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THE INFLUENCE OF FOLIAR FERTILIZATION WITH ORGANIC FERTILIZERS ON THE YIELD AND THE CHEMICAL CONTENT OF POTATOES GROWN IN STRUMICA REGION

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Abstract
The effect of foliar fertilization with organic fertilizers on the yield and the chemical content of potatoes grown in Strumica region were studied, in the period from the year of 2011-2012. The experiment was set in four variants and three repetitions. The variants in the experiment were: Control (no-fertilizing variant); Humusil (organic matter 1.86%; organic carbon 1.08%; humin acids 0.14%; N 224 mg/L; P_2O_5 71 mg/L; K_2O 1024 mg/L; CaO 180 mg/L); Humustim (organic matter 58.63 %; dry matter 12.38 %; humin acids 20.40 %; fulvo acids 2.15%; N 3%; P_2O_5 1.02%; K_2O 7.92%; Ca 3.70 %; Mg 1.03%); Ingrasamant foliar (N 0 %; P_2O_5 130 g/L; K_2O 130 g/L; ME in helate form and plant extracts 0.005 g/L). The experiment was arranged in 12 rows and in each variant and repetition was involved 100 plants, total in all experiment were involved 1200 plants. The planting was made in rows at a distance of 60 cm row by row and 20 cm in the rows. The row's length was 20 m. Three foliar treatments were applied with given above fertilizers at a concentration of 0.4%. The soil where the experiment was carried had a good fertility with nitrogen, phosphorus and potassium. The foliar fertilization had a positive influence on potatoes yield in all of the variants treated with different organic fertilizers. The highest potatoes yield of 54.62 t ha^{-1} was established in variant 4. The foliar fertilization had a positive influence on the chemical content of tubers potato, too. In three variants treated with different fertilizers, higher content of all tested parameters was found, compared to the control untreated variant. The highest average content of vitamin C (2.60 mg/100g), phosphorus (0.90 %), and potassium (1.30 %) was determined in the tubers potato in variant 3.
Key words: potatoes, foliar fertilization, yield.

Introduction

The main goal in the modern agriculture is to obtained higher yields that are characterized with good quality.

One of the most important agricultural measures, which together with the others should allow continuous, high and cost effective production, is plant nutrition (Vukadinović and Lončarić, 1997).

For normal growing, bigger yield and getting quality fruits is necessary normal regime of plant nutrition. Regular nutrition means availability of all macro and micro biogenic elements in the right phenophases of the plant development (Jekić, 1983, Horvat *et al*., 2008). Each biogenic element has its specific influence on the different plant parts. Plant nutrition has an influence on numerous physiological – biochemical processes, of which depends growing, developing and potato yield. Plants that are timely and regular nourished, gets fruits with characteristic form, color and size, with typically organoleptic properties (Sarić *et al*., 1989; Šaćiragić and Jekić, 1988). Because of different reasons, often happens limiting of biogenic elements in the root area. Intensive agriculture and use of high productivity cultivars led to a continuous decrease in soil micronutrient content (Ebert 2009, Kalinova *et al*., 2014). Using of foliar

fertilizers in the crop cultures nutrition, has a big influence for getting higher yields and productions that are characterized with better quality, too. Using of foliar fertilizers allows directly supply of leafs, flowers and fruits with biogenic elements in the most needed period. Foliar fertilization is a widely used practice to correct nutritional deficiencies in plants caused by improper supply of nutrients to roots (Poljak, *et al* 2005, Tomov *et al*., 2009). Foliar spray with fertilizers is necessary to further activity in the whole system of optimal mineral nutrition of plants. Foliar spray provides more economical water regime of plants and allows overcoming the physiological disturbances caused by adverse soil conditions that hamper mobility and absorption of nutrients (Kostadinov and Kostadinova, 2014). Potato, as one-year culture, has a big economic importance. The most importance has in the human nutrition, as raw material in the industry and in the livestock nutrition. In the human nutrition has a principle place because of its using for preparing lot of foods.

Potato is irreplaceable for preparing diet food. By industrial processing, potato can dehydrates and in this form it is easier for keeping and transporting. In the food industry it is using for preparing flour, mashed, fries etc. It is also used by many other industries for getting alcohol, starch, glucose, doctrines, and maltose. Potato is widely used in the conservatory and pharmacy industry (Lazić, 1990).

In the livestock nutrition it has great importance for dairy and fattening livestock.

Potato is an excellent pre-culture for all the cultures, especially for the cereals. After potato harvesting, soil stay clean and loose (Maksimoviћ and Jain, 1996). This makes it suitable for preparation and sowing of autumn crops. Potato is root vegetable that is characterized with big nutrition value. Potato is one of the richest sources of starch, minerals and fiber. It contains vitamins A, C and B6, minerals such as: iron, manganese, copper and potassium (Đinović, 1989).

The aim of this exploration is to determine the influence of foliar fertilization with liquid organic fertilizers on the yield and the chemical content of potatoes grown in Strumica region.

Material and methods

In the Strumica region, in the vicinity of the village Kuklis during the years of 2011 and 2012 was appointed field experiment in the protected space of 96 m^2.

Material of work was potato cultivar *carrera*. This is early cultivar and its vegetation period is 95-100 days. The tubers have right globular oval form. The experiment was set in 12 rows. The tests included 4 variants and 3 repetitions. Seeding was obtained in raw spacing of other 60 cm and between plants 20 cm. The rows had 20 m length. In each variant and repetition were included in 100 plants and total for the whole experiment had 1200 plants. The experiment was set in terms of watering. During the potato vegetation period were applied all basic agricultural measures.

Variants in the experiment were:

1. Control (no-fertilizing);
2. Humusil;
3. Humustim;
4. Ingrasa mant.

Each variant was treated foliar with 0.4% solution of the tasted fertilizers. The application of fertilizers was done with hand spray, by spraying the played leaves. The treatments were made in the evening hours. During the vegetation were conducted seven foliar treatments.

Three types of fertilizers were used:

- Humusil (organic matter 1.86%, organic carbon 1.08%, humic acid 0.14%, N 224 mg /L, P_2O_5 71 mg /L, K_2O 1024 mg /L, CaO 180 mg /L);
- Humustim (organic matter 58.63%, dry matter 12.38%, humic acids 20.40%, fulvo acids 2.15%, N 3%, P_2O_5 1.02%, K_2O 7.92%, Ca 3.70%, Mg 1.03 %);
- Ingrasa mant (N 0%, P_2O_5 130 g/L, K_2O 130 g/L, ME in helate form, plant extracts 0.005 g/L).

The harvesting was carried out in the full maturity of the potatoes separately by variations and repetitions.

Before setting up the experiment soil samples were taken for agrochemical and analyses were performed on the following parameters:

- pH value determined potentiometric with pH meter (Bogdanović, *et al*., 1966);
- Content of easy available nitrogen – determined by method of Tjurin and Kononova;
- Content of easy available phosphorus – determined by AL method and reading of

spectrophotometer (Bogdanović *et al*., 1966);
- Content easy available potassium – determined by AL method and reading of spectrophotometer (Bogdanović *et al*., 1966);
- Content of carbonates – determined with Schaiblerov Calcimeter (Bogdanović *et al*., 1966).

In the tubers potato separately by variants the following parameters were performed:
- Moisture content - determined by calculation when from 100%, the percentage of total dry matters is deducted;
- Content of total dry matters - determined by drying the material in dryer on temperature of 105 °C;
- Content of organic matter - determined by calculation when from 100% the percentage of total ash will be deducted.
- Content of total ash - determined by removing moisture from the prepared material, drier on temperature of 105°C. Then the rest was burned in electric oven by gradually increasing the temperature to 550°C. The burning was done until ashes became grey or white;
- Content of vitamin C - determined by method of Thilmans, which is based on the redox reaction between L-ascorbic acid and organic color 2.6-dichlorophenolindophenol;
- Content of nitrogen (N) - determined by Kjeldhal method (Saric *et al*., 1989);
- Content of phosphorus (P_2O_5) - determined using atomic emission spectrometry with inductively coupled plasma (ICP - AEC) (Saric *et al*., 1989);
- Content of potassium (K_2O) - determined by incineration of the material with concentrated H_2SO_4 and plamenfotometar (Saric *et al*., 1989);
- Content of proteins - determined with calculation when the % N is multiplying with coefficient 6.25.
- Content of iron (Fe) - determined using atomic emission spectrometry with inductively coupled plasma (ICP - AEC) (Saric *et al*., 1989);

Results and discussion

For getting high and quality potato yields it is necessary favorable soil and climatic conditions. The best potato yields are getting in deep sand and loose soil rich in readily available nutrients.

The optimal soil pH value for potato is weakly acidic from 6.0 till 6.5. Potato requires high soil permeability because tubers are deformed by compact soils. Potato requires good soil drainage. Waterlogged soil leads to numerous physiological changes in tuber that become watery and difficult to store. For successful cultivation of potatoes of great importance is the presence of organic matter improves soil structure and water capacity (Lazić *et al*., 2001, Baniuniene and Zekaite, 2008).

In Table 1 are shown the results of the soil agrochemical analysis before setting up the experiment.

Table 1. Agrochemical soil analysis

No.	Tag	Deep (cm)	pH		Available forms (mg/100 g soil)			$CaCO_3$ (%)
			H_2O	KCl	N	P_2O_5	K_2O	
1	Potato I part	0-20	7.35	6.75	8.30	20.70	25.20	/
2		20-40	7.40	6.70	8.10	21.30	24.80	/
Average		0-40	7.37	6.72	8.20	21.00	25.00	/
3	Potato II part	0-20	7.43	6.80	8.15	22.00	22.80	/
4		20-40	7.40	6.85	8,10	20.30	25.70	/
Average		0-40	7.41	6.82	8.12	21.15	24.25	/

From the data in the table can be concluded that soil in which the experiment was carried out has neutral pH, and good fertility with the available nitrogen, phosphorus and potassium. There is no presence of carbonates.

In Table 2 are shown the results for obtained yield in different varieties.

Table 2. Average potato yield 2011/2012

Variant	Total yield per variant (kg)	Average per plant (kg)	Yield (t ha^{-1})
1	114.90	0.383	47.87
2	121.50	0.405	50.62
3	126.90	0.423	52.87
4	131.10	0.437	54.62

LSD (0.05) = 2.403
LSD (0.01) = 3.497

Table 3. Average chemical content of tubers 2011/2012 (% of dry matter)

Parameter	Variant			
	1	2	3	4
Hygroscopic water	75.20	76.35	76.50	75.10
Dry matter	24.80	23.65	23.50	24.90
Organic matter	96.30	96.25	96.00	95.90
Ash	3.70	3.75	4.00	4.10
Vitamin C mg/100g	2.40	2.52	2.60	2.48
N	0.97	0.99	1.10	1.15
P_2O_5	0.75	0.87	0.90	0.87
K_2O	1.18	1.23	1.30	1.25
Fe	0.35	0.30	0.36	0.37
Proteins	6.09	6.22	6.90	9.42

From the obtained data can be concluded that foliar fertilization with liquid organic fertilizers had a positive influence on potato yield achieved. In all of the variants with different organic fertilizers was obtained higher yield compared to control (no-fertilizing) variant. Higher yield (54.62t ha^{-1}) was obtained in variant 4 where the treatments were made with organic fertilizer Ingrasa mant (N 0%, P_2O_5 130 g/L, K_2O 130 g/L, ME in helate form, plant extracts 0.005 g/L).

The lowest yield (47.87 t ha^{-1}) was determined in control (no-fertilizing) variant. The differences in achieved potato yield between separated variants were small. The positive foliar influence of used organic fertilizers on potato yield is due to their chemical composition. The presence of micro elements in the analyzed fertilizers has a great influence on the regular growing, development and potato yield (Gramatikov, 2005 Bansal and Trehan 2011). This elements has an influence on numerous physiological – biochemical processes that has a vital importance on culture vegetation cycle. Balanced nutrition plays a significant role for increasing of crop production and its quality and presents an essential component of nutrient management (Panayotova *et al*., 2014).

Obtained results in all of the variants with different organic fertilizers are statistically significant at LSD (0.05) level, but in the variants 3 and 4 the statistically significance is at LSD (0.01) level.

Foliar fertilization has a positive influence on the content of all determined parameters in the tubers (Table 3). In all of the variants treated with different kinds of fertilizers, the analyzed parameters have higher content compared to the control one.

The highest average content of dry matters (24.90%) and ash content (4.10%) was determined in the tubers from variant 4. The content of hygroscopic water is correlated with the content of dry matters, and its value is the highest in the variant 3 (76.50%). The content of organic matter (96.30%) is the highest in the control variant. The highest average content of vitamin C (2.60 mg/100g), phosphorus (0.90%) and potassium (1.30%) was determined in the tubers from variant 3. The highest average content of nitrogen (1.15%), proteins (9.42%) and iron (0.37%) was determined in the tubers from variant 4.

Conclusions

Based on the obtained results for the influence of foliar fertilization with different liquid organic fertilizers on potato yield, the following conclusions can be made:

- The soil where the experiment was carried out had a good fertility with nitrogen, phosphorus and potassium;

- Foliar fertilizing had achieved positive effects in all variants treated with different organic fertilizers compared to control one;
- The highest yield, 54.62 t ha^{-1} of potato was determined in variant 4 (Ingrasa mant (N 0%, P_2O_5 130 g/L, K_2O 130 g/L, ME in helate form, plant extracts 0.005 g/L));
- The results in all variant are statistically significant at the level LSD (0.05), and the results in variants 3 and 4 has statistical significance on the level LSD (0.01);
- The highest average content of vitamin C (2.60 mg/100g), phosphorus (0.90%) and potassium (1.30%) was determined in the tubers from variant 3 (Humustim (organic matter 58.63%, dry matter 12.38%, humic acids 20.40%, fulvo acids 2.15%, N 3%, P_2O_5 1.02%, K_2O 7.92%, Ca 3.70%, Mg 1.03 %));
- The highest average content of nitrogen (1.15%), proteins (9.42%) and iron (0.37%) was determined in the tubers from variant 4 (Ingrasa mant (N 0%, P_2O_5 130 g/L, K_2O 130 g/L, ME in helate form, plant extracts 0.005 g/L)).

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