

*Mile MARKOSKI, Zvezda BOGEVSKA, Petar PETROV, Vjekoslav TANASKOVIK, Margarita DAVITKOVSKA and Velibor SPALEVIC*<sup>1</sup>

## THE IMPACT OF FOLIAR NUTRITION ON THE YIELD OF BEETROOT CROP GROWN IN HIGH FERTILITY SOIL

### SUMMARY

The main purpose of this research is to determine the impact of soil fertility and foliar nutrition on the yield of beetroot crop grown near by the village Negorci, Gevgelija. The experiment was set up as a randomized complete block design in 2012 and 2013, with four treatments in three replications. The treatments in the experiment were as follows: 1.Control (unfertilized); 2.Foliar nutrition with Humusil fertilizer; 3.Foliar nutrition with Humustim fertilizer; and 4.Foliar nutrition with Ingrasamant foliar fertilizer. Foliar treatments of these three fertilizers were performed in form of 0.3 percent solution during the vegetative period.

Before the experiment was set up, determination of soil type was carried out, wherein the identified soil type was alluvial soil. Soil sampling was also performed in order to determine some chemical properties of the soil. The analysis of soil fertility showed that levels of nitrogen, phosphorus and potassium in available forms were high.

After harvesting the beetroot crop and measuring the yield, it was concluded that foliar nutrition and high content of available forms of nitrogen, phosphorus and potassium in the soil, had a positive impact on the yield of all three treatments. The highest average yield of 71.68 tonnes per hectare in two years of investigation was achieved in the treatment with application of Ingrasamant foliar.

**Keywords:** beetroot crop, foliar nutrition, alluvial soil, yield

### INTRODUCTION

Fertilization is one of the most important agricultural practices for ensuring good agricultural production. Controlled and well-dosed use of fertilizers keeps production of each crop sustainable. Very often, in order to achieve higher yields, fertilizers are applied in enormously high amounts. Uncontrolled use of fertilizers does not only have a negative impact on products quality, but it also leads to many environmental problems, which has long term consequences on the

---

<sup>1</sup> Mile Markoski, Zvezda Bogevska (corresponding author: zvezdabogevska@gmail.com), Petar Petrov, Vjekoslav Tanaskovik, Margarita Davitkovska Faculty of Agricultural Sciences and Food-Skopje. "Ss.Cyril and Methodius" University in Skopje. Blvd. Aleksandar Makedonski bb. R. Macedonia; Velibor Spalevic, Institute of Forestry, Podgorica, Montenegro.

Note: The author declare that they have no conflicts of interest. Authorship Form signed online.

ecosystem in general. This is why fertilization is a very complex process which deserves greater attention.

Fertilization is an important factor in beetroot crop production technology to achieve optimum yield and root quality. The beetroot crop is a plant with high nutrient demands because of forming abundant vegetative mass and many roots at the unit area. It is a great consumer of nitrogen, phosphorus, potassium, magnesium and calcium, as well as micro elements (Fit and Hangan 2010).

Foliar nutrition is an application of water soluble fertilizers directly to the leaf. Foliar fertilizers are quickly absorbed by plants and commonly are used as nutritional supplements for the plants (Fernandez and Eichert 2009) and as alternative nutrition in conditions when plants show high necessity for nutrients or in cases of deficiency in soil fertility.

Foliar nutrition is ideally designed to provide many elements in conditions that may be limiting production at a time when nutrient uptake from the soil is inefficient or nonexistent (Hiller, 1995).

The use of foliar fertilizers is becoming increasingly widespread and they are environmentally friendly and target focused, because unlike soil fertilizers, foliar fertilizers are assimilated directly into the organism in small quantities (Fernandez and Eichert 2009). The effectiveness of foliar fertilizers is estimated based on the assimilation and availability of the elements (Lea-Cox and Syvertsen 1995, Zhang and Brown 1999), reduction of phytotoxicity (Neuman and Prinz 1975), deficiency (Rombolà *et al.* 2000) and on the yield and the quality of the culture (Dong *et al.* 2005).

On the market there are different foliar fertilizers, which are often mixture of micronutrients and secondary nutrients. Their application is recommended in order to increase crop yield and quality of beetroot crop (Jablonski, 2003, Mousavi *et al.* 2007)

The beetroot crop is particularly demanding in terms of soil properties and fertility. The best yields can be achieved on fertile, deep soils, which are rich in organic matter and have good water-air regime. These properties are typical for alluvial soils, meadow soils as well as chernozem, while in heavy and dense soils, deformation of the root, low yield and poor quality may occur (Lazić *et al.* 1998).

The beetroot crop uptakes large amounts of nutrients. The edible part of beetroot crop has good quality if it is uniformly formed, without delays or disruptions in development. It is therefore necessary nutrients to be in easily available form and in sufficient quantities. Beetroot crop has high nutrient requirements, but can contain high levels of nitrates if it is fertilize with high amounts of nitrogen. By 10 tonnes yield, beetroot crop takes out 30 kg N, 10 kg P<sub>2</sub>O<sub>5</sub> and 50 kg K<sub>2</sub>O from the soil (Gjurovka, 2008).

## MATERIAL AND METHODS

The research experiment was performed in 2012 and 2013 at the field near by the village Negorci in Gevgelija, Macedonia with beetroot crop (variety Bikor) and foliar nutrition with different foliar fertilizers, as follows:

1.  $\emptyset$  – unfertilized (control treatment)
2. Foliar nutrition with Humusil. According to the declaration by the manufacturer Humusil has the following chemical properties: pH = 9.18, total salts = 8.39 mS, total organic matters = 1.86 percent, organic carbon = 1.08 percent, total macroelements (%) N = 2.28, P<sub>2</sub>O<sub>5</sub> = 0.71, K<sub>2</sub>O = 45.76, CaO = 1.80, MgO = 0.99, easily available microelements (%) Fe = 0.159, Mn = 0.0136, Cu = 0.007, B <0.001, Zn = 0.0109. This foliar fertilizer belongs to a group of organic-mineral fertilizers.
3. Foliar nutrition with Humustim. Humustim is organic fertilizer with following chemical properties: total organic matter = 58.63 percent, total dry = 12.38 percent, humic acids = 20.40 percent, fulvic acids = 2.15 percent, N = 3 percent, P<sub>2</sub>O<sub>5</sub> = 1.02 percent, K<sub>2</sub>O = 7.92 percent, Ca = 3.70 percent, Mg = 1.03 percent. The total microelements are in form of chelate complex expressed in percent as follows: Fe = 0.180, Mn = 0.010, Cu = 0.005, B = 0.002, Zn = 0.010.
4. Foliar nutrition with Ingrasamant foliar. Ingrasamant foliar is organic-mineral fertilizer and according to the declaration by the manufacturer has the following chemical properties: N = 0 percent, P<sub>2</sub>O<sub>5</sub> = 13 percent, K<sub>2</sub>O = 13 percent, microelements in chelate form (Fe = 0.230, Mn = 0.017, Cu = 0.007, B = 0.005, Zn = 0.016) and plant extracts 0.0005 percent.

The experiment was set up as a randomized complete block design with four treatments and three replications (plots) and total size of experimental field of 96 m<sup>2</sup>. The size of each plot (replication) was 8 m<sup>2</sup> (100 plants in 0.40 m of row spacing and 0.20 m plant spacing in the row). In each treatment were included 300 plants. Investigation was carried out on alluvial soil, quite common for beetroot crop production in Gevgelija region. In order to determine the agrochemical and physical soil properties, the soil analysis were performed before setting up the experiment. The experimental field for years ago has been used for vegetable production, and was intensely fertilized with mineral and organic fertilizers. The field experiment is provided with irrigation from private wells and the relief is flat. Meteorological parameters for average temperatures and monthly rainfalls during the investigation were provided from the National Hydrometeorological Service of Republic of Macedonia.

According to mechanical-chemical composition (Table 1), the arable layer (0-40 cm) is loam whereas physical clay fraction is represented by 55.4%, field capacity is 33.69% and with porosity of 50.90%.

In terms of pH reaction, the analyzed soil show neutral to slightly alkaline reaction, which is suitable for growing beetroot crop. Beetroot is sensitive to the soil reaction. For normal growth and development and favorable yields the best pH reaction of the soil should be ranged from 6.5 to 7.00

(Gjurovka, 2008). The acidic soils lead to lower yields and poor quality of the root (Lazić *et al.* 1998).

Table 1. Physical and chemical soil properties of field experiment

Depth cm	Porosity vol. %		Field capacity vol. %		Physical clay %		pH in H <sub>2</sub> O		Humus %		mg/100 soil					
	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	$\bar{x}$	$\sigma$	N		P <sub>2</sub> O <sub>5</sub>		K <sub>2</sub> O	
0-40	50.9	1.0	33.7	2.1	55.4	4.1	7.37	0.04	2.97	0.6	10	3.1	100.6	19.3	57.3	9.7

$\bar{x}$ -mean;  $\sigma$  (SD)-standard deviation

From the results of the chemical soil properties, we can conclude that there is an enormous imbalance of nutritional regime in the soil, especially the content of available nutrient elements. Namely, the content of the three basic biogenic macro elements is relatively high; especially alarming is the phosphorus content. Laboratory analyses were performed by standard methods (Džamić *et al.* 1996, Bormann, 2007, Pelivanoska, 2011, Mitrikeski and Mitkova 2013).

The use of soil fertilizers may have a negative effect and would further deteriorate the current soil fertility and adversely affect other components of the environment. The purpose of agricultural crop production is to get higher yields with improved quality and environment protection in the same time. These can be achieved by applying foliar fertilizers and cultivation of varieties suitable for current soil properties.

All necessary agro-technical and plant protection practices in the present study were applied during the vegetative period of beetroot crop.

Table 2. Period of foliar nutrition of beetroot in 2012 and 2013

Treatment	First foliar nutrition	Second foliar nutrition	Third foliar nutrition	First foliar nutrition	Second foliar nutrition	Third foliar nutrition
1. Control	/	/	/	/	/	/
2. Humsil	29.6.2012	15.7.2012	30.7.2012	22.6.2013	09.7.2013	23.7.2013
3. Humustim	29.6.2012	15.7.2012	30.7.2012	22.6.2013	09.7.2013	23.7.2013
4. Ingrasamant	29.6.2012	15.7.2012	30.7.2012	22.6.2013	09.7.2013	23.7.2013

Foliar application of fertilizers is carried out with 0.3 percent solution of fertilizers, with the dorsal spray pump every 15 days, three times during the vegetation (Table 2). The application of fertilizers started about 30 days after

transplanting. The obtained results for yield were subjected to statistical analysis of variance and means were compared by using the least significant difference (LSD) at the 5% level of probability ( $P < 0.05$ ) test.

## RESULTS AND DISCUSSION

Climate and soil are the most important factors that affect the yield and quality of beetroot crop (Petrov, 2014). The Gevgelija region is characterized by a warm modified Mediterranean climate (Filiposki, 1996). Precipitation and air temperature are meteorological factors that play major role in open field production. The results from our investigations on these two parameters are presented in Table 3 and 4. The total amount of precipitation from May to August during 2012 and 2013 was 204.9 and 111.8 mm respectively (Table 3).

Table 3. Monthly and growing season precipitation (mm) for Gevgelija region for the period 2012-2013

Year	Month				
	V	VI	VII	VIII	Total
2012	142.3	44.8	0.00	17.8	204.9
2013	22.4	53.1	34.4	1.9	111.8

In later stages of growth longer dry periods appeared, followed by high temperatures which increased the evaporation rate, so the beetroot crop had no ability to satisfy the water requirements for normal plant development. Irrigation is an important measure for proper high and quality crop production in Republic of Macedonia (Tanaskovik et al. 2011), especially in dry periods, when soil nutrients are less available for plants. The temperature is a major climatic factor for development of beetroot crop. The optimum temperature for beetroot crop growth is 15-23°C (Aladzajkov, 1966, Lazić et. al. 1998, Gjurovka, 2008). During the two-year field investigations, the mean daily and monthly temperatures ranged within the optimum values (Table 4). The maximum temperature values were noted in July and August, with average values of 28.4 and 27.6°C respectively.

Table 4. Monthly and growing season temperature (°C) for Gevgelija region for the period 2012-2013

Year	Month				
	V	VI	VII	VIII	Average
2012	19.1	26.1	29.8	27.6	28.4
2013	21.9	24.3	27.0	27.7	27.65

From the obtained data presented in Table 5, we can conclude that the beetroot yields in all investigated treatments are pretty high or more than 64 tonnes per hectare. Namely, the highest yield is achieved in treatment four with 71.68 tonnes per hectare or about 6.9 tonnes per hectare more yield compared

with control treatment. If our results for yields are presented in comparative values, than treatment four shows almost 11% higher yield compared with control treatment. Treatments number two and three yielded 3 and almost 6% higher in comparison with control treatment. The results are statistically significant at 0.05 level of probability. Regarding the yields between the experimental years, there were noted differences that are result of meteorological conditions. Generally, the results in our study are higher compared with average yields in the literature data for beetroot crop in Republic of Macedonia ranging from 20 to 40 tonnes per hectare (Aladzajkov, 1966). Similar yields to average in Macedonia, but with more recent data, were obtained in Seychelles with different varieties grown on sandy-loam soil and with average yield of about 36.43 tonnes per hectare (Ijoyah *et al.* 2008). Zdravkovska (2015) reported similar results for average beetroot yields (69.43 tonnes per hectare) in Skopje region as those achieved in our study, but with foliar nutrition with microbiological fertilizers. Higher average yields in comparison with ours were achieved in northeastern Poland where several Lithuanian, Dutch and Polish beetroot cultivars gave about 91.61 tonnes per hectare (Majkowska-Gadomska and Wierzbicka 2006).

Table 5. Beetroot yields (t/ha) for 2012 and 2013

Treatment	Years			
	2012	2013	Average	%
1. Control	64.00 <sup>a</sup>	65.65 <sup>a</sup>	64.83 <sup>a</sup>	100.00
2. Humsil	66.23 <sup>b</sup>	67.28 <sup>b</sup>	66.76 <sup>b</sup>	103.00
3. Humustim	67.64 <sup>c</sup>	69.37 <sup>c</sup>	68.51 <sup>c</sup>	105.70
4. Ingrasamant	71.23 <sup>d</sup>	72.13 <sup>d</sup>	71.68 <sup>d</sup>	110.60

\*Values in rows followed by the same letter are not significantly different at the 0.05 probability level

As we mentioned above, the results in our study shows untypical high yields in treatment without fertilization, which can be ascribed of soil fertility (high content of total and available forms of nitrogen and enormously high content of available forms of phosphorus and potassium). As a result of improper and uncontrolled fertilizers management in agricultural production in the country (Tanaskovik *et al.* 2011), many soil types used for vegetables production are brought into a state of impaired nutritive regime (Tanaskovik *et al.* 2009). Unfortunately, this was confirmed in our study, too. So, application of additional soil fertilizers in such soil condition would only have a negative impact on crop production and environment. In this case, the most economical and environmentally friendly acceptable measure is growing crops that can exploit available nutrients in the soil with proper foliar nutrition according to soil analysis and plant needs.

## CONCLUSIONS

In high soil fertility conditions with previously conducted soil analysis, the application of ecological foliar fertilizers consisted by macro and micro biogenic elements and plant extracts without soil fertilization enables in average 68.98 tonnes per hectare yields. This is very important especially if we want to protect the environment from additional fertilization in high fertility soil, as well as to reduce production costs of beetroot crop.

## REFERENCES

- Aladzajkov, L. (1966): *Specijalno gradinarstvo*. Univerzitet vo Skopje. Skopje
- Bormann, H. (2007): Analysis of the suitability of the German soil texture classification for the regional scale application of physical based hydrological model. *Advances in Geosciences*, 11. pp. 1–13.
- Džamić, R. Stevanović, D., Jakovljević, M (1996): *Practicum iz agrohemije*, Poljoprivredni fakultet, Beograd – Zemun. str. 1-162
- Dong, S.F., D. Neilsen, G.H. Neilsen, and L.H. Fuchigami (2005): Foliar N application reduces soil NO<sub>3</sub>-N leaching loss in apple orchards. *Plant and Soil*. 268:357-366.
- Fernandez, V. & Eichert, T. (2009): Uptake of hydrophilic solutes through plant leaves: Current state of knowledge and perspectives of foliar fertilization. *Critical Reviews in Plant Science* 28: 36-68
- Filipovski, F., Rizovski, R. Ristevski, P., 1996. *Characteristics of climate-vegetation-soil zones (regions) in the Republic of Macedonia*. Macedonian Academy of Sciences and Arts. Skopje.
- Fernandez, V., Eichert, T. (2009): Uptake of hydrophilic solutes through plant leaves: Current state of knowledge and perspectives of foliar fertilization. *Critical Reviews in Plant Science* 28: 36-68.
- Fit, E-M. & Hangan, M-C. (2010): The effect of differential fertilization upon Desirée and Ostara potatoes produced on districambosol soil. *Research Journal of Agricultural Science*, 42 (3): 137 - 142.
- Djurovka, Mihal (2008): *Gajenje povrća na otvorenom polju*. Poljoprivredni fakultet. Novi Sad. Tampograf. p. 40.
- Hiller, K.L. (1995): Foliar fertilization bumps potato yields in northwest. Rate and timing of application, plus host of other considerations, are critical in applying foliar fertilizers to potatoes. *Fluid Journal*, 3 (3): 29-30.
- Ijoyah, M.O., Sophie, V.L., Rakotomavo, H. (2008): Yield performance of four beetroot (*Beta vulgaris* L.) varieties compared with the local variety under open field conditions in Seychelles. *Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension*. Volume 7 Number 2. pp. 139 -142
- Jablonski, K. (2003): Efficiency of foliar and „to soil” fertilization of potatoes the urea-ammonium-nitrate solution (UAN 32). *Acta Agrophysica*, 85: 125-135.
- Lazić, B., Vladan, M., Mihal, Đ., Ilin Ž (1998): *Povrtarstvo*. Univerzitet u Novom Sadu. Poljoprivredni fakultet.
- Lea-Cox, J.D. & Syvertsen, J.P. (1995): Nitrogen uptake by citrus leaves. *J. Amer. Soc. Hort. Sci.* 120:505–509.
- Majkowska-Gadomska, J. & Wierzbicka, B. (2006): Effect of Foliar Application of Ecosol U on the Yield of Red Beet (*Beta vulgaris* L. ssp. esculenta) and the Concentrations of Minerals in Storage Roots. *Polish journal of natural sciences*. No 21(2): 531-541

- Mitrikeski, J. & Mitkova, T. (2013): *Praktikum po pedologija*. Treto izdanie. Univerzitet "Sv. Kiril i Metodij" - Skopje, Fakultet za zemjodelski nauki i hrana, Skopje. str. 1-164
- Mousavi, S.R., Galavi, M., Ahmadvand, G. (2007): Effect of zinc and manganese foliar application on yield, quality and enrichment on potato (*Solanum tuberosum* L.) *Asian Journal of Plant Sciences*, 6: 1256-1260.
- Neumann, M. & Prinz, R. (1975): The reduction by surfactants of leaf burn resulting from foliar sprays and a salt-induced inhibition of the effect. *J. Sci. Food Agric.* 26, 909-914.
- Pelivanoska, V. (2011): *Priracnik na agrohemiski ispitivanja na pochvata*. St. Kliment Ohridski University, Bitola. Scientific Tobacco Institute. Prilep. p. 1-105.
- Petrov P., (2014): *Effects of soil fertility and foliar fertilization of beetroot (Beta vulgaris L. var. cicla) in Gevgelija region*. Ss. Cyril and Methodius University in Skopje, Faculty of Agricultural Sciences and Food, Skopje. (MA thesis)
- Rombolà, A.D., Brüggemann, W., Tagliavini, M., Marangoni, B., Moog, P.R. (2000): Iron source affects Fe reduction and re-greening of kiwifruit (*Actinidia deliciosa*) leaves. *J. Plant Nutr.* 23:1751-1765.
- Tanaskovik, V., Cukaliev, O., Martinovski, G., Trpevski V. (2009): Results from the final year report of the project: Use of liquid fertilizers for drip fertigation and foliar application. Alkaloid AD. Skopje, Republic of Macedonia.
- Tanaskovik, V., Cukaliev, O., Romić, D., Ondrasek G. (2011): The influence of drip fertigation on water use efficiency in tomato crop production. *Agriculturae Conspectus Scientificus*. 76 (1): 57-63.
- The influence of drip fertigation on water use efficiency in tomato crop production. *Agriculture Conspectus Scientificus*, 76 (1): 57-63.
- Zhang, Q. L. & Brown, P. H. (1999): Distribution and transport of foliar applied zinc in pistachio. *J. Am. Soc. Hort. Sci.* 124 433-436
- Zdravkovska M. (2015): *Quantitative and qualitative characteristics of carrot (Daucus carota L.) and beetroot (Beta vulgaris ssp. Esculenta L.) grown by applying microbiological fertilizers*. Ss. Cyril and Methodius University in Skopje, Faculty of Agricultural Sciences and Food, Skopje. (MA thesis)