ВЛИЯНИЕ НА ТОРЕНЕТО С ОРГАНИЧЕН ТОР ВЪРХУ СЪДЪРЖАНИЕТО НА НЯКОИ БИОХИМИЧНИ ПОКАЗАТЕЛИ ПРИ КАРТОФИ
INFLUENCE OF FERTILIZATION WITH ORGANIC FERTILIZER ON THE CONTENT OF SOME BIOCHEMICAL PARAMETERS IN POTATOES

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Abstract

Potatoes are a valuable source of carbohydrates, vitamins and minerals and therefore have a particular significance to human diet. Different varieties suitable for cooking, baking, preparation of chips, etc., have been developed, which are characterized with specific biochemical composition of the tubers. Apart from the methods of selection, the technology of cultivation and in particular the applied fertilization approaches also influence the quality of the crop yield. This is especially important, since the current worldtrend is high-quality food production with minimal negative impact on the environment. The utilization of organic fertilizers is one of the prerequisites for achieving that goal. Moreover, the requirements for high quality are valid also when the production should be stored for certain periods. Therefore, the aim of the current study is to investigate the influence of different rates of fertilization with vermicomposton the content of ascorbic acid and monosaccharides in potatoes from the *Agria* variety. The experiments were performed with fresh production and with tubers stored under different conditions. The potatoes were grown in the fields in four variants, each with three replication and every replication on 10 m^2. The variants included: a control with non-treated plants and 3 fertilization rates – 50, 100 and 150 ml per cluster, respectively. The fertilizer was applied once during planting. The experimental results demonstrated that the highest content of ascorbic acid and monosaccharides was observed in the fresh samples treated with 100 ml fertilizer per cluster. On the other hand, a change in the concentrations of those metabolites was found after storage at 20^0C and 6^0C.

Key words: ascorbic acid, fertilizer, potato, storage, sugars.

INTRODUCTION

Potatoes are an important source of carbohydrates for human diet. They are used for the production of starch in the food industry and for technical purposes. Moreover, they are also rich in other nutrients like vitamin C, amino acids, minerals, etc. By the modern methods of selection has been obtained a multitude of potato varieties, which are suitable for the different needs of food industry – for baking, boiling, chips or puree production, etc. These varieties are characterized with specific biochemical parameters of the tubers, which reflect the wide range of starch, monosaccharide, amino acid and vitamin contents. The quality of crops may be influenced not only by selection, but by the cultivation techniques and in particular by the fertilization approach as well. For example the accumulation of ascorbic acid (vitamin C) changes a lot between the varieties of a single species (Pleshkov, 1965), but also depends to a large extent on the growing conditions of the plants: the climate (in moderate temperatures and optimal air and soil humidity vitamin C accumulates in higher concentrations than at high temperatures and drought stress); the type of soil (plants grown on light soils have increased quantity of ascorbic acid than those grown on heavy ones); the fertilization (phosphorus-potassium fertilizers induce an augmentation of vitamin C contents, while nitrogen-based ones have the opposite effect), etc.

It is well known that high-quality food may be produced by treatment with both organic and mineral fertilizers. The differences in the crop chemical composition and yield, which are measured after application of one of the two types of fertilization, may be caused by the difference in the quantity and balance of nutrients in the used fertilizer. Accordingly, some scientific studies confirm that the addition of equal quantities of the main nutritional elements (N,

P and K) by addition of specific proportions of either organic or mineral fertilizers does not significantly change the positive effect on the yield and quality of the obtained production with each of the different fertilizers (Jarvan and Edesi, 2009; Jarvan, 2006; AOAC, 1984).

Following the modern trends in agriculture, focused on healthy and high-quality food, arises the need to elucidate the problems related to storage and processing of crop production with minimal influence on quality markers. The present work aims to investigate the effect of treatment with vermicompost from red Californian worms on the contents of vitamin C and reducing sugars in potato tubers from the Agria variety after harvest and after certain periods of storage at different temperatures.

MATERIALS AND METHODS

Potato plants were cultivated in the field in the area of Svilengrad in 2014. The experiment was performed in the following way: variant 1 were control plants with no fertilization; variant 2 were treated with 50 ml vermicompost with a total humidity of 70% (dry material was used and the measurement was carried out in a beaker); variant 3 – the same conditions, but with 100 ml fertilizer; variant 4–150 ml fertilizer. Each of the variants was grown on a total area of 10 m^2 in three repetitions. The addition of fertilizer was done once, at the moment of planting. All other agrotechnical activities during the cultivation process, like irrigation, hoeing and pest control, were equal for all the variants.

Preliminary analysis of the utilized organic fertilizer has been carried out in order to determine the content of different chemical elements – nitrogen, phosphorus and calcium, as well as the soil pH (Tomov et al., 2009). The data is presented in table 1.

After harvest, the potato tubers were divided into 3 groups: the first was immediately subjected to vitamin C (by Tilmens) and reducing sugars measurements, the latter of which was carried out by the method of Hagedorn-Jensen with a modification by Popov (Ivanov and Popov, 1994). The other 2 groups were stored for a period of 1 month at two different temperature regimes: at 20^0C and 6^0C, respectively, after which the same biochemical markers were determined. The results were subsequently analyzed for statistical significance by one-way ANOVA.

RESULTS AND DISCUSSION

The results from the measurement of ascorbic acid content are presented in table 2. The highest concentration of the vitamin C, determined immediately after harvest, was detected in variant 3 (52,8 mg 100 g^{-1} FW), while the lowest in variant 1 (40,3 mg 100 g^{-1} FW). It was demonstrated that in the samples from fertilized plants the concentration of vitamin C was higher than the controls, with the largest amount observed in variant 3 (100 ml fertilizer), not in variant 4 (150 ml fertilizer). These results correspond to the findings of other authors and other potato varieties, in which the initial increase of the fertilizer quantities influences positively the concentration of ascorbic acid, while the excessive fertilizer amounts have the opposite effect (Neshev et al., 2014; Hamouz et al., 2009; Mozafar, 2008).

During the storage period a part of the vitamin C is metabolized and lost (Weber and Putz, 1999), but the total reduction of vitamin C depends on the storage temperature (Andre et al., 2007). In the samples kept at 20^0C the quantity of ascorbic acid was decreased with 21 to 52% in comparison to the analysed fresh tubers. Relatively similar values of vitamin C content were determined in all variants stored at low positive temperatures (6^0C), which were about 42 to 49% lower than those in fresh samples. In contrast to our results, other authors report an increase of ascorbic acid levels in chopped potatoes from different varieties kept at 4^0C for 6 days (Tudela et al., 2002). We hypothesize that during storage, especially at low positive temperatures, initially the biosynthesis of vitamin C is augmented in response to the suboptimal conditions and at day 6 the amounts of the vitamin are still higher (as reported by Tudela). After that, however, due to the prolonged shortage of nutrients, catabolism of vitamin C and the chronic mild cold stress in the case of storage at 6^0C, the total quantities of ascorbic acid start to diminish and at the end of the first month they are already lower than the initially measured values.

Table 1. Agrochemical analyses of soil and fertilizer from Californian worms

Substrate	Mineral nitrogen in mg/kg^{-1}			mg/100 g^{-1}		pH
	$N\text{-}NH_4$	$N\text{-}NO_3$	Total	P_2O_5	K_2O	
Soil	3,0	12,0	15	31,0	45,4	7,99
Fertilizer	39,0	205,2	244,2	1375	1429,4	7,09

Table 2. Quantity of ascorbic acid in potato tubers from the Agria variety.
Variant 1 – control (no fertilization), variant 2 – added 50 ml fertilizer from red Californian worms, variant 3 – 100 ml fertilizer, variant 4 – 150 ml fertilizer

Ascorbic acid contents in potato tubers (mg 100 g^{-1} FW)			
Variants	After harvest	After 1 month storage	
		at 20^{0}C	at 6^{0}C
Variant 1	40,3±0,4a	28,33±2,1a (↓29,8%)	23,3±2,1a(↓42,2%)
Variant 2	46,4±0,2b	21,9±0,2a (↓52,8%)	25,21±1,1a(↓45,7%)
Variant 3	52,8±0,4c	30,44±0,7b (↓42,4%)	26,78±0,3a(↓49,3%)
Variant 4	43,5±0,1a	34,4±2,2b (↓21%)	24,51±1,2a(↓43,7%)

In the columns, the values indexed with distinct letters (a, b or c) show a difference which is statistically significant with a P value of 0,05.

Table 3. Reducing sugar contents in potato tubers from the Agria variety. Variant 1 – control (no fertilization), variant 2 – added 50 ml fertilizer from red Californian worms, variant 3 – 100 ml fertilizer, variant 4 – 150 ml fertilizer

Reducing sugars contents in potato tubers (% FW)			
Variants	After harvest	After 1 month storage	
		at 20^{0}C	at 6^{0}C
Variant 1	0,54±0,01 a	0,72±0,04 a (↑33%)	3,34±0,08b (↑518%)
Variant 2	0,72±0,07 a	0,95±0,07 b (↑32%)	3,02±0,08b (↑319%)
Variant 3	0,97±0,13 b	1,52±0,79 c (↑56%)	2,86±0,24a (↑194%)
Variant 4	0,90±0,07 b	1,36±0,64 c (↑51%)	2,62±0,05a (↑191%)

In the columns, the values indexed with distinct letters (a, b, c) show a difference which is statistically significant with a P value of 0,05.

Except for vitamin C, another important biochemical marker of the biological value of potatoes is the quantity of total reducing sugars. Their content determines on one hand the gustatory characteristics and the colour of the thermally processed potatoes, but on the other hand poses a risk, because when in combination with some free amino-acids like asparagine, reducing sugars contribute to the formation of acrylamide at high temperatures (Javad et al., 2011). Table 3 presents the data obtained from the analysis of the levels of reducing sugars in our potato samples. In the fresh tubers (controls) were measured quantities between 0,54 and 0,97% fresh weight (FW).The highest values вере detected again in variant 3. The long-term storage of the tubers at the two temperature regimes lead to an increase in the concentration of reducing sugars in all variants. At 20^{0}C the augmentation was between 32 and 56% FW in comparison to the values indicated for the fresh tubers (0,72 to 1,52% FW respectively). At lower temperatures (6^{0}C) the rise of reducing sugar concentration was further boosted, with measured values between 2,62 and 3,34% FW for the different variants. The phenomenon observed at lower storage temperatures can be explained with dominance of starch catabolism processes over the synthetic ones in these conditions, as a result of which are accumulated increased amounts of reducing carbohydrates and the potatoes become sweeter (Knowles, 2009; Voss et al., 1914).

Following these results it appears that the appropriate combination of essential nutritional elements (nitrogen, phosphorous, potassium) as well as the presence of a number of biologically active substances and microelements in the fertilizer obtained from red Californian worms favour the accumulation of ascorbic acid in potato tubers. The significant amounts of phosphorus and potassium in the fertilizer influence positively also the biosynthesis of carbohydrates and in particular monosaccharides (glucose) which are the precursors of vitamin C formation. On the other hand by excessive fertilization with nitrogen-rich compounds the subsequent yield is significantly reduced, the gustatory characteristics of the tubers are deteriorated, the dry mass and the concentrations of starch and vitamins are decreased (Blagoeva et al., 2004), as well as the storage capacity. Therefore it seems that one of the prerequisites to obtain high-quality production is the optimal and balanced fertilization.

CONCLUSIONS

1. The treatment with 100 ml fertilizer from red Californian worms per cluster at the moment of planting leads to the accumulation of the highest quantity of ascorbic acid and reducing sugars in the tubers of the Agria potato variety. Thus, 100 ml of this fertilizer can be considered the optimal amount for obtaining the highest-quality production.

2. The storage of potato tubers at 20^0C and 6^0C for a month leads to a reduction of ascorbic acid levels in all variants, with a more prominent decrease of the vitamin C observed at 6^0C. Therefore, it may be concluded that prolonged storage reduces the nutritional value of the tubers.

3. The storage of potato tubers at 20^0C and 6^0C for a month leads to anincrease of the concentration of reducing sugars in all variants, with a more prominent effect observed at 6^0C.

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