DOI: 10.4025/actasciagron.v33i4.10918

Morphological attributes and production components of potato cv. Baronesa and its transformed genotype

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ABSTRACT. The aim of this paper was to compare the morphological attributes and production components of the wild-type Baronesa cultivar potato with those of Baronesa potato plants that have been genetically modified using the potato virus Y coat protein (CP) gene. The experiment was conducted under greenhouse conditions (Biosecurity Quality Certificate no. 081/98 issued by the National Biosecurity Technical Committee) at the Federal University of Pelotas (UFPel), Pelotas-RS. The shoot and root lengths and the mean leaf number were determined six times at 14-day intervals after sowing; the length, width and fresh weight of the tubers were measured during the last harvest, which occurred 84 days after sowing. There were no statistical differences between the two genotypes with respect to morphological attributes or production components.

Keywords: *Solanum tuberosum*, genetic modification, virus resistance.

RESUMO. Atributos morfológicos e componentes de produção de batata, cv. Baronesa e seu genótipo transformado. Plantas de batata, cv. Baronesa, resistentes ao PVY foram obtidas mediante transformação genética com gene que codifica para a proteína do capsídeo do vírus. O presente trabalho teve por objetivo comparar os atributos morfológicos e os componentes de produção da cv. Baronesa e de suas plantas geneticamente modificadas, em condições de casa de vegetação. Desse modo, a altura da parte aérea, comprimento da raiz e número médio de folhas foram determinados em seis épocas a intervalos regulares de 14 dias após o plantio, enquanto, volume, comprimento, largura e massa fresca dos tubérculos foram medidos na colheita final, aos 84 dias após o plantio. Não houve diferenças estatísticas significativas entre os dois genótipos, no que concerne aos atributos morfológicos e nem nos componentes de produção.

Palavras-chave: *Solanum tuberosum*, transformação genética, resistência a vírus.

Introduction

Tuber-seed production systems in Brazil face many obstacles, primarily with respect to low multiplication rates and reduced quality of the plant material. In addition, potato crops make use of low quality phytosanitary tuber-seeds, and this is the main factor contributing to the low productivity (MEDEIROS et al., 2002). Additionally, vegetative multiplication facilitates fungal, bacterial and viral diseases, causing great production loss (FORTES; PEREIRA, 2003).

In Brazil, potato virosis control is difficult due to the absence of severe winters, and the mild climate favors the reproduction of the aphid vector all year, especially during the potato crop season (DANIELS; PEREIRA, 2004). No region or season is free from the aphid vector, and control by insecticides is, in addition to being, as a rule, ineffective for virosis control (mainly for Potato Virus Y or PVY), harmful to the environment; for this reason, other strategies are currently being researched (DANIELS; PEREIRA, 2004).

Thus, the development of new tuber-seed production methods that can help overcome these problems is essential. Research on the genetic modification of different potato cultivars aiming to increase disease resistance and to improve the nutritional and industrial quality has been described in several papers (ANDERSSON et al., 2003; CRAIG et al., 2005; FIGUEIRA FILHO et al., 1994; LÓPEZ; CHAPARRO, 2007; ROMANO et al., 2001; TORRES et al., 2000).

PVY-resistant potato plants derived from the Baronesa cultivar were obtained by genetic transformation in 1995 via Agrobacterium, and the presence of the PVY pBI plasmid containing the gene encoding the Y virus capsid protein (CP) was confirmed in these plants by means of PCR, bioassay and ELISA techniques (POHL et al., 2009).

Morphophysiological indexes such as leaf area and plant height complement plant growth quantitative analysis and enable the determination of the effects of the use of different crop management techniques (CARDOSO et al., 2007; LUCCHESI, 1984; MESQUITA et al., 2007; VIEIRA et al., 2008).

This study aimed to evaluate the morphological attributes and production components of the wild-type potato cv. Baronesa (*Solanum tuberosum* L.) and of genetically modified Baronesa plants expressing the PVY resistance gene.

Material and methods

The experiment was conducted under greenhouse conditions (Biosecurity Quality Certificate n. 081/98 issued by the National Biosecurity Technical Committee) at the Federal University of Pelotas (UFPel), Pelotas, Rio Grande do Sul State, located at 31º 52' 05" S and 52º 21' 24" W. The experiment was conducted from September to November of 2010. Control and genetically modified tubercles (lineage 112P) expressing PVY-resistance genes (POHL et al., 2009) of the Baronesa cultivar were used. For each genotype, three tubercles were planted in 8-L vases that contained substrate (Polimix brand) enriched with 10 g of 4-11-9 fertilizer with micronutrients. After plant emergence, thinning was performed, and only one plant with only one stem was left in each vase. The plants were kept in the greenhouse at a relative humidity of 75-80% and a temperature between 23-28ºC until the end of the experiment.

The shoot height, root length and leaflet number were determined. At each harvest, the plants were separated into shoots and roots, and the root system was washed to eliminate any adherent substrate. The shoot height was measured from the base to the stem apex, and the root length was determined from the stem base to the root apex. These measurements were done using a millimeter ruler, and the results are expressed in meters.

The potato tubercles were harvested 84 days after sowing (DAS), and the number of tubers per plant, tuber length and width, fresh mass of the tuber (g plant^{-1}) and fresh mass of tubercles per area (kg m^{-2}) was determined. The density was taken to be four plants m^{-2}.

The experimental design was completely randomized in a factorial plan (2 x 6) made up of two genotypes (Baronesa and Baronesa Transformed) and six harvests, with three replications, being each represented by a vase containing one plant. The collections were done six times at regular 14-day intervals, and each collection consisted of three plants for each genotype (Control and Transformed).

The parameters were adjusted using orthogonal polynomials. For the production components, an experimental and entirely randomized design comparing genotypes at the end of the plant cycle (84 DAS) was used, and variance analysis and the genotype means were compared by the Tukey test ($p \leq 0.05$).

Results and discussion

Potato plant Baronesa cultivar shoot height followed a quadratic tendency during its development cycle for both genotypes, with high determination coefficients for Baronesa cv. ($R^2 = 0.99$) and Baronesa Transformed ($R^2 = 0.98$) (Figure 1). The data obtained confirmed the morphological characteristics of Baronesa cv. as a low-to-medium sized plant (PEREIRA et al., 2003), reaching a 0.53 m stem height at 60 days after sowing (DAS) for Control and 0.50 m for Transformed plants at 56 DAS. Studies conducted with Ágata and Achat potato cultivars showed that these plants reach a maximum shoot height at 50 DAS (MELO et al., 2003; PAULA, 1986), that is, ten days before the maximum height observed in this experiment.

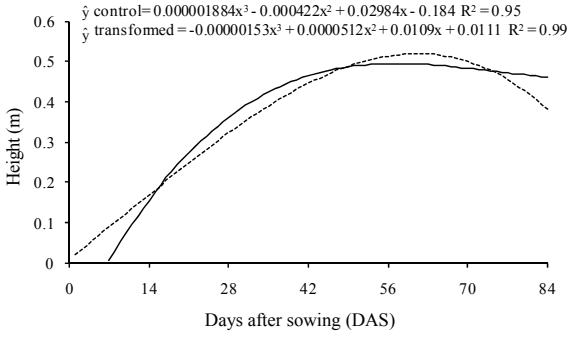

Figure 1. Baronesa cv. shoot height, according to plant ontogeny. Control (——) and Transformed (-----).

Root length also followed a quadratic tendency during the development cycle for both genotypes, with high $R^2 = 0.99$ (Baronesa) and $R^2 = 0.98$ (Baronesa Transformed) determination coefficients. Maximum values were 0.30 and 0.29 m for Control and Transformed plants, respectively, and the maximum vales were reached at 56 DAS (Figure 2). The similarity of results for the "control" and the "transformed" plants of cv. Baronesa was due to exposure of the plants to the same culture conditions, such as irrigation, soil and temperature, and these results indicate that the insertion of the

coat protein gene of the virus did not alter the behavior of the roots. According Sattelmacher et al. (1990) and Rahman et al. (2008), the root length of potato plants is dependent on the genotype, soil nutritional levels and environmental stresses such as salinity.

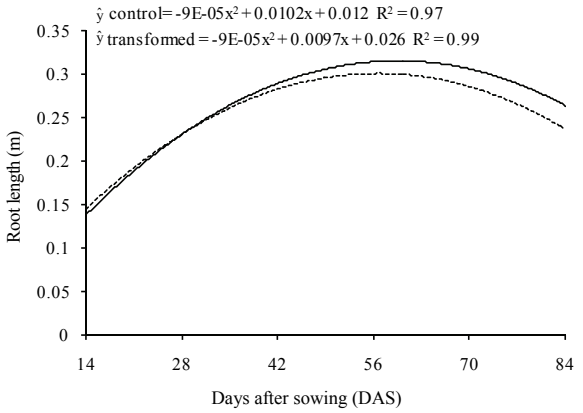

Figure 2. Baronesa cv. root length, according to plant ontogeny. Control (——) and Transformed (-----).

The number of leaflets followed a cubic tendency during the plant development cycle for both genotypes (Figure 3), with determination coefficients of 0.88 (Baronesa) and 0.99 (Baronesa Transformed). The maximum leaflet number was reached at 60 DAS, with values of 439 and 364 for Control and Transformed, respectively. Thus, Baronesa Transformed plants showed a smaller maximum number of leaflets than the non-transformed Baronesa cv. After these values were reached, there was a progressive decrease due a leaf senescence process, which reduced the number of leaves. Similarly, potato Ágata cv. reached the maximum number of leaves at 70 DAS, decreasing afterwards (MELO et al., 2003).

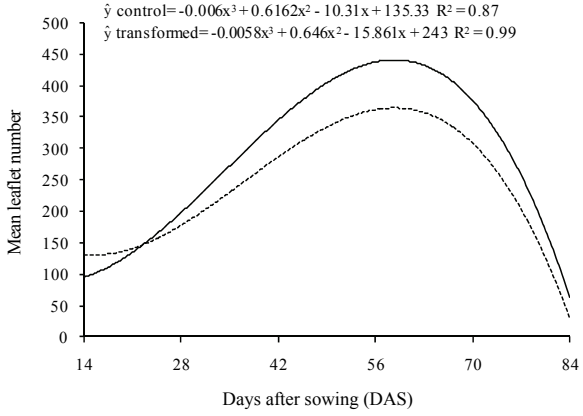

Figure 3. Baronesa cv. mean leaflet number, according to plant ontogeny. Control (——) and Transformed (-----).

With reference to the production components (Table 1), significant differences between genotypes with respect to the mean number, the width and length of tubers, and the fresh tuber mass, were not found. Studies by Bacarin et al. (2008) and Pohl et al. (2009) using the same cultivar and its transformed genotype did not reveal any significant differences between the two plant types with respect to the chlorophyll fluorescence parameters, the liquid photosynthesis rate and the growth patterns (total dry mass, dry mass production rate, relative growth rate, leaf area, leaf area growth rate, net assimilation rate, leaf area ratio, leaf weight ratio and specific leaf area).

Table 1. Baronesa production components and its transformed genotype as determined 84 days after sowing (DAS).

Production Components	Genotype	
	Baronesa Control	Baronesa Transformed
Tuber number per plant	10.33 A	6.33 A
Tuber mean width (mm)	30.94 A	35.55 A
Tuber mean length (mm)	50.29 A	68.41 A
Tuber fresh mass per plant (g plant^{-1})	114.06 A	130.54 A
Tuber fresh mass per area (kg m^{-2})	10.90 A	12.47 A

*Means followed by the same letter in each line did not show differences from one another by the Tukey test, with a 5% error margin.

Conclusion

Genetically modified potato cv. Baronesa plants expressing the PVY CP-gene do not have morphological attributes or tuber production characteristics that differ from those of the wild-type cultivar, indicating that the introduction of the virus protective cape capsid gene does not alter other characteristics in the original genotype.

Acknowledgements

We wish to thank Capes for financial support.

References

ANDERSSON, M.; TRIFONOVA, A.; ANDERSSON, A.; JOHANSSON, M.; BULOW, L.; HOFVANDER, P. A novel selection system for potato transformation using a mutated AHAS gene. **Plant Cell Reports**, v. 22, n. 4, p. 261-267, 2003.

BACARIN, M. A.; SCHIMITZ, D. D.; FALQUETO, A. R.; CASSOL, D.; TORRES, A. C.; PETERS, J. A.; BRAGA, E. J. B. Características fotossintéticas de batata, cv. Baronesa e seu genótipo transformado geneticamente para resistência ao PVY. **Horticultura Brasileira**, v. 26, n. 3, p. 383-387, 2008.

CARDOSO, A. D.; ALVARENGA, M. A. R.; MELO, T. L.; VIANA, A. E. S. Produtividade e qualidade de tubérculos de batata em função de doses e parcelamentos de nitrogênio e potássio. **Ciência e Agrotecnologia**, v. 31, n. 6, p. 1729-1736, 2007.

CRAIG, W.; GARGANO, D.; SCOTT, N.; NGUYEN, T. T.; LAO, N. T.; KAVANAGH, T. A.; DIX, P. J.; CARDI, T. Direct gena transfer in potato: A comparison of particle bombardment of leaf explants and PEG-mediated transformation of protoplasts. **Plant Cell Reports**, v. 24, n. 10, p. 603-611, 2005.

DANIELS, J.; PEREIRA, A. S. Resistência de genótipos de batata ao vírus do enrolamento da folha da batata (PLRV) e ao vírus Y (PVY). **Horticultura Brasileira**, v. 22, n. 3, p. 521-524, 2004.

FIGUEIRA FILHO, E. S.; FIGUEIREDO, L. F. A.; MONTE-NESHICH, D. C. Transformation of potato (*Solanum tuberosum*) cv. Mantiqueira using *Agrobacterium tumefaciens* and evaluation of herbicide resistance. **Plant Cell Reports**, v. 13, n. 12, p. 666-670, 1994.

FORTES, G. R. L.; PEREIRA, J. E. S. Batata-semente pré-básica. Cultura de tecidos. In: PEREIRA, A. S.; DANIELS, J. (Ed.). **O cultivo da batata na região sul do Brasil**, Brasília: Embrapa Informação Tecnológica, 2003. p. 421-433.

LÓPEZ, A.; CHAPARRO, A. Propuesta de un sistema de transformación de plantas de papa (*Solanum tuberosum* sp. *andigena* var. Pastusa suprema) mediado por *Agrobacterium tumefaciens*. **Agronomía Colombiana**, v. 25, n. 1 , p. 16-25, 2007.

LUCCHESI, A. A. Utilização prática da análise de crescimento vegetal. **Anais da Escola Superior de Agricultura Luiz de Queiroz**, v. 41, n. 1, p. 181-201, 1984.

MEDEIROS, C. A. B.; ZIEMER, A. H.; DANIELS, J.; PEREIRA, A. S. Produção de sementes pré-básicas de batata em sistemas hidropônicos. **Horticultura Brasileira**, v. 20, n. 1, p. 110-114, 2002.

MELO, P. C. T.; GRANJA, N. P.; MIRANDA FILHO, H. S.; SUGAWARA, A. C.; OLIVEIRA, R. F. Análise do crescimento da cultivar Ágata. **Batata Show**, v. 3, n. 8, p. 16-17, 2003.

MESQUITA, H. A.; ALVARENGA, M. A. R.; PAULA, M. B.; CARVALHO, J. G.; NÓBREGA, J. C. A. Produção e qualidade da batata em resposta ao boro. **Ciência e Agrotecnologia**, v. 31, n. 2, p. 385-392, 2007.

PAULA, M. B. Produção de matéria seca e absorção de macronutrientes por cultivares de batata. **Horticultura Brasileira**, v. 4, n. 1, p. 10-16, 1986.

PEREIRA, A. S.; SOUZA, Z. S.; CHOER, E. Principais cultivares. In: PEREIRA, A. S.; DANIELS, J. (Org.). **O cultivo da batata na região sul do Brasil**. 1. ed. Brasília: Embrapa Informação Tecnológica, 2003. p. 143-153.

POHL, S.; LOPES, N. F.; BRAGA, E. J. B.; SILVA, C. P.; SILVA, F. S. P.; PETERS, J. A. Características de crescimento de plantas de batata, cv. Baronesa e seu genótipo transformado geneticamente para resistência ao PVY. **Revista Ceres**, v. 56, n. 5, p. 736 743, 2009.

RAHMAN, M. H.; ISLAM, R.; HOSSAIN, M.; HAIDER, S. A. Differential response of potato under sodium chloride stress conditions *in vitro*. **Journal of Bio-Science**, v.16, p. 79-83, 2008.

ROMANO, A.; RAEMAKERS, K.; VISSER, R.; MOOIBROEK, H. Transformation of potato (*Solanum tuberosum*) using particle bombardment. **Plant Cell Reports**, v. 20, n. 3, p. 198-204, 2001.

SATTELMACHER, B.; KLOTZ, F.; MARSCHNER, H. Influence of the nitrogen level on root growth and morphology of two potato varieties differing in nitrogen acquisition. **Plant and Soil**, v. 123, n. 2, p. 131-137, 1990.

TORRES, A. C.; FERREIRA, A. T.; ROMANO, E.; CATTONY, M. K.; NASCIMENTO, A. S. Transformação genética da batata cultivar Achat via *Agrobacterium tumefaciens*. **Horticultura Brasileira**, v. 18, n. 1, p. 41-45, 2000.

VIEIRA, N. M. B.; ANDRADE, M. J. B.; CARVALHO, J. G.; JUNIOR, J. A.; MORAIS, A. R. Altura de planta e acúmulo de matéria seca do feijoeiro cvs. BRS MG Talismã e Ouro Negro em plantio direto e convencional. **Ciência e Agrotecnologia**, v. 32, n. 6, p. 1687-1693, 2008.

Received on August 17, 2010.
Accepted on November 27, 2010.