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PERFORMANCE OF SWEET POTATO (*IPOMOEA BATATAS* [L.] LAM) VARIETIES AS INFLUENCED BY ORGANIC-MINERAL FERTILIZER RATE AND STEM CUTTING LENGTH IN THE NIGERIAN AGRO-ECOLOGICAL ZONES

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ABSTRACT
A Field experiment was conducted in 2015 and 2016 wet seasons at the Research farms of the National Horticultural Research Institute Bagauda Sub-Station, Kano State and the Institute for Agricultural Research Ahmadu Bello University, Samaru-Zaria in Kaduna State. The study examined performance of sweet potato varieties as affected by organic- mineral fertilizer rate and stem cutting length in Nigerian Agro-ecological zones. The treatments consisted of two varieties of sweet potato (Dan Zaria, local variety and Mothers Delight), three rates of Organic-mineral fertilizer, (NPK 7: 7:7 with 20% organic matter) (at 0, 300 and 600 kgha^{-1}) and 300 kgha^{-1} NPK (20-10-10) as a check and three stem cutting lengths (15, 30 and 45 cm). The treatments were laid in a randomized complete block design in a split plot arrangement. The combination of organic-mineral fertilizer rates and stem cutting lengths were assigned to the main plot and the varieties were assigned to the sub-plot, and replicated three times. It was found that Mothers Delight was superior to Dan Zaria variety in growth parameters, such as number of leaves per plant, crop growth rate, leaf area index and yield attributes such as number of tubers per plant, tuber diameter per plant and total fresh tuber yield. Application of organic-mineral fertilizer at 600 kgha^{-1} or NPK fertilizer at 300 kgha^{-1} significantly had greater numbers of tubers in 2015 at Bagauda and in both years at Samaru, more leaves and higher leaf area index in both years at Bagauda and Samaru. On the other hand, stem cutting length of 45cm gave higher measured growth and yield attributes, compared to the two other cutting lengths at both locations in both years. In conclusion, Mothers Delight was superior to Dan Zaria for its higher growth and yield attributes and total fresh tuber yield. While 600 kgha^{-1} OMF (organic-mineral fertilizer) produced the highest growth and yield attributes and total fresh tuber yield.

Keywords: Nigeria, Organic-mineral fertilizer, Savannas, Stem cutting length, Sweet potatoes.

INTRODUCTION
The sweet potato is an herbaceous, perennial vine, bearing alternate heart-shaped or palmately lobed leaves. The edible tuberous root is long and tapered, with a smooth skin, whose color ranges between red, purple, brown and white. Its flesh ranges between white, yellow, orange and purple. Sweet potatoes are native to the tropical Americas and were first cultivated there at least 5,000 years ago (Consultative Group on International Agricultural Research [CGIAR], 2006).

The sweet potato is one of the most nutritious vegetables. Although the leaves and shoots are also edible, the starchy tuberous roots are by far the most important product. Besides starch, they are rich in dietary fiber, vitamins A, C and B6. All cultivars are more or less sweet flavored (North Carolina sweet potato commission [NCSPC], 2006). Sweet potatoes grow best where the summers are long and hot and there is plenty of rain. The plant does not tolerate frost. It grows best at an average temperature of 24 ^{0}C. Depending on the cultivar and

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conditions, tuberous roots mature in 2 to 9 months. They are mostly propagated by stem or root cuttings or by adventitious roots called "slips" that grow out from the tuberous roots during storage. Sweet potato can be grown in poor soils with little fertilizer (CGIAR, 2006). China is the largest grower of sweet potato; providing about 80 percent of the world's supply which totaled 130 million tons in 1990. In the past, most of China's sweet potatoes were grown for food but now most (60%) are grown to feed pigs (Japanese Society of Root and Tubert Crops [JRT], 2006). In Africa Nigeria is the largest producer of sweet potato with 3.46 million metric tons 2017 (Mwanja *et al.*, 2017).

MATERIALS AND METHODS

Field experiments were conducted in 2015 and 2016 wet seasons at the Research Farm of the Institute for Agricultural Research, Ahmadu Bello University Zaria. The coordinate of the centre of the Research fields using GPS at Samaru are11^0 11' N 07^0 38' E, and 686 m above sea level in the Northern Guinea Savanna, and that of the National Institute for Horticultural Research, Bagauda Sub-Station are 11^0 33' N 8^0 11'E, 500 m above sea level in the Sudan Savanna to study the performance of sweet potato varieties as affected by organic-mineral fertilizer rate and stem cutting length in Nigerian Agro-ecological zones. Soil samples were randomly taken at 0-15 cm and 15-30 cm depths before land preparation. Fifteen (15) points were sampled into a composite sample, thoroughly mixed and sub sampled for laboratory analysis. The sub sample was air dried, grounded and sieved through 2 mm sieve and 0.5 mm sieves after grinding a part of the sample. Soil particle size analysis was determined by the hydrometer method (Boyoucos, 1951). Soil pH was determined by potentiometric method as described by Anderson and Ingram (1993). Organic carbon was determined by chromic acid digestion (Heanes, 1984).

Soil total Nitrogen was determined by digestion through wet oxidation based on kjeldahl method (Bremmer and Mulvaney, 1982); Soil available Phosphorous was extracted by using Bray-1P method (Anderson and Ingram, 1993) and Cations exchange capacity (CEC) by saturation with IN NH_{4OAC} and extraction of $NH_{4\ OAC}$ with 2 M KCL (Anderson and Ingram, 1993). The treatments consisted of two varieties of sweet potato, Dan Zaria (Local variety) and Mothers Delight (improved variety), three rates of minero-organic fertilizer at 0, 300 and 600 kgha-^{1}, and inorganic fertilizer at 300 kgha^{-1} NPK 20-10-10 as check and three stem cutting length (15, 30 and 45cm). The treatments were laid in a randomized complete block design in a split plot arrangement, with the combination of organic-mineral fertilizer and stem cutting length assigned to the main plot and variety in the sub-plot and then replicated three times. The gross plot size was 18 m^2 consisting of 6 ridges spaced at 0.75 m and each 4m in length. The net plot was 4.5m^2 made up of the 2centre ridges, each 3m in length.

The land was cleared and harrowed to fine tilth and 75 cm ridges were made using tractor mounted ridger. Stem cuttings of 15, 30 and 45 cm taken from apical position of the vine each having at least 3 to 4 nodes were planted manually according to treatments, with 1/3rd of length buried into the soil in slanting position, and spaced at 30 cm between stands on 75 cm between ridges. The planting in 2015 at Samaru was carried out on 22nd July and on 24th July at Bagauda. In 2016 the planting was done on 16th July at Samaru and 17th July at Bagauda. Organic-mineral fertilizer (using NPK 7:7:7+ 20% organic carbon as commercial formulation from National Research Institute for chemical Technology, Zaria (NARICT) was side dressed during planting at the varying treatment rates of 0, 300 and 600 kgha^{-1} and 300 kgha^{-1} inorganic fertilizer using NPK 20:10:10 as check at both sites.

The common weeds found at both locations during the study period were mostly annual broad leaf and grasses which were controlled by hoe weeding at 3 and 6 weeks after planting.

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The common insect pest found during the study at Bagauda in 2015 wet season was sweet potato weevil (*Cylasformicarius*). In 2015 wet season at Bagauda, the adults of sweet potato weevil fed on the root tubers of sweet potato on the field thereby causing holes and black spots appearance on some tubers. Preventive measure was taken in 2016 wet season, where planting materials (the stem cuttings) were dipped into the solution of *chloropyrifos* (active ingredient) at the rate of 1.15 kg ai/ha before planting in 2016 season.

Harvesting was done manually when the leaves had turned yellow and had started shedding at sixteen weeks after planting. The root tubers were uprooted using the hand hoe. The harvesting was carried out at Samaru on 20th November 2015 and 22nd November 2015 at Bagauda. In 2016, harvesting was carried out on 14th November at Samaru and 16th November at Bagauda. The data collected were subjected to analysis of variance (ANOVA) to test the significance of difference between treatment means using the F-test as described by Snedecor and Cochran (1967) and treatment means were compared using the Duncan Multiple Range Test (DMRT) at 5% probability level (Duncan, 1955).

RESULTS AND DISCUSSION

The effects of Organic-mineral fertilizer rate and stem cutting length of sweet potato varieties on number of leaves at Bagauda and Samaru is presented in Table 1. Sweet potato varieties showed significant variation in leaves number at 8WAP and 8 WAP in 2016 at Bagauda and Samaru. Mothers Delight produced consistently more leaves than Dan Zaria. The number of leaves per plant was not significantly affected by organic-mineral fertilizer rate application at Bagauda and Samaru in both years and at all the sampling periods except at 4WAP at Bagauda and Samaru in 2015 only. The parameter increased with each OMF increase in rate up to 600 $kgha^{-1}$ at 4 WAP in both locations, number of leaves from at 300 kg ha^{-1} OMF and 600 kg ha^{-1}OMF were at par with that from 300 kg ha^{-1}NPK.

Stem cutting length influenced leaves number in both locations and years of studies at 4 and 8WAP in 2015 and 4 and 12 WAP in 2016, respectively, at Bagauda and 4 and 8WAP in 2015 at Samaru and 4 12 WAP in 2016 at Samaru. In each case across the location and years, leaves numbers increased with cutting length from 15-45 cm, with 45 cm stem cutting producing the highest number of leaves. Interaction between the factors on number of leaves during the study period was not significant.

Table 2 shows the effects of Organic-mineral fertilizer rate and stem cutting length of Sweet potato varieties on crop growth rate at various sampling periods in both years at Bagauda and Samaru, respectively. Sweet potato varieties recorded significant variation in CGR at 8-12WAP in both years and locations. In each case, Mothers Delight consistently had higher CGR than Dan Zaria.

Application of Organic-mineral fertilizer rate had significant influence on crop growth rate at both locations, and years and at all the sampling periods, except at 8-12 WAP in 2016 at Bagauda. In both years and locations CGR was highest when 600 $kgha^{-1}$ of OMF was applied. The untreated control consistently had the least value for CGR.Stem cutting length had significant on CGR at Bagauda at 8-12 WAP in 2015 and at 4-8WAP in 2016. In Samaru at 4-8 WAP in 2015 and at 8-12 WAP in 2016, in each case 30 cm stem cutting length consistently had higher CGR with the exception of at 8-12 WAP in 2015 at Bagauda where 45 cm stem cutting length had the highest CGR . Interaction between the factors on crop growth rate during the study period was not significant.

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Table 1: Effects of Organic-mineral Fertilizer and Stem cutting Length of Sweet Potato Varieties on Number of Leaves at Bagauda and Samaru in 2015 and 2016 wet Seasons

	Number of leaves per plant											
	Bagauda						Samaru					
	2015			2016			2015			2016		
Treatment	**4 WAP**	**8 WAP**	**12 WAP**	**4 WAP**	**8 WAP**	**12 WAP**	**4 WAP**	**8 WAP**	**12WAP**	**4 WAP**	**8 WAP**	**12 WAP**
Variety (V)												
Dan Zaria	19.85	90.03	284.46	21.40	67.65^{b}	161.45	28.85	105.03	295.66	63.60	87.65^{b}	172.41
Mothers Delight	19.87	84.43	265.45	21.94	80.83^{a}	167.31	29.87	124.43	305.44	71.74	98.83^{a}	195.11
SE±	0.932	4.943	22.57	0.945	2.736	8.452	1.932	5.943	32.57	1.935	3.726	6.372
Organic-mineral fertilizer rate (F) kg ha^{-1}												
0 (OMF)	16.33^{b}	69.51	242.28	22.93	69.51	163.41	38.33^{c}	91.19	273.36	42.67	89.51	183.32
300 (OMF)	20.45^{a}	74.65	302.12	22.23	74.66	154.01	46.60^{b}	126.40	351.23	54.27	94.66	194.31
600 (OMF)	19.89^{a}	77.33	279.77	21.58	77.33	169.34	60.77^{a}	184.34	399.46	71.58	97.23	207.53
300 (NPK)	22.76^{a}	62.80	275.64	19.55	75.47	170.76	59.26^{a}	154.79	376.53	69.55	85.51	190.46
SE±	1.318	5.682	31.92	1.336	3.870	11.953	4.118	7.651	35.920	5.331	6.640	15.953
Stem cutting length (L) (cm)												
15	18.17^{b}	78.14^{c}	201.42	19.41^{c}	75.34	148.02^{c}	39.15^{c}	88.16^{c}	251.21	52.11^{c}	93.42	261.51^{c}
30	19.62^{ab}	81.04^{b}	238.66	22.94^{b}	70.65	162.52^{b}	47.22^{b}	116.04^{b}	269.53	63.13^{b}	135.31	276.16^{b}
45	21.79^{a}	92.52^{a}	284.78	22.37^{a}	76.73	182.60^{a}	61.49^{a}	194.22^{a}	293.37	75.37^{a}	187.73	296.21^{a}
SE±	1.141	6.054	25.243	1.157	3.351	10.352	3.252	8.032	27.343	4.139	5.311	14.352
Interaction												
F x V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
L x V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x L x V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Means within the same column and treatment group followed by same letter (s) are not significantly different at 5% level of probability using DMRT, WAP = Weeks After planting; OMF= Organic-mineral fertilizer; NS=Not significant.

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Table 2: Effects of Organic-mineral Fertilizer Rate and Stem Cutting length of Sweet Potato Varieties on Crop Growth Rate (CGR) g/m2/day at Bagauda and Samaru in 2015 and 2016 wet Seasons

	Crop growth rate (CGR) g/m^2/day							
	Bagauda				Samaru			
	2015		2016		2015		2016	
Treatment	**4-8 WAP**	**8-12 WAP**	**4-8 WAP**	**8-12 WAP**	**4-8 WAP**	**8-12 WAP**	**4-8 WAP**	**8-12 WAP**
Variety (V)								
Dan Zaria	2.38	3.28^{b}	5.01	6.57^{b}	8.48	4.38^{b}	7.16	13.35^{b}
Mothers Delight	2.52	3.89^{a}	4.79	8.31^{a}	7.95	5.94^{a}	7.97	17.99^{a}
SE±	0.354	0.440	0.516	0.787	1.352	0.910	1.212	3.369
Organic-mineral fertilizer rate (F) kg ha^{-1}								
0 (OMF)	1.91^{c}	2.42^{c}	4.19^{b}	8.44	5.82^{b}	4.81^{c}	10.05	16.62^{b}
300 (OMF)	2.46^{b}	2.63^{b}	4.69^{ab}	7.15	7.72^{ab}	5.05^{b}	7.07	16.62^{ab}
600 (OMF)	3.31^{a}	4.50^{a}	5.10^{a}	7.15	8.44^{a}	5.31^{a}	7.14	18.49^{a}
300 (NPK)	2.09^{b}	3.42^{ab}	5.62^{a}	8.45	10.90^{a}	5.48^{a}	6.02	16.02^{a}
SE±	0.501	0.309	0.731	1.113	1.912	1.714	1.714	4.765
Stem cutting length (L) cm								
15	2.43	3.23^{b}	4.35^{c}	7.64	9.99	4.94	6.08^{c}	12.55^{c}
30	2.49	2.87^{c}	4.52^{b}	7.09	7.71	6.20	9.49^{a}	19.17^{a}
45	2.39	4.15^{a}	5.72^{a}	7.57	6.95	4.34	7.13^{b}	14.98^{b}
SE±	0.433	0.267	0.633	0.964	1.656	1.115	1.484	4.127
Interaction								
F x V	NS	NS	NS	NS	NS	NS	NS	NS
F x L	NS	NS	NS	NS	NS	NS	NS	NS
L x V	NS	NS	NS	NS	NS	NS	NS	NS
F x L x V	NS	NS	NS	NS	NS	NS	NS	NS

Note: Means within the same column and treatment group followed by same letter (s) are not significantly different at 5% level of probability using DMRT, WAP = Weeks After planting; OMF= Organic-mineral fertilizer; NS= Not significant.

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The effects of organic-mineral fertilizer rate and stem cutting length of Sweet potato varieties on leaf area index at Bagauda and Samaru is presented in Table 3. The sweet potato varieties tested exhibited significant variation in LAI at 4WAP in both years and 8 WAP in 2016 at Bagauda and 8 and 12WAP in both years at Samaru. Mothers Delight consistently resulted in higher LAI values than Dan Zaria. Application of organic-mineral fertilizer rate significantly influenced LAI at 12WAP in 2015 and 2016 at Bagauda and 4, 8 and 12WAP in 2015 and 12WAP in 2016 at Samaru. In each case, LAI increased with each increase in OMF rate up to 600 kgha^{-1}. In all cases, the LAI from 600 kg ha^{-1} OMF was similar to that by NPK at 300 kgha.$^{-1}$ except at 8 WAP in 2015 at Samaru where 0 kg ha^{-1} OMF was at par with 300 kg ha^{-1} NPK. Similarly, LAI was significantly influenced by stem cutting length where increase in stem cutting up to 45cm at 4WAP in 2015 at Bagauda and 4WAP in 2015 and 12WAP in both years at Samaru led to a corresponding increase in LAI. Interaction between the factors during the study period was not significant.

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Table 3: Effects of Organic-mineral Fertilizer Rate and Stem Cutting length of Sweet Potato Varieties on Leaf Area Index (LAI) at Bagauda and Samaru in 2015 and 2016 wet Seasons

	Leaf area index (LAI)											
	Bagauda						Samaru					
	2015			2016			2015			2016		
Treatment	**4 WAP**	**8 WAP**	**12 WAP**	**4 WAP**	**8 WAP**	**12 WAP**	**4 WAP**	**8 WAP**	**12 WAP**	**4 WAP**	**8 WAP**	**12 WAP**
Variety (V)												
Dan Zaria	2.26^{b}	2.70	3.22	1.21^{b}	2.83^{b}	4.76	2.59	3.98^{b}	4.12^{b}	1.45	3.21^{b}	3.63^{b}
Mothers Delight	2.31^{a}	2.60	3.14	1.39^{a}	3.06^{a}	4.79	2.55	4.13^{a}	4.22^{a}	1.32	3.34^{a}	3.81^{a}
SE±	0.110	0.112	0.084	0.066	0.110	0.219	0.030	0.068	0.023	0.076	0.160	0.149
Organic-mineral fertilizer rate (F) kg ha^{-1}												
0 (OMF)	2.09	2.42	3.01^{c}	1.26	2.78^{b}	4.68^{c}	2.49^{c}	3.90^{c}	4.05^{c}	1.34	3.22	3.47^{b}
300 (OMF)	2.25	2.72	3.11^{b}	1.32	2.59^{c}	4.84^{b}	2.65^{b}	4.22^{b}	4.12^{b}	1.40	3.06	3.56^{ab}
600 (OMF)	2.30	2.62	3.06^{a}	1.30	2.88^{a}	4.88^{a}	2.61^{a}	4.33^{a}	4.17^{a}	1.40	3.39	3.83^{a}
300 (NPK)	2.50	2.81	3.50^{a}	1.32	2.88^{a}	4.63^{a}	2.54^{a}	3.62^{c}	4.29^{a}	1.41	3.35	3.94^{a}
SE±	0.156	0.158	0.119	0.093	0.156	0.310	0.028	0.096	0.050	0.108	0.226	0.211
Stem cutting length (L) (cm)												
15	2.21^{c}	2.53	3.15	1.34	3.04	4.92	2.51^{c}	4.01	4.08^{c}	1.42	3.31	3.60^{c}
30	2.27^{b}	2.64	3.19	1.34	2.92	4.84	2.55^{b}	4.10	4.16^{b}	1.45	3.25	3.75^{b}
45	2.34^{a}	2.78	3.20	1.22	2.88	4.55	2.67^{a}	4.05	4.27^{a}	1.28	3.21	3.81^{a}
SE±	0.135	0.137	0.103	0.081	0.135	0.269	0.037	0.083	0.043	0.094	0.196	0.182
Interaction												
F x V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x L	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
L x V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x L x V	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note: Means within the same column and treatment group followed by same letter not significantly different at 5% level of probability using DMRT, WAP = Weeks after planting, OMF=Organic-mineral fertilizer; NS= Not significant

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The effects of organic-mineral fertilizer rate and stem cutting length of Sweet potato varieties on number of tubers per plant is presented in Table 4. Sweet potato varieties showed significant variation in tuber numbers in both years and locations, except in 2015 at Bagauda. In each situation, Mothers Delight produced more tubers than Dan Zaria.

Table 4: Effects of Organic-mineral Fertilizer Rate and Stem Cutting Length of Sweet Potato Varieties on Number of Tubers of at Bagauda and Samaru in 2015, 2016 wet Season and the Combined Mean

	Number of tubers per plant					
	Bagauda			Samaru		
Treatment	**2015**	**2016**	**Mean**	**2015**	**2016**	**Mean**
Variety (V)						
Dan Zaria	3.89	2.91^{b}	3.40^{b}	9.69^{b}	4.17^{b}	6.93^{b}
Mothers Delight	4.00	3.09^{a}	3.55^{a}	10.11^{a}	5.35^{a}	7.73^{a}
SE±	0.170	0.137	0.140	0.220	0.350	0.537
Organic-mineral fertilizer rate (F) kgha^{-1}						
0 (OMF)	3.89	2.24^{c}	3.07	8.12^{c}	5.23	7.28
300 (OMF)	4.06	2.98^{b}	3.52	8.51^{b}	4.70	7.16
600 (OMF)	4.00	3.77^{a}	3.89	8.59^{a}	4.54	7.69
300 (NPK)	3.83	3.18^{a}	3.51	8.62^{a}	4.56	7.20
SE±	0.240	0.194	0.198	0.311	0.496	0.760
Stem cutting length (L) (cm)						
15	3.00	2.91^{c}	2.96^{c}	9.33^{b}	4.08^{b}	6.71
30	3.75	3.11^{b}	3.43^{b}	10.08^{a}	5.25^{a}	7.67
45	4.08	3.73^{a}	3.91^{a}	9.42^{b}	4.95^{b}	7.19
SE±	0.208	0.168	0.171	0.269	0.429	0.658
Interaction						
F x V	NS	NS	NS	NS	NS	NS
F x L	NS	NS	NS	NS	NS	NS
L x V	NS	NS	NS	NS	NS	NS
F x L x V	NS	NS	NS	NS	NS	NS

Note: Means within the same column and treatment group followed by same letter not significantly different at 5% level of probability using DMRT, OMF = Organic-mineral fertilize; NS = Not significant.

There was significant difference in number of tubers per plant due to Organic-mineral fertilizer rate application in 2016 at Bagauda, and in 2015 at Samaru where number of tubers increased with each increase in organic-mineral fertilizer from0- 300kg ha^{-1} and further to 600kgha^{-1}. In 2016 at Bagauda, 600kgha^{-1}OMF gave similar number of tubers with that of 300kgha^{-1} NPK fertilizer check. In 2015 at Samaru, the same trend was observed. The no fertilizer treatment consistently had the least number of tubers per plant.

Varying stem cutting length from 15-30cm influenced number of tubers per plant (Table 5) significantly at both locations in years of study, except in 2015 at Bagauda and the combined mean at Samaru. In 2016 and the combined means at Bagauda, the number of tubers increased with each increase in stem cutting length from 15-30cm and further to 45cm. In 2015 and 2016 at Samaru, 30 cm cuttings produced more tubers per plant than 15 and 45 cm lengths, which were statistically similar. Interaction between the factors on number of tubers during the period of growth was not significant.

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Effects of organic-mineral fertilizer rate and stem cutting length of Sweet potato varieties on tuber diameter at Bagauda and Samaru in 2015, 2016 wet seasons and the combined means for the two years is presented in Table 5. The Sweet potato varieties differed significantly in tuber diameter in both locations and year of study except for the combined mean at Bagauda.

Table 5: Effects of Organic-mineral Fertilizer Rate and Stem Cutting Length of Sweet Potato Varieties on Tuber Diameter (Cm) At Bagauda and Samaru in 2015 and 2016 wet Seasons and the Combined Mean

	Tuber diameter per tuber (cm)					
	Bagauda			Samaru		
Treatment	**2015**	**2016**	**Mean**	**2015**	**2016**	**Mean**
Variety (V)						
Dan Zaria	9.16^{b}	7.37^{b}	8.27	8.24^{b}	7.01^{b}	7.63^{b}
Mothers Delight	9.27^{a}	7.68^{a}	8.48	8.76^{a}	7.69^{a}	8.23^{a}
SE±	0.237	0.289	0.242	0.175	0.220	0.195
Organic-mineral fertilizer rate (F) kgha^{-1}						
0 (OMF)	8.99^{d}	7.33	8.16^{d}	8.17^{d}	7.08	7.63^{d}
300 (OMF)	9.29^{b}	7.42	8.36^{b}	8.55^{c}	7.35	7.95^{c}
600 (OMF)	9.53^{a}	8.91	9.22^{a}	8.98^{a}	7.75	8.37^{a}
300 (NPK)	9.05^{c}	7.56	8.31^{c}	8.78^{b}	7.61	8.20^{b}
SE±	0.335	0.408	0.423	0.248	0.312	0.276
Stem cutting length (L) (cm)						
15	9.06	7.22^{c}	8.14^{c}	8.73	7.13^{c}	7.93
30	9.14	7.57^{b}	8.36^{b}	8.69	7.38^{b}	8.04
45	9.34	7.79^{a}	8.57^{a}	8.83	7.52^{a}	8.18
SE±	0.290	0.353	0.297	0.301	0.270	0.239
Interaction						
F x V	NS	NS	NS	NS	NS	NS
F x L	NS	NS	NS	NS	NS	NS
L x V	NS	NS	NS	NS	NS	NS
F x L x V	NS	NS	NS	NS	NS	NS

Note: Means within the same column and treatment group followed by same letter not significantly different at 5% level of probability using DMRT; OMF = Organic-mineral fertilizer; NS = Not significant.

The results also disclosed that Mothers Delight generally had thicker tubers than Dan Zaria (Table 5). Application of Organic-mineral fertilizer rate significantly influenced tuber diameter only in 2015 and the combined means in both locations. In each case tuber diameter increased with increase in OMF rate up to 600 kg ha^{-1}, and the highest value was recorded at 600kg ha^{-1} OMF. Stem cutting influenced tuber diameter in 2016 in both locations and the combined data at Bagauda only, where the tuber diameter increased with each increase in stem cutting length and the widest tubers obtained was with 45cm cuttings. Interaction between factors on tuber diameter during the period of growth was not significant.

The effects of organic-mineral fertilizer rate and stem cutting length of sweet potato varieties on total tuber yield at Bagauda and Samaru in 2015, 2016 wet seasons and combined mean is presented in Table 6. The sweet potato varieties varied significantly in their total fresh tuber yield in 2016 and the combined mean at Bagauda and 2016 at Samaru, where Mothers Delight significantly had higher total fresh tuber yield than variety Dan Zaria. Application of

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Organic-mineral fertilizer rate significantly influenced total tuber yield only in 2016 at Bagauda and in 2015 at Samaru. Total tuber yield significantly increased with each increase in OMF rate from 0-300 kg ha^{-1} OMF and further to 600kg ha^{-1} OMF. The highest total tuber yield was recorded by 600 kg ha^{-1} OMF at both locations.

Table 6: Effects of Organic-Mineral Fertilizer Rate and Stem Cutting Length of Sweet Potato Varieties on Total Tuber Yield (T.ha-1) At Bagaudaand Samaruin 2015 and 2016 wet Seasons and the Combined Mean

	Total tuber yield (t.ha^{-1})					
	Bagauda			**Samaru**		
Treatment	**2015**	**2016**	**Mean**	**2015**	**2016**	**Mean**
Variety (V)						
Dan Zaria	11.66	17.49^{b}	14.58^{b}	32.24	25.20^{b}	28.72
Mothers Delight	12.63	18.07^{a}	15.35^{a}	36.39	26.64^{a}	31.52
SE±	0.394	0.555	0.506	0.497	0.466	0.577
Organic-mineral fertilizer rate (F) kgha^{-1}						
0 (OMF)	13.02	15.50^{c}	14.26	32.64^{c}	26.93	29.79
300 (OMF)	11.19	18.99^{b}	15.09	36.86^{b}	26.04	31.45
600 (OMF)	11.34	19.47^{a}	15.41	38.98^{a}	26.08	32.53
300 (NPK)	13.04	17.16^{b}	15.10	32.42^{c}	24.61	28.52
SE±	0.415	0.574	0.715	0.665	0.521	0.532
Stem cutting length (L) (cm)						
15	11.99	16.38^{c}	14.19^{c}	25.46^{b}	23.93^{c}	24.70
30	11.33	17.96^{b}	14.65^{b}	24.21^{c}	27.22^{b}	25.72
45	13.12	19.00^{a}	16.06^{a}	37.12^{a}	33.49^{a}	35.31
SE±	0.608	0.680	0.619	0.497	0.547	0.362
Interaction						
F x V	NS	NS	NS	NS	NS	NS
F x L	NS	NS	NS	NS	NS	NS
L x V	NS	NS	NS	NS	NS	NS
F x L x V	NS	NS	NS	NS	NS	NS

Note: Means within the same column and treatment group followed by same letter not significantly different at 5% level of probability using DMRT; OMF = Organic-mineral fertilizer; NS = Not significant.

Stem cutting length significantly affected total tuber yield in 2016 (Table 6) and the combined mean at Bagauda and in both years at Samaru. It was observed that total tuber yield increased with each increase in stem cutting length from 15 to 30cm and further to 45 cm. There was greater vegetative variety of Mothers Delight in terms of number of number of leaves, CGR and LAI. This could have been attributed to production of larger LAI which resulted in greater light interception and assimilate production and thus high dry matter partitioned for leaves and vines production as observed in the study area.

The less robust growth of variety Dan Zaria in terms of vegetative characters such as number of number of leaves, CGR and LAI indicated that the variety is genetically a small stature plant. Such genetically controlled differences among sweet potato have been reported by Lukipudis (1989), Sharman and Singh (1990), Beukema and Vander Zaag (1990) and Harris (1992) who identified morphological variation and or similarities amongst varieties. The higher tuber number, wider tuber diameter and total fresh tuber yield recorded by Mothers Delight

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varieties could be as a result of its larger assimilatory leaf area which enhances dry matter production. It could further be attributed to the genetic variation between the two varieties tested in this study as earlier observed and reported by Manrique and Bartholomew (1991) Harris (1992) and Babaji *et al*. (2009).

In this study, the significant and positive responses of growth and yield attributes to the application of OMF and NPK fertilizer is a confirmation of the essentiality of these nutrients sources for the overall performance of sweet potato and was reflected on enhanced growth parameters which include number of leaves per plant, CGR and LAI. The responses of these growth parameters to the high rate of OMF (600 kg ha^{-1}) could be attributed to the collective role of the fertilizer nutrients (NPK) and micro nutrients in enhancing the metabolic processes which bring about the production and translocation of dry matter. Therefore, application of 600 kg ha^{-1} OMF supplies reasonably adequate quantities of the nutrients for optimum dry matter production as also observed and reported by (Beukema and Vanderzaaq (1990) and Harris (1992).Furthermore, application of 600 kg ha^{-1} OMF or 300 kg ha^{-1}NPK resulted in higher values for yield related parameters such as number of tubers, tuber diameter and total fresh tuber yield. This showed that applying 600 kg ha^{-1} OMF was as good as 300 kg ha^{-1} NPK. The response of tuber yield characters and total fresh tuber yield to higher rate of OMF up to 600 kg ha^{-1}showed that they were optimized with this OMF rate.

In this study (Table 6), vegetative growth and yield attributes significantly increased with increase in stem cutting length as evidenced by increase in number of number of leaves, CGR and LAI, with 45 cm stem cutting length having greater growth attributes than the other lengths. This could probably be due to higher number of nodes as well as more food reserve associated with longer stem cutting lengths than shorter stem cutting lengths. These nodes serve as points of emergent of vines. Longer stem cutting contains higher amount of assimilates, which probably favoured larger vines production. Larger vines are a precursor of higher number of leaves, higher number of leaves lead to greater photosynthesis which resulted to the production of high dry matter. The higher values for aforementioned growth parameters associated with 45 cm cutting further permits more nodes to be buried at planting, which leads to more roots initiation and better establishment. With more nodes, the number of buds increased and this serves as a source of growth for rooting and sprouting. This observation corroborates the report by Amoah (1997) that cuttings with more nodes attained 100% establishment earlier than cuttings with fewer nodes. This also agrees with the findings of Ray *et al.* (2001) and Nedunchezhiyan *et al.* (2012) who reported significant increase in growth parameters with increase in stem cutting length.

The significant influence of stem cutting length on yield parameters at 45 cm stem in this study has been observed. The yield parameters such as number of tuber, tuber diameter and total tuber yield were enhanced significantly at 45 cm stem cutting length. This could be explained by the higher number of nodes on the 45 cm stem cutting length which were buried and provided more points for tuber root initiation. According to Amoah (1997), tuber initiation and bulking begin earlier on cuttings with more nodes than those with fewer nodes as a result of the early rapid growth which translated into higher roots yield and greater marketable yields. His results also agreed with the findings of Beyene et *al.* (2015), Hall (1986) Baustita and Vega (1991) and Essilfie *et al.* (2016) who reported increase in yield parameter with increase in stem cutting length.

CONCLUSION AND RECOMMENDATIONS

The study one can concluded that sweet potato, Mothers Delight variety was superior to Dan-Zaria in crop growth and yield attributes, while Dan-Zaria had more starch and dry

matter contents. Application of 600 kg ha^{-1}OMF produced higher growth and yield attributes than the other rates. The use of 45 cm stem cutting length was more productive than the other lengths. It was recommended that, for higher growth and yield Mothers delight, 600 kg ha^{-1} organic mineral fertilizer and 45cm stem cutting length should be selected for further research in the study areas.

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