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EFFECTS OF OIL PALM ASH AND MOUND HEIGHT ON THE YIELD OF WATER YAM AND SOIL PHYSICAL PROPERTIES

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ABSTRACT
Integrated application of oil palm ash, NPK 15:15:15 and mound height on soil physical properties and performance of water yam was carried out in 2018 and 2019 cropping seasons. Experimental design used was a randomized complete block design (RCBD) with a split plot; the two factors employed were the mound height used and nutrient sources. The experiment consisted of three height of mound (60, 40 and 20 cm) and four nutrient sources (Control, NPK 15:15:15 at 400 kg/ha, oil palm residues at 10 t/ha, NPK 15:15:15 at 200 kg/ha + oil palm residues at 5 t/ha). Water yam tubers were cut into tuber sett of 200 g size and planted in a plot of size 5 x 4 m. the spacing used was 1 m by 0.8 m, each plot has a total of 25 heaps. Data were collected on germination percentage (%) of water yam at 15 and 30 days, soil physical properties (Moisture content (%), soil bulk density (g/cm^3), total porosity (%) and temperature (^{0}C), vine length (cm), number of leaves, dry weight of aerial parts, number of main stems, fresh weight of tubers/heap, number of tubers per heap, length of tuber, tuber diameter, tuber weight per plot (kg) and tuber weight per ha (t/ha). The results revealed that plots treated with oil palm residues either singly or in combination with NPK 15:15:15 germinated better. At 15 days after planting, plots with mound height of 20 cm gave the highest germination percentage. Plots with mound height of 60 cm produced significantly better percentage germination compared with other mound heights used. Higher moisture content was observed in plots treated with oil palm residues either applied singly or combined with NPK 15:15:15. Moisture content in mounds with 60 cm heights were significantly better in both years. Soil bulk density, soil total porosity and soil temperature were observed to have reduced with increase in mound height in both years. The growth parameters and tuber characters measured were highest in plots with sole application of NPK in both growing seasons. Growth, tuber and yield characters observed were significantly better in plots with highest mound (60 cm) in both years. Plots with sole NPK at 400 kg/ha, and NPK at 200 kg/ha plus oil palm residues at 5 t/ha were significantly better in tuber weight per plot and tuber weight per hectare in both seasons.

Key words: water yam, fertilizer, mound height, growth, yield

INTRODUCTION
Water yam (*Discorea. alata*) is an important species of the dioscoreacea family grown in Nigeria for its edible white flesh. The specie is less popular than white yam in Nigeria. It is often regarded as food for the poor (Nwike *et al* 2017). It plays major role in local yam trade. According to Wireko-Manu *et al*. (2013), water yam contains high level of Total Dietary Fibre (TDF) which makes it suitable for management of pile, constipation and diabetes. It is also rich in Vitamin C, beta carotene, vitamin E, calcium, potassium, magnesium, copper and antioxidants. These nutrients are known to play vital role in general body upkeep as well as immune functioning, wound healing, suppression of blood sugar, bone growth and anti-ageing. Also, according to Nwike *et al* (2017). Water yam is a good source of vitamin B6 which is needed in the body to breakdown substances called homcystein which can directly damage blood vessel walls, hence reducing the risk of heart disease. Common recipes made from water yam in Nigeria include porridge, yam fritters,

pounded yam fufu, yam balls, grated water yams and yam mixed with vegetables.

Low yield in water yam could be due to decline in soil fertility and lack of soil management requirements for yam cultivation, such as integrated nutrients management. Research recommendations with respect to integrated nutrient management are scarce for the studied ecological zone. Organic manures are important in the maintenance of an adequate supply of organic matter into soil, with consequent improvement in soil physical and chemical conditions. Growth and yield of crops were increased with improve soil physical and chemical conditions (Bechini and Marino, 2009; Dobermann and Cassmann, 2004). Enormous quantities of organic wastes such as oil palm ash and poultry manure are available in Nigeria where they pose disposal problems and environmental hazards, and are at the same time effective sources of nutrients for tuber crops such as water yam.

Combined use of organic and inorganic fertilizer may be beneficial to soil and crop productivity in this agro ecology. A balanced use of organic and mineral fertilizer could enhance soil chemical, physical and biological properties in addition to rapid rate of nutrient turn over within the soil-plant system. Integrated use of organic wastes and mineral fertilizer is reported to reduce the cost and amount of fertilizer required by crops (Dobermann and Cassmann, 2004; IAEA, 2003 and Krupnik *et al.*, 2004). Bair (1990) opined that proper soil fertility management and sustainable agriculture can be achieved with the use of both mineral fertilizer and organic manure. Paul and Mannan (2006) suggested that integrated nutrient management through combined use of organic wastes and chemical fertilizers can be an effective approach to combat nutrient depletion and promote sustainable crop productivity. Replenishing the nutrients removed by crops by recycling agricultural wastes into the soil can sustain soil and crop productivity. Practices which focus on recycling agricultural wastes into the soil would contribute to improved quality and health of the soil.

Seedbed preparation is considered one of the factors for increasing the yield of yam per unit area. According to (Lal, 1986), the primary aim of good seedbed preparation are: to control weeds, manage surface trash, provide aeration, shape or level the soil, improve physical conditions of the soil, incorporate fertilizers, break hard pans and allow better water and air infiltration. With good seedbed preparation, the roots can penetrate the compacted zone as it seeks out water and nutrients. Also the formation of lateral roots can increase when tuber crops are planted on heap (Singh and Malhi, 2006).

There is dearth of information on effect of integrated application of burnt oil palm residues, NPK 15:15:15 fertilizer and height of mound used on soil physical properties and performance of water yam in a southern guinea savanna zone of Nigeria. Southern guinea savannah, which is characterized by; inherently low soil fertility status and rapid nutrients depletion especially organic matter. However, the zone is also characterized by abundant agricultural land and high potential for crop production; however, soils of this agro ecology are characterized by inherently low in soil fertility and rapid nutrient depletion and other forms of soil degradation.

This study examines the effects of integrated application of burnt oil palm residues, NPK 15:15: 15 fertilizer and height of mound used on soil physical properties and performance of water yam.

Materials and Methods

Site of the experiment

The study was carried out during the cropping seasons of 2018 and 2019 at a farm in Ponyan, Yagba East LGA, Kogi State; Ponyan is located in the southern Guinea savanna ecological zone of Nigeria with latitude 7^0 57' 48" N and longitude 5^0 43' 32" E. It has average rainfall of about 1232 mm per annum and annual temperature range of 18`C – 32`C, mean relative humidity of about 60% and it is 389 m above sea level. The major soil order within the experimental site is Ultisol (Babalola, 2010).

Experimental Design

The soil used for the experiment is sandy clay loam and the physical and chemical properties of the soil are presented in Table 1. Experimental

design used was a randomized complete block design with a split plot set-up, the two factor employed were height of the mound used and nutrient sources. The experiment consisted of three height of mound (60cm, 40cm and 20cm) and four nutrient sources (No amendment plot as control, NPK 15:15:15@ 400kg/ha, Oil palm residues @ 10 t/ha, NPK 15:15:15@ 200 kg/ha+ Oil palm residues @ 5t/ha).

Land Preparation and Manure Application
The site was cleared manually with cutlass; the debris was packed from the field manually. Heap used for the experiment were made according to the specification of each treatment (Height of the mound). Oil palm residues used were collected from the oil palm plantation of the College of Agriculture, Kabba. Dry palm fronds were burnt to ashes; the ashes were allowed to stay for 48 hr before been packed in to a sack and later spread on the plots a week before heap preparation.

Field Layout
Water yam tubers were collected from local market at Ponyan, the tuber were cut into tuber setts of 200 g size and planted in a plot of size 5 x 4 m^2. the spacing used was 1 m by 0.8 m, each plot has a total of 25 heaps. The heights of the heap used were according to the design of the experiment. Yam set was dressed with apron plus and nemagon at rate of 1.5 kg/ha to control nematode attack on the crop. Planting was done on 15th and 16th of March in 2018 and 2019 respectively. Germination count was taken at 15 and 30 days after planting. Weeding was carried out at 3 weeks' interval. Individual sprouted plant was supported using stick staking of 2.5m in height. Rodents were controlled with baits and trap while yam beetle was also control using Aldrin dust at the rate of 20 g/100 setts.

Laboratory Studies
Soil samples were collected with soil auger at 0 - 30cm depth. The soil samples were air-dried, ground and sieved through a 5 mm mesh. Particle size analysis was done using Bouyoucos hydrometer method (1951) and AOAC, (2005). Soil pH was determined in soil water solution ratio of 1:2. Organic matter was determined by the Walkley black method. Total N was determined by the Kjeldhal digestion method. Exchangeable base was determined through extraction with NH_4OAC, Ca and Mg were read using Atomic Absorption Spectrophotometry (AAS) while K was determined using flame photometry (AOAC, 2005).

Determination of soil physical properties
Soil physical properties were taken at 75 days after planting, five undisturbed samples were collected at 0 – 15cm depth from each plot using core samples and were used for the determination of bulk density, total porosity and gravitational moisture contents after oven drying at 100^{0}C for 24 hours, total porosity was calculated from the value of bulk density and particle density. Soil temperature was determined at 15.00 (3 pm) with soil thermometer inserted to 10 cm depth five readings were made per plot.

Data collected were subjected to the statistical analysis of variance procedure for a randomized complete block design according to Steel and Torrie (1980) and treatment means was compared using Least Significant Difference at 0.05.

Results and Discussion
The condition of the experimental site before the experiment is presented in Table 1. The results indicated that the soil to be sandy clay loam with pH 6.7. The bulk density was 1.46 g/cm^3. The soils had total porosity of 41.5 %. The soils are low in organic matter 2.36 %, low in soil nutrients, such as nitrogen, available phosphorus and exchangeable cations. Amendment in the form of organic residues would benefit both the soils and crops. Sanchez *et al*. (1997) reported that decline in soil fertility and high acidity are fundamental cause of declining crop yields.

The effect of integrated application of burnt oil palm residues and NPK fertilizer and height of mound used on germination percentage of water yam is presented in Table 2. Significant difference was observed in germination percentage of water yam at 15 and 30 day samplings. Inconsistence results were obtained in the germination percentage 2018 and 2019 seasons. Cumulative percentage germination indicated that plots fertilized with oil palm residues applied either singly or combined with NPK 15: 15: 15 germinated better than plots

treated with NPK 15: 15: 15 alone and the control in 2018. However, no significant difference observed in the germination percentage of water yam in 2019.

The result showed that yam sett performed differently on germination percentage to different nutrient sources. Nitrogen content increases in soil by the application of organic fertilizer may stimulate the faster crop germination. The oil palm residues generally improved the germination which might be due to favourable soil physical environment caused by the addition of organic manure (Sarma and Gogoi, 2015).

In all the treatments, germination rate was high (93.3-98.1 %). This high germination rate could also be attributed to the treatments of the yam setts with nemagon and rodenticide before planting which reduced the incidence of pest and disease attack on the water yam.

Effects of height of mound on germination percentage of water yam is also presented in Table 2. Significant difference was observed in the germination percentage of water yam at 15 and 30 days after planting. At early stage of sampling (15 days), plots with mound height of 20 cm gave the highest percentage germination at both growing seasons. However, this was statistically similar to plots with mound height of 40 cm. Plots with mound height of 60 cm were significantly inferior to mound height of 20 and 40 cm at 15 days after planting. At 30 days after planting, plots with mound height of 60 cm produced significantly better percentage germination compared with germination of mound height of 20 and 40 cm. Cumulative percentage germination was highest in plots with 60 cm height of mound which was significantly better than plots with mound height of 20 and 40 cm. The least cumulative germination percentage occurred in plots with mound height of 20 cm which was statistically similar to plots with mound height of 40 cm. The better performance of water yam with mound height of 60 cm could be attributed to soil physical condition enjoyed by water yam due to high volume of soil that surrounded the yam setts.

Effect of integrated application of burnt oil palm residues and NPK 15: 15: 15 fertilizer on soil moisture content, soil bulk density, soil porosity and soil temperature is presented in Table 3. There was no significant difference observed in soil bulk density, soil total porosity and soil temperature at 75 days sampling. However, significant difference was observed in soil moisture content. Higher moisture content was observed in plots treated with oil palm residues either applied singly or combined with NPK 15: 15: 15. The values of moisture content recorded in plots with oil palm residues was significantly superior to either values obtained in plots with NPK solely applied and the control. The results could be attributed to the ability of oil palm residues to conserve soil moisture.

Application of oil palm residues alone or in combination with NPK improved soil physical property compared to when NPK was solely used and the control. The improved soil moisture content observed in plots treated with oil palm residues was consistence with the findings of Mbagwu (1989, 1992), Obi and Ebo (1995), Akanni (2005) and Agele *et al* (2011). Improvement in the soil moisture content was attributed to enhancement of soil organic matter by the oil palm residues applied.

Significant soil moisture content was recorded due to different height of the mound used (Table 3). Though, moisture content in mound with 60 and 40 cm were significantly better in 2018 compared to soil moisture content of mound height of 20 cm. In 2019, soil moisture content in plots with 60 cm was significantly superior to soil moisture content of mound height (20 and 40 cm) which were statistically similar.

Significant difference was observed in soil bulk density in 2018 and soil total porosity and soil temperature in 2019 due to different height of mound used. Soil bulk density, soil total porosity and soil temperature reduces with increase in mound height.

However, no significant difference was observed in soil bulk density in 2019, total soil porosity and soil temperature in 2018. The better physical condition observed in plots with mound height of 60 cm could be due to proper tillage or proper seed bed preparation due to high volume of soil used.

Effect of integrated application of burnt oil palm residues and NPK fertilizer on vine length, number of leaves, dry weight of water yam shoot and number of main stem were presented in Table 4. Vine length, number of leaves, dry weight of water yam shoot and number of main stem were highest in plots amended with sole application of NPK which was followed by plots with oil palm residues and NPK at reduced level. Plots that received oil palm residue of 10 t/ha was significantly better in vine length, dry weight of water yam shoot and number of main stem than the control plot in both years. However, number of leaves in plots with sole application of oil palm residues and the control plots were statistically the same in 2019. The least vine length, number of leaves, dry weight of aerial part and number of main stem were recorded in the control plots.

Significant difference was observed in vine length, number of leaves, dry weight of water yam shoot and number of main stem of water yam as presented in Table 4. All the growth characteristics observed (vine length, number of leaves, dry weight of water yam shoot and number of main stem) were better in plots with highest mound (60 cm) in 2018 and 2019 seasons. Although, this values were statistically similar to plots with mound height of 40 cm in vine length in both years, dry weight of water yam shoot and numbers of main stem in 2018. However, number of leaves of plots with 40 cm mound height was significantly inferior with mound height of 60 cm at both years. Dry weight of aerial part and number of main stem in 2018 were also inferior to plots with 60 cm mound height. The least vine length, number of leaves, dry weight of water yam shoot and number of main stem was obtained in plots with mound height of 20 cm. The better physical condition observed in plots with mound height of 60 cm could be responsible for better growth parameters observed in plots with 60 cm mound height and consequently affects the performance of the water yam planted.

Effects of integrated application of burnt oil palm residues, NPK 15: 15: 15 fertilizer on fresh weight of tubers per heap, number of tubers per heap, length of tuber and tuber diameter of water yam tuber is presented in Table 5. Significant differences were observed in fresh weight of tubers per heap, number of tubers per heap, length of tuber and tuber diameter in both years except in number of tubers per heap in 2018. Plots treated with sole application of NPK 15:15:15 fertilizer produced the highest fresh weight of tubers per heap, number of tubers per heap, length of tuber and tuber diameter in both seasons, this was statistically the same with the values obtained in plots treated with NPK combined with oil palm residues at reduced rate, followed by plots that received sole application of oil palm residues at 10 t/ha. The control plot had the least of all these values in both years.

Height of mound significantly influenced fresh weight of tubers per heap, number of tubers per heap, length of tuber and tuber diameter in 2018 and 2019 growing seasons. Fresh weight of tubers per heap, number of tubers per heap, length of tuber and tuber diameter were best in mound height of 60 cm. However, mound height of 40 cm was superior to mound height of 20 cm in all the tuber characters measured. Mound height (20 cm) produced the least fresh weight of tubers per heap, number of tubers per heap, length of tuber and tuber diameter in both years.

The effect of integrated application of burnt oil palm residues and NPK fertilizer on tuber weight per plot and tuber weight per hectare is presented in Table 6. Significant difference was observed in tuber weight per plot and tuber weight per hectare due to different nutrient sources used. Plots that received sole NPK, and plots with combined application of NPK at 200 kg/ha plus oil palm residues at 5t/ha were significantly better in terms of tuber weight per plot and tuber weight per hectare in both seasons when compared to sole oil palm residues application at 10t/ha and the control plots. The control plots had the least tuber weight per plot and tuber weight per hectare in both years.

There was significant difference in tuber weight per plot and tuber weight per hectare due to the mound height used (Table 6). Plots with 60 cm mound height produced the highest tuber weight per plot and tuber weight per hectare in both seasons. This was followed by mound height of 40 cm which was statistically superior to mound height of 20 cm in both years. However, mound height of 20 cm produced the least tuber weight

per plot and tuber weight per hectare in 2018 and 2019.The better yield observed in 60 cm height mound could be attributed to proper seed bed preparation used, as a result high volume of soil used which encourage high aeration, reduced bulk density and increased soil moisture content which cumulated to better yield of water yam.

Conclusion

Plots with NPK fertilizer 15: 15: 15 at 400 kg produced the highest yield but the yield was statistically similar to plots with combined use of NPK 15: 15: 15 fertilizer and oil palm residues at reduced rate of 200kg /ha and 5t respectively. Due to high cost and scarcity of NPK 15: 15: 15 fertilizer in Nigeria, water yam farmers are advised to cultivate water yam using reduced rate of 200 kg /ha of NPK 15: 15: 15 fertilizer combined with 5 tonnes of oil palm residues. For optimum production of water yam in the study area, farmers should make use of 60 cm height.

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List of tables

Table 1: Condition of the soil before the Experiment

Properties	*Values*
Sand (%)	678
Clay (%)	215
Silt (%)	107
Soil texture	Sandy clay loam
Soil pH	6.7
Bulk density (g/cm^3)	1.46
Total porosity (%)	41.5
Organic matter (%)	2.36
Total N (%)	0.26
Available P (mg/kg)	2.94
Exchangeable cation (Cmol/kg)	
K	0.46
Ca	2.61
Mg	2.54

Table 2: Effects of integrated application of burnt oil palm residues, NPK 15 15 15 fertilizer and height of mound used on germination percentage.

Treatment	Germination Percentage (%) of water yam					
Nutrient source	15 days after planting		30 days after planting		Cumulative percentage germination	
	2018	2019	2018	2019	2018	2019
CTR	28.4c	38.1a	65.2a	59.3b	93.6b	97.4
NPK400	32.4bc	27.3b	60.9b	68.5a	93.3b	95.8
OPR10t	38.1a	29.9b	60.0b	67.5a	98.1a	97.4
NPK200+ OPR5t	34.2b	37.9a	62.7b	57.2b	96.9a	95.1
LSD	4.41	3.60	3.11	2.94	2.71	Ns
Height mound						
60 cm	26.3b	24.1b	72.5a	75.5a	98.8a	99.6a
40 cm	32.1a	29.8a	61.4b	64.3b	93.5b	94.1b
20 cm	34.4a	31.3a	59.7b	62.3b	94.1b	93.6b
LSD	2.74	3.21	6.42	4.63	3.11	2.67
Interaction NS vs HM	ns	Ns	ns	ns	ns	ns

NS= nutrient sources, HM= Height of mound and ns= not significant

Table 3:Effects of integrated application of burnt oil palm residues, NPK 15 15 15 fertilizer and height of mound used on soil physical properties.

Treatment	Moisture content (%)		Soil bulk density (g/cm^3)		Total porosity (%)		Temperature (^0C)	
Nutrient source	2018	2019	2018	2019	2018	2019	2018	2019
CTR	12.6b	11.9b	1.34	1.41	1.42	1.33	32.3	33.1
NPK400	11.6b	11.7b	1.36	1.44	1.46	1.36	32.3	33.1
OPR10t	15.6a	16.1a	1.31	1.29	1.43	1.29	32.2	33.2
NPK200+ OPR5t	15.2a	14.9a	1.33	1.34	1.42	1.30	32.2	33.1
LSD	1.96	2.14	ns	ns	ns	Ns	ns	ns
Height mound								
60 cm	14.6a	15.1a	1.21c	1.31	1.36	1.21c	31.4	31.9c
40 cm	13.8a	14.1b	1.26b	1.39	1.41	1.30b	32.3	32.6b
20 cm	11.8b	13.2b	1.32a	1.42	1.47	1.38a	32.5	33.0a
LSD	0.96	0.74	0.04	ns	ns	0.06	ns	0.08
Interaction NS vs HM	ns	ns	ns	ns	ns	Ns	ns	ns

NS = nutrient source, HM= Height of mound and ns= not significant

Table 4; Effects of integrated application of burnt oil palm residues, NPK 15 15 15 fertilizer and height of mound used on growth characters of water yam.

Treatment	**Vine length (cm)**		**Number of leaves**		**Dry weight of aerial parts**		**Number of main stems**	
Nutrient source	2018	2019	2018	2019	2018	2019	2018	2019
CTR	105.7c	113.1b	124.8c	136.1b	99.3c	106.4c	3.81c	3.21c
NPK400	235.4a	217.2a	247.6a	216.1a	163.4a	154.7a	4.21a	5.11a
OPR10t	197.3b	206.1a	178.3b	179.7b	138.7b	132.6b	4.31a	3.20c
NPK200+ OPR5t	226.4a	218.6a	233.4a	201.7a	154.3ab	141.6ab	4.12a	3.96b
LSD	12.4	16.7	24.8	20.3	17.4	14.7	0.26	0.22
Height mound								
60 cm	214.2a	203.9a	241.9a	213.8a	152.1a	166.7a	5.61a	6.04a
40 cm	189.7a	177.6a	193.5b	176.5b	134.6a	141.3b	4.15a	3.98b
20 cm	151.1b	146.3b	132.4c	156.9b	106.4b	106.6c	2.44b	3.17b
LSD	34.6	27.6	24.6	29.2	18.7	21.0	1.63	0.97
Interaction NS vs HM	ns	ns	ns	ns	ns	Ns	ns	ns

NS = nutrient source HM= Height of mound ns= not significant

Table 5; Effects of integrated application of burnt oil palm residues, NPK 15 15 15 fertilizer and height of mound used on tuber characters of water yam.

Treatment	**Fresh weight of tubers per heap**		**Number of tubers per heap**		**Length of tuber**		**Tuber diameter**	
Nutrient source	2018	2019	2018	2019	2018	2019	2018	2019
CTR	1.06b	1.27c	3.9	3.2b	19.6b	21.7b	07.8c	09.2c
NPK400	2.12a	2.42a	4.2	5.1a	37.4a	36.7a	15.7a	16.0a
OPR10t	1.34b	1.39c	4.3	3.2b	28.1b	24.6b	10.4b	11.9b
NPK200+ OPR5t	2.03a	1.96b	4.1	4.0a	36.5a	35.2a	14.9a	15.1a
LSD	0.31	0.21	ns	1.21	6.74	5.33	2.41	2.61
Height mound								
60 cm	2.51a	2,63a	5.6a	6.0a	34.4a	37.6a	17.4a	16.9a
40 cm	1.74b	1.68b	4.4a	3.9b	23.8b	24.1b	14.9a	13.7b
20 cm	1.23c	1.14c	2.4b	3.1b	19.7c	17.9c	09.2b	10.1c
LSD	0.33	0.41	1.49	1.09	6.44	4.81	3.97	2.66
Interaction NS vs HM	ns	ns	ns	ns	ns	Ns	ns	ns

NS = nutrient sources, HM= Height of mound and ns= not significant

Table 6; Effects of integrated application of burnt oil palm residues, NPK 15 15 15 fertilizer and height of mound used on yield of water yam.

Treatment	**Tuber weight per plot (kg)**		**Tuber weight per ha (t/ha)**	
Nutrient source	2018	2019	2018	2019
CTR	26.5b	29.3c	13.3b	14.7b
NPK400	53.0a	60.5a	26.5a	30.3a
OPR10t	33.5b	34.8bc	16.8b	17.4b
NPK200+ OPR5t	50.8a	49.0ab	25.4a	27.5a
LSD	12.41	19.14	4.11	5.19
Height mound				
60 cm	62.8a	65.3a	31.4a	32.7a
40 cm	43.5b	42.0b	21.8b	21.0b
20 cm	28.3c	29.5b	14.2c	14.8c
LSD	13.46	17.91	3.71	4.89
Interaction NS vs HM	ns	ns	Ns	ns

NS = nutrient source, HM= Height of mound and ns= not significant