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Research Article

Application of combined bioorganic fertilizers on groundnut (Arachis hypogaea L.) to enhance the yield

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Abstract

The present study aimed to determine the effectiveness of bio-organic fertilizers in producing local groundnut (Kaduna) from Muna Island, Indonesia. We desined the treatment series was done with 07 bio-organic fertilizer treatments named T1, T2, T3, T4, T5, T6, T7, T8 based on arbuscular mycorrhizal fungi (AMF) and livestock manure *as a* fertilize to provide nutrients needed for crop production.ie. Chicken manure Fertiliser (CMF) is a rich source of nutrients and is best applied in fall or spring after it has had a chance to compost, +recommended dose of NPK chemical fertilizer

Based on the results, combined application of AMF and CMF applied at T7 gave the best yield, which was probably due to the improved soil organic matter.

Keywords: Kaduna, groundnut, Chicken manure Fertiliser, arbuscular mycorrhizal fungi, yield, bioorganic fertilizers, Arachis hypogea L.

Introduction

The groundnut (Arachis hypogea L.) is one of the most essential and economical oleaginous crops grown in tropical and subtropical regions of the world, mainly because of its oil, protein, and carbohydrates [1]. Peanut seeds contain oil (45%), protein (26–28%), carbohydrates (20%), and fiber content (5%) [2], indicating their high nutritional value for both humans and animals.

Groundnuts are grown in practically every country, with the continent accounting for roughly a quarter of the world's production. In Africa, groundnuts are typically cultivated in moderate rainfall areas across the continent, usually by women. In the past, groundnut was grown mainly as a secondary crop in subsistence farming conditions, but in recent years the crop has gained importance due to the shortage of edible oil particularly in Asia and African countries. Today, farmers consider groundnut as a high-input high- risk crop because of the large seed requirement, the scarcity of good quality inputs and appropriate production technologies.

Agroecologies for groundnut production in Nigeria: Traditional commercial groundnut producing areas encompass the Sahel, Sudan and derived savanna, Northern Guinea and most parts of the Southern Guinea vegetation zone. The major groundnut producing states are Kano, Katsina, Kaduna, Jigawa, Sokoto, Zamfara and Kebbi in the Northwest; Adamawa, Bauchi, Yobe and Borno in the Northeast; and Benue, Plateau, Taraba, Nasarawa, FCT Abuja, Kogi, Niger and Kwara in the Central Zone. The recommended varieties and planting time of each of these agroecologies are presented in Table 1.

Table 1. Agroecologies, recommended varieties and planting time for groundnut production in Nigeria.

Agroecological zones (AEZ)	State	Recommended Varieties	Planting date
Wet Season			
Sahel Savanna	Sokoto, Yobe, Borno, Jigawa	Samnut 24 Samnut 25 Samnut 26	Early July
Sudan Savanna	Kebbi, Sokoto, Zamfara, Katsina, Kano, Jigawa, Yobe, Borno, Bauchi	Samnut 24 Samnut 25 Samnut 26	End of June to early July
Northern Guinea Savanna (NGS)	Kebbi, Zamfara, Katsina, Kano, Kaduna, Bauchi, Gombe, Adamava, Niger	Samnut 21 Samnut 22 Samnut 23 Samnut 24	Mid- to end June
Southern Guinea Savanna (SGS)	Niger, Kwara, Nasarawa, Borno, Bauchi, Gombe, Benue, Taraba, Adamava	Samnut 10 Samnut 21 Samnut 22	1st Planting: May 2nd Planting: End July
Derived Savanna	Kwara, Nasarawa, Benue, Taraba, Kogi, Oyo	Samnut 10 Samnut 21 Samnut 22	1st Planting: May 2nd Planting: End July
***Dry Season**	All states	Samnut 24 Samnut 25 Samnut 26	End October or Early February

*The challenge in the dry season is the low temperature during Harmattan months of December to January. Low temperatures significantly affect germination and growth.

Source: http://oar.icrisat.org/8856/1/2015-084%20Gnut%20Production%20in%20Nigeria.pdf

It was introduced by early European explorers to Europe and the old world tropics where it became an important food and export crop. India is the world's largest producer of groundnut, accounting for nearly 33% of total world production and together with China accounting for nearly 60% of world production. Other major producers USA, Nigeria, Indonesia and Senegal (Table2).[3]

Table2: Major peanut producers: area planted, yield and production(2021)

World Peanut Production by Country

	Country	Production (Tons)	Production per Person (Kg)	Acreage (Hectare)	Yield (Kg / Hectare)
	China	17,572,798	12.607	4,508,393	3,897.8
	India	6,727,180	5.034	4,730,770	1,422
	Nigeria	4,450,050	22.544	3,875,267	1,148.3
	Sudan	2,828,000	69.319	3,130,260	903.4
	United States of America	2,492,980	7.606	563,210	4,426.4
	Myanmar	1,615,715	29.997	1,108,664	1,457.4
	Senegal	1,421,288	90.378	1,110,934	1,279.4
	Argentina	1,337,229	30.054	387,014	3,455.2
	Guinea	957,662	80.587	911,993	1,050.1
	Chad	939,252	61.176	824,198	1,139.6
	Tanzania	680,000	12.546	990,000	686.9

Source: https://www.atlasbig.com/en-us/countries-peanut-production[3]

Countries by Peanut Production.

- Worldwide 48,756,790 tonnes of peanut is produced per year.
- China is the largest peanut producer in the world with 17,572,798 tonnes production per year.
- India comes second with 6,727,180 tonnes yearly production.
- With 4,450,050 tonnes of production per year, Nigeria is the third largest producer of peanut.
- China, India and Nigeria produce together more than 50 % of world's total peanut globally.
- United States of America, with 2,492,980 tonnes of production per year is ranked at 5.

Source: https://www.atlasbig.com/en-us/countries-peanut-production[4]

State	Area		Yield		Production	
	1000 HA	ROG (%)	Kg/Ha	ROG (%)	1000 MT	ROG (%)
Kano	423	-4.41	782	-1.07	331	-5.47
Niger	231	-2.27	1365	2.55	316	0.28
Kaduna	203	4.11	1650	-1.31	335	2.79
Benue	199	2.03	1787	-1.18	356	0.86
Zamfara	145	-3.22	839	-0.03	121	-3.25
Taraba	143	28.48	1237	-8.67	177	19.80
Bauchi	140	2.65	955	1.75	134	4.40
Borno	109	5.93	2067	-9.34	226	-3.41
Katsina	105	4.67	529	-0.86	56	3.82
Nassarawa	67	1.02	1153	-0.10	77	0.92
Others	394	NA	580	NA	443	NA
Nigeria	**2159**	**-0.82**	**1191**	**-0.04**	**2571**	**-0.85**

Source: Calculated from NBS (www.nigeriastat.gov.ng)[5]

Table3: Groundnut trends in top 10 producing states of Nigeria

Halim et al. [6] reported that low plant production causes low soil fertility, especially in Ultisol soils with low cation exchange capacity of granite, sediments and tuffs.

As we know about the nutrition required to enhance the production of groundnut is mainh sources are chemical and bioorganic fertilisers. Present study we are using the mycorrhiza fungi and Chicken Mannure as a fertiliser. It is suggested that the fungi are most efficient in low to moderately fertilized soil thus may be crucial in sustainability of low-input farming [7,8].

The arbuscular mycorrhiza fungi are a form of the mutualistic relationship between fungi and roots of higher plants. This symbiosis can benefit plants by increasing nutrient uptake,especially P, and increasing resistance to drought and pathogen attack (Smith and Read, 2008)[9]. Neumann and George (2010)[10] reported thatthe extra-radical phase of mycorrhizal fungi acts as an extension of the root system to absorb mineral nutrients from the soil and helps release nutrients from the soil sorption complex, especially P, Cu, and Zn. Jing et al. (2020)[11] reported that arbuscular mycorrhiza fungi inoculation also enhances growth performance in leaves and stems, benefitting the interception and absorption of light and thus maximizing photosynthesis, transpiration, CO2assimilation and gas exchange capacity.

Arbuscular mycorrhizal (AM) fungi are obligate biotrophs that participate in an ancient symbiosis with plants [12,13]. Through this symbiosis, AM fungi provide plants increased access to soil resources in return for carbon in the form of sugar and lipids[14]. Besides the nutritional benefit to the plants, AM fungi can also increase plant tolerance to environmental stress [e.g., water [15], salinity [16], and heavy metals [17]. AM fungi are known to stimulate plant photosynthetic activity [18] and enhance plants' disease resistance[19,20]. Because of these benefits, considerable effort has focused on finding ways to propagate and study these fungi for potential applications including agriculture, landscaping, and landscape restoration[21,22].Chicken manure is different from other types of manure, since it is more mature. Chicken manure in addition for adding nutrients to the soil can also improve soil structure and encouraged the life of soil microorganisms [23-28].

Materials and methods

Site Selection and Land Preparation

The present study aimed to determine the effectiveness of bio-organic fertilizers in producing local groundnut (Kaduna) from Muna Island, Indonesia. The ideal field for groundnut production should have soil that is well drained and light colored with Silt loam. Silt soils, comprised mainly of intermediate sized particles, are fertile, fairly well drained and hold more moisture than sandy soils, but are easily compacted. Loams are comprised of a mixture of clay, sand and silt that avoid the extremes of clay or sandy soils and are fertile, well-drained and easily worked. Soils that make a ribbon when moist soil is rubbed between index finger and thumb are not advisable but soils that fall apart when rubbed should be used, as produce from such soils are clean and bright.

The area of land used was 45 m x 15 m, and experimental plots were made measuring 3 m x 2 m. The drainage width between groups was 60 cm, and the drainage width between plots within the group was 25 cm.

Mycorrhiza fungi propagules were obtained from Maize cultivation in polybag propagation media. The cow manure fertilizer was applicated one week before planting. The fertilizer application was adjusted to each plot's treatment dose by being spread evenly over the plot[6]

The application of arbuscular mycorrhiza fungi (AMF)was carried out simultaneously with planting

groundnut seeds by inserting them into the planting hole in an appropriate amount as stated in randomized block design(RBD). The chicken manure fertiliser (CMF) applied in plot before 7 days of planting. These CMF was mixed in plot as per the RBD.

Experimental layout and management

The field experiment arranged in a randomized complete block design, with four replications was conducted in Northern Guinea, Nigeria. There were eight (T1 to T8) treatments, arbuscular mycorrhizal fungi (AMF) and chicken manure Fertiliser (CMF) and recommended dose of NPK chemical fertilizer.

Properties	Value
Soil texture	Silt loam
pH (Soil:H2O 1:5)	6.7
EC (dS m^{-1})	7.0
N-NO3 (mg kg^{-1})	8.2
Available Phosphorus (mg kg^{-1})	6.9
Potassium (mg kg^{-1})	102.3
Organic C %	1.03
AMSc* spore count ($10g^{-1}$ soil)	

AMSc*: Arbuscular mycorrhizal spore count

Table 4: Salient Physical and chemical properties of soil before experiment.

Properties	Chicken Manure
pH (H2O 1:5)	7.5
EC (dS m^{-1})	8.0
Organic Matter (g kg $^{-1}$)[a]	522.3
Total N (g kg $^{-1}$)b	28.7
Total P (g kg $^{-1}$)[C]	42.31
Total K (g kg $^{-1}$)[d]	40.2
Total Ca (g kg $^{-1}$)[d]	37.8
Total Mg (g kg $^{-1}$)[d]	31.9

[a]Walkley Black Method. [b] Kjeldahl Method. [C] Vanadomolybdate method. [d]Wet digestion Method.

Table 5. Properties of chicken manure used in the experiment.

The randomized block design (RBD) was done

1] AMF+CMF (0+0) (control), 2] AMF+CMF (0+ 3 kg per plot)

3] AMF+CMF (5 g per plant+0 kg per plot) 4] AMF+CMF (5 g per plant+3 kg per plot)

5] AMF+CMF (10 g per plant+0 kg per plot) 6] AMF+CMF (0 g per plant+6 kg per plot)

7] AMF+CMF (10 g per plant+6 kg per plot) 8] Recommended dose of NPK chemical fertilizer

The recommended dose for inorganic fertilizers was 130kg N, 130kg P, and 67kg K [19] applied to appropriate plots in form of urea, triple super phosphate (TSP) and muriate of potash (MOP)

Data collection and statistical analysis

The variables like pod weight (g), total pod number, filled pod number, percentage of empty pods (%), seed number, the weight of 100 seeds (g), dry seed weight (g) were observed.

Results and discussion

The different variables of groundnut after biofertilizer treatments are mentioned in Table 1. The highest average of pod weight, total pod number, filled pod number, and seed number occurred with the treatment of AMF+CMF (10 g per plant+6 kg per plot) (T7 : Pod weight-55.0 g, total pod number 52 pods, filled pod number 50 pods, and seed number 72.5 pods and Dry seed weight 47.5 seeds.

The result in Table 6 indicates that in the growth and development of groundnut plants, mycorrhiza fungi showing the good results with the combination of chicken manure fertiliser. After harvesting, application of chicken manure tended to increase soil organic matter compared to the control, however, the application of chemical fertilizer did not show the same effect.

Treatment	Pod weight 100 seeds (g)	Total pod number	Filled pod number	Seed number	Dry seed weight 100 seeds (g)
T1	42.9	40.0	36.0	58.0	42.2
T2	44.6	44.5	40.0	61.2	43.9
T3	46.7	47.0	41.5	64.2	44.0
T4	47.0	49.0	47.0	68.0	46.5
T5	43.2	45.0	41.5	64.2	44.0
T6	47.9	48.0	44.0	62.3	44.5
T7	**49.8**	**52.0**	**50.0**	**72.5**	**47.5**
T8-RD NPK	44.3	46.0	38.0	62.5	44.0

RD NPK: recommended dose of NPK chemical fertilizer

Table 6. Effect of bio-organic fertilizer treatments on yield components of groundnut

Conclusion

Possibilities of AMF to produce organic exudates that could stimulate surrounding microbial communities capable of decomposing organic material have been proven [29, 30].

The application of bioorganic and chicken manure fertilizers positively influenced the growth and yields of groundnut plant. The results showed that the application of bio-fertilizer significantly affected all the observed variables ie. Pod weight, total pod number, filled pod number, seeds number, dry seed weight. The addition of compost significantly improves soil chemical and physical properties, although at the low rate there was effect. Manure application could increase soil fertility, improve soil physical and chemical properties which might create enable condition for crop growth [31]. After harvesting, application of chicken manure tended to increase soil organic matter compared to the control, however, the application of chemical fertilizer did not show the same effect.

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