Comunicata Scientiae
Horticultural Journal

ORIGINAL ARTICLE
published: 31 May 2024
https://doi.org/10.14295/CS.v15.3674

Growth and yield of Brazilian potato cultivars

Emerson Andrei Lenz[1], Arione da Silva Pereira[2]*, Carlos Reisser Junior[2], Santiago Vianna Cuadra[2], Fernanda Quintanilha Azevedo[2], Giovani Olegário da Silva[3], Francieli Fátima Cima[1], Tuane Araldi da Silva[1], Daiana Döring Wolter[1]

[1]Universidade Federal de Pelotas, Pelotas, RS, Brasil
[2]Empresa Brasileira de Pesquisa Agropecuária - Embrapa Clima Temperado, Pelotas, RS, Brasil
[3]Empresa Brasileira de Pesquisa Agropecuária - Embrapa Hortaliças, Brasília, DF, Brasil
*Corresponding author, e-mail: arione.pereira@embrapa.br

Abstract

The analysis of plant growth of cultivars is useful for understanding the dynamics of accumulation and partition of photoassimilates during the crop cycle, and this information is important for the crop management of each cultivar. The objective of this study was to evaluate potato cultivars BRS Ana, BRSIPR Bel, BRS Clara, BRS F63 (Camila) and Macaca for growth and yield, under subtropical climatic conditions of Southern Brazil. Plant samples were collected every 20 days, beginning 40 days after planting (DAP), totaling five collections, and physiological growth indexes and the dry mass partitioning to plant organs were estimated. 'BRSIPR Bel' showed the fastest development of assimilatory system. 'BRS Ana' had the most vigorous plants and the largest leaf area, reaching the leaf area index 4.0 at 70 DAP. 'BRSIPR Bel' e 'BRS Ana' had the highest dry mass yield, 214 g and 206 g of dry mass plant^{-1}, respectively. 'BRS F63' (Camila) and 'BRSIPR Bel' presented earlier tuberization and were the most efficient cultivars in the partitioning of dry mass to tubers, with the highest coefficient of dry mass partitioning to tubers estimated between 40 and 64 DAP. These two cultivars also showed the highest yield of marketable tubers.

Keywords: dry mass, growth curve, leaf area, *Solanum tuberosum L.*, tuber yield

Introduction

The potato (*Solanum tuberosum* L.) is a staple food with high yield potential and excellent nutritional characteristics (Lutaladio & Castaldi, 2009; Teagasc, 2020). Considering as a food crop for human consumption, it is the third main crop, after wheat and rice (CIP, 2020). In Brazil, it is both an important cash crop for the agrobusiness as well as food security for many small farmers (IBGE, 2024).

Potato yields are lower under in tropical and subtropical climates compared to temperate climates, because the shorter photoperiods and higher temperatures (EMBRAPA, 2020). In breeding for these conditions, it has been proposed to select genotypes with early tuberization and longer cycle (Rodrigues et al., 2009; Lyra et al., 2015).

Plant growth can be defined as an irreversible increase in mass, size or volume, and is the result of jointed action of genetic, hormonal and environmental factors (Peixoto et al., 2011). The amount of radiation intercepted by plants is one of the main factors for dry mass production (Allen & Scott, 1980). However, the increase in leaf area beyond the optimal level of solar radiation interception by the crop will not result in greater capture of solar energy (Camargo et al., 2015). In addition to the efficient conversion into photosynthetic products, its partition to the organs of economic importance is also a determining factor of yield differences among genotypes (Timlin et al., 2006; Castellanos et al., 2010; Oliveira et al., 2016).

The quantitative analysis of plant growth is a useful and accessible tool, which can help explain yield differences, being used in several crops, such as potato (Fernandes et al., 2010), rice (Alvarez et al., 2012), pepper (Pedó et al., 2013), and sweet potato (Conceição et al., 2005). This technique consists of measuring, at regular intervals, biomass accumulation, morphological and

Received: 26 November 2020
Accepted: 06 March 2024

physiological properties, for establishing mathematical relationships to quantify plant production through physiological growth index (Peixoto et al., 2011; Lopes & Lima, 2015). Thus, allowing to evaluate the growth and partition of assimilates to the organs of the plant.

The knowledge of the dynamics of growth and partition of photoassimilates, including under the soil, is important to help determine the best spacing between plants, the best stages of development to perform the cultural practices, such as time of earthing up, side dressing application, phytosanitary control, and topkilling (Silva et al., 2020).

The objective of this study was to evaluate the growth and yield of five Brazilian potato cultivars, under low-altitude subtropical climate conditions of extreme South of Brazil.

Material and Methods

Five potato cultivars developed by the Embrapa's Breeding Program were analyzed, which have the following characteristics: 'Macaca', early maturity (85 to 90 days), low vigor plants, upright growth habit, and tubers with medium-low dry mass content (Pereira et al., 2003); 'BRS Ana', late maturity (110 to 120 days), vigorous plants, upright growth habit, and tubers with medium dry mass content (Pereira et al., 2010); 'BRS Clara', medium maturity (100 to 105 days), semi-upright plant growth habit, medium size, and tubers with medium dry mass content (Pereira et al., 2013); 'BRSIPR Bel', medium maturity (110 days), semi-upright plant growth habit, medium size, and tubers with medium to high dry mass content; 'BRS F63' (Camila), medium maturity (100 to 105 days), medium vigorous plants and semi-upright growth habit, and tubers with medium dry mass content (Pereira et al., 2018). 'BRSIPR Bel' was developed in partnership with the Agronomic Institute of Paraná.

The experimental design was a randomized complete blocks, with four replications. Plots consisted of 30 plants, spaced 0.75m between rows and 0.30 m within row. The experiment was conducted during the fall season, from 02 March to 29 June 2016, in the experimental field of Embrapa Temperate Agriculture, in Pelotas, RS, Brazil (31°41' S, 52º26' O, 60 m a.s.l.). The climate of the region, according to Koppen classification, is subtropical humid *cfa* type, without defined dry season and with hot summers.

The soil of the field is classified as Eutrophic Red-Yellow Argisol. The chemical analysis of the arable layer (0-20 cm) prior to planting resulted in: pH (H_2O)= 5.6; SMP index= 6.4; clay= 18%; organic matter= 1.4% (m/v); K= 113 mg dm^{-3}; P= 25.6 mg dm^{-3}; Al= 0.0 $cmol_c$ dm^{-3}; Ca= 2.2 $cmol_c$ dm^{-3}; Mg= 1.1 $cmol_c$ dm^{-3}.

As the base fertilization, 2.300 kg ha^{-1} of the commercial formula 5-20-10 of N-P_2O_5-K_2O was applied in the planting furrow. And, side-dressing at the time of earthing up, 29 days after planting (DAP), 100 kg ha^{-1} of urea (N= 46%).

Type II and category G1 seeds were used, which had been stored for eight months in a cold chamber (3.5±0.5°C), with the exception of seeds of 'Macaca', which has short dormancy and quick sprouting (Pereira et al., 2003). Seed tubers of this cultivar were stored in a cold chamber for three months and dipped in a 5ppm gibberellic acid solution, left to dry in the shade and muffled for one week before planting.

The experiment was carried out under rainfed conditions. The total rainfall over the experimental period was 843 mm. Other cultural and phytosanitary practices followed the recommendations of the region.

Samples of three plants per plot were collected every 20 days, starting 40 DAP, totaling five collections. In each collection, the first plant of the row was discarded to simulate the surround effect. Plants of each sample were separated into leaves, stems and tubers.

The dry mass content (DM) was measured in leaves and stems using the whole sample; and tubers using a subsample of 40 g of three medium-sized tubers. The samples were placed in a forced air circulation greenhouse at a temperature of 65±5°C up to constant weight.

The primary data of plant dry mass, plant fresh mass (FTM) and tuber dry mass (TDM) were submitted to regression analysis, based on the means of each collection to correct the natural variability existing among plants (Elias & Causton, 1976). Because the data did not meet the ANOVA assumptions and they were quantitative, physiological indexes were estimated through the trend of adjusted curves (Dias & Barros, 2009).

To represent tuber growth, the primary data of tuber dry mass were adjusted by the same model. The absolute plant growth rate (AGR), in plant g^{-1} d^{-1}, and the TDM production rate, in plant g^{-1} d^{-1}, were determined by the first derivative of the respective plant and tuber growth equations.

Leaf area measurement was performed with the electronic leaf area meter (Li-3000, Licor Inc., Lincoln, NE, USA), and the leaf area index (LAI) was obtained by the ratio between leaf area and area occupied by plants. The leaf area ratio (LAR), in cm^2 g^{-1}, was obtained through the ratio between leaf area and plant dry mass. The leaf area specific (LAS), in cm^2 g^{-1}, was by the ratio between leaf area and leaf dry mass (LDM). The LM ratio, in g g^{-1}, was through the ratio between LDM and total DM.

The percentage of DM in the plant organs was obtained through the ratio between the DM of each plant component (stems, leaves and tubers) and the total DM, multiplied by 100.

The DM partition coefficient for the tubers was obtained by the ratio between the DMT production rate and the absolute growth rate of the plant.

Productivity was determined considering nine plants per replication, collected at 120 DAP.

The data were submitted to analysis of variance and means compared by the Tukey test, at 5% probability of the error.

Results and Discussion

Plants of 'BRSIPR Bel' were the first to emerge, 15 days after planting (DAP), followed by 'BRS Ana', 'BRS F63' (Camila), 'BRS Clara', and 'Macaca', at 18, 19, 20, and 22 DAP, respectively.

The adjustment of the logistic model to the primary data of dry mass (DM), which represents the growth of annual species (Lopes & Lima, 2015), was obtained with a high coefficient of determination (R^2 ≥0.91), for all five cultivars (**Figure 1**). 'BRSIPR Bel' and 'BRS Ana' produced 214 g and 206 g DM $plant^{-1}$, respectively; 'BRS Clara', 180g DM $plant^{-1}$; and 'BRS F63' (Camila) and Macaca, 135 g and 105 g DM $plant^{-1}$, respectively. In general, DM production was higher in cultivars known to be later, and lower in earlier cultivars. The relationship between DM production and cycle corroborates reports that long-cycled genotypes have higher yield (Rodrigues et al., 2009; Lyra et al., 2015).

As for the absolute growth rate (AGR), the maximum was reached early (53 DAP) by 'BRS Clara' (4.61 g DM $plant^{-1}$ d^{-1}), as well as 'BRS F63 (Camila)', compared to other cultivars, but with a duration shorter than the maximum AGR of 'BRSIPR Bel' and 'BRS Ana', which maintained a high production for a longer period of time (Figure 1f). 'BRS F63' (Camila) reached a maximum AGR of 2.90 g DM $plant^{-1}$ d^{-1}, while 'Macaca' had the lowest Maximum TCA, 2.15 g MS $plant^{-1}$ d^{-1}. AGR has three important aspects in deafferenting genotypes: 1) the period that the cultivars take to reach the maximum point of AGR, 2) the maximum AGR value, and 3) the maximum duration of AGR.

Regarding the leaf area index (LAI), 'BRS Ana' reached LAI 4.0 at 70 DAP, followed by 'BRSIPR Bel' and 'BRS Clara', which reached a maximum LAI of 3.5 earlier (60 DAP) (**Figure 2**a). 'Macaca' and 'BRS F63' (Camila) reached LAI of 2.3 and 1.8 cm² cm^{-2}, respectively. The

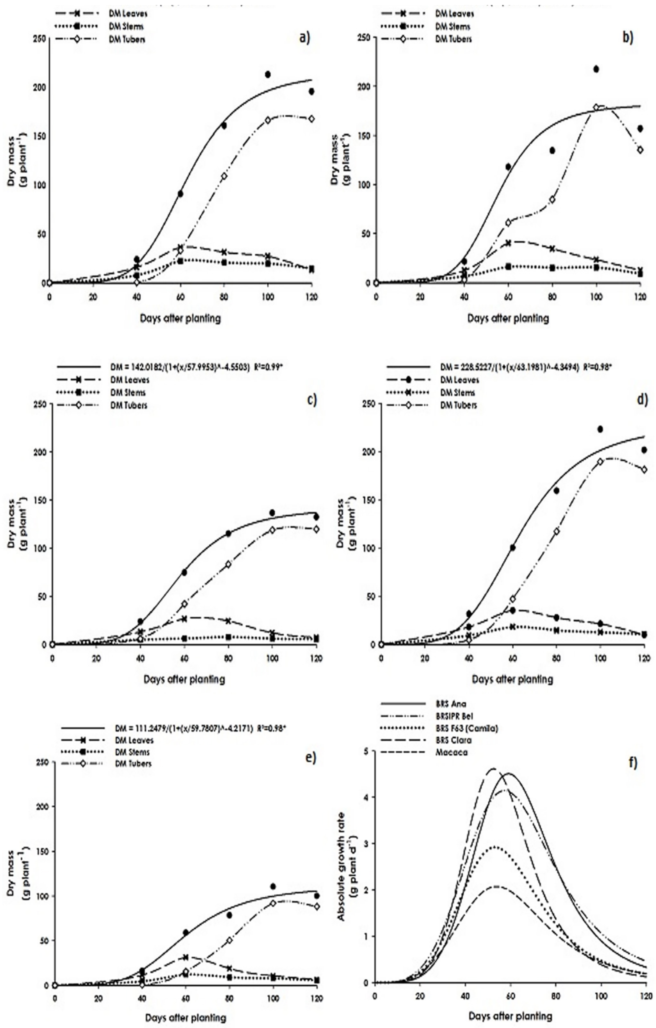

Figure 1. Dry mass accumulation in potato cultivars a) BRS Ana, b) BRS Clara, c) BRS F63 (Camila), d) BRSIPR Bel, e) Macaca; f) Absolute growth rate of potato cultivars. Embrapa, Pelotas, RS, Brazil, 2020.

reduction in LAI can be attributed to senescence and leaf abscission, prioritized in the partitioning of assimilates to tubers, and to the occurrence of *Phytophthora infestans* (Mont.) de Barry at the end of the cycle. 'BRS Clara', classified as resistant to late blight, had the lowest reduction in LAI in the final third of the cycle, followed by 'BRS F63' (Camila), moderately resistant, and 'BRS Ana', moderately susceptible and with a long vegetative cycle.

Regarding the leaf area ratio (LAR), the highest values observed at 40 DAP can be attributed to high photosynthetic capacity and a low respiratory cost, when a large number of leaves were exposed to solar energy capture (Figure 2b). From there, the LAR showed a downward trend due to the self-shading of the leaves and the growth of the tubers. Similar behavior has been reported for other solanaceous crops (Castellanos et al., 2010; Aumonde et al., 2013; Pedó et al., 2015). 'BRS F63' (Camila), despite the smaller leaf area, presents a higher efficiency in the use of radiation. On the other hand, 'BRS

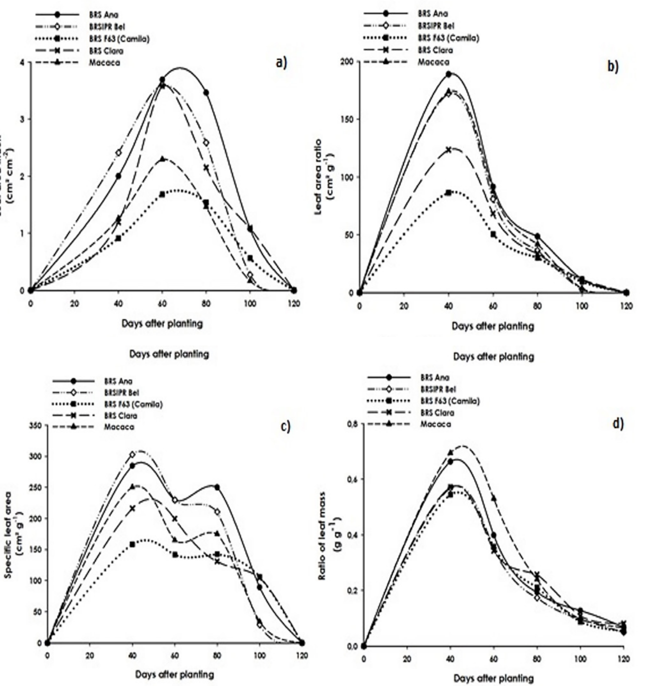

Figure 2. a) Leaf area index; b) Leaf area ratio; c) Specific leaf area; d) Ratio of leaf mass of potato cultivars. Embrapa, Pelotas, RS, Brazil, 2020.

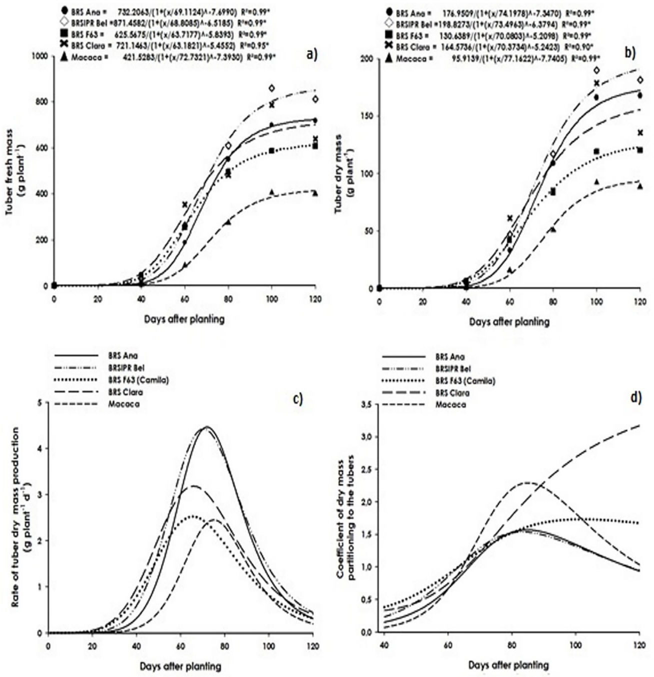

Figure 3. a) Tuber fresh mass; b) Tuber dry mass; c) Rate of tuber dry mass production; d) Coefficient of dry mass partitioning to the tubers in potato cultivars. Embrapa, Pelotas, RS, Brazil, 2020.

Ana' had high LAR values, but due to leaf shading in the lower part of the plant, not all photosynthetic equipment contributed effectively to production. According to Camargo et al. (2016), there is a positive linear correlation between the size of the photosynthetic device and the absorption of light energy, but up to LAI 3.0.

Regarding the specific leaf area (SLA), it was higher in 'BRS Ana', followed by 'BRSIPR Bel' and 'Macaca', suggesting that the leaves of these cultivars are thin (Figure 2c).

As for the leaf mass ratio (LRM), it was lower in 'BRS F63' (Camila) at 40 DAP, indicating precocity in the export of assimilated leaves to other organs of the plant (Figure 2d). 'BRSIPR Bel' and 'BRS Clara' were intermediate in LRM, while 'Macaca' and 'BRS Ana' showed priority of vegetative development for a longer period of time.

The productivity of tuber fresh mass (TFM) and the accumulation of tuber dry mass (TDM) of the cultivars are represented in **Figures 3**a and 3b, respectively. The adjustment of the logistic model data was obtained with a high coefficient of determination (≥90%), for all five cultivars and for both parameters. 'BRSIPR Bel' had the highest production of TFM at the end of the cycle (189 g plant-1), followed by 'BRS Ana' (176 g plant-1), indicating high production potential of these cultivars. 'BRS Clara', 'BRS F63' (Camila) and 'Macaca' did not reach the same production levels of TFM (154, 122 and 94 g plant^{-1}, respectively).

The tuber dry mass production rate (TDMR), similar to the absolute growth rate, showed that three factors are important differentiators of genotypes and have a strong influence on final productivity (Figure 3c). They are the time that the genotype takes to reach the maximum TDMR, the TDMR value and the maximum TDMR period. 'BRS F63' (Camila) and 'BRS Clara' (65 DAP) were the first cultivars to reach maximum TDMR, five days before 'BRSIPR Bel', seven days before 'BRS Ana' and ten days before 'Macaca', although this is the earliest cultivar. 'BRS Ana' and 'BRSIPR Bel' produced higher TDMR (4.46 and 4.42 g plant-1 d-1, respectively) than 'BRS Clara', 'BRS F63' (Camila) and 'Macaca' (3.18, 2.52 and 2.44 g plant^{-1} d^{-1}, respectively).

As for the dry mass partition coefficient for tubers (DMPCT), it was increasing from the beginning of tuber growth to 40 DAP (Figure 3d). According to Oliveira et al. (2016) and Dwelle (1990), tubers become priority drains in the partition of assimilated from the beginning of their growth and production also depends on the strength of the source-drain relationship. Between 64 and 67 DAP, the DMPCT exceeded the unit for all five cultivars, indicating that, from there, there was relocation of assimilates from other organs to the tubers. According to Lyra et al. (2015), clones with early tuberization and long cycle are more productive. 'BRS F63' (Camila) presented the highest DMPCT between 40 and 64 DAP, followed by 'BRSIPR Bel', indicating earliness of growth and drain strength of the tubers of these cultivars. The intense increase in DMPCT after 60 DAP observed in 'Macaca' can be attributed to the delay in emergence, the priority of vegetative development at the beginning of the cycle and the early cycle, which resulted in a short effective period of tuber growth.

Percentages of DM in leaves, stems and tubers throughout the cycle for the five cultivars are presented in **Table 1**. 'BRS F63' (Camila) presented 25% of the total dry mass of the plant in the tubers at 40 DAP and had a higher percentage of the total DM of the plant allocated in the tubers up to 80 DAP. From there, the dry mass partition for the tubers was very similar to 'BRSIPR Bel', both reaching 90% of the total DM of the plant in the tubers at the end of the cycle. This is possibly due to the greater ability of these cultivars to partition assimilates into the tubers. 'BRS Ana' and 'Macaca' presented a higher percentage of DM in shoots, leaves and stems, at 40 and 60 DAP, respectively, which is a period of intense vegetative growth, indicating the preference of development of shoots during this period. As a consequence, the tuber growth began later in these cultivars.

Regarding the total tuber yield at the end of the crop cycle, there was no difference among cultivars (**Table 2**). However, in relation to the yield of marketable tubers and the percentage of fresh mass of marketable tubers, 'BRSIPR Bel' and 'BRS F63' (Camila) were higher, with 25.51 t ha^{-1} and 20.23 t ha^{-1}, and 75% and 81%, respectively. These superiorities can be attributed mainly to the earliness of tuberization and the efficiency of partition of assimilates to tubers (Lyra et al., 2015; Oliveira et al., 2016).

Table 1. Percentage of dry mass of leaves, stems and tubers of potato cultivars at 40, 60, 80, 100, and 120 days after planting. Embrapa, Pelotas, RS, Brazil, 2020.

Cultivar	Days after planting				
Órgão	40	60	80	100	120
		BRS Ana			
Leaves	66.35	39.87	19.41	12.73	6.74
Stems	31.88	24.59	12.79	9.26	7.50
Tubers	1.77	36.45	67.79	78.01	85.76
		BRSIPR Bel			
Leaves	56.86	35.16	17.36	9.53	4.90
Stems	28.88	17.94	9.14	5.57	5.19
Tubers	14.25	46.90	73.50	84.90	89.91
		BRS F63 (Camila)			
Leaves	54,50	35,70	21.15	8.70	5.32
Stems	20,01	8,16	6.60	4.36	4.17
Tubers	25,49	56,14	72.25	86.93	90.51
		BRS Clara			
Leaves	57.19	34.25	25.7	10,79	8,10
Stems	29.67	13.83	11.29	7,16	5,77
Tubers	13.14	51.92	62.98	82,06	86,12
		Macaca			
Leaves	69.44	53.07	23.97	9.75	6.47
Stems	27.79	20.50	11.74	7.16	5.61
Tubers	2.77	26.43	64.29	83.09	87.91

Table 2. Means of total yield, marketable yield and percentage of marketable tuber yield of potato cultivars. Embrapa, Pelotas, RS, Brazil, 2020

Cultivar	Total yield (t ha^{-1})		Marketable yield (t ha^{-1})		Marketable yield (%)	
BRSIPR Bel	33.56	a[1]	25.51	a	76.0	a
BRS Ana	30.68	ab	17.22	ab	56.5	b
BRS Clara	26.99	ab	16.50	ab	60.4	b
BRS F63 (Camila)	25.06	ab	20.23	a	80.7	a
Macaca	18.80	b	10.16	b	54.0	b
CV (%)	22.6		24.9		9.0	

[1]Means followed by the same letter in the column, do not differ significantly by the Tukey test, at 5% probability of the error.

Although cultivars with greater leaf area development have great capacity to intercept solar radiation and dry mass production, the productivity of tubers also depends on the partition of the assimilates to the tubers, and the drain force of tubers is essential in determining crop productivity (Oliveira et al., 2016).

The results of this work allow us to conclude that the five cultivars differ in growth pattern and partitioning of assimilates. 'BRSIPR Bel' presents faster assimilation system development; 'BRS Ana' has the largest leaf area, prioritizing the development of the photosynthetic system up to 60 DAP; 'BRSIPR Bel' and 'BRS Ana' have the highest total dry mass yields; 'BRS F63' (Camila) and 'BRSIPR Bel' are more efficient in partitioning assimilates to tubers, achieving higher yield of marketable tubers, and together with 'BRS Clara', are also earlier in tuber growth. 'BRSIPR Bel' has the highest yield potential in the fall crop conditions of low-altitude of south of Brazil, and next to 'BRS F63' (Camila), it has the highest marketable productivity.

References

Allen, E.J., Scott, R.K. 1980. An analysis of growth of potato crop. *Journal of Agricultural Science* 94: 583-606.

Alvarez, R.C.F., Crusciol, C.A.C., Nascente, A.S. 2012. Análise de crescimento e produtividade de cultivares de arroz de terras altas dos tipos tradicional, intermediário e moderno. *Pesquisa Agropecuária Tropical* 42: 397-406.

Aumonde, T.Z., Pedó, T., Martinazzo, E.G., Moraes, D.M., Villela, F.A., Lopes, N.F. 2013. Análise de crescimento e partição de assimilados em plantas de maria-pretinha submetidas a diferentes níveis de sombreamento. *Planta Daninha* 31:99-108.

Camargo, D.C., Montoya, F., Moreno, M.A., Ortega, J.F., Córcoles, J.I. 2016. Impact of water deficit on light interception, radiation use efficiency and leaf area index in a potato crop (*Solanum tuberosum* L.). *Journal of Agricultural Science* 154: 662-673.

Castellanos, M.S., Abril, M.S., Lopes, C.E.N. 2010. Análisis de crecimiento y relación fuente-demanda de cuatro variedades de papa (*Solanum tuberosum* L.) en el município de Zipaquirá (Cundinamarca, Colombia). *Revista Facultad Nacional de Agronomía Medellín* 63: 5253-5266.

CIP. International Potato Center. 2020. *Potato facts and figures*. https://cipotato.org/potato/potato-facts-and-figures/ <Access on Sept. 30>

Conceição, M.K., Lopes, N.F., Fortes, G.R.L. 2005. Partição de matéria seca entre órgãos de batata-doce (*Ipomoea batatas* (L.) Lam), cultivares Abóbora e Da Costa. *Revista Brasileira de Agrociência* 10: 313-316.

Dias, L.A.S., Barros, W.S. 2009. *Biometria Experimental*. Suprema Gráfica e Editora Ltda., Viçosa, Brasil. 408 p.

Dwelle, R. 1990. Source/Sink Relationships during tuber growth. *American Journal of Potato Research* 67: 829-833.

Elias, C.O., Causton, D.R. 1976. Studies on data variability and the use of polynomials to describe plant growth. *New Phytologist* 77: 421-430.

EMBRAPA. Empresa Brasileira de Pesquisa Agropecuária. 2020. *Sistema de produção da batata*. https://www.spo.cnptia.embrapa.br/conteudo?p_p_id=conteudoportlet_WAR_sistemasdeproducaolf6_1ga1ceportlet&p_p_lifecycle=0&p_p_state=normal&p_p_mode=view&p_p_col_id=column-2&p_p_col_count=1&p_r_p_-76293187_sistemaProducaoId=8803&p_r_p_-996514994_topicoId=1301 <Access on Sept. 30>

Fernandes, A.M., Soratto, R.P., Silva, B.L., Schlick, G.D.S. 2010. Crescimento, acúmulo e distribuição de matéria seca em cultivares de batata na safra de inverno. *Pesquisa Agropecuária Brasileira* 45: 826-835.

IBGE. Instituto Brasileiro de Geografia e Estatística. 2024. https://www.ibge.gov.br/explica/producao-agropecuaria/batata/br <Access on Apr. 30>

Lopes, N.F., Lima, M.G.S. 2015. *Fisiologia da produção*. Editora UFV, Viçosa, Brasil. 492 p.

Lutaladio, N., Castaldi, L. 2009. Potato – The hidden treasure. *Journal of Food Composition and Analysis* 22: 491-493.

Lyra, D.H., Ribeiro, G.H.M.R., Figueiredo, I.C.R., Guedes, M.L., Carneiro, O.L.G., Pinto, C.A.B.P., Pereira, A.S. 2015. Início da tuberização, duração do ciclo vegetativo e tolerância ao calor em genótipos de batata. *Pesquisa Agropecuária Brasileira* 50: 582-592.

Oliveira, J.S., Brown, H.E., Gash, A., Moot, D.J. 2016. An explanation of yield differences in three potato cultivars. *Crop Ecology and Physiology* 108: 1434-1446.

Pedó, T., Aumonde, T.Z., Lopes, N.F., Villela, F.A., Mauch, C.R. 2013. Análise comparativa de crescimento entre genótipos de pimenta cultivados em casa de vegetação. *Bioscience Journal* 29: 125-131.

Pedó, T., Aumonde, T.Z., Lopes, N.F., Mauch, C.R. 2015. Crescimento e conversão de energia solar em tomateiro enxertado sob cultivo protegido. *Semina: Ciências Agrárias* 36: 1927-1934.

Peixoto, C.P., Cruz, T.V., Peixoto, M.F.S.P. 2011. Análise quantitativa do crescimento de plantas: conceitos e prática. *Enciclopédia Biosfera* 7: 51-76.

Pereira, A. da S., Bertoncini, O., Castro, C.M., Melo, PE., Medeiros, C.A.B., Hirano, E., Gomes, C.B., Treptow, R.O., Lopes, C.A., Nazareno, N.X.R., Machado, C.M.M., Buso, J.A., Oliveira, R.P., Ueno, B. 2010. BRS Ana: cultivar de batata de duplo propósito. *Horticultura Brasileira* 28: 500-505.

Pereira, A. da S., Bertoncini, O., Silva, G.O., Castro, C.M., Gomes, C.B., Hirano, E., Bortoletto, A.C., Melo, PE., Medeiros, C.A.B., Treptow, R.O., Dutra L.F., Lopes, C.A., Nazareno, N.R.X., Lima, M.F., Castro, L.A.S., Krolow, A.C.R., Suinaga, F.A., Reisser Junior, C. 2013. BRS Clara: cultivar de batata para mercado fresco, com resistência à requeima. *Horticultura Brasileira* 31: 664-668.

Pereira, A.S., Silva, G.O., Bertoncini, O., Castro, C.M., Bortoletto, A.C., Hirano, E., Azevedo, F.Q., Lima, M.F., Gomes, C.B., Dutra L.F., Suinaga, F.A., Carvalho, A.D.F., Melo, PE., Lopes, C.A., Reisser Junior, C., Pinheiro, J.B., Medeiros, C.A.B., Krolow, A.C.R., Castro, L.A.S., Nazareno, N.R.X. 2018. BRS F63 (Camila): A fresh market potato cultivar, with high yield potential and resistance to virus Y. *Horticultura Brasileira* 36: 136-140.

Pereira, A. da S., Souza, Z.S., Choer, E. 2003. Principais cultivares. In: Pereira, A. da S., Daniels, J. (ed.) *O cultivo da batata na Região Sul do Brasil*. Embrapa, Brasília, DF, Brasil. p. 143-153.

Rodrigues, G.B., Pinto, C.A.B., Benites, F.R.G., Melo, D.S. 2009. Seleção para duração do ciclo vegetativo em batata e relação com a produtividade de tubérculos. *Horticultura Brasileira* 27: 280-285.

Silva, G.O., Azevedo, F.Q., Ragassi, C.F., Carvalho, A.D.F.D., Pereira, G.E., Pereira, A. da S. 2020. Growth analysis of potato genotypes. *Revista Ceres* 67: 207-215.

Teagasc. The agriculture and food development authority. 2020. *Potatoes*. https://www.teagasc.ie/crops/crops/potatoes/ <Access on Sept. 30>

Timlin, D., Rahman, S.M.L., Baker, J., Reddy, V.R., Fleisher, D., Quebedeaux, B. 2006. Whole plant photosynthesis, development, and carbon partitioning in potato as a function of temperature. *American Society of Agronomy* 98: 1195-1203.

Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.