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Eco-Agriculture for Effective Solid Waste Management in Minna, Nigeria

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Abstract**—**The increasing volume of solid waste generated, collected and disposed daily complicate adequate management of solid waste by relevant agency like Niger State Environmental Protection Agency (NISEPA). In addition, the impacts of solid waste on the natural environment and human livelihood require identification of cost-effective ways for sustainable municipal waste management in Nigeria. These signal the need for identifying environment-friendly initiative and local solution to address the problem of municipal solid waste. A research field was secured at Pago, Minna, Niger State which is located in the guinea savanna belt of Nigeria, within longitude 6^0 36^1 43^{11} - 45^{11} and latitude 9^0 29^1 37.61^{11} - $.62^{11}$ N. Poultry droppings, decomposed household waste manure and NPK treatments were used. The experimental field was divided into three replications and four (4) treatments on each replication making a total of twelve (12) plots. The treatments were allotted using Randomized Complete Block Design (RCBD) and Data collected was analyzed using SPSS software and RCBD. The result depicts variation in plant height and number of leaves at 50% flowering; Poultry dropping records the highest height while the number of leaves for waste manure competes fairly well with NPK treatment. Similarly, the varying treatments significantly increase vegetable yield, as the control (non-treatment) records the least yield for the three vegetable samples. Adoption of this organic manure for cultivation does not only enhance environment quality and attainment of food security but will contribute to local economic development, poverty alleviation as well as social inclusion.

Keywords**—**Environmental issues, food security, NISEPA, solid waste.

I. Introduction

GLOBALLY, contemporary trend in population growth, urbanization, socio-economic development processes and civilization have led to increase waste generation in the urban cities. Since the creation of Niger state in 1976, the population of Minna have being increasing rapidly by about 50% from 1976-1991 and 60% 1992-2006, similar figures are recorded in most urban areas across the state. This coupled with the struggle for survival and increase in socio-economic development has amplified the rate of waste generation, collection and disposal across the state. These have complicated adequate management of solid waste by relevant agency like Niger State Environmental Protection Agency (NISEPA). Use of organic amendment applied to soil not only enhance the nutrient status but also reduce the pest incidences [1]. Consequently, the need to identify cost-effective environment-friendly initiative for reducing and reusing vast proportion of solid waste generated in the state for enhance livelihood and attainment of food security.

Generally, solid waste dumpsites serve as incubation and proliferation centers for flies, mosquitoes and rodents which could constitute serious environmental and health problem to the inhabitant. This may perhaps lead to outbreak of epidemics and spread of infectious diseases resulting to spending valuable resource on drugs in addition to the huge amount of money budget for solid waste management annually. Reference [2] reported increase adverse health effects from residence near individual landfill sites. In addition, [3] concludes that both nearby and far away residences are affected by location of dumpsites close to settlement. Consequently, there is need to identify environment-friendly initiative such as waste reduction, reuse and recycling for solid waste in the state for effective solid waste management.

Cultivation of crop in recent time particularly vegetables requires additional soil nutrient and mostly used are chemical fertilizers. Soil nutrient depletion as a result of continuous cultivation is a major challenge to farmers [4]. Generally, increase use of this these chemical products have varying effects on the soil and is a threat to sustainability of soil fertility. Effects of chemical fertilizers in the soil lead to deterioration of the balance of the current element [5]. Consequently, for high and sustainable fruit and vegetables yield, eco-friendly agronomic practices should be employed such that is safe and beneficial to soil organisms. Organic manure from different sources on the other hand helps in boosting vegetable crop growth, fruit and seed yield and quality as they contain most of the nutrients essential for plant growth and development [6]. Hence, adoption of this waste for agriculture will improve community economic well-being and sustainable livelihood across the state.

The increase in the rate of waste generation signals the need for identifying local solution to address municipal solid waste problem. As well as, identifying ways of improving farmer's soil nutrient need through development of strategies for sustainable environmental protection, food security, and poverty eradication for the attainment of sustainable development. Today, the major challenge of agriculture is loss of soil fertility, this compel the farmers to use fertilizers which as a result of poverty is rarely available and it prolong utilization may constitute hazard to the natural environment. Despite the importance of inorganic manures, its use is limited

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due to scarcity, high cost, nutrient imbalance and negative residual effects on soils [7]. Consequently, the need for the assessment of the effect of solid waste on vegetables performance is fundamental for its promotion and adoption for enhance production, rural and urban livelihood as well as improve environmental quality.

II. Study Area (Location)

An experimental farm was secured by Niger State Environmental protection Agency (NISEPA) at Pago, Minna Niger State. The farm is located in the guinea savanna belt of Nigeria, within longitude 6^0 $36^{1}43^{11}$ - $45^{11}$and latitude 9^0 29^{1} 37.61^{11} - $.62^{11}$ N (Fig. 1). Pago is a small Gbagyi settlement characterized with about six months of dry season and six months of rainy season, the annual rainfall has been estimated to be between 1200mm and 1300mm.The temperature is generally beyond 27^0 Celsius and relative humidity is about 80% during the rainy season. The cultivation was done during dry weather condition low relative humidity, high temperature and no rainfall condition (dry season farming).

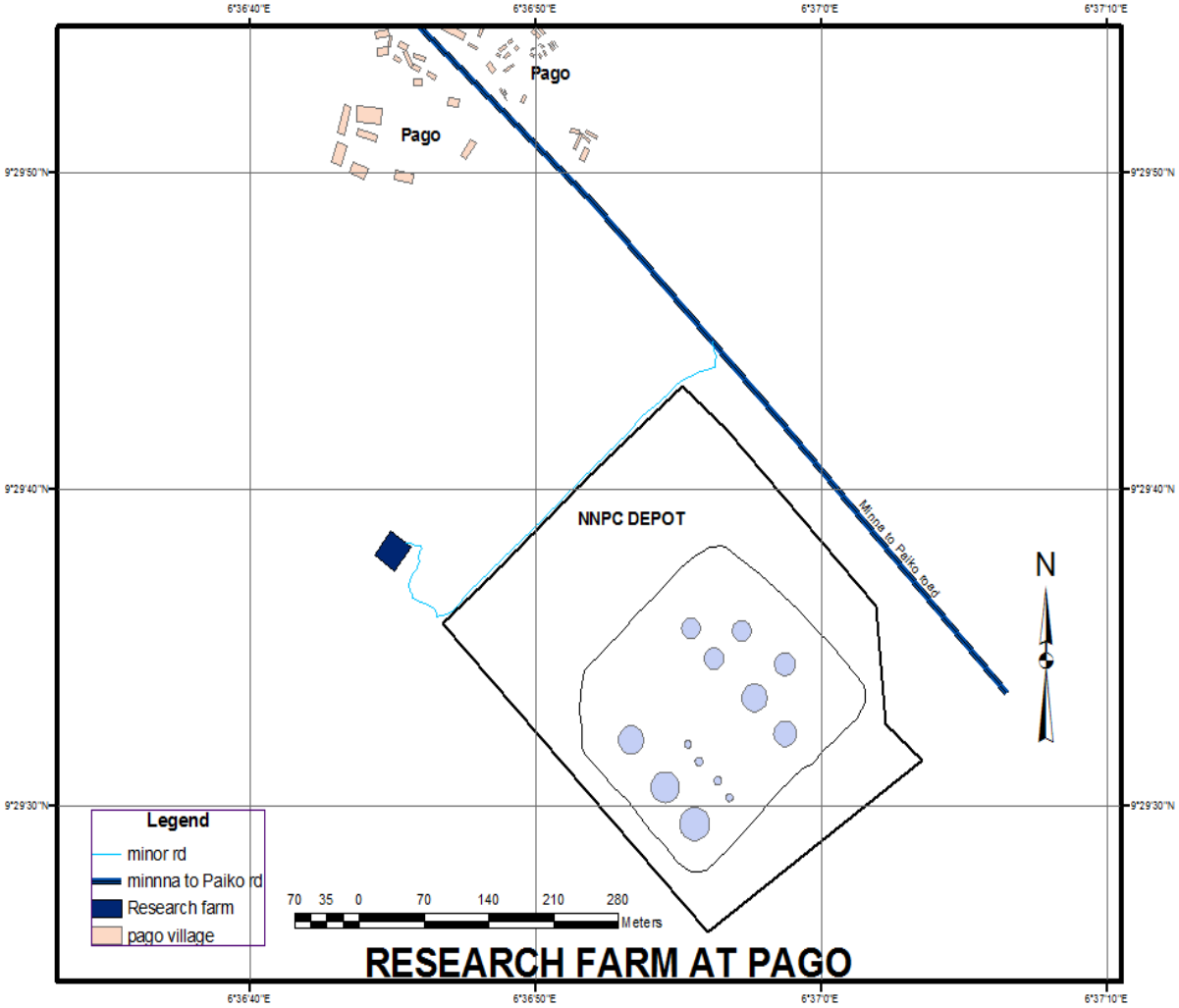

Fig. 1 Research Farm

III. Methodology

Seeds of three vegetable landraces: *Hibiscum esculantun* (okra), *Lypersicum esculantun* (Tomatoes) and *Solanum indicon* (Garden egg) were sourced from farmers around Minna. Tomatoes and garden egg nurseries were established on 1st October 2012 to provide seedlings for transplanting after three weeks. Poultry droppings (P) were collected from Yandeyi commercial battery cage poultry house at Pago and decomposed household waste manure was collected from refuse dump sites within Minna Township.

Soil samples were collected, air dried, sieved and then analyzed for some chemical and physical properties using standard laboratory methods. Data was obtained on pH, percentage of organic matter, total nitrogen, available phosphorus (ppm), percentage sand, silt and clay, exchangeable Na^+, K^+, Ca^{2+} and Mg^{2+} to ascertain the type and status of the soil of the experimental site prior to the study. Similarly, the poultry droppings and decomposed house waste manure used were also analyzed for Mn, Fe, Cu, Zn, available

P, Ca, Na, K and Mg constituents before their incorporation into the soil to ascertain their initial status (contents).

The experimental site was cleared of vegetation using hoes and cutlasses. Ridges were constructed 75cm apart each measuring 2m long. Each plot comprise of eight ridges giving a unit area of 10.5m^2. The experimental field was divided into three replications and four (4) treatments on each replication making a total of twelve (12) plots on the experimental field. The treatments were allotted using Randomized complete Block Design (RCBD). The study used fertilizer by variety factorial experiment with four (4) treatment combinations. The four treatments used in the study are; 8 tons of poultry manure/ha (P8), 8 tons of decomposed household waste manure/ha (HW8), NPK fertilizer (100 kg/ha N, 50 kg/ha P_2O_5 and 50 kg/ha K_2O) (F) and no manure / fertilizer (control) (C). Two weeks prior to sowing, properly cured organic manures (poultry droppings and decomposed household waste manure) were incorporated into the ridges manually, following which the seeds were sown to plant spacing of 50cm on ridges made 75cm apart for okra, tomatoes and garden egg.

Manual weeding was done at three (3) weeks after sowing for all the vegetables. Fertilizer application was done immediately after weeding for the concern plots. The rate of 8 t ha^{-1} of organic manure was used in this study based on the recommendations of 5-6 t ha^{-1} and 5 t ha^{-1} giving by [8]. Also the recommendation of 100kg N ha^{-1}, 50kg P ha^{-1}, 50kg K h^{-} 1given by [9] was used for the fertilizer treatments. Irrigation was adopted using watering cans to supply water requirement of the vegetables after cessation of rain.

Data was collected on plant height and number of leaves at 50% flowering. In addition, species yield weight was determined after each harvest from the four middle rows for each plot, this was done using a salter balance for fruit yield capability for five consecutive weeks during harvest. Data collected was analyzed using SPSS software and Randomized complete Block Design means were compared.

IV. Result and Discussion

A. Chemical Properties of Soil and Organic Waste

The chemical properties analysis showed that soil of the study area had low organic carbon/ total nitrogen content and the general nutrient composition of the soil is less than those of the organic waste added (Table I). Reference [10] states that Poverty, intensification and extensification of marginal lands were identified as major threats to the sustainability of soil and water resources.

TABLE I
Chemical Composition of Soil and Organic Waste

Samples	Soil	Poultry Dropping	Decompose Waste
O/C / TN %	.20/.26	.48/.40	.32/.2
P (mg kg)	11.77	15.0	14.68
Na^+	.12	.31	.21
K^+	.19	.34	.38
Mg^+	.99	.75	1.84
Ca^+	.49	.88	.96
pH/H_2O $CaCl^{-12}$	6.0/5.3	-	6.0/4.2

The soil composition is about 80.6% sandy, 7.1% silt and 12.3% clay and textural class is sand-loamy while decomposed waste had 75% sandy, 8.3% silt and 16.3% clay also the textural class is sand-loamy (Table II).

TABLE II
Composition of Soil and Decomposed Waste

Soil Composition	Sand	Silt	Clay	Texture
Soil	80.6%	7.1%	12.3%	sand-loamy
Waste	75.3%	8.3%	16.3%	sand-loamy

B. Assessment of Vegetable Growth

Field experiment conducted between September and December 2012 unveil the efficacy of various growth performances and nutritional composition of some vegetable. Comparison of vegetable height and number of leaves at 50% flowering depict variation in plant height and number leaves with different organic waste treatment. Poultry dropping records the highest height and number of leaves and waste manure competes fairly well with NPK fertilizer treatment while control records the lowest height and least no of leaves (Figs. 2 and 3).

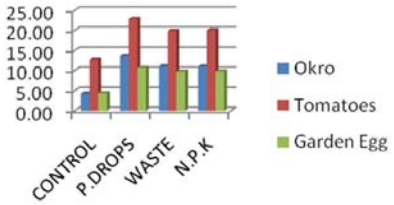

Fig. 2 Vegetable Height at 50% Flowering

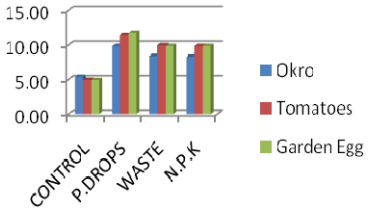

Fig. 3 No of Leaves at 50% Flowering

TABLE III
Effects of Nutrient Sources on Plant Heights

Treatment	Okra	Tomato	Garden egg
Control	4.4 ± 0.1^c	12.8 ± 0.6^c	4.5 ± 0.2^c
Poultry dropping	13.7 ± 1.9^a	22.8 ± 0.3^a	10.8 ±0.4^a
NPK	11.1 ± 0.6^b	20.1 ± 0.9^b	9.8 ± 0.2^b
Waste	11.2 ± 0.5^b	19.9 ± 0.8^b	9.7 ±0.2^b

Means followed by the same letter in a column are not significantly different at p=0.05.

Despite the apparent differences, analysis of variance confirms that poultry dropping have significantly higher height than others while NPK and Waste have no significant differences in height as control record the least height (Table III). Interaction effect of variety and different type manure and fertilizer affected plant height significantly [11] Similar result is recorded for leave concentration; poultry have significantly higher number of leave concentration, no significant

difference between waste and NPK as control had the least number of leaves for the three vegetables (Table IV).

TABLE IV
EFFECTS OF NUTRIENT SOURCES NUMBER OF LEAVES PER PLANT

Treatment	Okra	Tomato	Garden egg
Control	5 ± 0.1^{c}	5 ± 0.1^{c}	5 ± 0.3^{c}
Poultry dropping	10 ± 0.2^{a}	12 ± 0.6^{a}	12 ± 0.5^{a}
NPK	8 ± 0.2^{b}	10 ± 0.1^{b}	10 ± 0.1^{b}
Waste	8 ± 0.5^{b}	10 ± 0.2^{b}	10 ± 0.1^{b}

Means followed by the same letter in a column are not significantly different at p=0.05.

C. Vegetable Yield Assessment

Generally, nutrient treatment significantly increase vegetable yield, as the control (non-treatment) records the least yield for the three vegetables; 5.90, 48.67 and 23.09 kg/hec in that order for okro, tomatoes and garden egg (Fig. 4), [12] recorded similar result. Poultry droppings treatment records the highest yield for the three vegetables; 39.94, 189.19 and 263.13kg/hec respectively for okro, tomatoes and garden egg. However, despite the apparent competition of vegetable height and number of leaves at 50% flowering between waste and NPK treatment, there is significant difference between the yields of the two treatments. Decomposed household treatment records significantly higher yield than NPK. The visualization of the vegetable yield under varying treatment confirms the fact that additional nutrient application significantly increase vegetable yield. Therefore, the result reaffirms the fact that the soil of study area cannot give reasonable yield to support local farmer's livelihood without additional treatment. These generally, endanger sustainable socio-economic development and attainment of food security across the country.

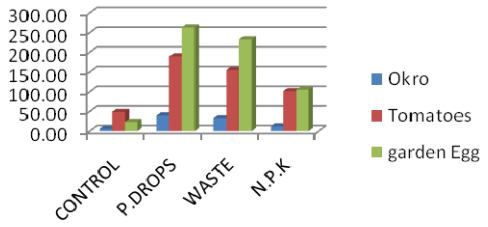

Fig. 4 Mean Vegetable Yields (Kg/hec)

The variance analysis reaffirms the fact that additional nutrient treatment is inevitable for cultivation of vegetables as mostly poultry dropping have significantly higher yield, followed by waste treatment which record significantly higher yield than NPK while control significantly records the least yield (Table V). This is an indication that additional treatments produced significantly higher yield and justify the adoption of chemical fertilizer for cultivation in recent term. The present result shows that organic waste treatments (poultry and waste) have significantly higher yield. Additions of organic manures result in increased soil organic matter content [13], [14].

The experiment reveals that soil treatment is crucial in recent time as increase human pressure on available soil resource have led to soil degradation, coupled with the fact that shifting cultivation is currently impossible and bush fallow system is unsustainable. In response to the growing population and need for farm land expansion due to availability of herbicides and pesticides. Consequently, continuous cultivation is on increase as a piece of land is cultivated year after year leading to low yield that is distinctive of agricultural practices in recent times. As a result, there is need for environment-friendly initiatives towards proper soil management and conservation for continuous cultivation and higher yield such that will balance the delicate equilibrium in soil composition.

TABLE V
EFFECTS OF NUTRIENT SOURCES ON YIELD

Treatment	Okro	Tomato	Garden egg
Control	5.9 ± 3.8^{d}	48.7 ± 7.2^{c}	23.1 ± 6.9^{b}
Poultry dropping	39.9 ± 3.2^{a}	189.2 ± 21.3^{a}	263.1 ± 74.9^{a}
NPK	12.0 ± 2.1^{c}	101.5 ± 18.2^{b}	105.2 ± 56.7^{b}
Waste	33.0 ± 2.3^{b}	155.3 ± 35.4^{a}	232.8 ± 110.3^{a}

Means followed by the same letter in a column are not significantly different at p=0.05.

The growing environmental challenges have led to increase interest in identification of environment- friendly measures that will enhance environmental sustainability such that will convert waste to resource particularly in tropical countries where the climatic condition favour organic decomposition. The productivity of vegetables in Nigeria is much lower than the potential productivity because of the indiscriminate use of inorganic fertilizer with resultant deterioration of soil health [15]. The higher vegetable performance and yield recorded for poultry dropping and waste treatments in the present research ascertain the fact that waste and poultry dropping treatments does not only competes favourably with chemical fertilizer but increase vegetable performance and yield than NPK. This finding is in agreement with [16], who observed that organic manures played an important and significant role in increasing yield. As well as, indicating that available soil need additional treatment for any meaningful yield since control record lowest height, least leave concentration and yield. Vegetables can be grown on a wide range of soil types; their yield is known to be mostly limited by soil fertility and cultural management [17]. Specifically, the influence of poultry and waste treatments on vegetable height and leave concentration demonstrated that these treatments could be an economical alternative to chemical fertilizer that is commonly used across the state.

V. CONCLUSION

The research demonstrated the effects of different nutrient sources (poultry, decomposed waste and NPK) on vegetables performance and yield. Generally, fundamental to sustainable livelihood in any environment is adequate management of its environmental resource and waste generate. As a result, we should all join the global community and have a rethink to prevent waste generation, reduce the amount of waste generation, identify sustainable ways of reusing waste generated and developed cost effective, efficient and

environment-friendly technology for recycling such that nothing get to the dumpsite for enhance environmental quality and sustainability of human livelihood. Consequently, eco-agriculture should be widely accepted and promoted by the stakeholders for higher yield and healthy livelihood.

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