Original Research Article

Morphology and growth of new potato genotypes under different doses NPK

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ABSTRACT

Aims: estimate the morphological characteristics of potato genotypes grown with different doses of NPK fertilizer 4-14-8. **Study design:** The experiment was conducted in randomized blocks with subdivided plots and three replicates. **Place and Duration of Study:** The experiment was carried out in the municipality of Guarapuava – PR, Brazil, during the growing seasons of 2013/2014 and 2014/2015. **Methodology:** In the main plots the doses of 0, 2, 4 and 6 t ha^{-1} of NPK fertilizer 4-14-8 were arranged and in the subplots the genotypes (Ágata, BRS Camilla and clone C0205). Were evaluated: The leaf area index (LAI), percentage of light absorption, number of tubers, fresh mass of tubers. In the first agricultural year the evaluations were performed at 25 and 45 days after the emergency (DAE) and in the second seasson at 28 and 48 DAE. Interaction between potato genotypes and fertilizer rates for LAI was observed at 45 DAE in 2013/14 and absorbance at 25 DAE in 2013/14. For the seasson 2013/14, the genotypes showed a significant difference for LAI, absorbance, number of tubers and fresh mass of tubers at 25, LAI and fresh mass of tubers at 45 DAE, clone C0205 presented the largest differences for these characteristics. Fertilizer doses did not influence LAI, absorbance at 25 DAE and 45 DAE in 2013/14 and, at 2014/15 at 28 DAE, there was no response for tuber number and LAI, and at 48 DAE for tuber number, absorbance. Genotypes responded to NPK fertilizer doses 4-14-8 for LAI and absorbance.

Keywords: Solanum tuberosum, fertility, variety, absorbance.

1. INTRODUCTION

The potato production chain (*Solanum tuberosum*) is one of the largest and most complex in the Brazilian scenario, as it encompasses a series of activities for food production ranging from seed potatoes to direct production for consumption as food [1].

Betweenm the main cultivars used in Brazil, the cultivar Agata is highlighted. This cultivar was developed for temperate regions, which are characterized by long days and mild summer temperatures. When used in a tropical climate, it can have its productivity compromised, due to the high temperatures and short photoperiod. When subjected to these conditions the photosynthetic capacity of the plants is affected by the increase and losses with the respiration [2].

When evaluating the productive potential of a plant, it is necessary to verify the different contributions of plant growth [3]. Decision making regarding the timing of the use and management of certain cultivars will be influenced by the morphological characteristics of the plants. The greater number of stems of a plant can lead to greater productivity. According Feltran e Lemos [4], the greater number of stems of a plant can lead to greater productivity. Potato breeders face the challenge of providing genotypes that meet the needs of producers and consumers The need of the producers is for cultivars of early cycle, allied to the high yield, whereas for the consumer the need is of tubers with quality [5].

Among the factors that may influence the productivity of potato plants, the leaf area index (LAI) is one of the main factors, as it is directly related to the photosynthesis of the plants. According to Cardoso [6], to achieve high productivity it is necessary to keep the plants with the photosynthetically active leaf area longer.

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Understanding the behavior of the morphological characteristics of the potato plants is fundamental for success in productivity and maximizing the productive potential of the genotypes. Potato plants that are not developed for Brazilian climate conditions may be affected by the tropical climatic conditions of the country.

When submitted to low light intensity, stem elongation is higher, increasing plant height, reducing leaf size, delaying the initiation of tuberization and foliar senescence, reducing the production of tubers per plant. On the other hand, high light intensity results in increased photosynthesis, stimulates flowering, increases the dry mass of tubers and accelerates the process of initiation and filling of tubers [6].

Another important factor for the production of potatoes is the amount of nutrients needed for the production of tubers, because the potato has a high extraction of nutrients from the soil. In addition, nutrition is one of the factors that most affect the productivity and quality of tubers, between other factors such as growing environment, genetic potential and age of plants [7].

In order to meet the nutritional needs of the potato crop, it is necessary, according to Job [8], to improve and assure the use of nutrients by the crop and to allow better utilization of the nutrients by the plant root system.

To meet the nutritional need of potato plants is essential to achieve high productivity, especially in tropical soils that have as general characteristic low fertility [9]. In addition, it is necessary to understand the role of fertilization in the different physiological processes of the crop, thus allowing precise supply of nutrients, avoiding expenses and consequently maintain productive potential.

Thus, the objective of the work was to estimate the growth of potato genotypes, grown with different doses of NPK fertilizer 4-14-8.

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2. MATERIAL AND METHODS

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The experiments were carried out in the agricultural years of 2013/14 and 2014/15 in the city of Guarapuava-PR. In the agricultural year 2013/14, the experiment was conducted at Fazenda Lageado Grande, district of Palmerinha, with central coordinates of 25 ° 18'23 "S and 51 ° 36'40" W, from December 2013 to April 2014, and in the second agricultural year (2014/15) conducted in the experimental field of the State University of the Center-West, with central coordinates in 25º23'04 " S and 51º29'36"O, from October 2014 to February 2015.

Tubers of the Agata genotype were purchased from the producer in the two agricultural years, while the tubers from genotypes C0205 and 'BRS Camila' were supplied by Embrapa Produtos de Mercado (Canoinhas / SC).

Soil preparation was started one month prior to the implantation of the crop with subsoiling and two gradations followed by the grooving of the area.

In the seasson 2013/14 the planting of the tubers was carried out on 07/12/2013, with a heap held 15 days after the emergency (DAE). In the seasson 2014/15, the planting was carried out on 04/10/2014, with heap held 18 DAE.

Phytosanitary management was carried out according to the usual practices of the region for the crop in the two seassons.how is soil properties, how is climate conditions every year in experimental area. All of theö must be explained and given.

The treatments consisted of three potato genotypes: Agata cultivar, BRS Camila cultivar and clone C0205 and four doses of NPK fertilizer 4-14-8 with boron: 0; 2; 4 and 6 t ha^{-1}. The experimental design was a randomized block design with subdivided plots, with the

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fertilizer doses allocated to the main plots and the genotypes allocated to the subplots, with three replications, in both agricultural years.

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The subplot measured 3 x 4.8 m, composed of 6 lines, with 10 plants per line, spacing 0.80 m between rows and 0.30 m between plants in the agricultural year of 2013/14. In the agricultural year of 2014/15, 12 plants per line were used, with spacing between 0.80 m and 0.25 m between plants. NPK fertilizer was distributed in total dose just prior to manual planting of the tubers.

Comment [F8]: Why is it different??? This situation can be effected many characters!!it must be explained!!

Samples were collected for morphological characteristics at 25 and 45 DAE in the seasson 2013/14 and at 28 and 48 DAE in the seasson of 2014/15. Four whole plants were collected from each subplot, always leaving the two external lines as a border and a border plant between the collections.

Morphological parameters analyzed in the two agricultural years were: leaf area index (LAI), percentage of light absorption, number of tubers (number pl^{-1}) and fresh mass of tubers (g pl^{-1}).

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Light data were obtained using the Prochec RFA quantizer (Decagon Devices), and data collection was performed the following day after each sample collection. Collection times were close to 10:00 am. The radiation was measured in three points below the plants: in the planting line, in the line between and between the planting line and the line, in each of these three points the radiation was quantified 4 times. In addition to these measurements below the canopy, two measurements of radiation above the canopy were made. The data were annotated and the mean of the data below and above the canopy was then averaged, and then the percentage of light absorption was calculated.

For determination of dry mass (DM), the samples were dried in a forced circulation air oven at 70 ºC until reaching a constant mass and then weighed. For the evaluation of the

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LAI, leaf samples of the plots were used, which had their area quantified with the aid of an integrator of leaf area of table (LI-3100 C, Liquor) and, based on the quantification of the leaf area, MS total of the leaves and the planting density, the IAF was calculated. Genotype C0205 was used only in the first agricultural year.

The analysis of variance, Tukey test and regression for NPK doses were performed in the SISVAR program, version 5.6 [9]. We considered the linear and quadratic regression model between the doses and the evaluated characteristic, and the criterion for choosing the regression model was the equation that resulted in the highest coefficient of determination (R^2)

3.1 RESULTS AND DISCUSSION

Significant interaction between fertilizer doses and potato plant genotypes was observed for LAI data at 45 DAE and light absorbance at 25 DAE in the crop year of 2013/14 (Table 1). Among the genotypes, for the LAI data, a significant difference occurred at 25 and 45 DAE in the agricultural year of 2013/14, and clone C0205 differed statistically with LAI higher than the cultivars Ágata and BRS Camila in both seasons. The plants responded in a quadratic manner to the fertilizer doses for the IAF data at 48 DAE in the agricultural year 2014/15, with the highest IAF dose being 8.5 t ha^{-1}. According to Andriolo et al. [10], the higher the N dose, the greater the leaf area of the plants and the greater the accumulation of nutrients in the leaves.

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It should be given about boron doses or boron uses literature

The plants responded quadratically to fertilizer doses for absorbance data at 28 DAE in the agricultural year 2014/15, and the dose that resulted in the highest absorbance was 4.2 t $ha^{-1.}$ For the other seasons, there was no difference in the response of the plants to the doses (Table 1). Betweem the genotypes for the tuber numbers, a significant difference occurred at 25 DAE in the agricultural year of 2013/14, and clone C0205 did not differ statistically from the cultivar BRS Camila, although both differed statistically

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from the cultivar Ágata, with a value of 28 % bigger For the other epochs it was verified that there were no differences between the genotypes. The number of tubers is dependent on the competition between the stems for resources, especially light conditions, nutrients and water. This characteristic, number of tubers, varies according to cultivar and environmental conditions [11].

Table 1 – Table 1. Leaf area index (LAI) and percentage of light absorption (absorbance) of potato genotypes as a function of the doses (0, 2, 4, 6 t ha^{-1}) of NPK fertilizer 4-14-8 in two collection times at 25 and 45 days after emergence (DAE) of the plants in the agricultural year 2013/14 and at 28 and 48 DAE in the seasson 2014/15.

Tratamentos	IAF				Absorbância (%)			
	2013/14		2014/15		2013/14		2014/15	
	25	45	28	48	25	45	28	48
Genótipos (G)								
Ágata	3,34b[1]	4,13b	2,15	2,17	33,7b	63,2	66,2	62,4
BRS Camila	5,09b	3,46b	1,12	2,11	30,5b	46,3	64,9	47,4
C0205	8,20a	5,55[a]	-[2]	-	53,7a	68,1	-	-
Anova	*[3]	*	ns	ns	*	ns	ns	ns
CV1 (%)[4]	39,5	60,4	80,1	26,7	28,5	20,3	41	18,9
Doses (D)								
0	3,82	3,61	1,97	1,20	39,4	51,2	59,5	58
2	6,99	4,61	1,22	2,05	27,8	54,9	61,9	56,2
4	4,45	4,74	1,66	2,58	48,2	69,7	79,6	48,4
6	6,92	4,55	1,69	3,00	38,7	56,2	68,1	56,9
Regressão	ns	*	ns	**/Q[5]	ns	ns	*/Q	Ns

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CV2 (%)	35,5	34,6	84,8	25,2	34,1	21,7	22,0	38,7
G x D	ns	*	ns	ns	*	ns	ns	ns

*[1] Means followed by the same letter did not differ significantly by the Tukey test at 5% probability; [2] in the second agricultural year the clone C0205 was not used in the experiment; [3] *, ** and ns represent statistical difference at 5% and 1% of probability, and absence of significant statistical difference, respectively; [4] CV_1 and CV_2 indicate the coefficient of variation of plot and subplot, respectively; [5] linear (L) and quadratic (Q) response of potato plants to fertilizer doses.*

Figure 1 (A) shows the behavior of each genotype in relation to LAI as a function of the fertilizer doses at 45 DAE in the agricultural year of 2013/14, in which it is verified that each genotype responded differently to the doses of fertilizer, with the cultivar Ágata presenting a positive quadratic response, with lower LAI at 3.8 t ha^{-1}, the cultivar BRS Camila presents a quadratic negative response, with a higher LAI at the dose of 3.2 t ha^{-1} and clone C0205 presented positive linear response.

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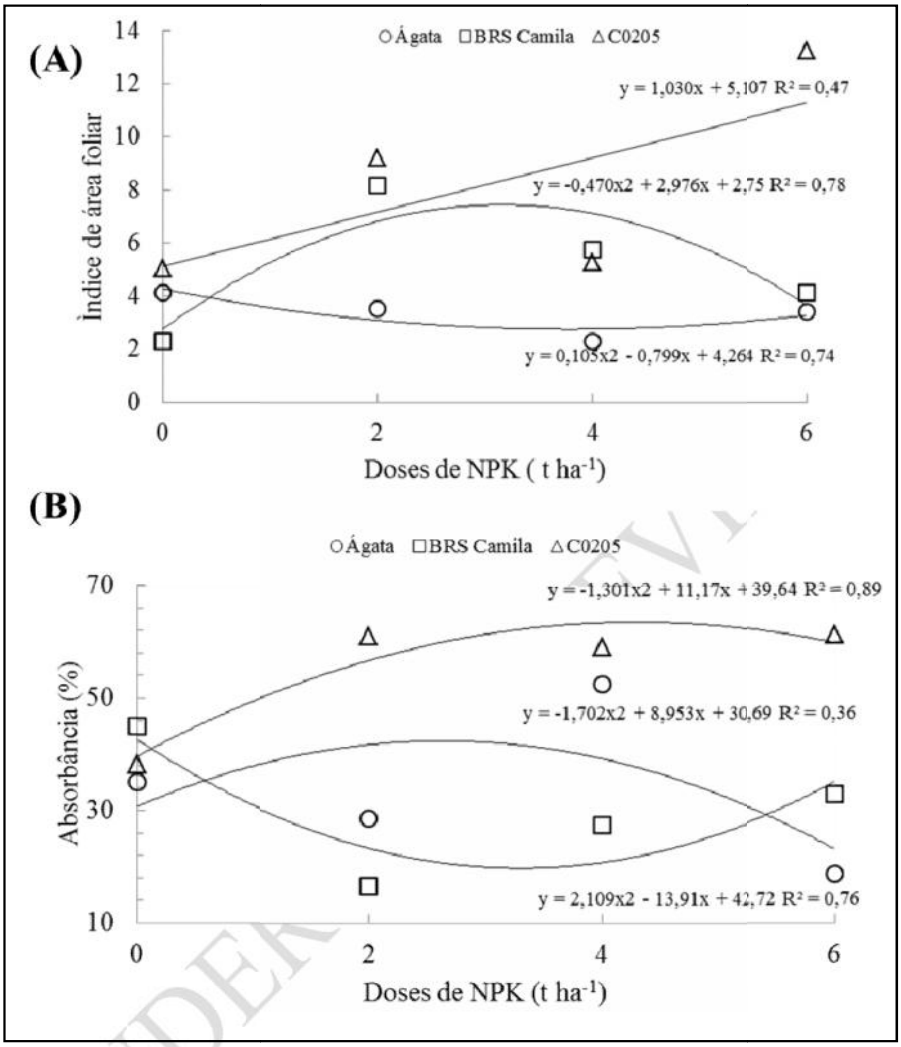

Figure 1. Depletion between doses (0, 2, 4, 6 t ha^{-1}) of NPK fertilizer 4-14-8 and potato plant genotypes: (A) leaf area index at 45 days after emergence in the seasson 2013/14; (B) for absorbance (%) at 25 days after emergence (AED) in the seasson 2013/14.

Figure 1 (B) shows the behavior of each genotype in relation to the absorbance at 25 DAE in the agricultural year of 2013/14. It was verified that each genotype responded differently to fertilizer doses, with clone C0205 and the cultivar Ágata presented a quadratic positive response, with a higher absorbance at the dose of 4.3 and 2,6 t ha^{-1},

respectively, while the cultivar BRS Camila showed a quadratic negative response, with a lower absorbance at the dose of 3,3 t ha^{-1}.

The IAF is an important morphological parameter of the plant [12]. Plants with higher LAI have greater interception of light, which allows, according to Silva et al. [2], that the plant remain for a longer period of time with photosynthetically active leaves.

In addition, the vegetative growth is directly related to the fertilizer doses in the plants, greater availability N, the main nutrient responsible for the vegetative growth. It was observed in Table 2 that there was no significant interaction between fertilizer doses and potato plant genotypes, number of tubers and fresh mass of tubers in both agricultural years.

Table 2. Number of tubers (no pl-1) and fresh mass of tubers (g pl-1) of potato genotypes as a function of the doses (0, 2, 4, 6 t ha-1) of NPK fertilizer 4-14 -8 in two collection seasons at 25 and 45 days after emergence (DAE) of the plants in the seasson 2013/14 and at 28 and 48 DAE in the seasson 2014/15.

	Número de tubérculos (nº pl^{-1})				Massa fresca de tubérculos (g pl^{-1})			
Tratamentos	2013/14		2014/15		2013/14		2014/15	
	25	45	28	48	25	45	28	48
Genótipos (G)								
Ágata	4,98b[1]	8,96	3,92	6,65	23,1c	466,1b	37,3	480,4
BRS Camila	7,19a	8,88	3,25	4,85	127a	539,0a	45,0	438,2
C0205	6,38a	8,33	-[2]	-	76,8b	492,3b	-	-
Anova	*[3]	ns	ns	ns	*	*	ns	ns
CV1(%)[4]	57,1	20,5	22,4	42,2	53,8	38,6	39,1	15,6
Doses (D)								

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0	5,13	6,97	2,46	4,17	47,5	480,9	29,5	329,3
2	7,79	10,5	2,88	5,92	44,1	525,3	33,1	532,3
4	5,74	8,03	4,58	6,38	117,7	514,1	67,5	484,1
6	6,08	9,35	4,42	6,50	93,9	476,2	34,5	544,7
Regressão	*/Q[5]	*/Q	ns	ns	*/Q	*/Q	*/Q	*/Q
CV2 (%)	28,6	23,6	51,8	34,9	60,9	24,7	50,9	30,2
G x D	ns	ns	ns	ns	ns	ns	ns	ns

*[1] Means followed by the same letter did not differ significantly by the Tukey test at 5% probability; [2] in the second agricultural year the clone C0205 was not used in the experiment; [3] *, ** and ns represent statistical difference at 5% and 1% of probability, and absence of significant statistical difference, respectively; [4] CV_1 and CV_2 indicate the coefficient of variation of plot and subplot, respectively; [5] linear (L) and quadratic (Q) response of potato plants to fertilizer doses.*

Between the genotypes for fresh tuber mass data, there was a significant difference at 25 and 45 DAE in the agricultural year of 2013/14, with the cultivar BRS Camila differing from genotypes C0205 and 'Agate' with a 39% to C0205 and 82% higher in relation to 'Agate' at 25 DAE. At 45 DAE 'BRS Camila' differed statistically from the other genotypes with an 11% higher value than clone C0205 and 'Agate' For the other epochs it was verified that there was no difference between the genotypes.

The fact that the cultivar Agate has a lower fresh mass of tubers when compared to clone C0205 can be explained by the higher number of primary stems of 'Agate' when compared to the other genotypes tested, since according to Fernandes et al. [13] cultivars that present larger numbers of stems per area, have a smaller average size of tubers.

The plants responded in a quadratic manner to the fertilizer doses for the number of tubers at 25 and 45 DAE in the seasson 2013/14, and the doses that resulted in a larger

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number of tubers were, respectively, the doses of 3.1 t ha^{-1} and 3.8 t ha^{-1}. For the other epochs it was verified that there was no difference in the number of tubers of the plants in relation to the doses.

The plants responded in a quadratic manner to the fertilizer doses for the data on the fresh mass of tubers at all times for both agricultural years (Table 2), and the doses that resulted in a higher fresh mass of tubers were 7.2 t ha^{-1}, 2,9 t ha^{-1} for the 25 and 45 DAE in the seasson 2013/14. Plants that present higher height, number of nodes and stems and LAI, tend to produce more tubers, and these characteristics are determined according to the genetic potential of plants, as well as the nutrition to which they are submitted.

The increase in the number of tubers is related to the increase of the fresh mass of tubers, in the case of this experiment, the genotypes 'BRS Camila' and C0205 presented greater number of tubers, when compared to 'Agata'. The increase in NPK doses results in higher tubercle production, as well as in fresh mass [13].

This increase in NPK dose increases the fresh mass of tubers because of the higher LAI of the plants, and plants with higher LAI tend to intercept more solar radiation, so that it may result in a greater amount of fresh mass of tubers, since increase in the availability of N, promotes the growth and increase of the photosynthesizing area and increased photoassimilates production, which are translocated and stored in the tuber [6].

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4.1 CONCLUSION

The genotypes responded to NPK fertilizer doses 4-14-8 for LAI, and clone C0205 presented the best results in the first agricultural year.

Comment [F11]: In material method, there are boron doses, NPK only one (4-14-8) , what does it mean! Not clear.
In material method part shoul dbe detail explained.

The genotypes responded to the light absorption percentage, with C0205 presenting the best results, so that plants with greater leaf area presented greater light absorption in the agricultural year of 2013/14.

The above results resulted in a higher number of tubers and fresh mass of tubers for the C0205 genotype.

Comment [F12]: the characteristics of clones and varieties should be well defined in material method. Otherwise this difference may be caused by the klon/varieties or genotype. Could you detail explained , please.

Comment [F13]: Not adeguate. there are need to add new literature

REFERENCES

1. Camargo Filho WP, Camargo FP. Produção de batata no Brasil, 1990-2007: evolução, distribuição regional de safras. Horticultura Brasileira, 2008,(26):1024-1026.
2. Silva F L, Pinto CABR, Alves JD, Benites FR. G.; Andrade CM, Rodrigues GB, Lepre AL, Bhering LL. Caracterização morfofisiológica de clones precoces e tardios de batata visando a adaptação a condições tropicais. Bragantina, 2009(68)295- 302. DOI:10.1590/S0006-87052009000200002
3. Eschemback, V. Crescimento, desenvolvimento e produtividade de cultivares modernas e antigas de batata em diferentes ambientes. Dissertation (Mestrado). UNICENTRO. Guarapuava-PR, Brazil, 2014,55 p.
4. Feltran JC, Lemos LB. Características agronômicas e distúrbios fisiológicos em cultivares de batata. Cientifica, 2005,(33)106 – 113 DOI:10.15361/1984-5529.2005v33n1p106-113
5. Silva GO, Pereira AS, Suinaga FA, Ponijaleki, R. Qualidade da pele e produtividade de tubérculos de batata BRS Clara. Horticultura Brasileira, 2013,(31)613-617 DOI:10.1590/S0102-05362013000400017
6. Cardoso AD. Produtividade e qualidade de tubérculos de batata sob diferentes doses e parcelamentos de nitrogênio e potássio. Tese (PhD). Universidade Federal de Lavras, UFLA, 2010,109 p.

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7. Fernandes AM, Soratto RP, Silva BL. Extração e exportação de nutrientes em genótipos de batata: I - macronutrientes. Revista Brasileira de Ciências do Solo, 2011,35(6), 2039-2056. DOI:10.1590/S0100-06832011000600020

8. Nobile FO, Prado RM, Spadoni TB. Adubação nitrogenada e critérios de amostragem foliar para a cultura da batata. Comunicata Scientiae, 2012,(3)23-29. Available at: <http://hdl.handle.net/11449/73441>

9. Ferreira D F. Sisvar, version 5.6. Universidade Federal de Lavras, Lavras; 2010.

10. Andriolo GL, Bisognin DA, De Paula AL, De Paula FLM, Godoi, RS, Barros GT. Curva crítica de diluição de nitrogênio da cultivar Asterix de batata. Pesquisa Agropecuária Brasileira,2006(41)1179-1184. DOI:10.1590/S0100-204X2006000700015

11. Souza ZS. In: Ecofisiologia. O cultivo da batata na Região Sul do Brasil. Pereira AS, Daniels J. Brasília: Embrapa Informação Tecnológica, 2003,84-104.

12. Busato C, Fontes PCR, Braun H, Busato CCM. Estimativa da área foliar da batateira, cultivar Atlantic, utilizando dimensões lineares. Ciência Agronômica, 2010(41)702-708.

13. Fernandes AM, Soratto RP, Silva BL, Schlick, GDS. Crescimento, acúmulo e distribuição de matéria seca em cultivares de batata da safra de inverno. Pesquisa Agropecuária Brasileira, 2010(45)826-835. DOI:10.1590/S0100-204X2010000800008

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