DOI:10.21276/ijlssr.2018.4.3.4

Research Article

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Yield of Potato (*Solanum tuberosum* L.) as Influenced by Variety and Planting Date in the Sudan Savanna Ecological Zone of Nigeria

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ABSTRACT

Potato is a temperate crop requiring low temperatures for growth and yield. Production of potato in the Sudan savanna agro-ecological zone of Nigeria is restricted to periods of low temperatures that prevailed from early November to late February. The general approach for potato in this region is to relate the planting date to coincide with the period of relatively low temperatures, as high temperature inhibits growth and yield. It is in view of the above that field experiments were conducted in two locations at the Teaching and Research Farm of the Kebbi State University of Science and Technology, Aliero, during 2016/2017 dry season. The aim was to determine the most suitable potato variety and most appropriate planting date in the study area. Treatments consisted of factorial combinations of four Planting dates (1st November, 15th November 1st December and 15th December 2016) and four potato varieties (Bertita, Diamant, Lady-christl and Nicola). The experiments were laid out in a Randomized Complete Block Design with three replications. Results revealed that number of tubers per plant, weight of tubers per plant, mean tuber weight, mean tuber diameter and fresh tuber yield were higher when planted on 1st to 15th November. Bertita proved to be the most robust in terms of growth; and with Nicola, in terms of yield compared to the other varieties. Based on the results of this study, it could be concluded that planting of potato from 1st November to 15th November coupled with either Bertita or Nicola gives the highest potato yield in the study area.

Key-words: *Solanum tuberosum,* Savanna Ecological Zone, Tuberization, High altitude regions

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a temperate crop belonging to *Solanaceae* family. Potato is the fourth most important food crop in the world [1]. It is believed to have originated from high plains of Andes Cordillera, where the Incas cultivated the crop largely for food. In tropical Africa, countries like Malawi, Rwanda, Kenya, Ethiopia, Cameroon, and Nigeria are among the main potato producing areas, where potato is produced on commercial scale, particularly on high altitude regions where temperatures and humidity are relatively low and suitable for potato growth, development and yield [2].

How to cite this article

Muhammad A, Mohammed IU, Yusuf H, Kwaifa NM, Tanimu MU. Yield of Potato (*Solanum tuberosum* L.) as Influenced by Variety and Planting Date in the Sudan Savanna Ecological Zone of Nigeria. Int. J. Life Sci. Scienti. Res., 2018; 4(3): 1759-1765

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Potato introduction and cultivation in Nigeria began in the early 1920s by Europeans involved in tin mining on the Jos plateau [3].

In Nigeria, the area under potato cultivation during 2014 stands at 142, 680 hectares of land with an average production of 1,184,865 metric tonnes. Farmers yield was about 8.3 t ha^{-1} in Nigeria [3,4]. Over 85% of potato produced in Nigeria comes from Jos plateau. Other important potato areas include Biu and Mambila plateaus [5].

Potato is a highly cherished crop usually considered as a food for the rich in the lowland Northern Nigeria like Kebbi, Sokoto, Zamfara and the likes. However, its production is restricted to areas on high altitudes like Jos, Mambila and Biu plateaus; due to the relatively low night temperatures that prevail in these regions throughout the year which resulted to high cost of potato in north-western states. [3] Reported a huge potential for potato production in lowland Northern Nigeria but cautioned that its production can only be

possible during cold dry season (Harmattan periods) that prevails from November to February in the Sahel and Sudan savanna regions of Nigeria. During this period, the temperatures are relatively low and conducive for economic production of the crop under irrigation [2].

Considering the variability of temperature and short (4 months) duration of the cold season, it is pertinent to relate planting date to coincide with the period of relatively low temperatures, as these high temperatures inhibit tuberization [6]. The overall performance of potato varieties is influenced through the size of its foliage, time of tuber initiation; and length of time the foliage remained alive and photosynthesizes thereafter; its inherent ability to partitions assimilates to tubers, maturity period and response to environmental conditions [5]. No single variety possesses all the desirable production and post-harvest qualities. It is therefore assumed that growth; yield and quality of a particular potato variety are genetically controlled, but can be influenced by external factors such as fertilizer, irrigation, temperature, radiation, day length, planting date, pests and diseases [7]. Therefore, the choice of adapted and high yielding potato variety is vital for successful production. In order to have effective and efficient introduction programme for potato in the study area, a scientific research that evaluates some promising irrigated potato varieties for responses to different planting dates is necessary.

MATERIALS AND METHODS

Study area- The experiments were conducted at the University Teaching and Research Farm during 2016/2017 dry season. The two locations; Fadama Teaching and Research farm are located at Jega (lat. 12°12.99' N; long. 4° 21.90'; 197 m above sea level) and the University orchard at Aliero (lat. 12°18.64'N; long. 4°29.85'; 262 above sea level). Both Jega and Aliero are located in Sudan Savanna ecological zone of Nigeria. The areas possess long dry season that is characterized by cool dry air (harmattan), which prevails from November to February and hot dry air extending from March to May. The locations are mainly used for cultivation of vegetable and cereal crops.

Minimum and maximum temperature ranges were 18–29°C and 30–42°C, respectively. Minimum and maximum solar radiation ranges were 3.72 wm^{-2} to 4.56 wm^{-2} and 844.17 wm^{-2} to 976.840 wm^{-2} respectively. The relative humidity ranged from 26% to 39% and wind speed ranged from 1.9 to 5 ms^{-1}.

Treatments and experimental design- Treatments consist of factorial combination of four potato varieties (Bertita, Diamant, Lady-christl and Nicola) and four planting dates (D_1, D_2, D_3 and D_4) corresponding to 1st November, 15th November, 1st December and 15th December, respectively. The treatments were laid out in a Randomized Complete Block Design with three replications.

Cultural practices- Seed tubers for the four (4) potato varieties were sourced from Potato Research Program of the National Root Crops Research Institute (NRCRI), Vom sub-station, Jos, Plateau State. The seed tubers were pre-sprouted for 3–6 weeks before planting. The seed tubers were dressed with fungicide (Mancozeb powder at 2.0 a.i. kg ha^{-l}) a day prior to planting. Planting was done according to treatments. Whole or cut tubers of approximately 20 g were planted per hill at inter and intra-row spacing of 75 and 30 cm, respectively. Plots of 3.0 × 4.5 m (13.5 m^2) were marked out in each block, leaving 1.5 m space between blocks. Each plot was made into six ridges to be spaced 75cm apart. Water channels were constructed for the effective supply of water to each furrow during irrigation. The net plot areas consist of the two middle rows 1.5×3.0 m (4.5 m^2).

The source of water was a tube-well. Water pump machine was used to draw water from the source (tube well) to the experimental field through the constructed water channels. Irrigation was scheduled at 3-6 days interval depending on the crop's need.

A recommended dose of 600 kg NPK (20: 10: 10) ha^{-1} was applied in two equal split doses; at planting and at 4 Weeks after Planting (WAP), respectively. The fertilizer was applied 10 cm away from a plant stand at a depth 5cm and covered. Weeds were controlled manually using hoe as at 3, 7 and 10 WAP. Insects were controlled using Karate (Cypermethrim) sprayed at 4 ml L^{-1} of water. The crop was harvested by digging with hoe following a light irrigation a day to harvest in order to facilitate easy lifting of tubers.

DOI:10.21276/ijlssr.2018.4.3.4

Data collection and analysis- The data collected were subjected to analysis of variance using general linear model (GLM) of the Statistical Analysis System [8]. The treatment means were separated using Duncan's Multiple Range Test [9]. Correlation coefficient analysis was conducted to determine the relationships between yield, growth and yield parameters.

RESULTS

Number of Tubers per plant- Planting on 1st and 15th November gave the higher values for number of tubers per plant than on 1st and 15th December. The same trend was observed in results from Jega and the combined means. However, in Aliero, Bertita, Diamant, and Nicola produced significantly number of tubers per plant than Lady-christl. At Jega, higher number of tubers per plant was observed on Bertita and Nicola than Diamant and Lady-christl. In the combined mean, Bertita, Diamant and Nicola produced higher number of tubers per plant than lady-christl (Table 1).

Table 1: Number of Tubers per plant, tuber weight per plant, mean tuber weight and fresh tuber yield of potato as influenced by variety and planting dates in Aliero, Jega and the Combined Locations during 2016/2017 dry season

Planting Date (Treatments)	Tuber number Plant^{-1}			Tuber weight per plant (kg)			Mean Tuber Weight (g)			Fresh Tuber Yield (t ha^{-1})		
	ALR	JEG	COMB	ALR	JEG	COMB	ALR	JEG	COMB	ALR	JEG	COMB
1st November	8.09^{a}	7.51^{a}	7.80^{a}	0.42^{a}	0.34^{a}	0.38^{a}	51.72^{a}	45.63^{a}	48.67^{a}	23.33^{a}	18.88^{a}	21.11^{a}
15th November	7.81^{a}	7.28^{a}	7.54^{a}	0.39^{a}	0.32^{a}	0.35^{a}	50.58^{a}	44.52^{a}	47.55^{a}	21.66^{a}	17.77^{a}	19.44^{a}
1st December	6.46^{b}	5.64^{b}	6.05^{b}	0.26^{b}	0.21^{b}	0.23^{b}	41.27^{b}	37.64^{ab}	39.44^{b}	14.44^{b}	11.66^{b}	12.77^{b}
15th December	6.21^{b}	6.36^{b}	6.28^{b}	0.21^{b}	0.19^{b}	0.20^{b}	34.01^{b}	30.42^{b}	32.21^{c}	11.66^{b}	10.55^{b}	11.11^{b}
SE±	0.480	0.333	0.291	0.042	0.045	0.026	3.641	3.444	4.212	1.414	1.343	1.089
Bertita	8.95^{a}	8.13^{a}	8.54^{a}	0.47^{a}	0.39^{a}	0.44^{a}	52.90^{a}	48.83^{a}	51.86^{a}	26.10^{a}	21.66^{a}	24.44^{a}
Diamant	7.89^{a}	6.49^{b}	7.33^{a}	0.27^{b}	0.30^{b}	0.28^{b}	36.59^{b}	25.42^{b}	31.00^{c}	14.99^{b}	16.66^{b}	15.55^{b}
Lady-christl	5.30^{b}	6.34^{b}	5.81^{b}	0.28^{b}	0.16^{c}	0.22^{c}	28.17^{c}	23.33^{c}	25.75^{c}	15.55^{b}	8.88^{c}	12.22^{c}
Nicola	9.03^{a}	8.88^{a}	8.95^{a}	0.46^{a}	0.42^{a}	0.44^{a}	51.93^{a}	47.61^{a}	49.77^{a}	25.55^{a}	23.33^{a}	24.44^{a}
SE±	0.480	0.333	0.291	0.042	0.045	0.026	3.641	3.444	4.212	1.414	1.343	1.089
Interaction												
Pld x Var	NS	NS	**	NS	NS	**	NS	NS	**	**	**	**

Means followed by the same later (s) in a treatment group are not significantly different at 5% level using DMRT

There was significant interaction between planting date and variety in the combined means (Table 2). The table shows that planting on 15th and 1st December resulted in lower number of tubers per plant across all the varieties.

On the other hand, planting on 1st and 15th November produced a significantly higher number of tubers per plant in Bertita and Nicola than Diamant and Lady-christl.

Table 2: Interaction of Variety and Planting date on Number of Tuber per plant for combined locations during 2016/2017 dry season

Planting date	Variety			
	Bertita	**Diamant**	**Lady-christl**	**Nicola**
1st November	9.04[a]	5.95[bc]	5.55[c]	8.65[a]
15th November	8.45[a]	6.16[bc]	5.88[bc]	7.06[b]
1st December	6.43[bc]	3.57[d]	3.34[d]	5.56[c]
15th December	6.06[bc]	3.33[d]	3.90[d]	3.72[d]
SE±		0.58		

Means followed by the same later (s) are not significantly different at 5% level using DMRT

Weight of Tubers per plant (kg)- Planting on 1st and 15th November resulted to significantly heavier tubers per plant than the other planting dates in both locations and the combined means. At Aliero, Bertita and Nicola gave significantly heavier tubers per plant than Diamant and Lady-christl; while at Jega and the combined mean, Bertita and Nicola gave significantly heavier tubers per plant than Diamant and the least was by Lady-christl (Table 1). There was significant interaction between planting date and variety in the combined mean (Table 3). Varying planting dates 1st November, 15th November, 1st December and 15th December in conjunction with Bertita variety produced heavier tubers per plant. While planting on 1st and 15th December resulted in the least tuber weight per plant across all the varieties tested.

Table 3: Interaction of Variety and Planting date on Tuber weight per plant for combined locations during 2016/2017 dry season

Planting date	Variety			
	Bertita	**Diamant**	**Lady-christl**	**Nicola**
1st November	0.40[a]	0.18[cd]	0.14[cd]	0.32[ab]
15th November	0.32[ab]	0.18[cd]	0.12[d]	0.2[4c]
1st December	0.22[c]	0.10[d]	0.14[cd]	0.2[4c]
15th December	0.18[cd]	0.10[d]	0.10[d]	0.14[cd]
SE±		0.02		

Means followed by the same later (s) are not significantly different at 5% level using DMRT

Mean tuber weight- Mean tuber weight was significantly affected by planting date in both locations and the combined mean. Planting on 1st and 15th November produced significantly heavier tubers than planting on 1st and 15th December. However, varietal effect was also significant in both locations and the combined mean. In both locations, heavier tubers were recorded in Bertita and Nicola, followed by Diamant and the least was by Lady-christl. In the combined mean, the same trend was observed except that Diamant and Lady christl were at par (Table 1). The interaction between the treatment factors was significant in the combined mean (Table 4). Planting on 1st and 15th November resulted in higher mean tuber weights by Bertita and Nicola. While 15th and 1st December resulted to lower mean tuber weights by Diamant and Lady-christl.

Table 4: Interaction of Variety and Planting date on Mean Tuber Weight for combined locations during 2016/2017 dry season

Planting date	Variety			
	Bertita	**Diamant**	**Lady-christl**	**Nicola**
1st November	103.16[a]	52.50[bc]	44.17[d]	78.67[b]
15th November	72.95[b]	29.17[d]	27.92[de]	66.67[bc]
1st December	41.67[d]	19.85[e]	20.00[e]	23.33[e]
15th December	57.25[bc]	22.50[e]	23.75[e]	20.00[e]
SE±		8.42		

Means followed by the same later (s) are not significantly different at 5% level using DMRT

Fresh tuber yield- Planting on 1st November and 15th November recorded significantly higher fresh potato tuber yield than planting on 1st December and 15th December in both locations and the combined mean. Bertita and Nicola had significantly higher fresh potato tuber yield than Diamant and Lady-christl in Aliero trial. But in Jega and the combined means, Diamant was superior to Lady-christl (Table 1). There was a significant interaction of planting date and variety on fresh tuber yield of potato in both locations and the combined means (Table 5).

In Aliero, planting on 1st and 15th November resulted in higher fresh tuber yield with Bertita and Nicola; and 1st December with lady- christl. Planting on 15th December gave the lowest yield with all the varieties. In Jega, planting on 1st and 15th November resulted in higher fresh tuber yield with Bertita and Nicola. Planting on 1st December gave the higher yield with Bertita, Diamant and lady-christl. Planting on 15th December gave higher yield with Bertita than only Nicola. In the combined mean, higher yield was obtained by planting on 1st and 15th November with Bertita and Nicola.

Table 5: Interaction of Variety and Planting date on fresh tuber yield during 2016/2017 dry season

Planting date	Variety			
	Bertita	**Diamant**	**Lady-christl**	**Nicola**
		Aliero		
1st November	24.67[a]	12.05[bcd]	17.61[b]	24.70[a]
15th November	24.23[a]	10.07[d]	12.05[bcd]	21.19[a]
1st December	17.19[b]	12.25[bcd]	15.04[a]	10.58[d]
15th December	10.72[d]	9.55[d]	10.10[d]	7.08[d]
SE±		2.82		
		Jega		
1st November	22.77[a]	13.57[bc]	17.30[ab]	20.54[a]
15th November	21.28[a]	15.88[b]	15.71[b]	20.97[a]

1st December	12.77^{bc}	14.94^{b}	12.06^{bc}	10.02^{cd}
15th December	12.23^{bc}	9.58^{cd}	10.10^{cd}	6.56^{d}
SE±			2.09	
		Combined		
1st November	23.72^{a}	12.81^{de}	17.45^{bc}	22.62^{a}
15th November	22.75^{ab}	12.975^{de}	13.88^{de}	21.08^{ab}
1st December	14.98^{de}	13.59^{de}	13.55^{de}	10.3^{ef}
15th December	11.475^{e}	9.565^{ef}	10.10^{ef}	6.82^{ef}
SE±			2.17	

Means followed by the same later (s) are not significantly different at 5% level using DMRT

DISCUSSION- The greater performance of Bertita, Nicola and Diamant in terms of number of tubers per plant; and the former two, in terms of weight per tuber and per stand as well as the overall fresh tuber yield could be linked to genetic make-up of the varieties [10]. Attributed potato tuber yield and related components to inherent genetic make-up of the varieties. Such genetically controlled variations among potato varieties were reported [3,11,12].

Temperature is the major limiting factor on potato production in the study area, as cool night temperatures (11–20°C) are required for tuber development and growth [13]. The number of tubers per plant, weight of tubers per stand, means tuber weight and tuber yield were positively increased with 1st and 15th November planting. These positive responses could be linked to lower temperatures that prevailed during critical potato developmental stages like tuber initiation and bulking (6–12 weeks after planting) which determined the overall tuber yield. The coolest periods of the season occurred from 15th to 31st January which corresponds to 1st to 15th November planting dates. At that period (15th to 31st January), the crop was 8–12 weeks, giving it the conductive low temperatures which might have led to higher production of assimilate and their subsequent translocation and partitioning to tubers. Similar findings were reported by [3,10,14-16]. Most of the yield components were generally optimized with 1st–15th November planting dates in conjunction with Bertita and Nicola.

These significant interactions with respect to number of tubers per plant, tuber weight per plant, mean tuber weight and fresh tuber yield could be due to the effect of low temperatures that prevailed during the critical potato growth stages (January) resulting from 1st to 15th November planting, coupled with the inherent yield potential of Bertita and Nicola. Similar results were reported by [17].

CONCLUSIONS

Based on the results of this study, it could be concluded that planting of potato from 1st to 15th November coupled with either Bertita or Nicola gives the highest potato yield in the study area. Therefore, for maximum potato production in the study area, farmers should arrange to plant from 1st to 15th November, a delay in planting after 15th November could reduce yield by up to 34–47%. More so, Bertita and Nicola are the potato varieties that give high yield and therefore recommended to farmers in the study area. Ensuring sustainable potato production in the Northwestern region of Nigeria where the crop is highly cherished but can only be produced in the dry season during harmattan through irrigation when the temperatures are low (November to February).

ACKNOWLEDGMENTS

The authors are highly grateful to the Kebbi State University of Science and Technology for availing the laboratory and University Teaching and Research Farm. Authors are very grateful to the effort made by Waziri

Umaru Federal Polytechnic, Birnin Kebbi who provided support and courage in addition to research grant for this project.

CONTRIBUTION OF AUTHORS

MA and HY designed and conducted the experiment; together with IUM wrote and edited the manuscript while UMT and NMK collected and analyzed the data.

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Received: 18 Feb 2018/ Revised: 23 Mar 2018/ Accepted: 24 Apr 2018