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PRODUCTIVITY OF SOME ROMANIAN POTATO VARIETIES IN THE AGROCLIMATIC CONTEXT OF THE BÂRSA COUNTRY

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Abstract

A highly economic important crop, potato is grown in more than 100 countries and is the fourth consumed food in the world. Twelve Romanian potato varieties were investigated for their growth parameters and yield to determine suitability for production. Experiments were conducted to National Institute of Research and Development for Potato and Sugar Beet Brasov using a randomised block design with four replications. Determination of the tuber number and their mass was done in each repetition. The potato yield was determined in each elementary plot and the yield per hectare was calculated. Darilena produced the tallest plants (90.5 cm) and Castrum. produced the shortest (58.88 cm). The number of stems per hill ranged from 2.5 cm (Foresta cv.) to 9.25 cm (Marvis). Tuber weight average per hill ranged from 2055 g (Sarmis) to 500 g (Castrum). Ervant (37.44 t/ha) and Azaria (37.94 t/ha) records superior productivity and Asinaria and Darilena showed adaptability to climate conditions and suitability for culture under high economic efficiency. Specific technologies must be established for each variety to reach the maximum potential in periods of stress that occur due to climatic variations.

Key words*: climatic conditions, cultivars, growth parameters, potato, yield.*

INTRODUCTION

Potato is now the world's third most important food crop in terms of human consumption, after wheat and rice (FAOSTAT, 2019) despite the large proportion of potato produce used for seed and as animal feed. Consumption of fresh potatoes accounts for approximately two-thirds of the harvest and around 1.3 billion people eat potatoes as a staple food (more than 50 kg per person per year) including regions of India and China.

A large majority (73.1%) of the EU's harvested production of potatoes in 2020 came from just five Member States; these were Belgium, Germany, France, the Netherlands and Poland. These five countries accounted for a slightly smaller majority (66.8% in 2020) of the area planted to potatoes in the EU, with Romania accounting for an additional 10.0% (EUROSTAT, 2022).

Potato produces the highest amount of energy per unit area and has the highest dry matter yield which may be 74.5% compared to wheat and 58% compared to rice (Ahmed et al., 2017). Besides consumption of fresh potatoes for cooking (boiled, baked, fried, etc.), potato tubers are used in a wide spectrum of applications, like alcohol production, dehydrated and frozen food products, animal feed, commercial starch (Devaux et al., 2021).

None of the currently used varieties or cultivars has potential for production in all environments and for all uses (Bradshaw, 2007), since agroecologies vary with respect to soil type, moisture and temperature regimes, fertility condition and the onset, intensity and duration of rain as well as availability of irrigation facilities (Gebremedhin et al., 2008; Fantaw et al., 2018).

The most desired type of cultivar is one that combines high yield with stability in a dynamic (or agronomic) sense (Piepho 1996; Flis et al., 2014).

Potato has high climate requirements. The availability and amount of water at specific growing stages effect the potato quality and yield. Potato is a water-stress crop, and a long-term lack of water is the main abiotic factor that limits yield (Cantorea et al., 2014). Water deficit decreases number of leaves, stem height, tuber growth and yield per plant. Also high temperature, drought, soil salinity and nutrient stresses adversely affect assimilation and

translocation of the photosynthetic end product to the tubers and substantially curtail plant growth, tuberization, tuber bulking, and hence tuber yield and quality (Minhas, 2012; Dahal et al., 2019).

Average tuber weight, stems/plant, tubers/plant and tuber weight/plant are the most important components in potato improvement for increasing tuber yield (Islam et al., 2002; Arslan, 2007).

The aim of present the study was to investigate the performance and stability of some Romanian potato varieties regarding the yield in years with different climatic conditions.

MATERIALS AND METHODS

The experiment was conducted at the Laboratory of Technology and good agricultural practices from National Institute of Research and Development for Potato and Sugar Beet Brasov, Romania, in years 2020-2021. The soil was a cambic chernozeum with pH 6.7. The pre-crop was wheat and for current fertilizer was used 1000 kg/ha N:P:K:15:15:15+S. The size of the plots was 9 m^2, the repetition was four-fold, the planting scheme was 75 cm × 30 cm, having 4 rows with 10 plants each one. Potatoes were planted manually on 6 April 2020 and 3 May 2021.

Twelve potato cultivars were analyzed: Asinaria, Azaria, Cezarina, Castrum, Foresta, Darilena Ervant, Marvis, Sarmis, Sevastia, Christian and Brasovia (control).

Were applied pre- and post-emergent treatments for weeds control, two treatments for Colorado beetle and eight treatments for late blight control in each year. Were collected data regarding the quantitative traits (plant height, haulms, aerial plant weight, number and tubers weight). Potato tubers were harvested semi-mechanized on September 20, 2020 and, respectively, October 4, 2021.

Weather conditions during the experiment are summarized in Figures 1 and 2. Rainfalls from growing season totaled 463.8 mm in 2020 with more 6.4 mm than the multiannual average and 429.7 mm in 2021 with 27.7 mm below multiannual average, respectively.

Temperatures were over multiannual average in both growing season, +1.0°C in 2020 and +0.9°C, respectively.

Results were subjected to statistical analysis, using one-way analysis of variance (ANOVA). Statistical differences with P-values under 0.05 were considered significant and means were compared by Duncan Multiple Range.

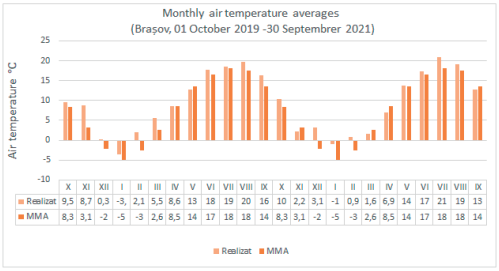

Figure 1. Temperature average
(Brașov, October 2019- September 2021)

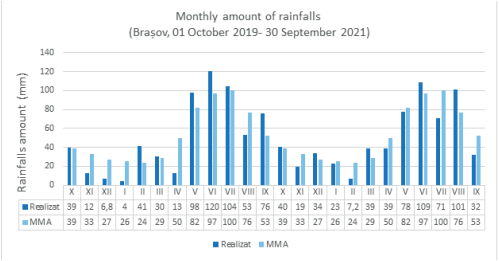

Figure 2. Rainfalls amount
(Brașov, October 2019- September 2021)

RESULTS AND DISCUSSIONS

Main haulm

Its obviously that the variety affect the number of haulms/plant. An increase in absorption of solar radiation can ensure a higher photosynthesis potential and promote synthesis and accumulation of reserve carbohydrates in the potato tuber which has a positive effect on the final tuber yield (White et al., 2007). But under specific climatic conditions the haulms number vary greatly between varieties and in the same variety in different developmental stages.

The control cultivar (Brasovia) presented a relatively high number of haulms in both years taken in the study and was significantly surpassed by the Marvis cv. and significantly distinct from the Christian cv at the first assessment of the year 2020.

Table 1. Main haulm number in different cultivars (2020-2021)

Variety	25.06.2020		30.07.2020		06.06.2021		26.07.2021	
	Main haulm no.	Sign.	Main haulm no.	Sign.	Main haulm no.	Sign.	Main haulm no.	Sign.
Sevastia	6.00	ns	3.13	ooo	4.13	oo	4.63	ns
Marvis	9.25	*	5.75	o	8.13	ns	7.63	ns
Castrum	3.38	oo	3.63	ooo	3.50	ooo	3.13	o
Asinaria	5.38	ns	7.63	ns	5.13	o	4.75	ns
Sarmis	8.25	ns	7.00	ns	6.75	ns	6.00	ns
Cezarina	4.50	ns	4.88	oo	4.88	o	4.13	ns
Christian	10.50	**	6.25	ns	5.75	ns	6.25	Ns
Ervant	4.25	o	5.25	oo	3.50	ooo	3.75	O
Azaria	5.13	ns	5.50	o	5.00	o	5.88	Ns
Foresta	2.50	ooo	2.88	ooo	2.25	ooo	2.00	ooo
Darilena	4.75	ns	4.25	ooo	3.13	ooo	4.88	Ns
Brasovia (control)	6.63	-	7.63	-	6.88	-	6.00	-

In the year 2021, the values were much tighter, even existing the situation some negative differences compared to the control at first assessment for Foresta, Darilena, Ervant and Castrum cultivars (Table 1).

Plant height

Its generally know that the variety affected plant heights.

In 2020 the highest plant height was observed to Darilena cv. (90.50 cm at the first assessment, respectively 109.50 cm at the second assessment) and the lowest to Castrum (58.99 at the first assessment, respectively 59.38 cm at the second assessment) and in 2021 to Ervant cv. (69.00 cm at the first assessment, respectively 73.63 cm at the second assessment) riched the heighest plants compared with the control cultivar.

In 2021 Ervant cv. continue to present the highest plant to the both assessment (69.0 cm, respectively 73.63 cm) (Table 2).

Table 2. Plant height in different cultivars (2020-2021)

Cultivar	Plant height (cm)	Sign.	Plant height (cm)	Sign.	Plant height (cm)	Sign.	Plant height (cm)	Sign.
	25.06.2020		30.07.2020		06.06.2021		26.07.2021	
Sevastia	73.63	o	76.50	ns	54.88	ns	64.00	*
Marvis	69.25	oo	61.38	ooo	52.25	ns	51.88	ns
Castrum	58.88	ooo	59.38	ooo	43.63	O	48.13	ns
Asinaria	75.88	ns	73.13	Oo	56.50	ns	65.25	*
Sarmis	90.25	ns	103.88	*	64.75	**	63.63	*
Cezarina	75.50	ns	91.25	os	55.00	ns	60.25	ns
Christian	79.75	ns	73.50	o	66.88	**	71.25	**
Ervant	66.00	oo	62.38	ooo	69.00	***	73.63	***
Azaria	80.88	ns	95.25	ns	61.75	ns	63.63	*
Foresta	71.88	o	77.75	ns	52.75	ns	56.38	ns
Darilena	90.50	ns	109.50	**	57.88	ns	62.38	ns
Brasovia (control)	84.25	-	89.63	-	53.75	-	51.00	-

Aerial plant weight

The development of the canopy, studied through the green mass of the aerial part of the potato plants, shows that it was influenced by the climatic conditions. The green mass of the potato plants varied a lot in the two years. In 2020, at the first assessment, a maximum of 991 g/plant was recorded for the Sarmis cv. and a minimum of 304.13 g for the Castrum cv., and a decrease in foliage for all varieties at the

second assessment, the highest values being for the Sarmis cv. (680.38 g), and the lowest in the Ervant cv. (98.63 g).In 2021, the recorded values were lower than in 2020 for all varieties. At the first assessment, a maximum of 507.88 g/plant was recorded in the Christian cv. and a minimum of 213.63 g in the Castrum cv. and a decrease in foliage in all varieties at the second assessment, the highest values being in the Asinaria cv. (413.13 g), and the lowest in the Marvis cv. (249.50 g).

Brasovia (control) cv. presented a significant decrease in values at the second assessment (413.38 g) in 2020 compared to the first, when the plants were very well developed, a situation that was not repeated in 2021 when the values were within the limits determined by climatic conditions (Table 3).

Table 3. Aerial plant weight in different cultivars (2020-2021)

Cultivar	25.06.2020		30.07.2020		06.06.2021		26.07.2021	
	Aerial plant weight (g)	Sign.	Aerial plant weight (g)	Sign.	Aerial plant weight (g)	Sign.	Aerial plant weight (g)	Sign.
Sevastia	508.75	o	288.13	ns	265.38	ns	280.88	ns
Marvis	529.63	o	237.25	o	335.25	ns	249.50	ns
Castrum	304.13	ooo	244.63	o	213.63	o	323.38	o
Asinaria	432.88	oo	226.50	oo	301.63	ns	413.13	ns
Sarmis	991.25	ns	680.38	***	414,00	ns	312.63	ns
Cezarina	492.13	o	492.75	ns	321.50	ns	309.00	ns
Christian	903.25	ns	169.13	ooo	507.88	*	364.88	ns
Ervant	398.38	oo	98.63	ooo	346.75	ns	291.13	o
Azaria	650.88	ns	526.88	ns	430.88	ns	276.50	ns
Foresta	603.75	ns	340.50	ns	204.50	o	283.50	ooo
Darilena	858.75	ns	450.38	ns	270.63	ns	340.25	ns
Brasovia (control)	852.38	-	413.38	-	364.13	-	271.25	-

Cultivars differed in the duration the canopy was maintained and had infuence on tuber number and weight, and finally on the yield.

Tuber number

Tuber number per plant ranged from 5.63 tubers (cv. Castrum) to 24.75 tubers (cv. Christian) to the first assesment and from 6.88 tubers (cv. Castrum) to 22.75 tubers (cv. Ervant) to the second assesment in 2020 and from 7.13 tubers (cv. Foresta) to 17.25 tubers (cv. Christian) to the first assesment and from 7.25 tubers (cv. Castrum) to 16.75 tubers (cv. Marvis) to the second assesment in 2021 (Table 4).

Table 4. Tuber number in different cultivars (2020-2021)

	25.06.2020		30.07.20		06.06.21		26.07.21	
Cultivar	Tub. no./hill	Sign.	Tub. no./hill	Sign.	Tub. no./hill	Sign.	Tub. no./hill	Sign.
Sevastia	7.13	oo	10.38	Oo	10.50	ns	13.50	ns
Marvis	11.88	ns	15.00	Ns	19.38	ns	16.75	ns
Castrum	5.63	ooo	6.88	Ooo	7.75	o	7.25	oo
Asinaria	12.13	ns	18.50	ns	12.13	ns	16.38	ns
Sarmis	11.38	ns	16.63	ns	12.50	ns	10.63	ns
Cezarina	12.00	ns	22.75	ns	17.13	ns	14.63	ns
Christian	24.75	***	18.63	ns	17.25	ns	16.38	ns
Ervant	11.00	ns	16.13	ns	15.25	ns	13.88	ns
Azaria	11.75	ns	16.50	ns	14.63	ns	13.63	ns
Foresta	8.38	o	11.38	oo	7.13	o	7.25	oo
Darilena	9.38	o	13.50	o	8.25	o	12.75	ns
Brasovia (control)	13.63	-	20.75	-	14.63	-	14.25	-

The capping on the number of tubers in a plant cannot be explained by the lack of genetic tuberization capacity, but by the existence of physiological imbalances, nutritional or hormonal, under the direct influence of the ecological conditions of a year.
A gradual decrease in tuber number was observed with a gradual increase of water stress. As other authors have found, the number of tubers is significantly influenced by drought (Deblonde and Ladent, 2001; Al-Mahmoud et al., 2014).

Tuber weight

The weight of the tubers is in accordance with their number. At the first assessment in 2020, the Sevastia cv. recorded the lowest weight (197.25 g), and cv. Sarmis (795.88 g) the biggest one.
At the second assessment cv. Sarmis (2055.13 g) continued to record the highest weight, with a distinctly significant difference compared to the control, while cv. Castrum (513.00 g) presented the lowest weight. In 2021, for all varieties, the weight of tubers was lower than in 2020.
Climatic conditions negatively influenced the degree of accumulation of tubers, only cv. Ervant (9385.25 g, respectively 789.88 g) had at both assessments (distinctly significant difference) weight greater than the Brasovia cv. (204.38 g, respectively 436.25 g) (Table 5).

Table 5. Tuber weight in different cultivars (2020-2021)

Cultivar	25.06.2020		30.07.2020		06.06.2021		26.07.2021	
	Tub. weight/hill	Sign.	Tub. weight/hill	Sign.	Tub. weight/hill	Sign.	Tub. weight/hill	Sign.
Sevastia	197.25	o	788.50	oo	99.25	ns	476.63	ns
Marvis	460.50	ns	1289.75	ns	274.63	ns	524.25	ns
Castrum	180.50	oo	500.13	ooo	95.25	o	259.88	ns
Asinaria	438.38	ns	982.00	ns	118.13	ns	613.75	ns
Sarmis	795.88	ns	2055.13	**	283.88	ns	567.50	ns
Cezarina	554.88	ns	1340.75	ns	193.00	ns	482.88	ns
Christian	762.00	ns	1009.25	ns	265.88	ns	671.00	*
Ervant	756.75	ns	1259.75	ns	385.25	**	789.88	**
Azaria	584.38	ns	1440.38	ns	272.75	ns	455.88	ns
Foresta	465.50	ns	877.38	o	78.00	o	399.50	ns
Darilena	486.25	ns	1158.50	ns	110.88	ns	600.25	ns
Brasovia Mt	544.75	-	1382.88	-	204.38	-	436.25	-

Yield

Understanding the stress-related physiological, biochemical, and molecular processes is crucial to develop the screening procedures for selecting potato cultivars that can better adapt to drought. The elucidation of such processes may offer new insights into the identification of specific characteristics that may be useful in breeding new cultivars aimed at maintaining or even enhancing potato yield under the changing climate (Gervais et al., 2021).
The productions obtained in 2020 were very good. They were between 37.06 t/ha for the Castrum cv. and over 61 t/ha for the Darilena and Sevastia cultivars. In 2021, production was between 37.97 t/ha for the Azaria cv. and 13.11 t/ha for the Foresta cv. The control cultivar (Brasovia) presented relatively high productions in both years (43.49 t/ha, respectively 30.09 t/ha), being stable under the influence of adverse climatic conditions (Table 6).
We have to mention a significant decrease in the production of all cultivars in 2021 compared to the previous year. The drought at the time of tuberization and the uneven distribution of precipitation caused the accumulation to be deficient, none of the varieties being able to reach their maximum potential.

Table 6. Total tuber yields (Braşov, 2020-2021)

Cultivar	Total yield (t/ha)	Dif. (t/ha)	Sign.	Total yield (t/ha)	Dif. (t/ha)	Sign.	Mean yield of the two years
	2020			2021			
Ervant	59.20	15.71	**	37.44	7.34	ns	48.32
Castrum	37.06	-6.43	Ns	19.57	-10.53	o	28.32
Marvis	54.05	10.56	Ns	29.87	-0.22	ns	41.96
Azaria	60.66	17.17	**	37.97	7.88	ns	49.32
Christian	58.59	15.10	**	30.86	0.77	ns	44.73
Asinaria	44.40	0.91	Ns	29.10	-0.99	ns	36.75
Foresta	55.92	12.43	*	13.11	-16.99	ooo	34.52
Sevastia	61.12	17.63	**	25.90	-4.19	ns	43.51
Darilena	61.13	17.64	**	28.38	-1.71	ns	44.76
Cezarina	59.73	16.24	**	24.04	-6.05	ns	41.89
Sarmis	53.68	10.19	Ns	32.35	2.26	ns	43.02
Brasovia (control)	43.49	-	-	30.09	-	-	36.79
DL 5%	10.82	-	-	8.42	-	-	
DL 1%	14.50	-	-	11.28	-	-	
DL 0.1%	19.14	-	-	14.89	-	-	

Among the varieties, the mean yield of the two years was the highest in Azaria cv. (49.32 tons) which was followed by Ervant cv. (48.32 tons) while Catrum cv. produced the lowest (28.32 tons).

CONCLUSIONS

The tolerant varieties showed comparatively less reduction in plant height, plant mass, tuber number per plant and yield. The lowest reduction in tuber yield was found in Ervant and Azaria cv. followed by Sarmis cv. The mean production was higher in 2020.

The number of tubers and haulm to tubers weight ratio turned out to be less sensitive to changes in the growing regime.

Yield per ha showed significant variation and ranged from 37.06 ton/ha (Castrum cv.) to 61.13 tons/ha (Darilena cv.) in 2020 and from 37.97 tons/ha (Christian cv.) to 13.11 tons/ha (Foresta cv.) in 2021.

In both years Ervant (59.20 t/ha, respectively 37.44 t/ha) and Azaria (60.66 t/ha, respectively 37.94 t/ha) records superior productivity and Asinaria and Darilena showed adaptability to climate conditions and suitability for culture under high economic efficiency. Specific technologies must be established for each variety to reach the maximum potential in periods of stress that occur due to climatic variations.

The results of this field study confirm that weather conditions do influence potato canopy development and subsequent tuber yield. The weather conditions leads to the significant differences in the potato varieties productivity, indicated that higher temperatures lowered potato yields, less precipitation hindered the yields and growth of potato cultivation.

REFERENCES

Al-Mahmud, A., Al-Mamun, A., Shamimuzzaman, M., Shafiur, R., Shawquat, A., Bazzaz, M. (2014). Plant Canopy, Tuber Yield and Growth Analysis of Potato under Moderate and Severe Drought Condition. *Journal of Plant Sciences, 2*(5), 201–208. doi: 10.11648/j.jps.20140205.

Ahmed, B., Sultana, M., Chowdhury, M. A. H., Akhter, S., Alam, M. J. (2017). Growth and yield performance of potato varieties under different planting dates. *Bangladesh Agron. J., 20*(1), 25–29.

Arslan, B. (2007). Relationships Among Yield and Some Yield Characters in Potato (*S. tuberosum* L.). *Journal of Biological Sciences, 7*. 973–976. DOI**:** 10.3923/jbs.2007.973.976.

Bradshaw, J.E. (2007). Potato-Breeding Strategy. In: *Potato Biology and Biotechnology: Advances and Perspectives*, (eds). Vreugdenhil D, Bradshaw J, Gebhardt C, Govers F, Mackerron DKL, Taylor MA and Ross HA. Elsevier Ltd., Amsterdam, Netherlands, pp. 157-178.

Cantorea, V., Wassarb, F., Yamaç, S.S., Sellamic, M.H., Albrizioc, R., Stellaccid, A.M., Todorovic, M. (2014). Yield and water use efficiency of early potato grown under different irrigation regimes. *International Journal of Plant Production, 8*(3), 409–428.

Dahal, K., Li, X.Q., Tai, H., Creelman, A., Bizimungu, B. (2019). Improving potato stress tolerance and tuber yield under a climate change scenario - A

current overview. *Front Plant Sci., 10.* 563. doi: 10.3389/fpls.2019.00563.

Deblonde, P.M.K., Ladent, J.F. (2001). Effects of moderate drought conditions on green leaf number, stem height, leaf length and tuber yield of potato cultivars. *European Journal of Agronomy. 14*. 31–41.

Devaux, A., Goffart, J.P., Kromann, P. (2021). The Potato of the Future: Opportunities and Challenges in Sustainable Agri-food Systems. *Potato Res., 64*. 681–720 https://doi.org/10.1007/s11540-021-09501-4

EUROSTAT (2022). Key figures on the European food chain. https://ec.europa.eu/eurostat/documents/15216629/15559935/KS-FK-22-001-EN-N.pdf/1cb9d295-6868-70e3-0319-4725040cfdb8.

Fantaw, S., Ayalew, A., Tadesse, D., Medhin, Z., Agegnehu, E. (2018). Evaluation of potato (*Solanum tuberosum* L.) varieties for yield and yield components. *Journal of Horticulture and Forestry, 11*(3), 48–53, DOI: 10.5897/JHF2016.0475

FAOSTAT (2019) Food balance sheet. http://www.fao.org/faostat/en/#data/FBS.

Flis, B., Domański, L., Zimnoch-Guzowska, E., Polgar, Z., Pousa, S.A., Pawlak, A. (2014). Stability analysis of agronomic traits in potato cultivars of different origin. *Am. J. Potato Res., 91.* 404–413 DOI 10.1007/s12230-013-9364-6.

Gebremedhin, W., Endale, G., Lemaga, B. (2008). *Potato variety development. In Root and tuber crops:* The untapped resources, ed. W. Gebremedhin, G. Endale, and B. Lemaga, 15-32. Addis Ababa: Ethiopian Institute of Agricultural Research. http://publication.eiar.gov.et:8080/xmlui/handle/123456789/1496.

Gervais, T., Creelman, A., Li, X.Q., Bizimungu, B., De Koeyer, D., Dahal, K. (2021) Potato Response to Drought Stress: Physiological and Growth Basis. Front. *Plant Sci., 12.* 698060. doi: 10.3389/fpls.2021.698060.

Islam, M.J., Haque, M.Z., Majunde, U.K, Hossain, M.F. (2002). Growth and yield potential of nine selected genotypes of sweet potato. *Pak. J. Biol. Sci., 5*. 537–538.

Minhas, J. S. (2012). Potato: production strategies under abiotic stress, in *Improving Crop Resistance to Abiotic Stress*, eds. Tuteja N., Gill S. S., Tiburcio A. F., Tuteja R. (Weinheim: Wiley-VCH Verlag GmbH & Co.KGaA)1155-1167.10.1002/9783527632930.ch45.

Piepho, H.P. (1996). *Analysis of genotype-by-environment interaction and phenotypic stability*. In Genotype-by-environment interaction, ed. M.S. Kang and H.G. Gouch, 152–174. New York: CRC Press.

White, P.J., Wheatley, R.E., Hammond, J.P., Zhang, K. (2007). Minerals, soils and roots. In: Potato Biology and Biotechnology: Advances and Perspectives, (eds). Vreugdenhil D, Bradshaw J, Gebhardt C, Govers F, Mackerron DKL, Taylor MA and Ross HA. Elsevier Ltd., Amsterdam, Netherlands pp. 739-75.