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Yield variability of Irish potato (*Solanum tuberosum* L.) as affected by cultivars and sowing date in the Sudan Savanna Zone of Nigeria

Wailare A. M. and Madu A. I.*

Department of Crop Production, Faculty of Agriculture Food Science and Technology, Kano University of Science and Technology, Wudil, Nigeria.

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Field experiments were conducted in the Sudan Savannah Zone of Nigeria during the 2015/2016 dry season. The Research Farm of Audu Bako Collage of Agriculture, Danbatta (12° 44′ N and 8° 51′ E) and Federal College of Education Technical, Bichi (12°24′N and 8.24′E) represented the two locations. Subjects of interest were to determine the effect of variety and sowing date on yield of Irish potato. Treatment combinations were five certified varieties (Nicola YL, Nicola GL, Bertita, Ditta and Marabel) and four levels of sowing date (early November, middle of November, end of November and middle December), respectively. In three replications, treatments were laid down in a split plot design with varieties in main plots and sowing dates in sub- plots. All cultural practices for dry season production of Irish potato and determination in physico-chemical properties of soil samples were observed. Data collected on yield components were analyzed using a trial version (statistix-version 10). Statistically the results obtained from measured yield and yield parameters were taken from sampled plants. The parameters include: number of tubers per plant, tuber weight per plant (kg), tuber yield in kg/ha, unmarketable tuber yield in kg/ha and unmarketable tuber yield per plant (%). The results based on a comparison between five varieties of Irish potato and four levels of sowing dates show that variety and sowing date have statistically significant effects. Variety Nicola GL and Nicola YL, when sown in the middle of November, were higher in yield.

Key words: Sudan savannah, Irish potato varieties, sowing dates and yield.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is an annual, herbaceous, tuber crop of the Solanaceae family that contains all the essential food ingredients required for maintaining proper health (FAO, 1986). The potato plant produces swollen underground tubers when mature. Potato has its region of origin in the high plains of the Andes Cordillera where the Incas cultivated the plant largely for food. In Africa, it was not cultivated until the end of the 19th century that potato was imported from Europe by missionaries and thereafter by colonial

*Corresponding author. E-mail: ibrahhimah@gmail.com. Tel: 08032875000.

administrations (Raemaekers, 2001). Irish potato was introduced into Nigeria early in the 20th Century by European miners in Jos Plateau (Obighesan, 1976). In Nigeria, the area under potato cultivation during 2014 stands at 142, 680 ha of land with an average production of 1,184, 865 metric tons (Muhammad et al., 2018; Ugonna et al., 2013). Over 85% of potato produced in Nigeria comes from Jos plateau (Muhammad et al., 2015). Jos Plateau has a high altitude and thus a cool climate, which is favorable for the development of the crop in the area (Obighesan, 1976). Being a hardy plant, potato is cultivated the world over under different growing conditions. However, best results in tropical areas are obtained in regions where the climate is tempered by altitude (1,800-2,300 m) or, alternatively, at a low altitude; provided the crop is grown during the coolest season (the dry season). Potato prefers a light, moist and well-drained soil. It can tolerate slightly acid soil (pH of 5.5-6.0) (Raemaekers, 2001). The crop is efficient in converting land, labour, water and capital into a highly nutritious food. This is not surprising if for no other reason than it has a shorter growing cycle of about 95 days than most other tuber crops in the tropics (Wuyep et al., 2013).

Thirty percent of world's potato production is from developing countries and it is expanding more rapidly than most of the other food crops. It is also becoming an important source of rural employment and income for growing population (Horton, 1987).

Tubers are good, easy and cheap to process in making many forms of food; when boiled, roasted, cooked, frayed or mixed with other food items to provide nutritional value that ranked it as the world's healthiest food (FOA, 2008). Potato is the world's fourth-largest food crop, following maize, wheat and rice (FAO, 2008). It is the world's leading vegetable crop and is grown in 79% of the world's countries (Muhammad et al., 2013). The average composition of the potato is about 80% water, 2% protein, and 18% starch. As a food, it is one of the cheapest and easily available sources of carbohydrates and proteins; and contains appreciable amount of vitamins B and C as well as some minerals. Hundreds of millions of people in developing countries depend on potatoes for their survival (FAO, 2008). Higher and rapid population growth of country like Nigeria will require the production of crop like potato. The potato crop has special significance to the developing countries as it has high production potential per unit area and time, and has high nutritional value to sustain burgeoning populations and to overcome malnutrition and hunger (Pandey, 2002).

Apart from more conventional aspects of using Irish potato as foodstuff, industrial processing such as potato starch, glucose, dextrose, biscuit, confectionaries and drinks are becoming increasingly prominent in Nigeria. These have considerably widened the range of possible uses and are enough to necessitate an increase production. Introduction and production of the crop in the study area will serve as an addition. The National Root Crops Research Institute, Vom, the plant breeders, universities and colleges are from their own part continually responding in an attempt to increase production. But unfortunately, due to some reasons (climatic variables) most of the efforts or responses were largely confined in the northern guinea savannah of Nigeria. Less attention was given to the study area, despite the fact that extending its production to the study area will contribute to addressing national needs. Several factors do affect the yield attributes of potato of which selection of appropriate varieties and sowing date being among the most important ones. This will first require preliminary information on better adoption of appropriate varieties, and using the optimum time of sowing. Within this view and increasing need, this research was designed and conducted to provide preliminary information on important aspects of potato cultivation. This includes appropriate time of planting and evidence for a superior variety of potato for yield attributes in the current study area through evaluating the effect of variety and sowing date on yield of the Irish potato.

MATERIALS AND METHODS

Field experiments were conducted in Sudan savanna ecology of Nigeria. Dry season research (2015) was undertaken with two locations, namely the Research Farms of Audu Bako College of Agriculture Danbatta (12° 44′ N and 8° 51′ E) and Federal College of Education Bichi (12° 24′ N and 8. 24′ E) Kano State; with elevations of 418 and 535 m above sea level, respectively. Treatments consisted of five varieties of Irish potatoes (namely: Nicola YL, Nicola GL, Bertita, Ditta and Marabel) with four levels of sowing dates (early November, middle November, end of November and middle December) for each of the locations. They were laid down in a split plot design in three replications with variety in main plots and sowing date in sub plots. Before sowing, each of the experimental sites was cleared, harrowed, demarcated and prepared in ridges of total plot size of 150 m^2. It was further divided into three replications with an alley of 2 m between them. Replications were transformed into main plots of 10 m × 1 m with an alley of 1 m between them. Main plots were further divided into sub plots of 1 m × 2.5 m containing six rows of 3-m length. Varieties are certified and improved for dry season production with useful traits. Seed tubers of uniform size were treated with soil-borne disease-preventing chemical and sown at a depth of 5 cm and 20 cm between stands. First farrow watering was on sowing and at weekly intervals, and was stopped 2 weeks before harvesting; weed and pest control were followed. Data were collected at harvest on yield attributes (number of tubers per plant tuber weight per plant (kg), tuber yield kg/ha. Unmarketable tubers are below standard size, diseased and or pest damaged; their percentage per plot and number in kg/ha) were subjected to analysis of variance (ANOVA) as described by Snedecor and Cochran (1976) using a trial version (statistix-version 10). Significant means of treatments were separated using LSD All-Pairwise Comparisons Test.

RESULTS

Table 1 shows the detail of the Physico-chemical properties of soils of the experimental sites.

Table 1. Physico-chemical properties of soils at the experimental site (2015).

Location	Danbatta		Bichi	
Sample Collection, Depth in cm	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**
Physical composition (%)				
Clay	5	5	7	9
Silt	10	10	8	10
Sand	85	85	85	81
Textural class	Loamy sand	Loamy sand	Loamy sand	Loamy sand
Chemical composition				
pH in H20 (1:2.5)	6.33	7.00	5.9	5.9
pH in CaCl2 (0.01 M)	5.16	4.01	4.83	4.10
Organic carbon (g kg^{-l})	0.47	0.18	0.56	0.18
Total Nitrogen (g 0.5 kg^{-l})	0.04	0.28	0.07	0.11
Available P (mg kg^{-1})	21.95	25.81	23.78	27.64
Exchangeable bases (cmol (+) kg^{-l})				
Ca	1.83	1.67	3.17	2.33
Mg	1.25	1.25	1.17	1.08
K	0.20	0.18	0.22	0.20
Na	0.12	0.12	0.09	0.12
CEC (cmol kg^{-l})	4.57	3.88	5.14	9.23

Source: Department of Soil Science, Faculty of Agriculture Bayero University, Kano.

Meteorological records of each experimental site are presented in Appendix I. The results of the soil analysis of the experimental sites indicated that the soils were loamy sand in texture with sand having a higher proportion of 81- 85%. With respect to soil located in Danbatta, the soil was slightly acidic to neutral with pH range of 6.3-7.0; while that of Bichi site was slightly acidic at both 0-15 and 15-30 cm depths, with the pH of 5.9. Chemically, the two soils shared similar composition in that they have very low levels of organic carbon (0.18-0.56 g kg^{-l}), low CEC (3.88-9.23 cmol kg^{-1}), low sodium (0.09-0.12) and magnesium (1.08-1.25), and very low to high levels of total nitrogen (0.04-0.07g 0.5 kg^{-1}, 0.11-0.28 g kg^{-1}) at 0-15 cm and 15-30 cm, respectively.

However, the results of the soil analyses also showed that the trial sites have moderate potassium (0.18-0.22 cmol (+) kg^{-1}), high available phosphorus (21.95-27.64 cmol (+) kg^{-1}), but differ in calcium composition with Danbatta site having low calcium (1.83-1.67 cmol (+) kg^{-1}) and higher in Bichi site. Climatic variables (Appendix Table1) indicated that total rainfall received during the experimental period is zero with mean maximum and minimum temperature of 31.83 and14.51°C, and range in relative humidity of 52.45and13.45. The average maximum and minimum temperature for each month in the period of trial from November to March during the 2015 dry season are: November 33.46 and 14.01°C, December 25.95 and 11.95°C, January 28.39 and 11.31°C, February 35.38 and 14.15°C, March 35.95 and 21.11°C. Likewise, the ranges in relative humidity for this time period are: November 75.52 and 16.87, December 54.07 and 19.39, January 47.01 and 12.98, February 48.67 and 8.03, March 36.99 and 9.96.

The effects of variety and sowing date on number of tubers per plant at Danbatta, Bichi and combined during the 2015 dry season is shown in Table 2. From Danbatta site, the number of tubers per plant produced was significantly (P≤ 0.05) affected by variety. Nicola GL followed by Ditta produced higher and similar number of tubers per plant. This was followed by Nicola YL, Marabel and Bertita in an ascending order. Number of tubers per plant produced was not significantly affected by sowing date. Higher number of tubers per plant produced was on sowing date of middle of December, early November, middle November and lowest from end of November. Interaction between variety and sowing date shows insignificant effect on number of tubers per plant produced.

Number of tubers per plant at Bichi was highly significantly (P≤ 0.01) affected by variety. Nicola YL followed Nicola GL and higher in number of tubers per plant produced. They were followed by Marabel, Ditta and Bertita, respectively. At highly significant level, sowing date affected the number of tubers produced per plant. Higher number of tubers per plant was produced at different sowing dates; middle of November was the highest, early November followed, end of November and middle of November was the lowest. Interaction between variety and sowing date shows insignificant effect on number of tubers produced per plant.

Table 2. Effect of variety and sowing date on number of tubers per plant of Irish potato (*Solanum tuberosum* L.) at Danbatta, Bichi and combined during the 2015 dry season.

Treatment	Location		
variety	Danbatta	Bichi	Combined
Nicola YL	2.18[ab]	2.30[a]	2.24[ab]
Bertita	1.15[c]	0.84[b]	1.05[d]
Marabel	1.48[bc]	1.62[ab]	1.55[cd]
Ditta	2.29[a]	1.12[b]	1.70[bc]
Nicola GL	2.43[a]	2.39[a]	2.41[a]
SED+	0.32	0.37	0.39
Significance	*	**	**
Sowing date			
Early November	1.88[a]	1.84[ab]	1.86
Middle of November	1.83	2.38[a]	2.18
End of November	1.51	1.38b[c]	1.45
Middle of December	2.15	1.01[c]	1.68
SED+	0.33	0.33	0.26
Significance	NS	**	NS
Interaction			
V×SD	NS	NS	NS

Means along the same column with unlike letter(s) are different at P≤ 0.05 using LSD All-Pairwise Comparison Tests. NS= not significant, *= significant at P≤ 0.05, **= significant at P≤ 0.01, V= variety, SD= sowing date and SED=standard error of difference.

At combined effects, numbers of tubers produced per plant were highly significantly (P≤ 0.01) affected by variety. Nicola YL and Nicola GL produced higher number of tubers per plant (kg). They were followed by Ditta, Marabel and Bertita, which respectively produced almost similar number of tubers per plant. Sowing date shows insignificant effect on number of tubers per plant produced. Potato sown at middle of November produced higher number of tubers per plant. Other sowing dates produced similar number of tubers per plant. Interaction between variety and sowing date shows insignificant effect on number of tubers produced per plant.

Table 3 shows the effect of variety and sowing date on tuber weight per plant (kg) at Danbatta, Bichi and combined during the 2015 dry season. From the Danbatta location, tuber weight per plant was significantly (P≤ 0.05) affected by variety. Nicola YL followed by Nicola GL measured higher tuber weight per plant (kg). They were followed by Ditta, Marabel and Bertita, which were similar in tuber weight per plant (kg). Tuber weight per plant was significantly (P≤ 0.05) affected by sowing date. The effect of sowing at the middle of November outnumbered other sowing dates in tuber weight per plant (kg). This was followed early November, middle of December and lowest from end of November.

At Bichi site, the effect of variety on tuber weight per plant (kg) was not significant. Nicola GL followed by variety Nicola YL yielded higher tuber weight per plant (kg). They were followed by Marabel, Bertita and Ditta which were almost similar in tuber weight per plant (kg). Effect of sowing date was highly significant (P≤ 0.01), with effect of middle of November at a higher level than other sowing dates in tuber weight per plant (kg). This was followed by early November, middle of December and end of November in a respective manner. Interaction between variety and sowing date at Bichi location was insignificant. At combined level, Nicola GL was higher in tuber weight per plant (kg), followed by variety Nicola YL. Respectively, Marabel, Bertita and Ditta followed Nicola GL in tuber weight produced per plant. Sowing date of middle of November outnumbered other sowing dates in tuber weight per plant. This was followed by early November, middle of December and end of November respectively. Interaction between variety and sowing date at Bichi location was insignificant.

Interaction between variety and sowing date on tuber weight per plant (kg) at 4WAS from Danbatta is shown in Table 4. Interaction between variety and sowing date was significant (P≤ 0.05). Nicola YL sown at the middle of November produced higher tuber weight per plant (kg); while the lowest weight was from Marabel sown at the middle of December.

Table 5 shows the effect of variety and sowing date on tuber yield in kg/ha at Danbatta, Bichi and combined during the 2015 dry season. Statistically from Danbatta location, the effect of variety was significant (P≤ 0.05). Nicola GL and Nicola YL produced similar tuber yield.

Table 3. Effect of variety and sowing date on tuber weight per plant (kg) of Irish potato (*Solanum tuberosum* L.) at Danbatta, Bichi and combined during the 2015 dry season.

Treatment variety	Location		
	Danbatta	Bichi	Combined
Nicola GL	0.07[b]	0.41	0.25
Bertita	0.05[b]	0.30	0.18
Marabel	0.05[b]	0.31	0.17
Ditta	0.07[b]	0.28	0.15
Nicola YL	0.09[a]	0.35	0.22
SED+	0.07	0.65	0.27
Significance	*	NS	NS
Sowing date			
Early November	0.12[ab]	0.57[ab]	0.63
Middle of November	0.19[a]	1.08[a]	0.35
End of November	0.05[b]	0.19[b]	0.26
Middle of December	0.07[b]	0.45[b]	0.13
SED+	0.05	0.29	0.21
Significance	*	**	NS
Interaction			
V×SD	*	NS	NS

Means along the same column with unlike letter(s) are different at P≤ 0.05 using LSD All-Pairwise Comparison Tests. NS= not significant, *= significant at P≤

Table 4. Interaction between variety and sowing date in tuber weight (kg) per plant of Irish potato (*Solanum tuberosum* L.) at Danbatta.

Sowing date	Variety				
	Nicola GL	Bertita	Marabel	Ditta	Nicola YL
Early November	0.07[c]	0.06[c]	0.08[c]	0.05[c]	0.36[b]
Middle of November	0.12[bc]	0.04[c]	0.06[c]	0.08[c]	0.67[a]
End of November	0.06[c]	0.04[c]	0.04[c]	0.05[c]	0.08[c]
Middle of December	0.05[c]	0.05[c]	0.03[c]	0.09[c]	0.09[c]
SED+			0.05		

Means along the same column with unlike letter(s) are different at P≤ 0.05 using LSD All-Pairwise Comparisons Test. SED=standard error of difference.

Bertita and Ditta which followed produced similar tuber yield and lower yield was from Marabel. Similarly, effects of sowing date on tuber yield in kg/ha were insignificant (P≤ 0.05). Sowing date of middle of December was higher in tuber yield in kg/ha, it was followed by middle of November, early November and end of November respectively. Interactively no significant effects between variety and sowing date on tuber yield in kg/ha. From Bichi, the site variety shows highly significant (P≤ 0.01) effect on tuber yield in kg/ha. Nicola YL followed by Nicola GL is higher in tuber yields produced. Marabel, Ditta and Bertita, respectively followed. An effect of sowing date in tuber yield was highly significant (P≤ 0.01). Among the sowing dates, middle of November was the highest early, November fallowed. They were followed by End of November and middle December was the lowest in tuber yield in kg/ha. Combined effects show that variety has significant (P≤ 0.05) effect on tuber yield in kg/ha. Nicola YL fallowed by Nicola GL are higher in tuber yield in kg/ha. Ditta, Marabel and Bertita followed and produced almost similar tuber yield in kg/ha. The effects of sowing date on tuber yield were significant (P≤ 0.05). Sowing date at the middle of November gives higher tuber yield in kg/ha, followed by early November, middle of December and end of November, respectively. There were no significant interaction effect between variety and sowing date on tuber yield in kg/ha.

Table 6 shows the interactive effect of variety and

Table 5. Effect of variety and sowing date on tuber yield in kg/ha of Irish potato (*Solanum tuberosum* L.) at Danbatta, Bichi and combined during the 2015 dry season.

Treatment variety	Location		
	Danbatta	Bichi	Combined
Nicola GL	0.57	0.39^{ab}	0.47^{ab}
Bertita	0.44	0.10^{d}	0.27^{c}
Marabel	0.36	0.33^{bc}	0.34^{bc}
Ditta	0.49	0.21^{cd}	0.35^{bc}
Nicola YL	0.58	0.53^{a}	0.55^{a}
SED+	0.13	0.07	0.09
Significance	NS	**	*
Sowing date			
Early November	0.49	0.34^{b}	0.41^{ab}
Middle of November	0.51	0.53^{a}	0.52^{a}
End of November	0.42	0.22^{bc}	0.32^{b}
Middle of December	0.53	0.15^{c}	0.34^{b}
SED+	0.12	0.06	0.0
Significance	NS	**	*
Interaction			
V×SD	NS	*	NS

Means along the same column with unlike letter(s) are different at P≤ 0.05 using LSD All-Pairwise Comparison Tests. NS= not significant, *= significant at P≤ 0.05, **= significant at P≤ 0.01, V=variety, SD=sowing date and SED=standard error of difference.

Table 6. Interaction between variety and sowing date in tuber yield in kg/ha of Irish potato (*Solanum tuberosum* L.) at Bichi.

Sowing date	Variety				
	Nicola GL	Bertita	Marabel	Ditta	Nicola YL
Early November	0.40^{cd}	0.11^{gh}	0.40^{cd}	0.17^{ef}	0.60^{bc}
Middle of November	0.87^{a}	0.21^{ef}	0.67^{ab}	0.33^{de}	0.57^{bc}
End of November	0.17^{ef}	0.08^{hi}	0.10^{gh}	0.30^{de}	0.43^{cd}
Middle of December	0.11^{gh}	0.00^{i}	0.13^{fg}	0.03^{hi}	0.50^{bc}
SED+			0.06		

Means along the same column with unlike letter(s) are different at P≤ 0.05 using LSD All-Pairwise Comparisons Test. SED=standard error of difference.

sowing date on yield in kg/ha. Sowing date of middle of November shows higher tuber yield from Nicola GL at Bichi location. Table 7 shows the effect of variety and sowing date in unmarketable tuber yield in kg/ha at Danbatta, Bichi and combined during the 2015 dry season. From Danbatta location Marabel followed by Nicola YL measured higher unmarketable tuber yield in kg/ha. Bertita Nicola GL and Ditta produced similar unmarketable tuber yield in kg/ha. Sowing date of middle of November was higher on unmarketable tuber yield in kg/ha. This was followed by end of November, early November and middle of December, respectively. From Bichi location, effect of variety on unmarketable tuber yield was significant (P≤ 0.05). Higher unmarketable tuber yield was from Nicola YL. Others were similar in unmarketable tuber yield in kg/ha produced. The effect of sowing date on unmarketable tuber yield in kg/ha was insignificant. Sowing date of middle of November is higher in unmarketable tuber yield in kg/ha; it was followed by early November, middle of December and end of November respectively. There were no significant interaction effects between variety and sowing date on unmarketable tuber yield in kg/ha.

At combined level effect of variety on unmarketable tuber yield in kg/ha was significant (P≤ 0.05). Marabel followed by Nicola YL is higher in unmarketable tuber

Table 7. Effect of variety and sowing date on unmarketable tuber yield in kg/ha of Irish potato (*Solanum tuberosum* L.) at Danbatta, Bichi and combined during the 2015 dry season.

Treatment variety	Location		
	Danbatta	Bichi	Combined
Nicola GL	0.20	0.05[b]	0.12[b]
Bertita	0.25	0.03[b]	0.14[b]
Marabel	0.35	0.23[a]	0.29[a]
Ditta	0.22	0.05[b]	0.14[b]
Nicola YL	0.33	0.07[b]	0.19[a]
SED+	0.10	0.05	0.04
Significance	NS	*	*
Sowing date			
Early November	0.27	0.10	0.18
Middle of November	0.30	0.12	0.19
End of November	0.31	0.07	0.21
Middle of December	0.20	0.06	0.13
SED+	0.04	0.03	0.04
Significance	NS	NS	NS
Interaction			
V×SD	*	NS	NS

Table 8. Interaction between variety and sowing date on unmarketable tuber yield in kg/ha of Irish potato (*Solanum tuberosum* L.) at Danbatta.

Sowing date	Variety				
	Nicola GL	Bertita	Marabel	Ditta	Nicola YL
Early November	0.16[bcd]	0.17[abcd]	0.17[abcd]	0.17[abcd]	0.26[abcd]
Middle of November	0.33[bcd]	0.22[abc]	0.14[cd]	0.12[cd]	0.26[abc]
End of November	0.20[ab]	0.10[cd]	0.12[cd]	0.15[bcd]	0.37[a]
Middle of December	0.12[cd]	0.08[d]	0.07[d]	0.10[cd]	0.28[abc]
SED+			0.04		

Means along the same column with unlike letter(s) are different at P≤ 0.05 using LSD All-Pairwise Comparisons Test. SED=standard error of difference.

yield in kg/ha produced. Others are similar on unmarketable tuber yield in kg/ha. Interaction between variety and sowing date in unmarketable tuber yield in kg/ha at Danbatta is presented in Table 8. Nicola YL shows higher unmarketable tuber yield in kg/ha at sowing date of end of November. This was followed by Nicola GL in middle November. No significant effects of sowing date were observed from remaining varieties.

Table 9 shows the effects of variety and sowing date on unmarketable tuber yield per plant in percentage at Danbatta, Bichi and combined during the 2015 dry season. Nicola GL and Nicola YL show higher percentages. This was followed by Marabel, Ditta and Bertita. Effects of sowing date in unmarketable tuber yield per plant (%) were highly significant (P≤ 0.01). Sowing dates for middle of November, early November end of November and middle of December, respectively, produced unmarketable tuber yield per plant (%).

At Bichi location, effects of variety on unmarketable tuber yield per plant (%) were insignificant. Nicola YL shows higher percentage followed by Nicola GL, Ditta, Marabel and west was from Bertita. Effect of sowing date on unmarketable tuber yield per plant (%) was also insignificant. sowing date of early of November, middle November, end of November and middle of December, respectively produced higher unmarketable tuber yield per plant (%). Statistically no significant interaction was found for the location. The combined effect of variety and sowing date on unmarketable tuber yield per plant (%) was not significant. Nicola YL followed Nicola GL in the number of higher unmarketable yield of tubers per plant (%). The rest are almost similar. Effect of sowing date on unmarketable tuber yield per plant (%) was significant (P≤ 0.05). The sowing dates of middle of November,

Table 9. Effect of variety and sowing date on unmarketable tuber yield (%) per plot of Irish potato (*Solanum tuberosum* L.) at Danbatta, Bichi and combined during the 2015 dry season.

Treatment variety	Location		
	Danbatta	Bichi	Combined
Nicola GL	55.08	33.17	44.13
Bertita	41.08	17.25	29.17
Marabel	50.50	25.75	38.13
Ditta	46.00	29.58	37.79
Nicola YL	54.25	50.00	52.42
SED+	13.70	10.96	5.81
Significance	NS	NS	NS
Sowing date			
Early November	55.07[a]	37.13	46.10[a]
Middle of November	65.47[a]	34.60	50.27[a]
End of November	50.20[a]	29.93	40.07[a]
Middle of December	26.80[b]	22.93	24.87[b]
SED+	8.12	7.62	6.18
Significance	**	NS	*
Interaction			
V×SD	NS	NS	NS

early November, end of November and middle December, respectively produced unmarketable tuber yields per plant (%). Statistically, there is no significant interaction from combined effect.

DISCUSSION

Results from both locations and combined measured yield parameters show that variety and sowing date have an effect on yield attributes of Irish potato. Measured parameters show yields were higher from Nicola GL followed by Nicola YL at Danbatta, Bichi and combined. These two varieties generally performed substantially better than other varieties. This could be due to their better adaptation, including tolerance to harsh weather conditions of the new environment (experimental sites). The differences could also be due to the varying levels of adaptation of the cultivars to local temperature and soil conditions. Moreover, other inherent traits like green leaf for photosynthetic efficiency from Nicola GL and more leaf area for better light interception from Nicola YL may also contribute to their better yield performance in the new environment over other remaining varieties. This is in line with an assertion that: maximum productivity depends primarily on rates of light interception and carbon assimilation by the crop surface (Watson, 1978). The significance effects of the variety could be attributed to genetics and ability of the crop (Irish potato) to utilize available environmental resources such as water, nutrients, temperature, light and agronomic practices. These factors, however, could vary in their effect across different locations as well as among different potato species (Watson, 1978).

Effects of sowing date on yield of Irish potato were observed in the dry season of 2014/2015 from two locations. Measured parameters on yield were higher when a sowing date of middle November was used. This could be attributed to effects of mean maximum 33.46°C and minimum 14.01°C temperatures during the month of November (Appendix Table 1), which favored the crop during earlier stages of crop development. This is in line with assertion made by Nash et al. (2008) that the highest yields are currently produced in areas where the daytime temperature is often over 38°C during the hottest part of growing season and nights are cool 18°C. Wurr et al. (1990) also reported that the final yields of crop are in many cases dependent on satisfactory growth during earlier stages of crop development, which is achieved through planting at the most suitable time. Sowing at middle of November matched with the coldest period in January 11.31°C. At this stage, the crop is at tuber initiation and bulking stage (75 days). This is consistent with an assertion made by Ifenkwe and Okonkwo (1983); that is, under irrigation, Irish potato production in Nigeria should coincide with the coldest month (November – January) so that the time of tuber bulking will coincide with the period of low temperature. Time of sowing also determines time of flowering and it has a major influence on dry matter accumulation, seed set and seed yield (Sofield, 1977). Gallagher and Biscoe (1978) also reported that crops sown at the optimum time

make the best use of the available growth factors such as temperature and solar radiation at different stages of growth for high productivity.

Wurr et al. (1990) also stated that for each type of crop, appropriate and proper time of sowing is one of the basic requirements for obtaining maximum yield and high profit returns. For example, Mortazavi-bak and Ramin-pour (2009) recommended that potato planting date should be calculated based on the length of the growing season, because the number of tubers produced per plant is affected by optimum sowing date.

Conclusion

The experimental results show that two varieties, Nicola GL and Nicola YL, have higher yields at Danbatta, Bichi, and combined. Similarly, an optimum sowing date that gives better yield is the middle of November.

RECOMMENDATION

It is suggested that for dry season production, varieties Nicola GL and Nicola YL are preferred, with corresponding sowing date of middle of November, and these varieties could be used to improve yields of Irish potato production in the Sudan savanna zone of Nigeria.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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