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The Effect of Two Mineral Fertilizers and Wood Ash on Growth and Yield of Pepper on Nutrient Depleted Soil

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Abstract

Peppers are of two broad types; sweet pepper (Capsicum annum var conoides) and hot pepper (Capsicum annum var longum); widely grown fruit vegetables used as condiment and medicine in many parts of the tropics. There is need for intensive management available soils for fertility and productivity maintenance. The input for bumper harvest for pepper on nutrient depleted soil has being solely mineral fertilizers application; which affects the soil reaction. Response of peppers to wood-ash and mineral fertilizers on such soil has not been so investigated. Hence, an experiment was conducted to assess the effect of two mineral fertilizers and wood-ash on the growth and yield of pepper under field conditions. The study was conducted at Michael Otedola College of Primary Education Teaching and Research Farm. The plot was partly eroded and being under continuous cultivation for years. Each experimental plot (2.0 m^2) and treatments were laid in complete randomized block design and replicated thrice. The treatments are; No fertilizer, 40 g Urea, 90 g NPK 15-15-15, 40 g Wood-ash, and 1:1 Urea + Wood-ash. Data collected were: plant height (PH, cm), leave area (LA, cm^2), number of fruits (NF) and fresh fruits weights (FW, g/plant). All data were subjected to analysis of variance (ANOVA, $\alpha 0.05$) and standard error. The results showed that PH was reduced (15.9±0.7) under urea only but increased (17.4±0.7) under urea + wood-ash application. Likewise, LA was higher (15.0±0.9) under urea + wood-ash at 7 and 6 weeks after transplanting respectively. The NF and FW were significantly higher (18, 145.4±2.0) under wood-ash and urea + wood-ash (17, 129.8±2.0) application compared with other urea (8, 25.2±2.0) and NPK (17,124.1±2.0) respectively. In conclusion, urea + wood-ash at 1: 1 and wood-ash increased pepper growth and yield variables on nutrient depleted soil. Applications of urea +wood-ash or wood-ash only improve pepper production on slightly acidic soil.

Keywords: *Fertilizers, Wood-ash, pepper, Nutrient depleted soil*

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Background to the Study

Nutrient supply constituted an important aspect for soil fertility management for pepper production (Fagbola, Olugbemi and Oyetunji, 2009; Oni and Fagbola, 2010). This will ensure higher fruit yields, better quality and yield stability that is needed for the international competitiveness (Hochmuth and Hanlon, 2010). The soils in Nigerian's soils are inherently low in fertility and need long fallow periods for nutrient and organic matter build-up in the traditional food crop production systems but these fallows have shortened and farmlands are more or less permanently cultivated which affect the soil fertility status (Olugbemi, 2016).

Cone pepper has erect and fruits is few centimeter long in conical form while the bell pepper plant is stout bushy and its fruits are large, soft, irregularly compressed, red or yellow and mild in taste (Louis, 2013). One of the most widely grown fruit vegetables worldwide is pepper *Capsicum* spp. This fruit is believed to have originated from Tropical America before spreading to Europe, Africa and other parts of the world (Ogundare and Aiyelari, 2010). There are two main groups of pepper; sweet peppers and hot peppers. According to (Idowu-Agida, Ogunniyan and Ajayi, 2012), sweet peppers are one of the main groups or classes of the various pepper fruits; these include: cone pepper and bell pepper (Ashilenje, 2013). The cayenne pepper is among the three major hot peppers grown in Nigeria. It is an annual tropical crop which is valued for its sensory attributes of color, pungency, and aroma (Ademoyegun, Fariyike and Aminu – Taiwo, 2011).

Pepper is used as condiment, medicine and as ornamentals in gardens (Sanusi and Ayinde, 2013). Peppers contain phytochemicals which assists in the prevention of cancer, stroke and other diseases when consumed in diets (Ademoyegun *et al.*, 2011). Extracts from pepper are used as botanical pesticides against crop pests in organic farming systems (Ashilenje, 2013). Pepper is known as a health benefiting spice which contains carotenoids, capsaicinoids, minerals and vitamins (Louis, 2013).

According to Okore, Mbanefo, Adeyemo, Onyekwere and Oyewenjo, (2012), vegetables and spices such as pepper take up large amount of nutrient from the soil hence the need for the addition of nutrients to the soil to increase their growth and yield. Farmers involved in pepper production usually employ different means of enriching the soil which includes the use of organic and inorganic fertilizers (Ademoyegun *et al.*, 2011). Martens, Johanson and Frankenberger, (2012) reported that organic manure promoted and increased of microbial activity which gradually releases nutrients to the crop for greater yield. According to Ogundare and Aiyelari (2012), research needs to be conducted to explore the possibility of using inorganic and organic nutrient sources as soil amendment and to control fungal diseases of pepper while ensuring an increase in the yield of pepper. (Hochmuth and Halon, 2010; Ogundare and Aiyelari, 2012).

Nigeria produces about 65% of total production of pepper in Africa which is about 695,000 metric tons (Halverson and Bartolo, 2010). However, there is need to increase production as there is increase in demand for pepper (Ekefan, Olukotun and Nwankiti , 2010). In order to obtain high yield of pepper, there is need to improve the available soil fertility status using

mineral and organic fertilizers and wood ash for maintaining the fertility of the soil (Ayodele, Alabi and Aluko, 2015). Different soil management practices affect the structure and activity of soil organisms (Okore *et al.,* 2012). Intensive cultivation, which leads to depletion of soil nutrients and acidity, is a major constraint on food production (FMARD, 2010). To overcome the rapid decline amendments such as fertilizer, manure, compost and animal dung that contain nutrients are applied to the soil to improve and maintain crop yield (Ameri and Fatemi, 2010; Abu-Zahra, 2011). However, constant uses of these materials indiscriminately result to soil nutrients imbalances and low soil pH or soil acidity (Martens, 2012).

According to Ogundare and Aiyelari (2010), soil acidity problem are in most cases controlled by the application of lime or calcium carbonate compound fertilizers and at local level the use of wood ash is preferred (Olugbemi, 2016). However, there is inadequate information the use of urea fertilizer plus wood ash in the production of pepper on acidic soil. Hence, this paper focused on the effect of mineral fertilizers and wood ash on the performance of pepper on nutrient depleted soil with objectives of assessing effect two levels of mineral fertilizers and wood ash on the growth and yield of pepper on the growth and yield of pepper on nutrient depleted soil.

Materials and Methods

Experimental location: The experiment was conducted at Michael Otedola College of Primary Education. Teaching and Research Farm (TR&F) Noforija; located on 6.6^0N and 4.0^0E. The farm is located on the northern shore of the Lagos lagoon, about 32 kilometres south of Ijebu Ode, Lagos state. The coordinates of the experimental farm for the experiment are as follow: N0637.168', E003.323', N0637.166', E003.325', N0637.164', E003.333' and N0637.169', E003.332.

Land Preparation and layout: The land was cleared and tilled manually with cutlass and hoe respectively for suitable planting medium. Each micro plot measured 2.0 m^2 with a walk way of 1.0 m^2 between each micro plot.

Soil Sample Collection for laboratory Analysis: soil samples were collected, bulked into composite, air-dried, crushed and sieved through 0.5mm mesh, for soil physical and chemical properties analyses (Table 1).

Experimental Materials and Procedures: The hot pepper (*rodo*) was sourced from local market and the seeds were extracted and air dried before being nursed for three weeks. The mineral fertilizers (NPK 15-15-15 and Urea) and wood ash were sourced from Department of Agricultural Education, Michael Otedola college of Primary Education, Noforija Epe.

Experimental treatments and Design: The treatments combinations are: No fertilizer application (NF), Urea fertilizer application (UF) at 40 g/2m^2, NPK 15-15-15 (NPK) at 90 g /2m^2, Wood ash only (WA) at 40 g /2m^2, Urea + Wood ash (1: 1; UWA). The experiment was laid in randomized complete block design (RCBD) with each treatment replicated three times given a total of fifteen micro plots. Weeding and irrigation were carried out on manually on regular basis throughout.

Planting and Treatments Application: The seedlings were transplanted into the prepared micro plots three weeks after nursing at 75 cm by 60 cm. the total plant per micro plot was four (4) pepper stands. The mineral fertilizers and wood ash were applied one week after transplanting.

Data Collection and Analysis: The growth parameters such as plant height, number of leaves, branches and flowers per plant were collected after transplanting. From five weeks up to twelve weeks (5–12 WAT) after sowing, the following data were collected: plant height, leave area, number of leaves, fruits and fresh fruits weight per plant. All data collected were analyzed using analysis of variance (ANOVA $Pr \leq 0.05$) and mean treatments were subjected to standard error.

Results and Discussion

The soil used for the trial was acidic (pH; 4.4) and organic carbon of 10.4 g/kg with moderate level of nitrogen and low available phosphorus (14.2 mg/kg). The soil was sandy loam soil with 832g / kg sand; a well drained soil (120 g/kg silt) which is capable of retaining moisture. The portion of the experimental site has been a partially eroded farm land subjected to amendment for this purpose (Table 1).

Table 1: The physical and chemical properties of the soil used for the experiment

Parameters	Values
pH (H_2O) (1.1)	4.4
Organic C (g kg^{-1})	16.5
Total N (g kg^{-1})	1.7
Available P (mg kg^{-1})	21.4
Exchangeable Bases (cmol kg^{-1})	
K	0.23
Ca	4.34
Na	0.30
Mg	0.53
Particle size distribution (g kg^{-1})	
Sand	832.0
Clay	48.0
Silt	120.0
Textural class	Sandy Loam

Source: Soil Science Laboratory, Dept. of Agronomy University of Ibadan

The pepper plant number of leaves ranged 11.0 to 25.3, at 5 WAT and the same trend was obtained at 6 WAT (11.0 and 25.0±2.5). At 5 WAT, the pepper plant number of leaves under urea and wood ash application was significantly higher throughout the trial compared to other soil treatments except (25.3±2.5) wood ash application at 5 WAT (Table 2). The number of leaves reduced significantly at 7WAT and ranged from 12.7 – 19.5, with the least value under urea fertilizer application (13.5±2.5 and 12.7±2.5) which was not significantly higher compared to no fertilizer application (Table 2).

Table 2: Number of leaves of pepper at 5, 6 and 7 weeks after transplanting

Treatments	5 WAT	6 WAT	7 WAT
A = UF	17.3	14.8	12.7
B = NPK	16.3	14.3	14.3
C = WA	25.3	21.3	16.0
D = UWA	25.0	25.0	19.5
E = NF	11.0	11.0	13.5
SE(df= 14)	1.5	2.5	1.9

Source: Field experiment, (2017)

LEGEND: A = Urea (10 g per plant), B = N.P.K 15-15-15 fertilizer (10 g per plant)
C = Wood ash (10 g per plant), D = Urea + wood ash (1: 1 per plant)
E = No fertilizer application (NF/control), WAT = weeks after transplanting SE = standard error.

From table 3, at 5 WAT, the pepper plant height ranged from 9.6 cm to 13.0 cm and at 6 WAT, similar trend was observed (9.6 cm to 13.8 cm) when no fertilizer was applied and when urea and wood ash were applied respectively. At 6 WAT, the pepper plant height ranged 12.3 cm to 16.6 cm, and at 7 WAT the same trend was followed under no fertilizer and wood ash application and when urea fertilizer alone was applied (12.2 cm - 15.9 cm) respectively. In all, urea + wood ash application gave the highest values of plant height (17.4±0.7) compared to other fertilizer application (Table 3).

Table 3: plant height of pepper at 5, 6 and 7 weeks after transplanting

Treatments	5 WAT	6 WAT	7WAT
A = UF	13.3	15.3	15.9
B = NPK	11.3	12.8	13.8
C = WA	13.8	14.9	16.3
D = UWA	13.7	16.6	17.4
E = NF	11.2	12.3	13.2
SE(df= 14)	±0.5	±0.8	±0.7

Source: Field experiment, (2017)

LEGEND: A = Urea (10 g per plant), B = N.P.K 15-15-15 fertilizer (10 g per plant)
C = Wood ash (10 g per plant), D = Urea + wood ash (1: 1 per plant)
E = No fertilizer application (NF/control), WAT = weeks after transplanting SE = standard error.

At 5 WAT, the leaves area of pepper ranged from 10.4 - 14.2 cm^2, and at 6 WAT the same trend was obtained where the least leave area (8.8 $cm^{2)}$ was observed under No fertilizer application while Urea + wood ash had the highest leave area of 15.0±0.9 cm^2. Furthermore, at 7 WAT, leaves area of pepper ranged 6.8 to 12.5±0.8 cm^2 under no fertilizer application and urea plus wood ash application respectively (Table 4).

Table 4: Leaves area of pepper at 5, 6 and 7 weeks after transplanting

Treatments	5 WAT	6 WAT	7WAT
A = UF	12.8	13.3	12.5
B = NPK	11.0	9.5	7.5
C = WA	13.4	11.9	7.7
D = UWA	14.2	15.0	12.1
E = NF	10.4	8.8	6.8
SE(df= 14)	±0.6	±0.9	±0.8

Source: Field experiment, (2017)

LEGEND: A = Urea (10 g per plant), B = N.P.K 15-15-15 fertilizer (10 g per plant)
C = Wood ash (10 g per plant), D = Urea + wood ash (1: 1 per plant)
E = No fertilizer application (NF/control), WAT = weeks after transplanting SE = Standard error.

From table 5, at 6 WAT, the pepper plant number of branches ranged from 2 to 4.7 and at 8 WAT the same trend was obtained when no wood ash nor mineral fertilizer and wood ash and fertilizers application respectively. However, at 8 WAT when urea and wood ash were applied, the number of branches increased and ranged from 3.7 to 7.3 respectively.

Table 5: Branches of pepper plant at 6 and 8 weeks after transplanting

Treatments	**6 WAT**	**8 WAT**
A = UF	3.3	5.0
B = NPK	3.0	6.3
C = WA	4.3	7.3
D = UWA	4.7	7.3
E = NF	2.0	3.7
SE(df= 14)	±0.4	±0.6

Source: Field experiment, (2017)

LEGEND: A = Urea (10 g per plant), B = N.P.K 15-15-15 fertilizer (10 g per plant)
C = Wood ash (10 g per plant), D = Urea + wood ash (1: 1 per plant)
E = No fertilizer application (NF/control), WAT = weeks after transplanting SE = standard error.

The pepper plant number of fruits ranged from 2.0 to 5.0 with average weights ranging from 5.6 – 38.2g/ plant at 8 WAT. And at 9 WAT, the numbers of pepper fruits ranged from 3 to 18±2 with fruits weights ranging from 5.6 – 45.8 g/plant at 12 WAT under the application of no fertilizer and wood ash only. Nevertheless, the highest number of pepper fruits (18±2.0) under wood ash application was not significantly higher (17±2.0) compared to urea and wood ash application (Table 5). However, the fruits yields (5.6 and 8.6±0.4 g/plant) under urea fertilizer application were significantly reduced compare to (38.2, 45.8±0.6 and 145.4g) the yields obtained under other fertilizers application (Table 5). Generally, NPK fertilizer

(124.1±2 g), wood ash only and urea + wood ash (145.4±2 g and 129.8±2 g) respectively increased the pepper fruits yield significantly.

Table 6: Number of pepper fruits and fresh fruits weight (g/plant) at 8, 9 and 12 weeks after transplanting.

Treatments	8 WAT	9 WAT	12 WAT
A = UF	(3) 7.8	(2) 6.3	(8) 25.2
B = NPK	(4) 29.2	(3) 22.9	(17) 124.1
C = WA	(4) 32.3	(3) 24.2	(18) 145.4
D = UWA	(5) 38.2	(6) 45.8	(17) 129.8
E = NF	(2) 5.6	(2) 5.6	(3) 8.6
SE(df= 14)	±0.4	±0.6	±2.0

Values in parenthesis are number of pepper fruit per plant

Source: Field experiment, (2017)

LEGEND: A = Urea (10 g per plant), B = N.P.K 15-15-15 fertilizer (10 g per plant)
C = Wood ash (10 g per plant), D = Urea + wood ash (1: 1 per plant)
E = No fertilizer application (NF/control) WAT = weeks after transplanting SE = standard error.

Inorganic fertilizers are potential nutrient supplier to the soil for plant uptake, however, the straight or simple fertilizer types such as urea on depleted soil will need to be supplemented with either organic or liming materials such as wood ash to increase the pH of such soil. However, this may not be too far from the previous findings that this differs in land that is acidic as long time chemical fertilizers application contribution to soil acidity. The pepper plants in this trial showed different responses to the two mineral fertilizers and wood ash as the yield was significant. Menino *et al,* (2008) showed that nitrogen did not significantly affect plant height but contributed to leave increase and makes the leaves look lush and greenish. The result obtained shown that the effects of mineral fertilizer were pronounced on the pepper growth, plant height, number of leaves, leaves area, branches, number of flowers, number of fruits, weight of peppers at week after transplanting. However, the applications of wood ash also shown positive effects but not as pronounced as that of urea fertilizer when compared to the significant effect shown by plot with urea fertilizer application as report by Ayodele *et al, (*2015).

In conclusion, mineral fertilizers; urea and NPK significantly improved the plant height, number of leaves especially urea when supplemented with wood ash, thus, these mineral fertilizers application improved soil fertility and pepper growth and yield. Pepper plant need nutrient for growth and yield. Hence, fertilizer application for pepper production on acidic soils requires caution in term of fertilizer materials or types to improve fruit yield. Hence, priority should be given to urea and wood ash application on acidic soil; these will be potential tools for better yield.
Moreover, it can be suggested that application of wood ash at ratio 1: 1 with urea to acidic soil will ameliorate the soil nutrient and pH status of such soil for pepper production.

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