Australian Journal of Crop Science
AJCS
AJCS 13(02):282-286 (2019) ISSN:1835-2707
doi: 10.21475/ajcs.19.13.02.p1416

Influence of seed tuber size and sprouting stage on the phytotechnical characteristics of the potato var. Ágata

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Abstract

The use of seed tubers of suitable bud stage is of paramount importance in potato crop production because it enables obtaining the number of stems closest to that desired. The objective of this study was to study the influence of bud stage and seed potato tubercle size on the plant characteristics of the potato var. Ágata. The experiment was carried out between January and April 2017. The treatments included two sizes of seed tubers of Agata variety types I (50-60 mm) and III (30-40 mm) and four stages of growth (A, larger sprout, shoots bigger than 1 cm; B, shoots of approximately 0.7 cm; C, shoots of approximately 0.4 cm; and D, less budding, incipient shoots of up to 0.1 cm). The number of stems and tubers per plant, the number of tubers per stem, the production and classification of tubers, and the average mass of tubers were evaluated. A positive association was found between the seed tuber size and sprouting stage and the number of stems per plant. The number of tubers and stems per plant was positively related to the mass of the seed tuber, especially when the tuber was most sprouted. The use of type I seed tubers with an earlier budding phase favors the production of the highest number of tubers per plant. Minor seed tuber yields a lower number of tubers per plant but yields a higher average mass of tubers. The use of smaller seed tubers (type III) is recommended because they could present a higher productive potential and a higher percentage of large tubers.

Keywords: *Solanum tuberosum* L., seeds, agronomic characteristics, potato size.

Introduction

The potato (*Solanum tuberosum* L.) is a commercial herb in Brazil (Pineli et al., 2005; Santos et al., 2016), largely due to its high productive potential and its nutritional properties (Conceição et al., 1999; Bártová et al., 2015). Potato production in Brazil is estimated at about 3.83 million tons, with the main producing states of this tuber situated in the south and southeast of the country (IBGE, 2016). Potato is the third most consumed food in the world (Embrapa, 2017a). Thus, it is an essential food in populous countries, having high contents of vitamin C, proteins, carbohydrates, and potassium (Ngobese et al., 2017; Narvárez-Cuenca et al., 2018).

The present study recognizes that the presence of tubers is of great importance for the *in natura* commercialization of potato (Feltran et al., 2004; Silva et al., 2007). Ágata and Mondial are among the main potato varieties cultivated in the country for *in natura* consumption because their tubers have commercially desirable characteristics (Evangelista et al., 2011).

Potato dormancy is a complex process with an extensive release phase, with the period of apical domination in seed potatoes beginning after harvest (Liu et al., 2017). The apical dominance of seed potatoes is affected by physiologic age, thus interfering with the number of main stems produced by the seed tuber (Krijthe, 1962; Danieli et al., 2018). With the progression of the seed potato age, the apical dominance decreases (Eshel & Teper-Bamnolker, 2012; Urrea-Hernandez et al., 2016). The physiologic age of seed potatoes also influences the number of tubers per plant and the size distribution of tubers (Knowles & Knowles 2006; Park et al., 2009). Most of the time, larger number of tubers per plant results in a smaller tubercle size (Bisognin et al., 1998).

The development of potato sprouting depends on the increase of growth-promoting phytohormones, such as auxins and gibberellins (Suttle et al., 2004). Hormonal balance with a greater accumulation of cytokinins in stolons favors tuberization (Fontes and Finger, 1999).

Seed potatoes and fertilizers are the main components of the production costs in bataticulture. Both factors influence the number and size of the tubers produced (Creamer et al., 1999). The size of the tuber produced is an important component of production, with larger tubers being more valued in the *in natura* market.

Seed potatoes with a stems number of rods produce a greater number of tubers. Thus far, there is no consensus among producers regarding the effect of the seed potato size and spacing. Hence, the producer considers the cost: the smaller the spacing is the greater the need for seeds, thus increasing the cost of production.

There is a direct relationship between larger and more sprouted seed tubers and the number of tubers produced. However, a large number of tubers per plant may result in an average mass below the suitable value for the *in natura* market, which prefers larger tubers, generally more than 42 mm in diameter. Given their fewer buds, smaller seed tubers may allow better adjustment of the stem density and source-drain ratio, resulting in the number and size of tubers produced. Thus, the objective of this study was to study the influence of bud stage and seed potato tubercle size on the plant characteristics of the potato var. Ágata.

Results

The size and budding stage of seed tubers were found to influence the number of stems per plant. There was an increase in the number of stems in less sprouted type I seedlings, whereas a decrease was observed in type III tubers (Table 1).

The number of tubers per plant, similarly to the number of stems, was positively associated with the mass of the seed tuber, especially when the tubers were more sprouted (Table 1). The number of tubers per stem was higher in plants originated from more budded type I seedlings and from less sprouted type III seedlings (Table 1). When type I seed tubers were used, a higher sprouting stage resulted in a larger mass of small tubers. On the other hand, when type III seed tubers were used, the sprouting stage did not influence the mass of small tubers.

The total production, the number of large tubers, the production of large tubers, and the number of small tubers were higher in plants originated from type I seed tubers, without interaction with the budding stage. The mean mass of tubers was higher in type III seed tubers, without interaction with the budding stage (Table 2). More sprouted seed tubers produced a higher number of large tubers per plant and a smaller average mass of tubers (Table 3).

Discussion

Bigger seed tubers have a higher number of buds, which can result in a larger number of stems and tubers per plant. The highest number of stems and tubers per plant competes for the lower average mass of the tubers produced, similar to that obtained by Teixeira et al. (2010). This may be associated with the higher stem density per plant, which may lead to an imbalance between the source and drain and, consequently, to juvenile tubers (Dellai et al., 2008).

The use of potato seeds that are still in the period of apical dominance is undesirable because planting at this stage results in a decreased stem population and low productive potential due to poor utilization of solar radiation (Bisognin et al., 2008; Danieli et al., 2018), which corrabora with the present work for the size of tubercle type III. Type I seed tubers that were more sprouted positively contributed to increasing the number of tubers, as a function of the bud stage, possibly because they presented lower dormancy compared with the type III seed tubers. The type I seed tubers were formed first in the seed field and possibly presented less dormancy; thus, they sprouted more easily.

The potato production components can be summarized into the number and average mass of tubers produced (Silva et al., 2006; Urrea-Hernandez et al., 2016). Type I seed tubers that were more sprouted positively contributed to the number of tubers. However, the large number of tubers formed in a plant largely results from small tubers among those produced in the plant (Filgueira, 1999; Danieli et al., 2018). On the other hand, the type III seed tubers resulted in a smaller number of stems and tubers per plant. Thus, the tubers produced were generally larger.

The number of stems per area should be adjusted to maximize the uptake of solar radiation and obtain a larger mass of tubers. Because the number of stems per seed tuber varies with the mass, adjustment of the spacing between seed tubers is applied in potato cultivation (Oliari et al., 2011). The recommended spacing ranges from 30 to 40 cm for type I seed tubers and from 20 to 25 cm for type III seed tubers (Embrapa, 2017b). The typical spacing of 40 cm and 80 cm for type I seed tubers in potato cultivation (Embrapa, 2017b) results in a population of 31,250 plants per ha. The usual spacing for type III seed tubers is 25 cm, which results in 50,000 plants per ha. Based on the number of plants and the production obtained per plant in the experimental conditions, the potential productivity (number of plants x production per plant) can be estimated at 83.1 and 122.5 t ha^{-1} for tuber types I and III, respectively.

Higher productivity can be obtained from the plants originated from type III tubers, possibly due to the better distribution of stems, which favors the capture of radiation and better adjustment of the source-drain ratio in each plant. Thus, for the Ágata variety, the mass production component of the tuber could be more important than the number of tubers per plant.

Materials and Methods

Place of study and experimental design

The experiment was carried out at the experimental station of the Institute of Agricultural Research of the Cerrado (IPACER), located in the city of Rio Paranaíba, Minas Gerais, Brazil. The climate of the region is classified as Cwa, which, according to the Köppen-Geiger classification, is characterized by two well-defined seasons. The planting was carried out on 27/01/2017; the harvesting was done 90 days after planting on 26/04/2017.

The seed tubers originated from virus-free mini-tubers with high phytosanitary quality. After harvesting and before cultivation, the seed tubers were stored in a cold room at temperatures of between 3 and 5 °C and relative humidity of between 90 and 95% for 40 days.

The treatments included four shoot stages and two seed tuber sizes, which were plotted in a 4 x 2 factorial design. The first factor corresponded to the sprouting level (sprout size), and the second factor to the size of the seed potato. The seed potato sizes used were 50-60 mm for type I and 30-40 mm for type III. The sprouting stages were: A, larger sprout, shoots bigger than 1 cm; B, shoots of approximately 0.7 cm; C, shoots of approximately 0.4 cm; and D, less budding, incipient shoots of up to 0.1 cm (Fig. 1). To obtain the sprouting stages, the seed tubers were left for 38, 30, 25, and 10 days, respectively, outside the cold chamber. A completely randomized design was used, with six replications. The experimental unit was a polyethylene vessel with a capacity of 250 dm^3 of soil. In each vase were planted two tubers with a spacing of 40 cm between them

Table 1. Effect of seed tuber size and sprouting stage on number of stems per plant, tubers per plant, small tubers, and tubers per stem.

Seed tuber size	Sprouting stage							
	A		B		C		D	
				Number of stems per plant				
I	5.83	Ba	4.92	Ba	5.17	Ba	7.10	Aa
III	3.58	Ab	3.42	Ab	2.83	ABb	2.08	Bb
				Number of tubers per plant				
I	25.47	Aa	15.83	Ba	16.17	Ba	15.32	Ba
III	13.75	Ab	11.00	ABb	10.17	Bb	9.50	Bb
				Number of tubers per stem				
I	4.22	Aa	3.26	Aba	3.14	ABa	2.69	Bb
III	3.58	Aa	3.35	Aa	3.64	Aa	4.46	Aa
				Amount of small tubers (kg/plant)				
I	0.18	Aa	0.08	BCa	0.05	Ca	0.11	Ba
III	0.06	Ab	0.04	Ab	0.02	Aa	0.03	Ab

The seed potato sizes used were 50-60 mm for type I and 30-40 mm for type III. The different stages of budding were: A, larger sprouting, shoots bigger than 1 cm; B, shoots of approximately 0.7 cm; C, shoots of approximately 0.4 cm; and D, less budding, incipient shoots of up to 0.1 cm. Averages followed by the same letters (uppercase and lowercase) do not differ from each other based on the SNK test at 5% significance level.

Fig 1. Seed tuber sizes (type I, 50-60 mm; type III, 30-40 mm) and shoot stages (A, larger sprout, shoots bigger than 1 cm; B, shoots of approximately 0.7 cm; C, shoots of approximately 0.4 cm; D, less budding, incipient shoots of up to 0.1 cm).

Table 2. Effect of seed tuber size on total and large tubercle production, number of large and small tubers, and average mass of tubers.

Seed tuber size	Production (kg/plant)		Number of large tubers		Amount of large tubers (kg/plant)		Number of small tubers		Average tuber mass (g)	
I	2.66	a	13.65	a	2.56	A	4.34	a	157.59	B
III	2.45	b	9.06	b	2.41	B	2.04	b	225.51	A

The seed potato sizes used were 50-60 mm for type I and 30-40 mm for type III. Means followed by the same letter do not differ from each other based on the SNK test at 5% significance level.

Table 3. Effect of sprouting stage on number of large and small tubers and mean tuber mass.

Sprouting stage of seed tubers	Number of large tubers		Number of small tubers		Average tuber mass (g)	
A	13.25	a	5.40	a	144.65	B
B	10.63	b	2.79	b	204.34	A
C	11.29	b	1.88	b	210.65	A
D	10.25	b	2.71	b	206.54	A

The budding stages were: A, larger sprout, shoots bigger than 1 cm; B, shoots of approximately 0.7 cm; C, shoots of approximately 0.4 cm; D, less budding, incipient shoots of up to 0.1 cm. Means followed by the same letter do not differ from each other based on the SNK test at 5% significance level.

and 20 cm from the edge of the vase; both were conducted until the harvest.

The evaluation included the number of stems per plant, the number of tubers per plant, the number of tubers per stem, the yield of small tubers, the large and total mass per plant, and the mean mass of tubers. Large tubers were those with an equatorial diameter of 42 mm or more, and small tubers were those with a diameter of less than 42 mm.

Statistical analysis

Data were submitted to analysis of variance. When the means were significantly different, the Student-Newman-Keuls test was applied at a significance level of 5%. The analysis was carried out by using the SPEED Stat spreadsheet software (Carvalho and Mendes, 2017).

Conclusion

Type I seed tubers, especially when more sprouted, favor the production of a larger number of tubers per plant. Type III seed tubers provide a lower number of tubers per plant but produce a higher average mass of tubers.

Crops originating from type III seed tubers may present a higher productive potential and a higher percentage of large tubers.

Acknowledgements

We thank the Institute of Agricultural Research of the Cerrado (IPACER), located in the city of Rio Paranaíba, Minas Gerais, Brazil, for the availability to conduct the experiment and to Lucas Resende Silva, for the commitment during the conduction of the research.

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