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Research Paper

Effect of Potato (*Solanum tuberosum* L.) Seed Size and Variety on Flowering Behavior and Berry Production

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The present study was aimed to elucidate the effect of 3 seed sizes (< 40 mm, 40 mm and > 40 mm) and 2 varieties (Bertita and Diamant) on flowering behavior and berry production of potato (*Solanum tuberosum* L.) in Jos Plateau State of Nigeria. The treatments were arranged in a completely randomized design (CRD) with 3 replications. The result showed that seed size and variety had significant effect on some of the parameters assessed. Variety Diamant was the earliest to form flower buds in 34.10 days and it also resulted in higher number of inflorescence at 7 weeks after planting (WAP) and flower buds at 7 and 8 WAP than variety Bertita. Berry formation was similar between varieties. Medium sized seed tubers (40 mm) took significantly longer mean number of days to form first flower buds while small sized seed tubers was the earliest (34.00 days). Number of inflorescence formed was similar with all the seed sizes and number of flower buds formed was higher in larger seed tubers than the medium and smaller seed tubers at 7 WAP. Larger and medium seed tubers resulted in similar mean number of berries, while the smaller seed tubers did not form berries.

Keyword: Potato, flowering, berry formation

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a starchy tuberous crop from the perennial nightshade family and the word potato refers to the edible tuber or the plant itself (Hijmans and Spooner, 2001). Potato is the world's fourth important food crop after wheat, rice and maize because of its great yield potential and high nutritive value (FAO; 2009; Kumar *et al*., 2013). Potato is grown for food, animal feed and other industrial uses. The food production is both for fresh ware markets and processing into crips (Struik and Wiersema, 1999). Flowering behavior in potato shows a wide range of genetic variability (Levy and Kedar, 1985; Bhargava and Banerjee, 1993) and is influenced by many factors which includes photoperiod, parent plant nutrition, soil characteristics, soil moisture and night temperature (Malagamba, 1988).

Increased flower production has been reported as a result of an increased number of inflorecence (Almekinders, 1992), an increase in number of flower buds (Werner, 1942; Turner and Ewing (1988) and reduced flower abortion (Werner, 1942; Bodlaender, 1963; Turner and Ewing, 1988). Almekinders and Struik, (1996) reported that the most important components in flower production are the stem production and flower primordial development and they are both highly dependent on the genotype and its interaction with temperature and photoperiod. Flowering has been suggested to be best under long day (16 h), abundant moisture is available and cool temperature (Almekinders and Struik, 1996).

In spite of the importance of the potato as a food crop and the considerable amount of research done in this crop, data on the flowering process of this crop are limited since potato are multiplied almost exclusive vegetatively by tubers. Hence, it has been mainly the breeders who were interested in flowering processes for crossing among cultivated and wild species, aimed at the production of new varieties. Potato is cultivated globally by the use of true seeds and vegetatively by use of tubers (Gopal, 1994). In Plateau State of Nigeria the crop is mainly cultivated by whole seed tubers in which the continuous use of seed tubers has been found to bring about degeneration of tubers and also reduced the quantity of production (Lenka *et al*., 2013). Most farmers believed that, smaller seed tubers (<40 mm) are for planting whereas, the larger potato tubers (> 40 mm) are

for marketing, therefore, during harvest, farmers carry out sorting of potato in to smaller and larger tubers, Consequently this has resulted in the decrease of potato yield and increased potato susceptibility to disease attack such as viruses and late potato blight (Okonkwo *et al*., 2009). Due to lack of seed programs, most farmers do not have the idea that the berries produce by potato flowers can be used as a viable alternative in raising of commercial potato. This research is therefore aimed to study the effect of seed size on flowering behavior and berry production of potato (*Solanum tuberosum* L.) in Jos, Plateau State. Nigeria.

MATERIALS AND METHODS

The study was conducted at the Botanical Garden, Bauchi Road Main Campus, University of Jos, Nigeria (Latitude 09°511'N and Longitude 08°53'E and Altitude 1,159 m above sea level) during dry season (November, 2015 to February, 2016). Two potato varieties Diamant and Bertita were obtained from National Root Crops Research Institute (NRCRI), Potato Programme Kuru, Plateau State, Nigeria. A completely randomized design (CRD) was used. There were 6 treatment combinations, consisting of 2 potato varieties and 3 seed sizes (<40 mm, 40 mm and > 40 mm) replicated 3 times. Soil preparation was done using loamy and sharp sand in the ratio of 3:1 and mixed thoroughly with goat manure at the ratio of 6:1. The mixture was filled in to polythene bags at the rate of 19 kg per bag. Each of the treatment was represented by 10 stands. Weeding was carried out by hand picking and plants were watered 3 times a week initially and 4 times a week at the onset of flowering to enhance flowering , avoid flower abortion and enhance yield .The following parameters were assessed: days to formation of first flower bud, number of inflorescences formed per plant, number of flower buds formed, number of flower buds aborted, colour of flowers, and number of berries formed per plant. The data collected were subjected to analysis of variance (ANOVA) and the means were separated by LSD (Steel and Torrie, 1960).

RESULTS

The main effects of variety and seed size on mean number of days to formation of first flower buds was significant (P<0.05). Variety Diamant formed buds earlier than variety Bertita (34.10 and 35.75 days, respectively) (Table 1). Among the seed sizes, medium seed sized tubers took more days (50.92) to form their first flower buds, followed by larger seed tubers (36.00) while small seed size took the least number of days (34.00) to form their buds . The interaction of variety and seed size on the mean number of days to the formation of first flower bud was not significant (P<0.05) (Table 1).

The mean number of inflorescences formed per plant is presented in (Table 2). The main effect of variety on number of inflorescences was not significant (P<0.05) at 6 and 8 weeks after planting (WAP) but was significant (P<0.05) at 7 WAP. At 7 WAP, variety Diamant resulted in significantly (P<0.05) higher mean number of inflorescences (1.66) than variety Bertita (1.17). The different seed sizes used showed no significant difference with mean number of inflorescence formed (Table 2). There was significant interaction of variety and seed size with respect to mean number of inflorescence formed per plant (Table 2).

Table 4 shows the interaction of variety and seed size on mean number of inflorescences formed per plant. At 6 WAP, with smaller seed sizes, variety Diamant resulted in 1.75 inflorescences per plant, while variety Bertita did not form any inflorescence at all. With medium and larger seed sizes, the varieties resulted in similar number of inflorescences (Table 4). At 7 WAP, with smaller seed sizes, variety Diamant resulted in 1.25 inflorescences, while variety Bertita did not formed any inflorescence. With medium and larger seed sizes variety Diamant recorded significantly (P < 0.05) higher mean number of inflorescences (1.67 and 2.10, respectively) than Bertita which had 1.33 and 1.00, respectively (Table 4). At 8 WAP, with smaller seed sizes, variety Diamant recorded 1.00 inflorescence, while variety Bertita did not formed any inflorescence at all. With medium and larger seed sizes, the varieties resulted in similar mean number of inflorescence (Table 4).

The mean number of flower buds formed per plant is also presented on Table 2. The two varieties showed no significant (P<0.05) difference on mean number of flower buds formed at 6 WAP but differs significantly (P<0.05) at 7 and 8 WAP. Variety Diamant resulted in significantly (P<0.05) higher mean number of flower buds (5.50 and 2.99) at 7 and 8 WAP, respectively) than variety Bertita which had 2.20 and 1.43 flower buds per plant at 7 and 8 WAP ,respectively . The main effect of seed size on mean number of flower buds was not significant (P<0.05) at 6 and 8 WAP but differed significantly (P< 0.05) at 7 WAP. At 7 WAP, the larger seed size had significantly (P<0.05) higher mean number of flower buds (5.35) than the smaller and medium seed sizes (3.50 and 3.35 respectively) (Table 2). There was significant interaction of variety and seed size on mean number of flower buds formed per plant.

Table 4 shows the interaction of variety and seed sizes on mean number of flower buds formed per plant. At 6 WAP, with small seed size, variety Diamant resulted in 6.90 flower buds, while variety Bertita had no flower buds. With medium and large seed sizes, variety Diamant resulted in significantly higher mean number of flower buds (7.75 and 6.47 flower buds, respectively) than variety Bertita (5.50 and 4.75 flower buds, respectively). At 7 WAP, with smaller seed sizes, variety Diamant resulted in 3.50 flower buds, while variety Bertita did not

Table 1. Effect of variety as affected by seed size on mean number of days to formation of first flower bud.

Variety	DAP
Diamant	34.10b
Bertita	35.75a
LS	*
$LSD_{0.05}$	1.34
Seed sizes	
Small size (< 40 mm)	34.00c
Medium size (40 mm)	50.92a
Large size (> 40 mm)	36.00b
LS	*
$LSD_{0.05}$	0.82
Interaction Variety × Seed size	NS

DAP: Days to formation of First Flower Bud after Planting.

Table 2. Effect of variety and seed size on mean number of inflorescence and flower buds formed per plant.

	Number of inflorescence formed per plant			Number of flower buds formed per plant		
	Age of plants (WAP)			Age of plants (WAP)		
	6	7	8	6	7	8
Variety						
Diamant	1.54a	1.66a	1.26a	7.13a	5.50a	2.99a
Bertita	1.68a	1.17b	1.00a	5.13a	2.20b	1.43b
LS	NS	*	NS	NS	*	*
$LSD_{0.05}$	0.82	0.42	0.83	5.17	1.31	1.30
Seed size						
Small size(< 40 mm)	1.75a	1.22a	1.00a	6.90a	3.50b	2.50a
Medium size(40 mm)	1.51a	1.50a	1.13a	6.63a	3.35b	2.17a
Large size(> 40 mm)	1.60a	1.55a	1.26a	5.75a	5.35a	2.49a
LS	NS	NS	NS	NS	*	NS
$LSD_{0.05}$	0.70	0.37	0.70	3.39	0.88	0.51
Interaction Variety × Seed size	*	*	*	*	*	*

Note: Pair of means that differ by more than their LSD are significantly different at 5% level of significance.

formed any flower buds. With medium and larger seed sizes, variety Diamant recorded significantly ($P < 0.05$) higher mean number of flower buds (5.30 and 7.70 respectively) than variety Bertita which had 1.40 and 3.00 flower buds per plant respectively. At 8WAP, with smaller seed sizes, variety Diamant resulted in the formation of 2.50 flower buds per plant while variety Bertita did not form any flower bud. With medium and larger seed sizes, variety Diamant resulted in significantly higher mean number of flower buds (2.83 and 3.63, respectively) than variety Bertita.

The number of flower buds aborted is presented in (Table 3). The main effect of variety on mean number of flower buds aborted was significant ($P < 0.05$). At 7 WAP, variety Bertita had significantly higher flower abortion (3.83) than variety Diamant. However, at 8 WAP, variety Diamant resulted in significantly ($P < 0.05$) higher mean number of flower buds aborted (2.37) than variety Bertita (1.50). The main effect of seed size on flower abortion was significant ($P<0.05$) at 8 WAP. Smaller seed sized tubers resulted in significantly ($P < 0.05$) higher mean number of flower buds aborted (3.00), than medium seed tubers and larger seed tubers. The interaction of variety and seed size on flower abortion showed no significant difference ($P < 0.05$) at all the sampling dates.

The mean number of berries formed per plant is shown in (Table 3). The main effects of variety and seed size on mean number of berries formed was not significant ($P < 0.05$). Small size seed did not form any berry at all, but the medium and larger seed size resulted in similar number of berries formed. There was significant ($P < 0.05$) interaction of variety and seed size on mean number of berries formed.

The interaction of variety and seed size is shown on Table 5. With small seed size, all the varieties did not form berries. With medium seed size, variety Bertita

Table 3. Effect of variety as affected by seed size on mean number of flower buds aborted and berries formed per plant.

	Number of flower buds aborted		Number of berries formed
	Weeks after planting		
	7	8	
Variety			
Diamant	2.09b	2.37a	1.50
Bertita	3.83a	1.50b	1.50
LS	*	*	NS
$LSD_{(0.05)}$	0.26	0.83	0.91
Seed size			
Small size(<40 mm)	3.31a	3.00a	-
Medium size(40 mm)	3.18a	2.25b	1.75a
Larger size(>40 mm)	2.23a	1.68b	1.25a
LS	NS	*	NS
$LSD_{(0.05)}$	1.09	0.71	0.78

Note: Pair of means that differ by more than their LSD are significantly different at 5% level of significance.

Table 4. Interaction of variety and seed size on mean number of inflorescence and flower buds formed per plant at 6, 7 and 8 WAP.

	Age of plants (Weeks after planting)								
	Number of inflorescence formed								
	6			7			8		
Variety	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Diamant	1.75	1.52a	1.35a	1.25	1.67a	2.10a	1.00	1.25a	1.52a
Bertita	-	1.85a	1.85a	-	1.33b	1.00b	-	1.00a	1.00a
LS	NS			*			NS		
$LSD_{0.05}$	0.58			0.30			0.59		
	Number of flower buds formed								
Variety	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
Diamant	6.90	7.75a	6.74a	3.50	5.30a	7.70a	2.50	2.83a	3.63a
Bertita	-	5.50a	4.75a	-	1.40b	3.00b	-	1.35b	1.35b
LS	NS			*			*		
$LSD_{0.05}$	3.66			0.93			0.92		

Note: Pair of means that differ by more than their LSD are significantly different at 5% level of significance.

Key
WAP (Weeks after Planting)
S1= Smaller seed size (<40 mm)
S2= Medium seed size (40 mm)
S3= Larger seed size (>40 mm)

Table 5. Interaction of seeds size and variety on mean number of berries formed per plant at 9 WAP.

	Seed size		
Variety	**Small**	**Medium**	**Large**
Diamant	-	1.50a	1.50
Bertita	**-**	2.00a	1.00
LS	NS		
$LSD_{0.05}$	0.64		

Note: Pair of means that differ by more than their LSD are significantly different at 5% level of significance.

resulted in significantly ($P < 0.05$) higher mean number of berries than variety Diamant. However, with large seed size, variety Diamant had significantly ($P < 0.05$) higher mean number of berries than variety Bertita.

DISCUSSION

The potato varieties used were similar in the number of days to appearance of first flower bud (34.10 to 35.75 days). Firman *et al*., (1991) reported that initiation of flowers usually occurred before tuber initiation and within 2 weeks of emergence but was earlier in some varieties than others. In a trial to investigate the effects of tuber removal on the flowering behavior of some potato genotypes, Ifenkwe and Deshi (2006) found the potato varieties took similar number of days to appearance of first flower bud (30-33 days). The different seed sizes had significant effect on the number of days to appearance of first flower bud (34, 50 and 36 days in small, medium and large seed sizes, respectively). This may be because the small seed tuber is in a hurry to complete its life cycle before it runs out of nutrition from mother tuber since large seed tubers consist of more parent plant nutrition than the smaller seed tubers. Malagamba, (1988) suggested parent plant nutrition among many other factors influencing flowering behavior of potato.

There were varietal differences with respect to the number of flower buds formed. Diamant produced the highest number of flower buds than Bertita. Ifenkwe and Deshi, (2006) reported varietal differences with respect to number of flower buds formed. A wide range of genetic variability has been reported to exist with respect to the flowering behavior in potatoes, some varieties flower freely while others are shy (Bhargava and Banejee, 1993). The different seed sizes significantly affected the number of flower buds formed at 7 weeks after planting with large seed sizes having highest number of flower buds (5.35), while small and medium seed sizes had similar number of flower buds. Patel *et al*. (2008) stated that increase in potato seed tuber size increases the number of stems produced per unit area. Almekinders, (1992) reported that increase in stem number increases the proportion of flowers on lateral stems from every inflorescence per plant.

The number of flower buds aborted varied with variety. Variety Diamant had the highest number of aborted flower buds (2.37), while flower abortion was significantly lower (1.50) in variety Bertita at 8 WAP. Genetic variability has been reported to exist between varieties with respect to flowering behavior (Bhargava and Banejee, 1993). The higher bud abortion in Diamant might be as a result of higher flowering intensity. Almekinders and Struik, (1996) observed the number of flowers per stem as a function of flower primordial initiation and survival and it varies between genotypes. The different seed sizes significantly affect the number of aborted flower buds at 8 WAP. Flower abortion was highest in small seed size (3.00), followed by medium seed size (2.25) and lowest in larger seed size (1.68). This suggests that increasing size of seed tuber enhance flowering under appropriate environmental conditions by reducing bud abortion. Malagamba, (1988) suggested parent plant nutrition among many other factors influencing flowering behavior of potato. The large seed tubers consist of more parent plant nutrition than the smaller seed tubers, which suggest reasons for more flower buds formed and less flower bud abortion in larger seed tubers than smaller seed tubers.

The used varieties did not differ in the number of berries produces. Ifenkwe and Deshi, (2006) found the number of berries varied with varieties. Almekinders and Strunk, (1994) observed the number of berries to be largely dependent on genotype. The smaller seed sizes did not produce any berries, while the medium and large seed sizes produced similar number of berries. This suggests that the berry formation may be affected by available nutrients in mother tubers during growth of plants.

Conclusion

The potato varieties used (Diamant and Bertita) took a similar number of days to flower. Although variety Diamant formed more flower buds than variety Bertita, flower abortion was more in variety Diamant, no wonder they had a similar number of berries formed. While small seed sized tubers were the earliest to form flower buds, medium seed sized tubers took longest period to flower. Large sized seed tubers formed more flower buds than small and medium which had similar number of flower buds. All the flower buds formed by small sized seed tuber were aborted and so no berries were formed. Large and medium seed tubers produced similar number of berries. Therefore, if you are interested in flower number and berry formation, it is suggested that medium and large seed sizes be used. It is recommended that more potato varieties be evaluated for their flowering behavior.

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