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Tuber Quality Parameters of Potato Varieties Depend on Potassium Fertilizer Rate and Source

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Abstract

The influence of potassium fertilizer source (K_2SO_4 and KCl) and fertilizer rates on potato tuber quality parameters under pot and field experimental conditions were studied. The pot experiment included high rate of potassium fertilizers providing 600 mg K_2O kg^{-1} soil from both sources, studded at four varieties. The field experiment included two fertilizer rates - 100 and 200 kg K_2O ha^{-1}. The dry matter content in tubers from the plants of the pot experiment was the highest for the controls of the three studied varieties - 19.78 % for „Louisiana"; 17.16 for „Riviera" and 17.26 % for „Hussar". The highest dry matter content (20.98 %) in field conditions was observed for variant K_{200} (K_2SO_4). For all variants from the pot trail fertilized with KCl the starch content was decreased approximately with 2.2 to 2.4 % in comparison to controls. The highest tuber starch content was observed also for the control (15.24 %) from the field study. The fertilization did not influence the reducing sugars content in tubers. The content was around 0.40 % independently of the trail conditions and cultivars. The application of KCl decreased the content of vitamin C in tubers for all variants from the pot trail compared to the controls (from 46 % at variety „Louisiana" to 61 % to Agria). In the field experiment the high rate of K_{200} KCl reduced vitamin C content with approximately 54 % (8.40 mg 100 g^{-1}) in comparison to variant K_{100} K_2SO_4 (18.10 mg 100 g^{-1}). Positive influence of KCl on crude protein content in tubers at all varieties from both trials was recorded.

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1. Introduction

Among all cultivated plants potatoes (*Solanum tuberosum L.*) have the highest botanical and biological diversity

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(Valchev, 2011). Used for food for more than 10 000 years, potatoes have high industrial and forage importance (Terziev and Karov, 2000; Donnelly and Kubow, 2011). According to Rytel et al. (2013), the quality of potato tubers and their chemical composition are influenced by genetics factors, soil fertility, weather conditions and chemical treatments that are applied. Potato tubers which have low nitrogen content more often have low dry matter content, as well as higher rates of reducing sugars (Zorb et al., 2014). According to the same authors, reducing sugars are critical precursors for acrylamide formation during frying which is considered carcinogenic and neurotoxic for humans. Nitrogen fertilization increases nitrogen content in potato plants (Neshev et al., 2014). The source of potassium (KCl or K_2SO_4) affect yield and quality of potatoes (Manolov et al., 2015). Bansal and Trehan (2011) established reduction of dry mater content in tubers after fertilization with KCl. When compared to KCl, K_2SO_4 improved the quality of tubers and is a preferred source of potassium for potatoes (Herlihy and Carroll, 1969; Manolov et al., 2015).

The aim of the study was to determine the influence of the source of the potassium fertilizer on some quality parameters of different potato varieties in a pot experiment. The second aim was to compare the effect of potassium source and its rates on tuber quality in field conditions.

2. Materials and methods

The pot experiment was performed with four potato varieties: „Louisiana", „Riviera" „Hussar" and „Agria". Potatoes were grown in 15-liter pots containing 15 kg soil with $pH_{(H2O)}$ 5.67. The soil contained 24.4 mg N_{min} kg^{-1}, 35.2 mg P_2O_5 100 g^{-1} and 43.9 mg K_2O 100 g^{-1} before the beginning of the study. The trail was designed to evaluate the cultivars responsiveness to zero potassium fertilization (K_0) and high rate of potassium fertilizer K_{600} (600 mg K_2O kg^{-1} soil) supplied either as K_2SO_4 or KCl. Ammonium nitrate and triple superphosphate were added to all variants to provide 200 mg N kg^{-1} and 150 mg P_2O_5 100 g^{-1} soil, respectively. The field experiment was conducted on shallow brown forest soil (Cambisols–coarse) in mountainous region under non irrigated conditions with the variety „Agria" by the randomized block design in 4 replications in 2015. The experiment included control and two rates of the potassium fertilizers K_{100} and K_{200} providing 100 and 200 kg K_2O ha^{-1} as K_2SO_4 or KCl. The same rates of nitrogen (as NH_4NO_3) and phosphorus (as triple superphosphate) fertilizers were applied to provide 140 kg N and 80 kg P_2O_5 ha^{-1}, respectively to all the variants including the control. The size of the harvesting plot was 16 m^2. Potato planting distance was 25 x 70 cm. The soil $pH_{(H2O)}$ was 5.44 and it contained 33.9 mg N_{min} kg^{-1}, 32.9 mg P_2O_5 100 g^{-1} and 23.5 mg K_2O 100 g^{-1} before the beginning of the study.

Total dry matter content was determined by oven drying at 70 °C for 24 h. The amount of starch was determined by using a polarimetric method (Liutskanov et al., 1994). The method of Hagedorn and Jensen was followed to establish the content of reducing sugars (Ivanov and Popov, 1994). Vitamin C was evaluated by dichlorophenolindophenol titration method (Ivanov and Popov, 1994). Total nitrogen was determined by Kjeldal's method and multiplied by 6.25 to convert to crude protein (Tomov et al., 2009).

Statistical analysis of collected data was performed by using Duncan's multiple range test (1955) of SPSS program. Statistical differences were considered significant at $p<0.05$.

3. Results and discussions

The highest dry matter content in tubers from the plants of the pot experiment was observed in the controls of the three studied varieties - 19.78 % for „Louisiana"; 17.16 for „Riviera"; 17.26 % for „Hussar" (Table 1). The results correspond with the data of our previous pot trail conducted with variety „Picasso" where the highest dry matter content was also found in the control (Manolov et al., 2015). Similar tendency was not observed for the variety „Agria". The highest dry matter content (19.37 %) for this variety was found in the tubers fertilized with K_2SO_4. The KCl fertilization decreased dry matter content in all varieties compared to controls (Table 1).

The content of dry matter of the tubers produced under field conditions was the highest (20.98 %) after fertilization with K_{200} (K_2SO_4). At variant K_{200} KCl, tuber dry matter content was the lowest - 18.40 % (Table 2). Kumar et al. (2007) also found that the fertilization with KCl decreased dry matter content in potato tubers (21.8 %), compared to fertilization with KNO_3 (22.5 %) and K_2SO_4 (22.3 %).

The highest starch content was observed in tubers of controls at three varieties from the pot trail: „Riviera", (8.05 %), „Hussar" (8.91 %) and „Agria" (8.31 %) (Table 1). The starch in tubers was the highest for variant K_{600} (K_2SO_4)

(10.25 %) only for „Louisiana" variety. The starch content decreased approximately with 2.2 to 2.4 % for all other varieties fertilized with KCl compared to controls.

Table 1. Quality parameters of tubers for potato cultivars from the pot experiment

Variants/ parameters		Dry matter	Starch	Reducing sugars	Vitamin C	Crude
K level	K source	(%)	(%)	(%)	(mg 100 g^{-1})	protein (%)
			Cultivar Luisiana			
K_0	Control	19.78 a	9.71 ab	0.40 a	12.02 a	12.23 b
K_{600}	K_2SO_4	18.24 b	10.25 a	0.41 a	10.37 b	13.73 b
K_{600}	KCl	15.05 c	8.10 b	0.38 a	6.53 c	14.52 a
			Cultivar Riviera			
K_0	Control	17.16 a	8.05 a	0.39 a	10.76 a	15.27 ab
K_{600}	K_2SO_4	16.09 b	6.96 ab	0.41 a	6.67 b	12.75 b
K_{600}	KCl	14.47 c	6.14 b	0.41 a	4.37 c	16.00 a
			Cultivar Husar			
K_0	Control	17.26 a	8.91 a	0.43 a	9.88 a	12.40 c
K_{600}	K_2SO_4	16.07 b	8.57 a	0.43 a	8.11 b	13.71 b
K_{600}	KCl	14.18 c	7.19 b	0.40 a	4.27 c	16.25 a
			Cultivar Agria			
K_0	Control	17.89 ab	8.31 a	0.40 a	8.63 a	13.50 b
K_{600}	K_2SO_4	19.37 a	7.50 ab	0.41 a	6.91 b	12.79 c
K_{600}	KCl	17.00 b	5.73 b	0.40 a	3.37 c	14.54 a

Figures with different letters are with proved difference according to Duncan's multiple range test ($p < 0.05$).

The content of starch in tubers of potatoes grown under field conditions was higher than the starch content in tubers of potato plants grown in containers, but the results from the field study showed the same tendency as the data recorded from the pot trail. The highest tuber starch content was observed for the control (15.24 %). The results were very close for variants $K_{100,}$ K_{200} (K_2SO_4) and K_{100} KCl. Otherwise, the variant K_{200} KCl resulted in lowest starch content (10.14 %) which was approximately 33 % lower compared to the control (Table 2).

Table 2. Quality parameters of tubers for potatoes from the field experiment

Variants/ parameters		Dray matter	Starch	Reducing sugars	Vitamin C	Crude protein
K level	K source	(%)	(%)	(%)	(mg 100 g^{-1})	(%)
K_0	Control	19.39 ab	15.24 a	0.39 a	11.50 d	14.50 c
K_{100}	K_2SO_4	19.01 b	14.16 b	0.38 a	18.10 a	12.63 e
K_{200}	K_2SO_4	20.98 a	12.99 c	0.41 a	16.20 b	13.25 d
K_{100}	KCl	19.53 ab	14.89 b	0.39 a	15.30 c	16.25 b
K_{200}	KCl	18.40 c	10.14 d	0.40 a	8.40 e	18.06 a

Figures with different letters are with proved difference according to Duncan's multiple range test ($p < 0.05$).

The content of reducing sugars in potato tubers influences their color and processing quality (Nikolova and Blagoeva, 2000; Keramat et al., 2011). The applied fertilizers and studied rates of K_2SO_4 and KCl did not influence considerably the reducing sugars content in tubers. The results (0.40 %) were found to be independent on the trail conditions and studied varieties and the differences were not statistically proved (Tables 1 and 2).

The most important vitamin in potato tubers is vitamin C (Mashev et al., 1999). The content of this vitamin was the highest for the controls at all varieties from the pot trail. Obviously high initial content of available potassium in the soil (43.9 mg K_2O 100 g^{-1}) was adequate for plant development. Higher potassium fertilizer rate (600 mg K_2O 100 g^{-1}) led to decreased vitamin C content in the tubers at all varieties in comparison to controls. The decrease was far less at plants fertilized with K_2SO_4 (from 14 % at Louisiana to 38 % at Riviera) in comparison to the controls. Application of KCl decreased content of vitamin C in tubers much higher (from 46 % at variety Louisiana to 61 %

to Agria) (Table 1). The differences among fertilizer treatments for all varieties were statistically proved.

In the field trail the situation was different. The vitamin C content was higher at the three variants, fertilized with potassium, compared to the control. The highest rate of K_{200} KCl led to 54 % reduction of vitamin C content (8.40 mg 100 g^{-1}) when compared to variant K_{100} K_2SO_4 (18.10 mg 100 g^{-1}) (Table 2). A lack of negative effect of lower KCl rate - K_{100} on quality parameters of potatoes was probably due to leaching of Cl^- from the upper soil horizon caused by rain water during vegetation. Chlorine anion is very mobile into the soil (Brady, 1974). The total amount of precipitation during the vegetation period (May – September, 2015) was 447 mm.

The information concerning potato tuber protein is still very limited. The most important specific potato protein is patatin (Bartova et al., 2013). Our results showed positive influence of KCl fertilization on crude protein content in tubers at all studied varieties from the pot trail as well as the cultivar „Agria" from the field study (Tables 1 and 2).

There was not found any considerably yield differences neither in pot experiment nor in field conditions.

4. Conclusions

Application of KCl worsened some quality parameters of potato tubers. Dry matter, starch and vitamin C content in potatoes grown in pot experiment were lower than variants fertilized with K_2SO_4 at all studded varieties. The same tendency was observed in field experiment but only with higher KCl rate K_{200}. Negative effect of Cl^- at field conditions was mitigated because of leaching of significant part of applied chlorine. There was not found any effect of both potassium sources on content of reducing sugars in potatoes under pot and field conditions which was almost the same at all varieties and experiments. Application of KCl had only positive effect on the content of crude protein in tubers.

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