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Optimum Plant Population and NPK Fertilizer Requirements for Livingstone Potato (*Plectranthus Esculentus* N.E. Br) Production under Two Distinct Agro-Ecologies in Nigeria

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Abstract: The field experiment was conducted at the experimental farms of the National Root Crops Research Institute, Umudike and Vom locations in Nigeria for 2 consecutive seasons to determine the optimum plant density and fertilizer requirements for Livingstone potato production under the high and low altitude agro-ecologies. Livingstone potato variety-var. Loangat was subjected to four plant densities (20,000; 40,000; 60,000; 80,000 plants ha^{-1}) and four rates of NPK 15:15:15 fertilizer (0, 200, 400 and 600 kg ha^{-1}). The effects of plant density and fertilizer was not significant on total tuber yield at Umudike in both years, however, both plant density and fertilizer effects were significant on total tuber yield at Vom except fertilizer rate that was not significant in 2005. On 2 year average the total tuber yield increased with increase in plant density with the maximum yield obtained at a density of 80, 000 plants ha^{-1} for both locations. While total tuber yield was depressed with NPK application at Umudike, the highest tuber yield was obtained with fertilizer application rate of 200 kg ha^{-1} in Vom. On the basis of economic analysis, it was recommended that for optimum yield of Livingstone potato, plant densities of between 60,000 and 80,000 plants ha^{-1} with NPK 15:15:15 applied at 200 kg ha^{-1} will be sufficient for good crop yield in soils deficient in plant nutrients at the two locations.

Key words: Livingstone potato, plant population, fertilizer, agro-ecologies, Nigeria

INTRODUCTION

Livingstone potato (*Plectranthus esculentus* N.E. Br) is a dicotyledonous perennial shrub belonging to the family *Labiatae*. The plant is commonly known as *kaffir potato* in English but locally as *rizga*, *nvat*, *vu*, sima or *rungwabi* depending on the locality. Livingstone potato is one of the widely cultivated minor root crops in the middle belt region especially Kaduna and Plateau states in Nigeria for the finger-like edible tubers (Schiffers, 2000; Olojede *et al*., 2004). The tuber is either eaten raw as snack after peeling and washing or boiled and eaten with rice, while the leaves are also consumed as vegetables (Demissie, 1997).

Although Livingstone potato is regarded as a minor root crop, nevertheless, its importance as an essential food crop and income generation to the rural household in the areas of production can not be over-emphasized. Nutritionally, the tuber is a carbohydrate food, but it is also fairly rich in protein (10.52 g/100 g) and some minerals namely, sodium (8-21.8 mg/100 g), calcium (55-90 mg/100 g), potassium (1225-15000 mg/100 g), iron (100-155 mg 100^{-1} g), magnesium (15.5-64.8 mg 100^{-1} g), copper (0.5-1 mg 100^{-1} g) and manganese (1-3 mg 100^{-1} g) (Olojede *et al*., 2004; Gila, 1984). In terms of protein content, when compared with yam (7 g/100 g), cassava (3 g 100^{-1} g), sweet potato (5 g/100 g) and cocoyam (7 g 100^{-1} g) (Leung, 1968); Livingstone potato rank highest in protein content relative to the major root crops grown in Nigeria. As an income generating crop, processed raw tubers are sold during the main season while processed dried forms are sold during the off seasons by women for income generation to the rural household. Further, the cultural attachment to Livingstone potato in some areas is so strong, that no ceremony is regarded complete without a meal of Livingstone potato served to the guests as a mark of social status.

In spite of the nutritional and socio-economic values of this crop, research efforts were just recently initiated on Livingstone potato along with other minor root crops in Nigeria with the purpose of harnessing their potentials (Olojede *et al*., 2004a, b). Initial results on agronomic studies indicated 400 kg ha^{-1} of NPK 15:15:15 as being

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optimum for Livingstone potato production. However, the plant density of 40,000 plants ha^{-1} used appeared inadequate for optimum yield hence the need to further fine tune the agronomic and cultural practices to push the yield close to the crop's potential.

The objective of this study, therefore, is to determine the optimum plant density and fertilizer requirements for Livingstone potato production under two distinct agro-ecological environments in Nigeria.

MATERIALS AND METHODS

The field experiment was carried out at the experimental farms of the National Root Crops Research Institute located at Umudike and Vom during the 2005 and 2006 cropping seasons. Umudike is located on Longitude 07° 33'E and Latitude 05° 29'N at an elevation of 122 m above sea level in the tropical rainforest while Vom is located on Longitude 09° 44'E and Latitude 08° 47'N at an elevation of 1350 m above sea level in the savanna middle belt of the North Central. Livingstone potato variety-var. *Loangat* was subjected to four plant densities (20,000; 40,000; 60,000; 80,000 plants ha^{-1}) and four rates of NPK 15:15:15 fertilizer (0, 200, 400 and 600 kg ha^{-1}). The experiment was laid out in split plot design with 3 replications. Plant density occupied the main plots and fertilizer rates sub plots. The land was ploughed, harrowed and ridged before planting. Planting was done on ridges spaced 1m apart while the intra-ridge or row spacing was varied according to the plant population. The unit plot size at Umudike was 6×5 m (30 m^2) while the plot size at Vom was 6×3 m (18 m^2). Premextra and gramozone were applied as pre-emergence herbicides at 5 kg ha^{-1} of active ingredients and was supported with two manual weedings at 8 and 12 weeks after planting (WAP). Fertilizer was applied at 8 WAP using different experimental rates of NPK 15:15:15. Harvesting was carried out at 6 months after planting in the 2 years. Yield and yield parameters collected were subjected to Analysis of Variance (ANOVA) according to Steel and Torrie (1980) and significant means separated by LSD at 5% alpha level. Also economic analysis was carried out on the experiment to establish the economic viability of Livingstone potato production at these locations using costs and returns analysis as adopted by Aboajah, (2001) and Islam *et al*. (2002).

RESULTS AND DISCUSSION

The effects of plant density and fertilizer were not significant on total tuber yield at Umudike in both years, however, both plant density and fertilizer application significantly affected total tuber yield in Vom in both years except fertilizer rate that was not significant in 2005 (Table 1). Interaction effect was not significant at the two locations for the 2 years under consideration hence the result was not presented. Although plant density and fertilizer effects were not significant at Umudike, the total tuber yield increased with increase in plant density with the highest yield obtained at 80,000 plants ha^{-1} in 2005 while the highest yield was recorded at 60, 000 plants ha^{-1} in 2006. However, the maximum yield was obtained at a density of 80,000 plants ha^{-1} on 2 year average.

While the total tuber yield increased with increase in fertilizer application in 2005, yield was reduced in 2006 with increase in fertilizer application. On 2 year average, highest yield was obtained without fertilizer application but this was similar to the yield obtained with application of 200 kg of NPK 15:15:15. The yield obtained at Umudike was found comparable to yield obtained in Vom indicating the plant to be adaptable to rainforest agro-ecology as reported by Schippers (2000). At Vom location, total tuber yield increased with increase in plant density in both years with the highest yield obtained at 80,000 plants ha^{-1} being similar to the yield obtained at

Table 1: Effect of Plant density and NPK Fertilizer on yield and yield components of Livingstone potato at Umudike and Vom in 2005 and 2006

	Umudike Location			Vom Location		
Treatments	2005 Total tuber yield (t ha^{-1})	2006 Total tuber yield (t ha^{-1})	Mean tuber yield (t ha^{-1})	2005 Total tuber yield (t ha^{-1})	2006 Total tuber yield (t ha^{-1})	Mean tuber yield (t ha^{-1})
Density ha^{-1}						
20,000	4.23	5.12	4.68	2.79	2.97	2.88
40,000	5.32	5.54	5.43	4.18	4.61	4.40
60,000	5.48	7.79	6.64	5.96	5.84	5.90
80,000	7.29	6.04	6.67	7.39	6.31	6.85
$LSD_{0.05}$	NS	NS	-	1.44	1.05	-
Fert rate (kg ha^{-1})						
0	5.51	6.89	6.20	4.80	4.19	4.50
200	5.70	6.56	6.13	5.99	4.97	5.48
400	5.35	5.98	5.67	4.80	5.69	5.25
600	5.78	5.04	5.41	4.71	4.88	4.80
$LSD_{0.05}$	NS	NS	-	NS	0.87	-

NS = Not Significant at 5% alpha level

Table 2: Economic performance of Livingstone potato production with different plant density and NPK rates at Umudike

Density	Fertilizer rate (kg ha^{-1})	Total cost (N ha^{-1})	Gross return (N ha^{-1})	Gross margin (N ha^{-1})	Return per naira (%)	Benefit cost ratio
20,000	0	115,804.50	212,100.00	96,295.50	83	1.80
40,000	0	121,498.90	275,450.00	153,951.10	126	2.30
60,000	0	141,313.70	502,600.00	361,286.30	255	3.60
80,000	0	145,480.04	414,750.00	269,269.96	185	2.90
20,000	200	139,692.50	224,350.00	84,657.50	61	1.60
40,000	200	145,386.90	271,600.00	126,213.10	87	1.90
60,000	200	169,201.70	422,100.00	252,898.30	149	2.50
80,000	200	169,368.40	424,200.00	254,831.60	150	2.50
20,000	400	149,692.50	205,800.00	56,107.50	38	1.40
40,000	400	155,386.90	229,950.00	74,563.10	48	1.50
60,000	400	179,201.70	381,850.00	202,648.30	113	2.10
80,000	400	179,368.40	314,650.00	135,281.60	75	1.80
20,000	600	174,507.30	191,100.00	16,592.70	9	1.10
40,000	600	180,201.70	198,100.00	17,898.30	10	1.10
60,000	600	189,368.70	407,750.00	218,548.30	116	2.20
80,000	600	189,368.40	258,300.00	68,931.60	36	1.40

60,000 plants ha^{-1}. While optimum tuber yield was obtained at 200 kg ha^{-1} of NPK application in 2005 the optimum was obtained at 400 kg ha^{-1} in 2006, however, on 2 year average the optimum was recorded at 200 kg ha^{-1}.

That there was lack of response to fertilizer application at Umudike was not surprising as the pre-plant soil test result indicated abundance of P (20.5 ppm) while percent total N (0.074) and available K (0.184 meq/100 g) are near the critical levels in which response to fertilizer application may not be expected. This is contrary to earlier result in which 400 kg ha^{-1} of NPK and plant density of 40,000 plants ha^{-1} was found optimum for Livingstone potato production for the same location (Olojede, 2004). With this result, Livingstone potato can be conveniently cultivated under the present soil condition without fertilizer application or perhaps if fertilizer must be applied this should not be more that 200 kg of NPK 15:15:15 at densities of 60,000-80,000 plants ha^{-1}. This was also confirmed by the result of the economic analysis presented in Table 2. Planting of Livingstone potato at a density of 60,000 plants ha^{-1} without fertilizer application gave a gross margin of N361, 286.30, while return per naira and benefit cost ratio were 255% and 3.60, respectively. Further, economic viability of planting Livingstone potato at densities between 60,000 and 80,000 plants ha^{-1} with NPK applied at 200 kg ha^{-1} was also indicated with benefit cost ratio of 2.50 and return per naira of 149% implying that a farmer can recover about 250% of his investment and N149.00 for every N100.00 invested.

As regards Vom location, that there was response to fertilizer application in Vom is an indication that the soil was deficient in major plant nutrients, although there was no soil test result to back up this claim. Albeit, planting of Livingstone potato at densities between 60,000-80,000 plants ha^{-1} with NPK 15:15:15 applied at 200 kg was found adequate for Livingstone potato production.

CONCLUSION AND RECOMMENDATION

It can be concluded from this result, that planting of Livingstone potato at densities between 60,000 and 80,000 plants ha^{-1} at both locations will be optimum for tuber yield. However, with regards to fertilizer requirement, fertilizer application may not be required in soils with high nutrient status as obtained at Umudike. However, for soils that are deficient in plant nutrients in this location, application of 200 kg ha^{-1} of NPK 15:15:15 will suffice for optimum yield. This same rate was found adequate for optimum yield performance under Vom agro-ecology in the Jos Plateau. It is therefore recommended that for optimum Livingstone potato yield, plant densities of between 60,000 and 80,000 plants ha^{-1} with NPK 15:15:15 applied at 200 kg ha^{-1} will be sufficient for good crop yield in soils deficient in plant nutrients at the two locations.

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