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EFFECTS OF NITROGEN, WOOD ASH AND INTRA-ROW SPACING ON STAND COUNTS AND NUMBER OF SEED TUBERS OF POTATO (*Solanum tuberosum* L.) PER SQUARE METER ON THE JOS PLATEAU, NIGERIA

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ABSTRACT
Field experiment was conducted during 2018 and 2019 rainy seasons at the experimental farm of Potato Programme, Kuru, National Root Crops Research Institute Umudike, Abia State of Nigeria. Kuru is located on (Lat. 09^{o} 44'N, Long 08^{o} 44" E, 1239.4m amsl) in the northern Guinea Savanna Ecological zone of Nigeria. The experiment was conducted to determine the effects of various rates of nitrogen (0, 60 and 120 kg N/ha), wood ash (0, 2.5 and 5.0 t/ha) and intra-row spacing (20, 30 and 40 cm) on stand count and number of seed tubers of potato. A split plot design was used where the factorial combinations of N and intra-row spacing were assigned to the main plots, while wood ash was assigned to sub plots. The treatments were replicated three (3) times. The result revealed that application of 60 - 120 kg N/ha and 2.5 - 5.0 t/ha wood ash enhanced crop growth and yield of potato like stand count and number of seed tuber, respectively. Therefore, during manure application of Nitrogen at 60 kg N/ha with wood ash at 5.0 t/ha and at reduced intra-row spacing (20cm and 30cm) is recommended for cultivation Potato in the region.

Keywords: Fertilization, Growth, Intra-row Spacing, Potato, Seed, Varieties, Yield.

INTRODUCTION
Potato (*Solanum tuberosum* L.) is a tuber crop belonging to the family *Solanaceae*. It ranks fourth as the world's economically valuable food crop after rice (*Oryza sativa*), wheat (*Triticum aestivum*) and maize (*Zea mays*) (United States Department of Agriculture [USDA], 2000). Potato is undoubtedly of ancient origin, although knowledge of its early stages of domestication is not as precise as for other crops such as barley (Ewing, 1997). Kroschel (1995) reported that potato originated in the highlands of South America, where it has been consumed for more than 8000 years. Spanish explorers brought the plant to Europe in the late 16th century as a botanical curiosity. By the 19th century, it had spread throughout the continent, providing cheap and abundant food. Potato arrived Africa around the turn of the 20th century. British farmers introduced it to East Africa in the 1880s. Its introduction by Europeans to Nigeria was by the tin miners on the Jos Plateau and by Germans in Cameroon (Ifenkwe, 1981). Thus, a plant confined to South America until the late sixteenth century, has in the course of time become a crop of world importance.

The world potato sector has been undergoing major changes and until the early 1990s, most potato was grown and consumed in Europe, North America and countries of the former

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Soviet Union. Since then, there has been a dramatic increase in potato production and demand in Asia, Africa and Latin America, where the total output rose from less than 30 million tonnes in the early 1960s to more than 165 million tons in 2007 (Food and Agriculture Organization [FAO], 2008).

The FAO (2015) data showed that for the first time in 2005, potato production of 160.12 million tons in the developing countries exceeded that of the developed world mark of 159.99 million tons. The world's potato hectareage, production and yield were put at 19,264,021ha, 3, 2071,196 and 16.64 t/ha, respectively (FAO, 2015). In 1996, the average yield of potato tubers throughout the world was about 16 t/ha (USDA, 2015). According to (FAO, 2008), average yields for different continents in 1996 were: Asia (12.60), Africa (11.3), North America (39.1), South America (12.6), Europe (16.2) and Oceania (28.8). The use of wood ash as soil amendment provides a unique opportunity to increase the competitive ability of crop growth by increasing soil pH and increasing soil fertility, well-nourished plants competes well with weed and smothers weed effectively (Hillary, 2009).

MATERIALS AND METHODS

The Study Area

Field experiment was carried out during the wet seasons of 2018 and 2019 at Kuru (Lat. 09^0 44^0N, and Long.08^0 $44^{''}$E and with an elevation of 1,400.4m above sea level) in the Northern Guinea Savanna zone of Nigeria, to assess the effects of wood ash, nitrogen and intra-row spacing on the performance of potato. The experiments were conducted at the research farm of Potato Programme of the National Root Crops Research Institute, Kuru, on the Jos Plateau.

Sampling Procedure

Soil of the experimental site was sampled and analyzed for the physical and chemical properties prior to land preparation. The wood ash used in this experiment was from African birch (*Anogeissus leocarpus*) plant. The wood ash was sampled and analyzed for its mineral contents. Meteorological data was collected from the Potato Programme weather station. No serious drought was observed during the period of experimentation. The minimum air temperature during the two (2) seasons ranged from 17.2 – 21.2^{o}C, while the maximum ranged from 23.0-27.7^{o}C. The mean relative humidity ranged from 16.53 – 84. 45%. Treatments evaluated included, nitrogen (0, 60 and 120 kg ha-1), wood ash (0, 2.5 and 5.0 t ha-1) and intra-row spacing (20, 30 and 40 cm). Factorial combination of nitrogen and intra-row spacing was assigned to main plot while wood ash was allocated to sub – plot.

The gross plot size measured 24 m2 while the net plot size was 12 m2. The experiment was laid out in a split plot design replicated three (3) times. Planting was done on the crest of the ridges spaced 100cm apart while the intra-row spacing was 20, 30 and 40 cm. The actual date of planting was 3rd May, 2018 and 16th May, 2019. The wood ash used in this experiment was from African birch (*Anogeissus leocarpus*) plant, it (wood ash) was incorporated on the crest of the ridges at planting, while urea fertilizer was applied manually by band method two

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weeks after planting. Weeds were controlled manually using traditional Africa hoe. Tubers were harvested manually by lifting, using garden fork.

Five (5) stands were selected and harvested; their tubers were counted to determine the mean number of seed tubers per plant. The weights of the randomly selected tubers were determined using electronic balance. Tubers harvested from each net plot (12m2) were weighed, tuber yield/stand determined and later the yield/net plot was expressed in tons per hectare.

Analytical Techniques

All the data was statistically analyzed using analysis of variance (ANOVA) according to the method described by Gomez and Gomez (1984), and treatment means were separated using Duncan Multiple Range Test (Duncan, 1955).

RESULTS AND DISCUSSION

Physico-chemical Properties of Soils in the Study Area

The results of Table 1 presents the physico-chemical properties of soils of the experimental sites during 2018 and 2019 cropping seasons. The result of physical and chemical properties of the experimental site indicated that the soil was low in fertility and required crop hormone growth enhancer application to boost the productivity of potato.

Table 1: Physico-chemical Properties of Soils of Experimental Sites in the Cropping Seasons

Properties	2018		2019	
	Soil depth (cm)		Soil depth (cm)	
	0 – 15	15 – 30	0 – 15	15 - 30
Particle size distribution (%)				
Sand	16.66	17.80	19.80	20.12
Silt	27.60	26.40	27.60	26.18
Clay	54.70	54.30	52.60	52.50
Textural characteristics				
pH in water	5.60	6.01	5.11	6.00
pH in 0.01 $Mcacl_2$	4.41	4.71	4.40	4.70
Organic carbon (%)	0.98	0.39	0.77	3.01
Total nitrogen (%)	0.08	0.04	0.07	0.03
Available P (Bray)ppm	3.54	1.02	3.68	0.78
Exchangeable bases(Meq/100g)				
Ca	4.50	4.90	4.46	3.33
Mg	2.36	3.01	2.10	2.40
K	0.53	0.60	0.55	0.48
Na	0.07	0.05	0.06	0.04
Exchangeable acidity (H+A1)	0.30	0.30	0.30	0.30
CEC	7.70	7.80	7.65	8.42

Analysis: Federal College of Land Resources Technology, Kuru, Plateau State

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Effects of Nitrogen, Wood Ash and Intra-row Spacing on Stand Count

The effects of nitrogen, wood ash and intra-row spacing on stand count of potato is presented in Table 2. The results reveals that nitrogen had no significant influence on stand count of potato in either of the sampling periods and in both years. The insignificant effect of N on stand count could be as a result of early stage of growth when plants were small and their demands were not beyond the native soil N level. This can be attributed to the slow release of N over the growth period.

Wood ash significantly affected stand count at 3 WAP and at harvest in 2018, however in 2019; stand count was significantly affected by wood ash only at harvest. In 2018, wood ash application rate of 5.0t/ha produced a significantly higher stand count than 0 t/ha (control) at 3 WAP and at harvest. Application of 2.5t/ha wood ash also produced significantly higher stand count than the control at harvest but was at par with 5t/ha and 0 t/ha at 3 WAP. At harvest in 2019, wood ash application rates of 2.5 and 5t/ha produced similar stand count, and each was significantly higher than the control.

The significant positive response of potato to the application of wood ash in these experiments explained the importance of the material as a source of P and K as earlier reported by Beukema and Za'ag (1990) and Haris (1992). Stand count at 3WAP in both years were significantly increased with progressive rise in wood ash up to the maximum applied rate of 5.0t/ha. This is in consonance with the findings of (Obi and Ekperegin 2001; Ojeniyi and Adejobi, 2002; and Reula and Janssen, 1996) who reported that wood ash is an effective source of plant nutrients such as Calcium, Phosporus, Potassium, Magnesium and other secondary elements. Wood ash is also a fast liming material that rapidly dissolves and neutralizes acid soil, apart from providing plant nutrients (Jerome, 2004). A report on the positive effect of wood ash on sweet potato was also reported by Sokoto *et al*. (2007). Each of K and P has a specific role in potato growth and absence of any in the soil may retard potato growth. P and K deficiency in soils of Nigerian Savanna had been occasionally reported in some areas on the Jos Plateau most especially intensely or continuously cultivated farms (Okonkwo *et al.*, 1995). However, reports by Ogbolu (1991) and Ojeniyi and Adejobi (2002) contradicted findings in this present study. The authors reported that wood ash was not as effective as fertilizer for vegetables and cassava. Therefore, it is not surprising that the growth responded positively to increasing wood ash rate.

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Table 2: Effects of Nitrogen, Wood Ash and Intra-row Spacing on Stand Count of Potato During 2018 and 2019 Cropping Seasons

Treatment	Stand count			
	3 WAP		Harvest	
	2018	2019	2018	2019
Nitrogen kg/ha (N)				
0	40.70	39.89	40.37	39.29
60	39.74	39.48	39.56	38.78
120	39.48	39.00	38.93	38.29
SE ±	0.484	0.109	0.363	0.411
Wood ash t/ha (W)				
0	38.89b	38.56	38.22b	37.52b
2.5	40.29ab	39.85	40.26a	39.37a
5.0	40.74a	39.96	40.37a	39.48a
SE ±	0.508	0.502	0.503	0.375
Spacing cm (S)				
20	54.74a	54.41a	54.33a	54.74a
30	36.74b	36.19b	36.67b	35.96b
40	28.44c	27.78c	27.85c	27.67c
SE ±	0.484	0.109	0.363	0.411
Interactions				
N x W	NS	NS	NS	NS
N x S	NS	NS	NS	NS
W x S	NS	NS	NS	NS
N x S x W	NS	NS	NS	NS

Note: Means followed by the same letter(s) within a treatment group and column are not significantly different using DMRT (P = 0.05). NS = Not significant (P = 0.05). WAP = Weeks after planting.

From the results of Table 2, each increase in intra-row spacing significantly reduced stand count at 3 WAP and at harvest in both years. There was no significant interaction of the three (3) factors on stand count at 3 WAP and at harvest in the two seasons.

Stand count was significantly and positively influenced by intra-row spacing in the two years of trial. This is in agreement with the findings of Augustine, J. A., (2018) who reported that every increase in intra-row spacing from 20 cm to 30 cm decreases the stand establishment count. Similarly, Malami and Sama'ila (2012) reported that widest intra-row spacing (100 and 75 cm) recorded least stand counts while closed intra-row spacing (50 and 25 cm) recorded the highest stand count respectively. This is obvious because varying intra-row spacing would either increase or decrease plant population per unit area.

Effects of Nitrogen, Wood Ash and Intra-row Spacing on Seed Tuber Yield

Nitrogen, wood ash and intra-row spacing significantly influenced seed tuber yield in 2018, 2019 and the combined (Table 3). The results show that Nitrogen application rates of 0 and 60 kg N/ha in 2018, 2019 and the combined were at par and produced statistically higher

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seed tuber than the 120 kgN/ha rate. The significant increase in number of seed tubers observed in this study as N rate was increased up to the maximum rate of 120Kg N/ha could be attributed to the high demand of N by the Potato crop and this confirms report by Okonkwo *et al*. (1998) who reported that N is an indispensable nutrient in the vegetative phase of potato, and that it stimulates and sustains growth of shoots and branches. Total number of tubers per square meter increased with increasing N rate in the combined data. The highest number of tubers was obtained with application of 60kg N/ha. The significant increase in number of tubers per square meter could be attributed to the ability of N to stimulate growth of stolon's which bulked to produce more tubers, percent number of marketable tubers and fresh and dry tuber weight. The positive response could be attributed to low fertility status of the experimental site in both years of trials, especially with respect to N.

Table 3: Effects of Nitrogen, Wood Ash and Intra-row Spacing on Number of Seed Tubers/M^2 of Potato during 2018 and 2019 Cropping Seasons

Treatment	**Number of seed tubers /m^2**		
	2018	**2019**	**Combined data**
Nitrogen kg/ha (N)			
0	3.96c	4.76a	4.36b
60	5.70a	6.37b	6.03a
120	4.19b	4.96c	4.57b
SE ±	0.162	0.154	0.151
Wood ash t/ha (W)			
0	4.83a	5.67a	5.25a
2.5	4.44b	5.24b	4.84b
5.0	4.59ab	5.17b	4.88b
SE ±	0.105	0.131	0.119
Spacing cm (S)			
20	4.89a	5.76a	5.33a
30	4.31b	4.84b	4.58b
40	4.64a	5.49a	5.06a
SE ±	0.162	0.154	0.151
Interactions			
N x W	NS	NS	NS
N x S	NS	NS	NS
W x S	NS	NS	NS
N x S x W	NS	NS	NS

Note: Means followed by the same letter(s) within a treatment group and column are not significantly different using DMRT (P = 0.05). NS=Not significant (P = 0.05), WAP = Weeks after planting.

As presented in Table 3, wood ash at 5.0t/ha increased seed tuber yield over the 2.5t/ha rate in 2018 and the combined data. The control was at par with both 2.5 and 5.0t/ha rates. In 2018 and combined data, seed tuber yield decreased with intra - row spacing while in 2019, 20 and 30cm spacing produced similar and higher seed tuber yield than 40cm spacing.

Okonkwo *et al.* (1995) also reported the positive effect of wood ash on sweet potato. According to the authors, K and P has a specific role in potato development and absence of any in the soil may decrease yield. As mentioned earlier, by Ogbolu (1991) and Ojeniyi and Adejobi (2002) in their separate report contradicted findings in this present study. The authors reported that wood ash was not as effective as fertilizer for vegetables and cassava. It is therefore not unexpected that yield in Potato responded positively to increasing wood ash rate.

The significant variation in number of seed tubers/m^2 between years could be attributed to prevailing weather condition that delayed crop maturity in 2019. This is in line with report by Pavlista (2005) who observed that increase in intra-row spacing decreased the yield of seed tubers and increased the proportion and yield of large tubers, while seed tuber number /m^2 and seed tuber yield increased with decrease in intra-row spacing. This is also in agreement with Tesfa *et al*. (2015) report. They reported that the reduction in the yield of seed tubers and the increase in ware tubers indicated an essential need of increasing spacing. Therefore it can be concluded that seed tuber number per square meter increased with corresponding decrease in intra-row spacing.

CONCLUSION AND RECOMMENDATIONS

The concluded that Nitrogen, wood ash and intra row spacing significantly enhanced stand count and seed tuber yield. It can be concluded from this study that Nitrogen at 60 kg N/ha and wood ash at 5.0 t/ha are preferable for stand count and seed tuber yield. Similarly, the highest stand count and seed tuber yield were produced at the reduced intra row spacing of 20cm and 30cm, while the use of 40cm intra-row spacing was not ideal for stand count and seed tuber yield of Potato. The use of Nitrogen at 60 kg N/ha, wood ash at 5.0 t/ha and reduced intra - row spacing of 20cm and 30cm are recommended for the growers of potato plant because they give high stand count and seed tuber yield.

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