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# Combined application of ammonium nitrate and goat manure: Effects on soil nutrients availability, Okra performance and sustainable food security

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## Abstract

Many see organic agriculture as the most sustainable form of farming and as the paradigm for global food production in the future. One of the solutions to food insecurity and malnutrition in Sub-Saharan Africa is to promote local crops, encourage the use of locally source materials as amendment, improve their traditional system of production, and so diversify subsistence crop. The major reasons are the lack of knowledge and skill in land preparation and agronomic practices, weather uncertainties, pest outbreak and above all the use of fertilizer. Hence, this research will be carried out to investigate the effects of integrated application of Urea fertilizer and Goat Manure on soil Nutrient Availability and Okra performance. Field trials were conducted with four treatments replicated three times in a Randomized Complete Block Design (RCBD). The treatments were Control (no Urea, no goat manure), 8t/ha-1 goat manure + 200kg/ha-1 urea fertilizer; 8t/ha-1 goat manure + 175kg/ha-1 urea fertilizer and 8t/ha-1 goat manure + 150kg/ha-1 urea fertilizer. Treatments were applied three weeks after planting by ring method with Urea and goat manure mixed. Soil physical and chemical properties, growth and yield parameters were evaluated. Data were analyzed using Analysis of Variance (ANOVA) and Duncan Multiple Range. 8t/ha-1 goat manure + 200kg/ha-1 urea fertilizer gave the highest plant height, leaf area as well as number of leaves than other treatment. However, the fruits weight, days of 50% flowering, number of fruit, fruits diameter and fruits length were significantly increased at 8t/ha-1 goat manure + 200kg/ha-1 urea fertilizer.

**Keywords:** Soil nutrients; Okra; Ammonium Nitrate (AN); Goat manure (GM); Performance

## 1. Introduction

The current conception of organic farming—as an agricultural production system based on ecological understanding in contrast to one reliant upon external inputs, particularly synthetic agrichemicals and fertilizer—is the result of nearly a century of intellectual thought and dialogue, field observations and experiences, systematic experimentation, and codification of rules [1]. Sustainable use of mineral fertilizer by Nigerian farmers has become a serious problem due to ever increasing cost and associated procurement difficulties. Besides this, the use of chemical fertilizers has created a lot of environmental issues thereby rekindling the interest of many researchers in the use of organic materials either in their sole form or combination with less amount of chemically produced materials [2]. Applying sustainability assessment tools can help to identify challenges, related to environmental, economic and social impact, in the development of sustainable food production systems in conventional and organic agriculture [3, 4].

Organic Farming is the combine approach of soil management through maintaining the sustainability, soil fertility and biological diversity. This type of farming cause lowering of toxicity, encourages biological cycles of beneficial living organism, maintain soil fertility and many more additional advantages provided by this method shifting the contemporary era towards organic food and organic farming. A large number of sustainability assessment tools have been developed to gain insight into the sustainability performance of farms [19, 5].

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Okra is an important vegetable and economic crop in some parts of the world which can reach optimum production in the absence of fertilizers and produce promising yield within a short period of time. However, several factors such as pathogens, pests, and very importantly viral diseases, hinder the realization of these intended objectives. Okra is one of the most grown vegetable crops in the tropics and important protective food for the maintenance of health and prevention of diseases. It contains valuable food ingredients, which can be successfully utilized to build up and repair the body [6 – 8]. Varieties vary by plant height, fruit size, color, early or late maturing, etc., viz; white velvet, green velvet, long pod, ladyfinger, dwarf green pods [9, 10].

The increasing population in most developing countries, especially those located in the tropics, reduction or elimination of bush fallow and the attendant rapid loss of soil fertility and productivity, high cost and scarcity of chemical fertilizers, soil physical degradation, acidity and nutrient imbalance, and other problems associated with the use of chemical fertilizers necessitated the search for locally acceptable, technically feasible, cheap, economically viable, environmentally sound and culturally adaptable means of soil fertility maintenance [11 – 13].

Studies on organic agriculture provide divergent views on its sustainability and potential to contribute to global food security [14, 15] especially yield differences between conventional and organic agriculture are a topic of discussion [16, 17]. Differences in yields are highly dependent on system and site characteristics (e.g., available nutrients and technology) [18].

In many developing countries, farmers have limited financial resources and can rarely afford to purchase sufficient mineral fertilizers. The use of synthetic fertilizers is beyond the reach of peasant farmers due to their cost and scarcity. Crops have become so expensive to grow those nutrient deficiencies limit the yields. Common crop management practices such as continuous cropping and reduced fallow periods, can hardly support sustainable cropping. The need therefore arises for production practices that will ensure high yield [2].

Yields obtained by Nigerian peasant farmers are often low when compared with the ones obtained at research stations and developed countries [20]. Continuous cultivation of soil coupled with use of inorganic fertilizers, has been implicated in soil acidification, reduction of soil organic carbon and organic matter, nutrient imbalance, deficiency of secondary macronutrients and micronutrients [21, 22]. Due to this, many peasant farmers have resulted to use of organic wastes especially those of livestock which are abundantly available [23].

The use of organic manure is beneficial to the soil in terms of alleviating soil acidity, improvement of soil physical properties and nutrient status [24, 25]. Sole application of mineral fertilizer by local farmer is constrained by ever increasing cost and removal of subsidy. This has prompted them to result to use of organic wastes which is also confronted with problems of high quantity involved, slow release of nutrients, handling and carriage costs. Currently in Nigeria there are a general shift in emphasis over the sole use of inorganic fertilizers to other sources of plant nutrients such as farmyard manure [26]; sawdust [9, 33]. This has necessitated the use of inorganic fertilizers in combination with organic fertilizers. This shift in emphasis is attributed low cost of effectiveness, destructive effect on physical and chemical soil properties, inadequate and untimely supply of organic fertilizer [27]. Unlike inorganic fertilizer, organic fertilizers are cheap, easy to come-by, always safe to use, not poisonous or kill crop and environmentally friendly, but must be applied in large quantity to the crop because the nutrient concentration is very low compared with inorganic fertilizer which would definitely result to high transportation cost of manure materials.

The integrated application of organic and inorganic nutrient sources rather than total dependence on any of the sources is expected to ensure reduction in expenditure on chemical fertilizers, a more balanced plant nutrition and control of soil acidity. Organic manure are many wastes and residues of plant or animal life. The best-known organic manure is the waste from mixed arable and livestock farming called farmyard manure. Farmyard manure is partially rotted straw containing urine and feaces. Other rotting plant remains is usually called composts. Undecomposed materials like straw are manure too. Organic wastes from industrial processes, town refuses and sewage sludge are also referred as manures. Common amongst the farm and bi-products at various adaptive trials areas in Nigeria are poultry droppings, cow dung, goat dung, sheep dung, brewery wastes, cocoa pod husks, tea fluff, *chromoleana odorata* mulch, *calapogonium* mulch. And ash wastes such as cocoa pod husk ash, wood ash, rice bran ash and sawdust ash. Organic fertilizer materials are cheap and easy to come by. Most of the organic fertilizer materials are wastes or bi-products of other agricultural crops and animal and they could be used to augment the soil nutrient status, the biological and physical conditions of the soil.

Inorganic fertilizers are essential components of any system in which the aims is to maintain good yield in the absence of organic manure [28]. However the rate of application and dosage has a greater influence on both crop yield and its environment [29]. Unlike inorganic fertilizers, organic fertilizers are cheap, easy to come-by, always safe to use , not

poisonous or kill crop and environmentally friendly, but must be applied in large quantity to the crop because the nutrient concentration is very low compared with inorganic fertilizer which would definitely results to high transportation cost of manure materials. Maize or corn is rated the third most important cereal crop of the world and the most important cereal crop in sub–Saharan Africa [30].

In view of the increasing demand for food due to population, high cost and scarcity of inorganic fertilizer due to government deregulation policy, and unavailability of high yielding crop varieties as planting materials; total reliance on inorganic fertilizer or organic materials alone as fertilizer may not be realistic. Complementary use of organic with inorganic fertilizer should be employed so as to sustain soil fertility management strategy for okra production. The key to sustainable soil fertility management is integrated application of organic and inorganic fertilizers. Efforts in this direction will ensure build-up of soil productivity and quality on long term basis. Also, by reduction in quantities of either component, cost of production and fertilization will be reduced, balanced plant nutrition will be ensured and these are expected to enhance crop growth, yield and quality [31, 32]. Hence, the objective of this study is to evaluate the effect of combined application of ammonium nitrate and goat manure on soil nutrients availability and okra performance.

## 2. Material and methods

Field experiments were carried out at the Teaching and Research Farm of Oyo State College of Education, Lanlate Southwest, Nigeria in 2020 cropping seasons to study the effects of combined application of ammonium nitrate and goat manure on soil nutrients availability and okra performance. Lanlate lies between latitude $7^0$ 30′N and Longitude $3^0$ 52'E in the tropical rainforest belt f Nigeria. There are two rainy seasons; one from April to July (early season) and the other from mid-August to November (late season). Annual average minimum and maximum temperatures are 24.80$^0$C and 28.10$^0$C respectively. The mean relative humidity is about 75%. The soil at the site is classified as an alfisol (Oxic tropuldalf) according to [34, 35]. There were four treatments replicated three times in a Randomized Complete Block Design (RCBD). The treatments were Control (no Urea, no goat manure), 8t/ha$^{-1}$ goat manure + 200kg/ha$^{-1}$ urea fertilizer; 8t/ha$^{-1}$ goat manure + 175kg/ha$^{-1}$ urea fertilizer and 8t/ha$^{-1}$ goat manure + 150kg/ha$^{-1}$ urea fertilizer. Treatments were applied three weeks after planting by ring method with Urea and goat manure mixed.

Surface (0-15 cm) soil samples were taken before the commencement of the experiments (initial soil analysis) and twelve weeks after treatment application. Immediately after collection of surface soil samples using steel auger, samples were bulked for each year, air-dried and allowed to pass through 2mm sieve for analysis as outlined by procedures of [36]. Total N was determined by Kjedahl method, P by molybdenum blue colorimetry while K, Ca and Mg extracted with ammonium acetate pH 7.0 extractant after which the exchangeable K was evaluated using flame photometer while Ca and Mg were evaluated by EDTA titration. Soil pH in water was determined using pH meter in 1: 2 soil water ratio medium. Organic carbon and organic matter was determined using Walkley Black dicromate method (1934) as modified by [37].

Data were analysed using Analysis of Variance (ANOVA) to determine the effects of treatments on the parameters measured and least significant differences (LSD) at 5% was to compare the treatment means.

## 3. Results

Analytical data of pre-cropping surface soil at the site of the experiment are shown in table 1. The tested soil was marginal in organic matter (OM), adequate in nitrogen, calcium, magnesium, and potassium but inadequate in phosphorus, and slightly acidic [9, 27]. It was loamy sand with a pH ($H_2O$) of 6.50, total N 0.09%, available P 5.6 mg/kg, organic C 1.73%, organic matter (OM) 2.62%. The respective values for exchangeable K, Ca, Mg and Na were 0.25, 2.6, 2.1 and 0.18cmol/kg. The OM falls within 0.5-4.0% established for soils of southwestern Nigerian [38] but lower than critical level of 3% specified by [39]. The total N, available P and exchangeable Ca fell below critical level levels of 0.15% N, 10.0mg/kg available P, 2.0cmol/kg exchangeable Ca and 0.4cmol/kg established for crop production in southwestern Nigeria [39]. Therefore, the soil requires the application of fertilizing amendment that will particularly supply P for enhancing okra.

Chemical compositions of goat manure used for the experiment indicates that goat manure contained 68.2g organic matter, 4.8g of Nitrogen, 4.1g of Phosphorus, 1.9g of Potassium, 1.0g of Calcium and 0.9g of Magnessium (Table 2).

**Table 1** Pre-cropping soil analysis

| Properties | Values |
|---|---|
| pH (H2O) | 6.50 |
| Organic Matter (%) | 2.62 |
| Total Nitrogen (N) g/kg | 0.09 |
| Available Phosphorous (P) (mg/kg) | 5.60 |
| Exchangeable Calcium (cmol/kg) | 2.60 |
| Exchangeable Magnesium (Mg) (cmol/kg) | 2.10 |
| Exchangeable Sodium (Na) (cmol/kg ) | 0.18 |
| Exchangeable Potassium (K) (cmol/kg | 0.25 |
| Sand (%) | 81.20 |
| Silt (%) | 5.60 |
| Clay (%) | 13.20 |
| Texture | Loamy sand |

**Table 2** Nutrients composition of Goat Manure

| Properties | Values |
|---|---|
| Organic Matter (%) | 68.2 |
| Total N (%) | 4.8 |
| P ($mg/kg^{-1}$) | 4.1 |
| K $cmol/kg^{-1}$ | 1.9 |
| Ca ($cmol/kg^{-1}$) | 1.0 |
| Mg ($cmol/kg^{-1}$) | 0.9 |

**Table 3** Effects of Ammonium nitrate and Goat Manure and their combinations on Soil Nutrient Composition

| Experiment | pH | OM | N | P | K | Ca | Mg |
|---|---|---|---|---|---|---|---|
| | | (%) | | (mg/kg) | (cmol/kg) | | |
| Control | 6.00a | 0.87e | 0.10b | 43.56b | 0.19bc | 3.23bc | 1.37a |
| $8t/ha^{-1}$ GM + $200kg/ha^{-1}$ U | 6.15a | 1.78c | 0.34a | 29.21d | 0.35a | 0.50e | 0.18 |
| $8t/ha^{-1}$ GM + $175kg/ha^{-1}$ U | 6.13a | 2.48b | 0.14b | 30.33cd | 0.25b | 5.10ab | 1.30a |
| $8t/ha^{-1}$ GM + $150kg/ha^{-1}$ U | 6.00a | 2.24b | 0.12b | 26.18e | 0.32a | 3.63bc | 1.35a |

Means in the same columns not followed by same letters are significantly different at 5% level of significance by Duncan's Multiple Range Test (DMRT)

Data on growth parameters of okra as influenced by Ammonium Nitrate (AN), Goat Manure (SDA) and their combined use at different rates (table 4) shows that Okra plant height was increased only at $150kg/ha^{-1}$ AN + $8t/ha^{-1}$ GM and $200kg/ha^{-1}$ AN + $8t/ha^{-1}$ GM increases the stem girth. Relative to control, their combined (AN and GM) use at different rates increased number of leaves and flowers.

Ammonium nitrate and Goat manure alone and combinations of their reduced rates increased number of fruits. The SDA and combinations at $150kg/ha^{-1}$ AN + $8t/ha^{-1}$ GM, $200kg/ha^{-1}$ AN + $8t/ha^{-1}$ GM, $175kg/ha^{-1}$ AN + $8t/ha^{-1}$ GM increased number of fruits and fruit weight significantly in 2017 (Table 5).

**Table 4** Effects of Ammonium nitrate and Goat Manure and their combinations on Growth parameters

| Treatment | Plant height (cm) | Stem girth (cm) | No of leaves per plant | No of flower per plant |
|---|---|---|---|---|
| Control | 114.37 | 8.13 | 25.26 | 0.78 |
| 200kg/ha$^{-1}$ AN + 8t/ha$^{-1}$ GM | 106.53 | 9.27 | 19.11 | 1.11 |
| 175kg/ha$^{-1}$ AN + 8t/ha$^{-1}$ GM | 99.56 | 8.56 | 19.22 | 1.33 |
| 150kg/ha$^{-1}$ AN + 8t/ha$^{-1}$ GM | 114.67 | 9.39 | 21.44 | 1.56 |

Means in the same columns not followed by same letters are significantly different at 5% level of significance by Duncan's Multiple Range Test (DMRT)

**Table 5** Effects of Ammonium nitrate and Goat Manure and their combinations on Yield parameters

| Treatment | No of Fruits per plant | Fruits weight (g) |
|---|---|---|
| Control | 2.2 | 35.7 |
| 200kg/ha$^{-1}$ AN + 8t/ha$^{-1}$ GM | 3.2 | 37.1 |
| 175kg/ha$^{-1}$ AN + 8t/ha$^{-1}$ GM | 3.3 | 32.6 |
| 150kg/ha$^{-1}$ AN + 8t/ha$^{-1}$ GM | 3.6 | 42.1 |

Means in the same columns not followed by same letters are significantly different at 5% level of significance by Duncan's Multiple Range Test (DMRT)

## 4. Discussion

It is clear that the prospect of obtaining enough chemical fertilizer to meet the requirement of the teaming farming population in the tropic is remote. The current price of fertilizer calls for its economic utilization to meet specific requirements of crops. The current world-wide shortage of fertilizer and its anticipated adverse effect on food production has made many countries to explore the manorial value of organic manure to reduce pressure on the demand for mineral fertilizer as complementary use. Research/studies have shown that the use of inorganic fertilizer in combination with organic materials is able to give the desired higher and sustainable crop yields than the sole use of inorganic fertilizer or animal manure. The GM and Ammonium nitrate combination increased soil N, P, K, Ca and Mg significantly. The combinations also increase organic matter (OM). The effect of ammonium nitrate in increasing the nutrients can be adduced to associated increase in OM (Table 3). The increase in soil nutrients due to application of GM is constant with earlier findings [2] and the fact that Organic fertilizers have beneficial effect on nutrient composition, structural, aggregation, infiltration, ration, microbial and other biological activities of the soil; this and with a host of others will subsequently improve okra productivity, particularly in the tropics. Hence it is observed in this study that combination of Goat manure and Ammonium nitrate had higher values of soil N, P, K, Ca and Mg due to nutrients supply from the two sources and the fact that GM gave highest values of soil K, Ca and Mg which thereby giving it liming effects.

Aside from its liming effect, it was found in the present work that GM significantly increased soil P, K, Ca and Mg. this is consistent with analysis data given for the material which show that it contained macronutrients. Wood ash and other types of plant derived ashes were also found to increase organic matter, N, P, K, Ca and Mg in soil which were made available for uptake of crops such as sesame [33]. Also [40] reported that the application of organic manure significantly increased the growth parameter and yield of okra which may be attributed to the high level of organic manure which supply essential plant nutrients growth.

The comparative effects of 300kg/ha NPK 15-15-15 fertilizer, 7t/ha poultry manure (PM) and six combinations of reduced levels of N-P-K 15-15-15 and PM, and control (no fertilizer) on maize performance, nutrient uptake and soil chemical properties were investigated for two years at Akure [31, 32].

Field experiments carried out in South-West Nigeria have shown positive response of yield and nutrients contents of okra to application of wood ash as reported by [41]. Application of 2, 4, 6, 8 tons/ha ash increase okra pod and weight [42]. For the planting of pepper and other vegetables in Eastern Nigeria at household levels, the use of poultry droppings, cow dung, goat manure, wood ash and composted residues for improving soil fertility has been adopted. Other studies [43, 44] carried out in parts of Africa found that plant derived ash increased P, K, Ca, Mg status of soil, pH

and yield of vegetables. Studies carried out earlier by the researcher in southwest Nigeria showed that combination at 75% Goat manure and 25% Urea increased the plant height, number of leaves as well as the yield of Amaranthus.

## 5. Conclusion

It is the combination of organic and inorganic fertilizers coupled with soil conservation farming system in the supply of nutrients to crops. The concept is more advocated for the tropics, especially the humid tropics where chemical or inorganic fertilizers did not make expected impact in revolutionizing crop production. Generally, all over the world especially in temperate agriculture, chemical fertilizer has consistently boost crop production with average of fifty percent increase in crops yield attributed to chemical fertilizer (CF).

Although crop production all over ages depends on organic manure such as animal wastes, crop residues, fallow, green manuring, sewage water, human excreta (e.g. China and Ghana) and recently biofertilizers such as azolla, mycorrhiza etc, total dependence of organic fertilizers is hampered by problems

Integrated plant nutrition (IPN) will also assist in environmental sanitation by utilization of farm, human, and municipal wastes etc. It is a waste to wealth programme. Compared with chemical fertilizers, IPN ensures more residual effect and overall development of soil physical, chemical and biological qualities, [45]. The IPN combines attributes of both organic and inorganic fertilizers, thereby enhancing crop performance.

It is therefore concluded that there are abundant organic wastes that could be used alone or combined with mineral fertilizers. The presence of organic manures in organo-mineral fertilizers ensures more residual effect, balanced nutrition and improvement in soil physicochemical properties. The use of the two sources has synergistic effect and reduces expenditure on scarce and expensive mineral fertilizers. It is a sustainable approach to ensuring high soil productivity and crop yield.

## Compliance with ethical standards

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### *Disclosure of conflict of interest*

There is no conflict of interest among the authors.

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