinct stages, categorized as vegetative and reproductive. Identification of heads or main branches, whether single or branched, helps determine these stages (Kandel *et al.,* 2020). Solar tracking in *H. annuus* is a noteworthy example of diurnal rhythm in plants. During the day, the shoot apex continuously reorients to follow the sun's position, causing the developing heads to track from East to West. Conversely, at night, the heads return to face east in anticipation of dawn. This cyclic movement diminishes and eventually ceases at anthesis, after which the sunflower head maintains an easterly orientation (Joshua *et al.*, 2014).

Sunflowers require fertile soils, with organic and inorganic sources of nitrogen, phosphorus, and potassium as soil amendments being beneficial. Granular fertilizers, ideal in spring for gradual nutrient release, or an organic approach with manure and other chemical options, can be used. Mokgolo *et al.* (2019) reported that application of poultry manure improved sunflower growth, grain yield, dry matter, and head dry matter in the second cropping season of their study. Animal manure is a valuable source of crop nutrient and organic matter which can improve soil biophysical conditions for sustainable crop production (Baiyeri and Tenkouano, 2007). Sustainable crop production systems, however, often combine the use of organic nutrient inputs with mineral fertilizers for optimum crop performance (Unagwu *et al.*, 2013; Nnadi *et al.*, 2019; Obalum *et al.*, 2020; Olawuyi *et al.*, 2022). This study was needed due to limited data on sunflower production in southeastern Nigeria and aimed to increase farmers' interest in this vital oil seed crop. Therefore, the study sought to evaluate the growth and seed yield of sunflowers (*H. annuus* L.) to coapplication of organic and mineral fertilizer in Nsukka, agro-ecological zone of Nigeria.

MATERIALS AND METHODS

The experiment was conducted between September and December 2022 at the Department of Crop Science Teaching & Research Farm, University of Nigeria, Nsukka, which experiences distinct wet (April - October) and dry seasons (November - March). Sunflower seeds were sourced from the seed collection of the Department of Crop Science, University of Nigeria, Nsukka, NPK 20:10:10 fertilizer was purchased from Ogige Market Nsukka, and decayed poultry manure sourced from the Department of Animal Science Farm, University of Nigeria Nsukka. The land area measuring 2,400 cm × 2,200 cm was cleared and ploughed. The seedbed was done manually which was partitioned into three blocks,

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each divided into 16 plots, each plots measuring 300 cm × 100 cm. The plots were separated from each other by 50 cm.

Soil characterization of the experimental site show that the soil is a sandy clay loam (70% sand, 7% silt and 23% clay), with a low pH in the range of 4.40-4.90, total nitrogen content of 0.15-0.42%, available phosphorus of 7.2-8.8 mg kg^{-1}, and exchangeable potassium of 0.12-0.25 cmol kg^{-1} (Ogbonna and Ogbonna, 2010; Aba *et al.,* 2021). Also, the soil shows a low organic matter content in the range of 1.10-2.00%, indicating low fertility status. The sunflower seeds were directly sown into the seedbed by drilling method at a depth of 2.54 cm with a spacing of 50 cm × 50 cm in each plot.

The experimental design was a factorial in randomized complete block design (RCBD) with three replications. Treatments were four rates each of NPK 20:10:10 fertilizer (0, 100, 200, 300 kg ha^{-1}) and poultry manure (0, 5, 10, 15 t ha^{-1}). Data were collected on growth parameters viz plant height (from the soil level to the tip of the plant), stem girth (2 cm from soil level), and number of leaves $plant^{-1}$, as well as on days to 50% and 100% flowering, head diameter, head weight, and seed weight.

Data were subjected to analysis of variance following the procedure appropriate for factorial experiments in RCBD using GenStat 10.4 analytical software. The Fisher's least significant difference (F-LSD) test at a 5% alpha level, according to Obi (2006), was employed to separate treatment means for cases of significant difference.

Table 1: Monthly rainfall, temperature and humidity during 2022 collected from meteorological station at the experimental site

	Rainfall (mm)	Temperature (°C)		Relative humidity (%)	
Months		Min.	Max.	Morning	Evening
Jan	9.40	22.0	27.39	33.74	25.87
Feb	0.00	24.21	28.68	41.43	26.93
Mar	15.5	25.0	31.55	55.68	38.58
Apr	15.32	23.73	28.93	56.07	43.8
May	276.15	21.84	29.77	59.29	48
Jun	181.86	21.07	28.93	59.2	49.8
Jul	281.88	21.65	28.61	63.35	50.32
Aug	129.94	21.45	27.29	64.26	56
Sep	247.38	22.9	26.93	57.8	51
Oct	252.27	22.13	29.71	62.04	52.39
Nov	0.51	23.6	30.63	54.2	42.87
Dec	0.00	18.90	33.65	43.03	27.68
Total	1410.21	-	-	-	-

Table 2: Main effect of poultry manure rates on the growth parameters of sunflower (*Helianthus annuus*) measured at 1, 3, 5 and 9 weeks after fertilizer application

PM rates (t ha^{-1})	Plant height (cm) Weeks after fertilizer application				Stem girth (cm) Weeks after fertilizer application				Number of leaves Weeks after fertilizer application			
	1	3	5	9	1	3	5	9	1	3	5	9
0	12.0	29.3	64.6	99.4	1.8	3.1	5.9	5.3	10.2	20.0	20.9	19.4
5	13.3	32.0	71.8	100.7	1.7	3.0	6.0	5.1	10.1	18.7	20.0	17.1.

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10	15.8	39.1	80.6	115.0	2.0	3.9	6.5	5.5	13.0	21.3	23.5	23.4
15	16.5	47.1	92.3	122.1	2.2	4.0	6.9	6.3	12.3	20.7	21.4	21.3
F-LSD ($p \leq 0.05$)	2.6	10.2	15.4	16.3	NS	0.7	NS	NS	2.4	NS	NS	NS

Interaction Effect of Poultry Manure and NPK 20:10:10 on Sunflower Growth and Seed Yield Table 6 shows that stem girth and number of leaves progressively increased during weeks 1, 3, and 5 but decreased in week 9. Table 7 shows that days to 50% flowering varied across the interactions, with the highest value (52.0) observed at 15 t 0-kg^{-1} and the lowest (40.0) at 15 t 100-kg^{-1}. Days to 100% flowering decreased with increasing interaction rates. Head diameter, head weight, and seed weight exhibited an upward trend with increasing interaction rates. The highest head diameter (20.0 cm), head weight (327.7 g), and seed weight (109.8 g) occurred at 15 t 300-kg^{-1}, while the lowest values are recorded at 0 t 0-kg^{-1} (head diameter, 9.0 cm; head weight, 35.2 g; seed weight, 11.0 g).

DISCUSSION

The annual rainfall of 1410.21 mm during the study period slightly exceeded the FAO (2010) reported range (1000 mm) for sunflowers, indicating adaptability to regions with higher rainfall. The prevailing temperatures fell within the crop's tolerance range, aligning with Schneiter and Miller (1981), who stated that temperatures between 8 °C and 34 °C pose no significant yield reduction.

The positive effect of poultry manure on sunflower growth was evident in increased plant height, stem girth, and leaf number. This aligns with the reports of Mokgolo *et al.* (2019), affirming that poultry manure enhances plant height of sunflower at various growth stages. The slow release of nutrients from poultry manure, as observed in non-significant effects on stem girth across some weeks, resonates with findings by Kihanda *et al.* (2006), Shahzad *et al.* (2015), and Mahmood et al. (2017). Application of organic fertilizer, specifically poultry manure, not only boosts soil fertility but also aids in nutrient recycling and potentially mitigating environmental pollution. This corresponds to the observations by Abumere et al. (2019), emphasizing the role of organic fertilizers in enhancing soil microbes, nutrient availability, and uptake by sunflower plants.

Days to 50% and 100% flowering decreased with increasing poultry manure rates, aligning with Agu et al. (2015). The non-significant effect of poultry manure on head diameter and weight may be attributed to the gradual release of nutrients (Abumere et al., 2019). The significant effect of poultry manure on seed weight implies that poultry manure enhances soil structure and soil fertility, thereby promoting enhanced nutrient uptake and leading to improved plant health and higher crop yields (Oshundiya et al., 2014; Ogunezi et al., 2019). This highlights the role of organic fertilizer in increasing sunflower seed yield and attributes. The application rates 15 and 10 t ha−1 produced similar seed yield; however, the former outyielded while the latter did not outyield the un-amended control. This observation makes the maximum application rate in this study to be the minimum rate for growing sunflower in the study area.

The significant effect of NPK 20:10:10 fertilizer on multiple facets of sunflower growth and yield, such as plant height, stem girth, number of leaves, days to flowering, head diameter, head weight, and seed weight can be attributed to the concentrated and balanced nutrient composition of NPK 20:10:10, minimizing nutrient wastage and ensuring efficient nutrient supply at different growth stages. This finding aligns with the work of Wahyu and Donald (2019), who observed the influence of NPK fertilizer on sunflower growth and seed yield. Among the four application rates of NPK 20:10:10, 300 kg ha−1 gave the highest values for plant height, stem girth, number of leaves, head diameter, head weight, and seed weight. Additionally, this application rate gave the lowest days to 50% and 100% flowering. This

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suggests that a balanced supply of nutrients, as provided by the 300 kg ha−1 rate, optimally supports sunflower growth, leading to increased plant growth and accelerated flowering. The positive relationship between nitrogen application and seed yield attributes is consistent with findings from Bakht et al. (2010), Ahmed et al. (2011), and Nasim et al. (2012). This study emphasizes the role of nitrogen in enhancing sunflower seed yield. The application of NPK
20:10:10, with its nitrogen content, likely contributes to improved seed yield by promoting favourable conditions for sunflower development.

The study shows positive growth and yield responses of sunflower to both organic and inorganic fertilizers, indicating an efficient conversion of applied nutrients for improved yield. The interaction effect between poultry manure and NPK 20:10:10 fertilizer further demonstrates the enhancement of growth and yield parameters in sunflower fields. Abumere et al. (2019) observed that inorganic fertilizer facilitated accumulation of dry matter compared to organic fertilizer. This is attributed to the faster release of nutrients from mineral fertilizers, accelerating dry matter accumulation. The increased accumulation of dry matter in sunflower shoots, particularly in plots with higher rates of both organic and inorganic fertilizers, underscores the importance of nutrient availability for economic yield. This aligns with the findings of Paul et al. (2017), who highlighted the advantages of integrating organic and inorganic nutrient sources over the use of inorganic fertilizer alone.

Although the study found non-significant effects of the interaction between poultry manure and NPK 20:10:10 for all parameters, their combination at 15 t ha−1 and 300 kg ha−1, respectively outyielded the un-amended control by about 10 times. This is large compared to the corresponding number of times by which poultry manure at 15 t ha−1 (4.8) and NPK 20:10:10 at 300 kg ha−1 (1.7) outyielded the control in the main effects. Similar to these results, Esilaba et al. (2005) and Ogbonna (2008) reported non-significant effects of the interaction between manure and fertilizer in eggplant, but found their combination to produce the best yield.

CONCLUSION & RECOMMENDATION

Sunflower is not a common crop in the study area but it can thrive with appropriate cultural practices. The study has shown that though poultry manure and NPK 20:10:10 interaction consistently showed non-significant effects, their complementary use at 15 t ha−1 and 300 kg ha−1, respectively gave the highest performance. Therefore, if poultry manure and NPK 20:10:10 must be combined in sunflower production, they should be applied at these stated rates, otherwise our data support adoption of sole application of either poultry manure at 15 t ha−1 or NPK 20:10:10 at 300 kg ha−1 for optimum growth/ productivity of sunflower in the derived savannah.

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