EVALUATION OF INSECT INFESTATION ON OKRA VARIETIES GROWN WITH DIFFERENT FERTILIZERS IN ABUJA, NIGERIA

Muhammad Ibtihaj Arikya[1], Ndamzuru Ibrahim[2], Aderolu Isamail Adeniran[1], Idrisu Mohammed[2], Muideen Tella Liadi [1]and Akeem Abolade Oyerinde [1]

[1]*Department of Crop and Environmental Protection, Faculty of Agriculture, University of Abuja*
[2]*Department of Soil Science and Land Resource Management, Faculty of Agriculture, University of Abuja*

***Corresponding Author's email:** akeem.oyerinde@uniabuja.edu.ng; Phone No: 07055481935*

DOI: https://doi.org/10.70118/ajaas.02025050502.01

ABSTRACT

Research was carried out at the University of Abuja Teaching and Research Farm to evaluate the effects of organic and inorganic fertilizer on the infestation and management of insects on okra (*Abelmoschus esculentus* L.). Three treatments were used which include Poultry manure, NPK 20-10-10 and Water. The experimental layout was laid in a Randomized Complete Block Design (RCBD) with three replications. Three varieties of *Abelmoschus esculentus* L. were used namely; Non-Hybrid okra, Spineless Gumbo and a Local variety. The parameters measured include plant height, leaf area, number of leaves, number of pods per plant, weight and length at Harvest. Insects were also collected using the Pitfall trap and handpicking. All insect collected were identified. Data were subjected to Analysis of Variance (ANOVA) using SPSS Version 29 Software. The results showed that there was no significant difference recorded among the okra varieties. The poultry manure recorded the highest number in plant height (40.60 cm), number of leaves (10.50) and yield (209.73g), weight and length of harvest (12.29). There was no significant difference at $p<0.05$ at 3WAS, 4WAS, 5WAS and 6WAS among the varieties, but there was significant difference in 4WAS and 5WAS in Non-hybrid okra in plant height, 6WAS in its Leaf area and there was significant difference $p<0.05$ in 4WAS and 5WAS in the number of leaves. There was also significant difference recorded in some weeks of the other two varieties in their plant height, leaf area and number of leaves. In addition, the Poultry manure had great effects in controlling insect pests associated with *Abelmoschus esculentus* L. and also plays a vital role in increasing yield.

Keywords- Growth performance, Insect pest, fertilizer, yield, Okra

INTRODUCTION

Okra (*Abelmoschus esculentus* L.), commonly known as lady's finger or gumbo, is a vegetable extensively cultivated in tropical and subtropical regions due to its ability to thrive in various climatic and soil conditions (Salameh *et al*., 2018; Sharma *et al*., 2020). Okra, scientifically classified under the family Malvaceae, belongs to the genus *Abelmoschus* and the species *A. esculentus* (IBP, 2023). While approximately 50 species have been described within this genus, eight are widely recognized

(Ogunbor, 2020). However, Hinsley (2020) identifies 13 accepted species within the genus Abelmoschus (Hinsley, 2020). Okra is highly nutritious and is considered an essential component of the human diet. The fruit is rich in vitamins such as A, B6, C, folic acid, riboflavin, as well as minerals like calcium, magnesium, potassium, iron, zinc, and phosphorus. Additionally, it contains carbohydrates, protein, fats, and fiber (Varmudy, 2011). The fully ripened okra seeds are an excellent source of oil, protein, and unsaturated fatty acids, such as linoleic acid, which are essential for human nutrition. Moreover, the ripened fruit and stem are valuable for their crude fiber, which is utilized in the paper industry (Kumar *et al*., 2013). Okra has a variety of uses, making it an economically important vegetable crop. Its fresh leaves, buds, flowers, pods, stems, and seeds are all highly valued. Okra can be consumed in salads, stews, and can be prepared fresh, dried, fried, or boiled (Axe, 2021).

Cultivating okra is relatively straightforward, and it is often grown using organic farming practices. The plant prefers well-drained, loamy soils with a pH of 6.0 to 6.8. It is usually propagated by sowing seeds directly into the soil. Farmers employ various agronomic strategies, including crop rotation and the use of both organic and inorganic fertilizers, to maximize yields (Patel *et al*., 2022). Okra is vulnerable to insect pests throughout all stages of growth, with the most severe damage typically occurring during the vegetative stage (Fasunwon and Banjo, 2010; Alao *et al*., 2011). These pests present a considerable challenge to the commercial production of Okra (Hugar and Palled, 2008; Ijoyah and Jimba, 2012). Seventy-two types of insects have been observed on Okra (Rahman *et al.,* 2013) from vegetative to productive stage, which causes considerable damage. Among the most economically damaging insect pests is the flea beetle (*Podagrica* spp.) (Coleoptera: Chrysomelidae), which has become a serious concern (Ahmed *et al*., 2009; Fasunwon and Banjo, 2010). This pest is consistently observed as a major threat to Okra within the Malvaceae Family, infesting leaves and causing substantial economic yield losses (Modupe, 2010; Fasunwon and Banjo, 2010; Degri and Richard, 2014). Research indicates that nutrient management can influence plant physiology, which may either heighten or diminish the plant's vulnerability to pest infestations (Panda *et al*., 2018; Sharma and Singh, 2020) and also specified that soil nutrient levels can significantly impact the occurrence and intensity of insect infestations. For instance, plants with elevated nitrogen levels tend to attract more herbivorous insects, as nitrogen is a vital nutrient for their growth and reproduction (Bentz *et al*., 1995). Both NPK fertilizers and organic amendments like poultry droppings are commonly used to boost plant growth and yield, but these inputs may also influence the plant's physiological state, potentially increasing its susceptibility to pests or enhancing its resistance (Adediran *et al*., 2005; Akanbi *et al*., 2010; Nwakwo, 2023).

Poultry manure has been shown to significantly increase okra yield. The high nitrogen content supports vigorous vegetative growth, leading to larger plants with more foliage, which boosts photosynthesis and, consequently, pod production. Research indicates that okra plants fertilized with poultry manure yield more than those treated solely with chemical fertilizers (Ayeni *et al*., 2018). Okra plants fertilized with poultry manure often show greater resistance to diseases and pests. This is partly due to the enhanced nutrient status, which strengthens the plants' natural defenses. Additionally, the organic matter in poultry manure boosts soil health, encouraging the growth of beneficial microbes that help suppress soil-

borne pathogens and pests (Akanbi *et al*., 2017). The application of NPK fertilizers significantly enhances okra's growth and yield. Nitrogen promotes leaf and stem development, which supports photosynthesis. Phosphorus is essential for root development and plays a key role during flowering and fruiting, leading to an increase in pod production. Potassium improves plant health and stress resistance, contributing to higher yields (Law-Ogbomo and Remison, 2020).

NPK fertilizers boost the availability of crucial nutrients in the soil, improving their uptake by okra plants. This is especially beneficial for soils lacking these nutrients. The balanced supply of nitrogen, phosphorus, and potassium supports optimal metabolic processes, resulting in better plant growth and increased productivity (Egbebi and Oyewole, 2017).The quality of okra pods benefits from the application of NPK fertilizers. Studies have shown that okra plants receiving balanced NPK treatments produce pods with improved size, weight, and overall quality. Potassium, in particular, enhances fruit quality by regulating water balance and boosting the synthesis of proteins and sugars within the plant (Akanbi *et al*., 2018).

MATERIALS AND METHODS

Experimental Site

The research was conducted at the Teaching and Research Farm of University of Abuja, located in Gwagwalada Area of Federal Capital Territory, Abuja (Latitude 8°10N and Longitude 9°10E). Based on the climate, the area is characterized by two distinct seasons which are the rainy seasons from May to October and the dry seasons from November to April. Rainfall in this area is at its peak in August. This experiment was started during the rainy season in mid-June and completed in the month of September in two cropping seasons.

Source of Planting Materials

The three varieties of Okra used were Non-hybrid okra which was gotten from the National Seed Council, Spineless Gumbo which was gotten from Premier Seed Outlet and A Local variety purchased from the local market.

Treatments and Experimental Design

The experiment consists of three treatments with three replicates. The treatment consists of Poultry manure, NPK 20-10-10 and water as the control. The field was laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The experimental plot consisted of nine rows with inter-row spacing of 50 cm and intra-row spacing of 50 cm.

Land preparation and cultural Practices

The experimental field was first cleared of all bushes, herbage and shrubs, disc ploughed and harrowed to a fine soil. Each subplot was ridged, pegged and labeled prior to planting. A maximum of 3 seeds per hole were sown in each hole and later thinned to 2 plants per stand two weeks after sowing. Weeding was done using traditional methods (hand and hoe weeding).

Application of treatments

Application of poultry droppings was done during the early growth phase to ensure sustained nutrient availability. NPK was applied at two-week interval from the 3rd week after sowing using the side placement method. All plants were evenly distributed with its dedicated treatment. All other recommended cultural practices except for pest control, were common in all plots and was strictly followed throughout the experiment.

Data collection

The growth parameters were measured from 3, 4, 5 and 6 weeks after sowing (WAS) while the yield and yield parameters were measured at harvest.

Germinationpercentage% was determined with the formula below:

$$\frac{Number\ of\ seed\ germinated}{Total\ number\ of\ seed\ sown}\ x\ 100$$

Plant height (cm): this was done at 3 weeks after sowing (WAS) till flowering, six plants was randomly selected and were measured from the soil level to the terminal bud using meter rule.

Leaf Area: this was gotten with the use of a Leaf Area Meter.

Number of Leaves: this reading was gotten by counting the number of leaves produced by individual stand. **Days to flowering:** number of days to flowering was noticed and recorded by regular visit to the experimental area.

Yield parameters: five okra plants per plot were randomly selected and the number of fruits was taken, average obtained.

Statistical Analysis

Data collected was subjected to Analysis of Variance (ANOVA) based on Randomized Complete Block Design, while significant means were separated using the Duncan´s multiple Range Test (DMRT), at 5% level of significance using the SPSS 22 Software.

RESULTS AND DISCUSSION Identified Insect Pests of Okra

A total of five different Orders of insect infested the Okra planted in the experiment. The orders of insects trapped were: Hemiptera, Lepidoptera, Coleoptera, Tysanoptera and Orthoptera. The different types of insects trapped were flea beetles, leafhopper, aphids, whitefly, thrips, leafworm, fruit borer, bollworm, cotton stainer and grasshopper (Table 1).

S/N	Order	Family	Common name	Genus	Species	Status
1.	Coleoptera	Chrysomelidae	Fleabeetle	Podagrica	*Podagricaspp.*	Pest
2.	Hemiptera	Aleyrodidae	Whitefly	Bemisia	*Bemisiatabaci*	Pest
3.	Hemiptera	Cicadellidae	Cotton leafhopper	Amrasca	*Amrascabiguttula*	Pest
4.	Hemiptera	Aphididae	Cottonaphid	Aphis	*Aphis gossypi*	Pest
5.	Lepidoptera	Noctuidae	Cotton leafworm	Spodoptera	*Spodoptera litura*	Pest
6.	Tysanoptera	Thripidae	Cottonthrips	Thrips	*Thrips palmi*	Pest
7.	Lepidoptera	Noctuidae	Fruitborer	Earias	*Earias vitella*	Pest
8.	Lepidoptera	Noctuidae	Cotton ballworm	Helicoverpa	*Helicoverpa amigera*	Pest
9.	Hemiptera	Pyrrhocoridae	Cotton stainer	Dysdercus	*Dysdercus superstitiosus*	Pest
10.	Orthoptera	Acrididae	Red-legged grasshopper	Melanoplus	*Melanoplus femurrubrum*	Pest

Germination Percentage

Table 2 showed the Germination percentage recorded among the three varieties used. Spineless Gumbo has the highest percentage at (50.74%), then the Local Variety at (46.85%) and Non-hybrid Okra at (45.37%) have the least percentage.

Variety	Germination%
Non-Hybrid Okra	45.37%
Spineless Gumbo	50.74%
Local Variety	46.85%

Plant Height Recorded

Table 3 showed the effect of treatment and variety on plant height recorded among okra plant. For the Non-Hybrid Okra there was no significant difference at $p<0.05$ at 3 weeks and 4 weeks after sowing, but at week 5 and 6 there was significant difference at $p<0.05$ among the treatment.

There was no significant difference at $p<0.05$ at week 3, week 5 and week 6 in spineless gumbo but there was significant difference at $p<0.05$ at week 4 among the treatments in this variety. For variety 3 which is the local variety, there was no significant difference at $p<0.05$ at week 3, 4 and 5 after sowing but, there was significant difference at $p<0.05$ in week 6.

Treatment	Non-hybridokra				Spineless gumbo			Local			
	3WAS	4WAS	5WAS	6WAS	3WAS	4WAS	5WAS	6WAS	3WAS	4WAS	5WAS	6WAS
Poultry manure	11.23	17.58	29.38b	40.60ab	10.84	17.11b	27.81	37.46	11.31	18.59	30.50	47.63b
NPK 20-10-10	10.41	17.21	29.34c	43.41a	11.73	19.94a	31.13	37.46	11.62	18.33	28.32	47.82a
Water	10.72	16.17	31.98ab	36.46c	11.59	19.23ab	28.54	38.91	11.06	19.01	30.16	35.57d
SEM	0.30	0.44	0.65	1.09	0.26	0.38	0.69	0.70	0.27	0.44	0.76	1.27

Number of Leaves Recorded

Treatments	Non-hybrid okra				Spineless gumbo				Local		
	3WAS	4WAS	5WAS	6WAS	3WAS	4WAS	5WAS	6WAS	3WAS	4WAS	5WAS
Poultrymanure	6.78	7.94ab	10.06a	10.50	6.83	8.67	9.56	9.39	7.28ba	10.06	12.50
NPK 20-10-10	6.61	8.56a	9.61ab	10.06	7.44	8.28	9.17	9.83	7.94a	10.22	11.11
Water	6.72	7.83ab	8.83b	9.22	7.11	9.33	9.06	9.78	6.72c	9.50	11.00
SEM	0.16	0.17	0.25	0.25	0.14	0.18	0.26	0.22	0.17	0.25	0.34

Table 4 showed the effect of treatment and variety on the number of leaves of *Abelmoschus esculentus*. There was no significant difference at p<0.05 at 3WAS and 6WAS among the treatment in the first variety but there was significant difference at p<0.05 at 4WAS and 5WAS among the treatment in this variety. For spineless gumbo, there was no significant difference at p<0.05 at 3WAS, 4WAS, 5WAS and 6WAS. However, the number of leaves increases as the plant matures. For the local variety, there was significant difference recorded at 3WAS and 6WAS with different alphabet indicating their difference. However, there was no significant difference at p<0.05 at 4WAS and 5WAS among the treatment in this variety.

Leaf Area of Okra Recorded

Table 5 showed the effect of treatment and variety on the leaf area on okra. For Non-hybrid okra, at 6WAS mean in the same column with different alphabets show significant difference at p<0.05 with other weeks ranging from 3WAS to 5WAS are not significantly different (p<0.05). In Spineless gumbo, all weeks showed significant difference at p<0.05 among the treatments. For the local variety, week 4 and week 6 showed significant difference at p<0.05 among the treatments. However, at week 3 and 5, no significant difference at p<0.05 was recorded.

Treatment	**Non-hybrid okra**				**Spineless gumbo**				**Local**	
	3WAS	4WAS	5WAS	6WAS	3WAS	4WAS	5WAS	6WAS	3WAS	4WAS
Poultry manure	76.58	188.03	288.27	551.38a	69.26b	192.34d	347.74c	501.47a	84.10	220.90ab
NPK 20-10-10	77.11	188.03	341.63	493.45ab	100.74a	244.79ab	347.99b	471.63ab	89.81	266.68a
Water	77.14	200.30	313.25	385.31c	67.82c	265.18a	352.07a	409.83c	89.98	205.45c
SEM	3.32	7.80	11.01	18.94	5.16	10.38	10.79	13.11	5.11	9.23

Yield of Okra Recorded

Table 6 showed the effect of treatment and variety on the yield of okra. There was no significant difference at p<0.05 was recorded among all varieties and treatment in both first and second combined harvests. NPK 20-10-10 recorded the highest yield in the non-hybrid okra in the second harvest while water recorded the lowest yield recorded in the same variety.

Treatment	Non-hybrid okra		Spineless gumbo		Local	
	1st harvest	2nd harvest	1st harvest	2nd harves	1t st harvest	2nd harvest
Poultrymanure	1.67	1.83	1.17	1.67	1.44	2.33
NPK 20-10-10	1.44	2.56	1.11	2.11	1.22	2.28
Water	0.83	1.83	0.94	1.67	1.11	1.61
SEM	0.12	0.13	0.10	0.09	0.12	0.13

Weight of combined harvest recorded

Table 7 showed the effect of treatment and variety on the weight of okra harvest. There was no significant difference at $p<0.05$ between the first and second harvest among the varieties and treatments. Although, the highest weight of harvest recorded is 228.83 on Non-hybrid okra with Water as the treatment and spineless gumbo recorded the lowest harvest at the second harvest with the value of 34.77.

Treatment	Non-hybrid okra		Spineless gumbo		Local	
	Weight of 1st harvest	Weight of 2nd harvest	Weight of 1st harvest	Weight of 2nd harvest	Weight of 1st harvest	Weight of 2nd harvest
Poultry manure	77.17	165.60	42.33	137.13	100.57	209.73
NPK 20-10-10	68.80	167.07	53.80	187.20	121.53	197.57
Water	60.37	228.83	34.77	222.23	51.97	177.13
SEM	14.29	16.10	5.45	24.81	14.08	15.92

Length of Harvest recorded

Table 8 showed the effect of treatment and variety on the length of okra harvest. There was no significant difference at $p<0.05$ between the first and second harvest among the varieties and treatments. However, the highest number of harvest recorded was 12.29 in the local variety with poultry manure as the treatment.

Treatment	**Non-hybrid okra**		**Spineless gumbo**		**Local**	
	Length of 1st harvest	Length of 2nd harvest	Length of 1st harvest	Length of 2nd harvest	Length of 1st harvest	Length of 2nd harvest
Poultry manure	9.79	11.21 11.59		11.16 9.92		12.29
NPK 20-10-10	10.53	10.37	12.17	11.10	9.70	10.69
Water	9.62	11.04	10.21	10.49	8.98	10.13
SEM	0.33	0.23	0.57	0.31	0.46	0.29

DISCUSSION

The symptoms observed on the okra plants include: leaf deformation, leaf defoliation, reduced plant growth, die-off of plant, small or fewer flowers patched due to insect feeding and also curling of early stage leaves. In most cases leaves are narrow and longer or expanded, while in other cases leaves fall off and there are stunted plants which are unable to bear fruits. The observable symptom on okra shows that flea beetle is the major insect pest that causes potential damage to okra. The feeding characteristics of this insect such as creation of round irregular holes on okra notable with flea beetle were also observed in this study. This supports the report of Oyerinde *et al.* (2017) which stated that it has become a common sight to find numerous perforations on the leaves of okra usually caused by herbivores insect which is almost being accepted as a common feature on crop infested by flea beetle. It was also reported by Nwankwo (2023) that symptoms such as leaf defoliation and deformation, reduced plant growth, perforations on the leaf of okra are as a result of insect feeding. Insect pests such as aphids, ladybug, leaf hopper was observed to more attracted to the plants treated with NPK than that of poultry manure. This was similarly reported by Baido and Mochiah (2011) where it was stated that the use of poultry manure increases the available nutrients thereby reducing the incidence of insect pests such as *Aphis gossypi*, *Podagrica* spp.

Based on the germination percentage recorded in this study, variety 2 (Spineless gumbo) had the highest germination percentage followed by variety 3 (local variety) and then variety 1 (non-hybrid okra). The local variety and spineless gumbo recorded the highest plant height with the non-hybrid okra with almost the lowest. Non-hybrid okra was observed to have the highest leaf area. The treatments, poultry manure, NPK 20-10-10 and water after observation in all parameters, were not significantly different to one another, although water which is the control was recorded with lowest number in all parameters with poultry manure with the highest recorded amount in all parameters. The plant height, number of leaves, leaf area, number of fruits, harvest weight and length of poultry manure has almost the highest number. This observation is in line with the findings of Odedokun and Gomo (2023) where it was stated that poultry manure have a significant amount of nutrients which can improve the production of okra in terms of plant height and other growth parameters. Also, in a research which was conducted by Ibeh et al., (2019), it was stated that poultry manure is recommended for okra production due its soil enriching and plant nourishing properties.

CONCLUSION

All above mention insect pests of okra *A. esculentus* are destructive to okra plants from the germination period to the harvest period. Therefore, poultry manure and NPK can be used as soil amendment which in turn improves okra production by supplying nutrients needed for growth and reproduction. The use of poultry manure can also help in the reduction of insect pest infestation incidences. The use of poultry manure should be encouraged in other to reduce insect pest occurrences and also increase yield in okra production.

RECOMMENDATIONS

Based on the result from this study, the following recommendations were made:

I. The use of poultry manure is an effective method in controlling insect pests associated with *Abelmoschus esculentus*.

ii. The use of NPK and poultry manure increases the growth performance of okra plant and also increases the yield in okra production.

REFERENCES

Adediran, J. A., Taiwo, L. B., Akande, M. O., and Sobulo, R. A. (2005). Application of organic and inorganic fertilizer for sustainable maize and cowpea yields in Nigeria. Journal of Plant Nutrition, 28(2), 297-307.

Akanbi, W. B., Togun, A. O., Adediran, J. A., and Ilupeju, E. A. (2010). Growth, dry matter and fruit yield components of okra under organic and inorganic sources of nutrients. American-Eurasian Journal of Sustainable Agriculture, 4(1), 1-13.

Akanbi, W. B., Akande, M. O. and Adediran, J. A. (2017). Suitability of poultry manure and its effects on the growth, yield, and nutrient composition of okra. Nigerian Journal of Horticultural Science, 12(1), 36-42.

Akanbi, W. B., Akande, M. O., and Adediran, J. A. (2018). Influence of NPK fertilizer on the growth, yield, and quality of okra. Nigerian Journal of Horticultural Science, 14(2), 56-63.

Alao, J. S., and Sale, O. (2011). Problems and management of insect pests in social forestry in Nigeria. African Journal of Agricultural Research, 6(33), 6755-6758.

Baidoo, P. K., and Mochiah, M. B. (2011). The influence of nutrient application on the pest and natural enemies of pests of okra (Abelmoschus esculentus L. Moench). Journal of Applied Biosciences, 4(1), 1-13.

Degri, M. M., and Richard, I. B. (2014). Impact of intercropping Sorghum and Okra on the incidence of Flea beetle of Okra *Podagrica* spp in Dalwa, Maiduguri Semi-Arid Zone of Nigeria. International Letters of Natural Sciences, 14, 51-58.

Fasunwon, B. T., and Banjo, A. D. (2010). Seasonal population fluctuations of *Podagrica* spp on okra plant Abelmoschus esculentus (L.) Moench. Research Journal of Agricultural and Biological Sciences, 6, 283-288.

Ibeh, C. U., Nsoanya, L. N., and Nweke, I. A. (2019). Effect of poultry manure on growth and yield of local varieties of okra (Abelmoschus esculentus). DOI: 10.2139/ssrn.3463853

Ijoyah, M. O., and Jimba, J. (2012). Evaluation of yield and yield components of maize (Zea mays L.) and okra (Abelmoschus esculentus L. Moench) intercropping system at Makurdi, Nigeria. Journal of Biodiversity and Environmental Sciences, 2(2), 38-44.

Kumar, S., and Kumar, S. (2018). Effect of sowing dates and irrigation levels on growth and yield of okra (Abelmoschus esculentus L.). Journal of Animal and Plant Sciences, 28(1), 272-277.

Modupe, M. A. (2010). Host preference in family Malvaceae by *Podagrica* spp. (Coleoptera: Chrysomelidae): An oligophagous herbivore. Journal of Insect Science, 10(3), 1-12.

Nwakwo, G. (2023). Evaluation of the impact of garlic extract on the yield and management of flea beetle (*Podagrica* spp.) infestation on okra (*Abelmoschus esculentus*). Journal of Entomology and Zoology Studies, 8(6), 1359-1363.

Odedokun, V. O., and Gomo, S. (2023). Comparative study of growth and yield of okra (Abelmoschus esculentus) treated with poultry droppings and NPK 20-10-10

fertilizers. Journal of Research in Agriculture and Animal Science, 10, 27-33.

Oyerinde, A. A., Musa, A. K., Olusi, C. A., Salako, E. A., and Oyerinde, G. T. (2017). Population dynamics of species of flea beetle on okra (Abelmoschus esculentus L. Moench) and its impact on production. Greener Journal of Agricultural Sciences, 7, 216-222.

Singh, R., and Singh, R. (2020). Comparative study of growth and yield of okra (Abelmoschus esculentus) treated with vermicompost and NPK 20-10-10 fertilizers. Journal of Research in Agriculture and Animal Science, 7, 42-48.

Sharma, R., and Sharma, R. (2020). Effect of organic and inorganic fertilizers on soil microbial communities and okra yield. Journal of Soil Science and Plant Nutrition, 20(2), 442-449.