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Variety and Intra-Row Spacing On Growth and Yield of Potato (*Solanum Tuberosum* L) By Nigerian Farmers to Improve Productivity in Jos Plateau State, Nigeria

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ABSTRACT: The objective of this paper was to evaluate the variety and intra-row spacing on growth and yield of Potato (Solanum tuberosum L.) by Nigerian farmers to improve productivity in Jos Plateau State, Nigeria during the 2024 rainy season using appropriate techniques. Data obtained show that the values of count, plant height, leaf area, stem girth at 30, 45, 60, and 75 days after planting; tuber number, length, diameter, and yield were assessed and results indicated no significant ($p>0.05$) effects on establishment count, plant height, tuber length, and diameter. However, significant ($p\leq0.05$) effects were observed in leaf area, tuber number, weight, and yield. Marabel (variety 2) outperformed Connect, recording the highest yield (85,700kg/ha), with the 30×25cm spacing also yielding highest (72,375kg/ha). Hence, Marabel and 30×25cm spacing are recommended for potato cultivation.

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Potato (*Solanum tuberosum L.*) is the world's leading non-grain food crop and the third most consumed food crop globally, following rice and wheat (FAO, 2013; Rykaczewska, 2013; Muhie *et al*., 2022). Over half of global potato production occurs in developing countries, contributing to an annual output of nearly 400 million tons, which plays a significant role in food security and socio-economic development (Devaux *et al*., 2014; Halterman *et al*., 2016). In Africa, Nigeria ranks as the seventh-largest potato producer with an annual yield of 1,284,370 tons. This is significantly lower than Algeria, Egypt, and South Africa, which produce 4,606,400 tons, 4,325,480 tons, and 2,450,540 tons, respectively (Dakusuk *et al.,* 2022). Despite Nigeria's substantial production, the country's average yield of 3.1 tons/ha is among the lowest globally, with production primarily taking place in small farms that rely on traditional farming tools (FAO, 2008; Dirisu, 2019). More than 75% of Nigeria's potato production is concentrated in the Jos Plateau, which is the heart of the country's potato farming (Dirisu, 2019).

Potatoes come in over a thousand distinct varieties worldwide, each differing in appearance, taste, and texture. While some are white and fluffy, others are red and firm, and some even have blue skin (International Potato Center, 2022). These varieties, originally from South-Central Chile, replaced earlier varieties from the Indian highlands (Mamzing *et al*., 2022). In Nigeria, common varieties include Marabel, Diament, Nicola, Jelly, Agria, and Connect (Dirisu,

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2019). Introduced in 2014 through the SEDIN project by the German Corporation for International Cooperation (GIZ), the Connect variety was brought from Germany to combat late blight disease and improve productivity (Ojediran, 2020). Marabel, a potato variety developed by Europlant Germany and released in Nigeria in 2014, is characterized by extra early maturity, high yield potential (23 t/ha), a high number of marketable tubers, and high dry matter content, making it well-suited for rainfed and Northern Guinea Savanna agroecological zones (Nigerian Seed Portal Initiative, 2014).

The performance of potato varieties in terms of growth and yield is influenced by both genetic traits and environmental conditions. Different cultivars vary in maturity time, disease resistance, and overall yield potential (Bilkia *et al*., 2014; Nxumalo *et al*., 2017). Potato yield is also heavily dependent on the adoption of optimal spacing practices. Studies show that inadequate intra-row spacing can reduce potato yield by as much as 50% (Masarirambi *et al*., 2012). Hence, the objective of this paper is to assess the variety and intra-row spacing on growth and yield of Potato (Solanum tuberosum L.) by Nigerian farmers to improve productivity in Jos Plateau State, Nigeria.

MATERIALS AND METHODS

The experiment was conducted at the Research and Demonstration Farm of the Federal College of Forestry, Jos. It is situated in the Northern Guinea Savanna zone at a latitude of 9°55'N and longitude of 8°54'E, with an average elevation of about 1,250 meters above sea level, standing approximately 600 meters above the surrounding plains. The area experiences a cool climate due to its high altitude, with average temperatures ranging between 21°C and 25°C. Rainfall typically occurs between April and September, while the dry season extends from October to March, with an annual mean rainfall of 1,260 mm as reported by Olowolafe (2002). The materials for the experiment included two potato varieties, Marabel and Connect, which were sourced from the Federal Ministry of Agriculture and Rural Development in Jos. Other materials used were cured organic manure, obtained from a certified supplier, and NPK 15:15:15 fertilizer. The experimental design employed a randomized complete block design (RCBD) with eight treatment combinations formed by two varieties and four planting depths, arranged in a 2 × 4 factorial structure. Each treatment was replicated three times, with varieties assigned to the main plots and planting depths to the sub-plots. The experimental area consisted of 24 plots, each measuring 2 m², laid out on a gross plot of 9 m × 21 m. Raised beds measuring 2 m² were constructed, and planting was carried out by assigning potato seeds to the plots with different intra-row spacings according to the treatments. Weeding was done manually two and four weeks after planting to prevent competition from unwanted plants.

Data collection involved measuring key growth and yield parameters. Establishment counts were determined by calculating the percentage of germinated seeds relative to the total number planted. Plant height was recorded at two, four, six, eight, and ten weeks after planting, measured from the base to the tip of the plant. The number of leaves was determined by counting leaves on five tagged plants per subplot at intervals of two weeks. Leaf area was calculated by multiplying the width and length of leaves by a constant (0.674) (He *et al*., 2020). Stem girth was measured using a Vernier calliper, while the number of tubers was obtained by counting those harvested from the five tagged plants at harvest. Tuber length was measured with a ruler, and tuber diameter was recorded using a calliper. Tuber weight was determined with a digital scale, and tuber yield was calculated by converting the weight to kilograms per hectare. The collected data were analysed using SPSS version 26 statistical tool.

Mean Establishment count: The results indicated that there was no significant difference at ($P > 0.05$) on the varieties in mean establishment count. Similarly, the result on the planting spaces shows no significant difference was recorded on the different planting spacing used on the experiment. There were no significant interactions with the treatments.

Table 1: Establishment Count

Treatment	Establishment Count
Variety	
V1	7.75
V2	8.41
P-value	0.446
Spacing	
30x30	4.05
30x40	3.85
30x25	3.76
30x50	3.82
P-value	0.211
Interaction	
VxS	NS

Mean Plant Height: The result on plant height is showed that there was no significant difference at ($P \leq 0.05$) on plant height with the varieties at 30, 45, 60 and 75 days after planting (DAP). In a similar manner, no significant difference was observed on the planting spacing used in the experiment. The result on the interaction between the varieties and the planting spacing also showed there was no positive interaction between the treatments.

Table 3: Mean Plant Height

Treatment	30DAP	45DAP	60DAP	70DAP
Variety				
V1	15.04	21.19	28.85	30.33
V2	21.19	20.90	28.95	30.12
P-value	0.397	0.741	0.921	0.82
Spacing				
30x30	15.33	21.63	29.38	30.63
30x40	14.74	21.50	29.21	30.08
30x25	15.54	21.88	29.67	31.75
30x50	13.29	19.17	27.38	28.46
P-value	0.158	0.143	0.365	0.123
Interaction				
VxS	NS	NS	NS	NS

Key: DAP= Days after planting, NS=not significant, V1=connect, V2=marabel, VxS=interaction between variety and spacing

Leaf Area: The results of the leaf area show that there was significant difference at ($P \geq 0.05$) on the varieties at 30 and 60 days after planting. At 30 and 60 DAP, variety two recorded the highest mean value (5.52 and 8.33) while variety one (5.08 and 7.77) recorded the least mean values respectively. The result on the planting spacing showed no significant difference ($p \leq 0.05$) was observed on the planting treatment throughout the sampled period, similarly there were no positive interactions on the varieties and planting spacing.

Table 4: Mean leaf Area

Treatment	30DAP	45DAP	60DAP	70DAP
Variety				
V1	5.08	6.39	7.77	6.75
V2	5.52	6.85	8.33	6.94
P-value	0.069	0.091	0.049	0.177
Spacing				
30x30	5.00	6.38	7.92	6.83
30x40	5.67	6.96	8.13	7.00
30x25	5.63	6.88	8.42	7.04
30x50	4.92	6.29	7.75	6.50
P-value	0.052	0.191	0.341	0.357
Interaction				
VxS	NS	NS	NS	NS

Key: DAP= Days after planting, NS=not significant, V1=connect, V2=marabel, VxS=interaction between variety and spacing

Stem Girth: The result shows that no significant difference ($P > 0.05$) was observed on the varieties. However, the result on the planting spacing showed significant difference ($P \leq 0.05$) was recorded at 30, 45 and 60 days after planting (DAP. At 30, 45 and 60 DAP, 30cm × 25cm planting spacing recorded the highest mean value (1.67, 2.11, 2.35) and the least mean value was recorded with 30cm × 50cm planting spacing (1.50, 1.93, and 2.23) respectively. There were no positive interactions with the treatments throughout the sampled periods.

Table 5: Stem Girth

Treatment	30DAP	45DAP	60DAP	70DAP
Variety				
V1	1.15	1.96	2.23	2.26
V2	1.59	2.03	2.28	2.30
P-value	0.177	0.113	0.066	0.153
Spacing				
30x30	1.53	1.97	2.23	2.26
30x40	1.56	1.96	2.24	2.25
30x25	1.67	2.11	2.35	2.34
30x50	1.50	1.93	2.23	2.26
P-value	0.035	0.015	0.022	0.089
Interaction				
VxS	NS	NS	NS	NS

Key: DAP= Days after planting, NS=not significant, V1=connect, V2=marabel, VxS=interaction between variety and spacing

Tuber Length at Harvest, Tuber Diameter at Harvest and Number of Tuber/Plant/Plot.: There was no significant difference in tuber length between the varieties at ($P > 0.05$). Similarly, planting spacing did not show any significant effect on tuber length, and no positive interactions were observed among the

treatments. Tuber diameter also exhibited no significant difference between the varieties (P > 0.05). Similarly, the planting spacing showed no statistical difference, and there were no positive interactions between the treatments. Unlike tuber length and diameter, the number of tubers showed statistical differences between the varieties. Variety one recorded the highest mean value (5.85), while variety two had the lowest (5.37). Planting spacing also significantly influenced the number of tubers per plant/plot (P ≤ 0.05), with 30cm × 25cm spacing recording the highest mean value (6.54) and 30cm × 40cm spacing the least (5.20). However, no positive interactions between the treatments were observed.

Table 6: Mean Tuber Length at Harvest, Tuber Diameter at Harvest and Number of Tuber/Plant/Plot

Treatment	Tuber Length At Harvest	Tuber Diameter At Harvest	Number of Tuber/Plant/Plot
Variety			
V1	3.61	3.86	5.85
V2	3.66	3.88	5.37
P-value	0.616	0.783	0.023
Spacing			
30x30	3.71	3.76	5.25
30x40	3.47	3.85	5.20
30x25	3.71	4.05	6.54
30x50	3.65	3.82	5.46
P-value	0.354	0.211	0.001
Interaction			
VxS	NS	NS	NS

Key: NS=not significant, V1=connect, V2=marabel, VxS=interaction between variety and spacing

Tuber Yield: The result of tuber weight is represented in table 8 below. The results indicated that there was significant difference at (P ≤ 0.05) on the varieties for both yield g/4m² and yield kg/4m². and Variety two recorded the highest mean value (13.71 and 34.28) and variety had the least (6.96 and 17.4). The result of the planting spacing showed there was no significant difference on the treatments. Similarly, no significant interactions were observed with the treatments. The yield in kg/ha^{-1} showed variety two had 85,700kg/ha^{-1} and variety one had 43,000kg/ha^{-1}. In the same vein, planting spacing (30cm× 25cm) recorded the highest yield value (72,375kg/ha^{-1} and the least was recorded by 30cm×50cm (58,875yield/ha^{-1}) respectively.

Table 8: Mean Tuber Yield

Treatment	(g/4m²)	(kg/4m²)	kg/ha^{-1}
Variety			
V1	6.96	17.4	43500
V2	13.71	34.28	85700
P-value	0.001	0.001	
Spacing			
30x30	9.96	24.9	62250
30x40	10.38	25.95	64875
30x25	11.52	28.95	72375
30x50	9.42	23.5	58875
P-value	0.312	0.114	
Interaction			
VxS	NS	NS	

Key: NS=not significant, V1=connect, V2=marabel, VxS=interaction between variety and spacing

The results of the establishment count in table1 shows no significant difference on the varieties and planting spacing at (P ≤ 0.05) respectively. The non-significant difference recorded indicated that the varieties adapted well to the environment because any one of it could be cultivated in the research areas due to their genetic traits. This agrees with the work of Tesfaye and Antenes (2020) who highlighted that varieties with improved genetic traits can leads to significant increase in both growth and yield parameters. The result on plant height indicates that varieties and planting spacing shows improvement throughout the sampled periods (30-70 DAP) with variety two recorded the best performance across the trends. Similarly, planting spacing shows similar trend across, but 30cm× 25cm spacing stood out in terms of mean values. This result is in line with the work of (Mvumi, *et al*; 2018) who posited that smaller in-row distance increased plant population density which promotes plant competition for resources and resulted in tall plants compared to others planted widely. The leaf area in table 3

revealed that varieties recorded improvement across the period considered but the performance of variety two (Marabel) was better in terms of mean values with significance at 30 DAP. The performance of leaf area in terms of planting spacing showed that 30cm×25cm did better compare to others spacing. This agrees with (Vander zaay *et al*; 1990), who also found a higher number of leaves of low plant densities. Similarly, (Mangani, *et al*; 2015) found that there was high number of leaves at low plant density of solanum.

The results of stem diameter presented in table 4 showed good performance with the varieties even though no significance was recorded across the sampled periods. However, variety two (Marabel) did better compared to variety one (Connect). This confirms the genetic traits and adaptability of the variety to the environment or study area. The effect of planting spacing on the stem girth showed that 30cm× 25cm performed better compared to other spacing. Mangami, *et al*., (2015) asserts that low planting spacing encouraged more leaves which in turn will leads to increase in the use of resource for growth in potato.

The results of yield parameters of this study show that tuber length, tuber diameter, tuber number/plant/plot and tuber yield where greatly influenced by variety and planting spacing. Variety two (Marabel) performed better compared to variety one (Connect) on all the parameters, again, this better performance of variety two (Marabel) stems out from it genetic traits and its adaptability to the environment. More so, there were no significant differences in all the intra-row spacing for the yield parameters in this study this results are in agreement with Lamesa and Zewdu, (2016), who found that the average number of tubers were not significantly affected by effects of planting spacing.

Conclusion: The result obtained at the end of the experiment revealed that no significant difference was recorded with the treatments on establishment count, plant height, tuber length and tuber diameter. However, significant differences were recorded on leaf area, number of tubers/plants and tuber weight. Variety two (30cm×25cm) performed better compared to variety one (Connect) and 30cm×30cm, 30cm×40cm, 30cm×50cm respectively.

Declaration of Conflict of Interest: The authors declare no conflict of interest.

Data Availability Statement: Data is available upon request from the first author or corresponding author or any of the other authors

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