*Journal of Agricultural, Food and Environmental Sciences*
*UDC 635.13-184.7*
*Original scientific paper*

# MORPHOLOGICAL CHARACTERISTICS AND YIELD OF CARROT (*DAUCUS CAROTA* L.) GROWN WITH APPLICATION OF MICROBIOLOGICAL FERTILIZERS

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**Abstract**
Sustainable and organic production systems in which the application of synthetic products are partially or completely excluded are becoming increasingly popular and are opening more opportunities for usage of microbiological fertilizers. Therefore this research is aimed at determining the impact of two types of microbial fertilizers on the morphological characteristics and the yield of carrot,to test the possibility for their extensive use.Experiment was set on open field in the area of the village Jurumleri, Skopje, during 2013. As research material was used carrot (*Daucus carota* L.), hybrid Maestro. The variants were set according to the type of microbiological fertilizer: Ø control - not applied microbiological fertilizer, variant 1 - treatment with microbiological fertilizer Micro - I Vita containing several groups of azotobacter, nitrifying microorganisms and phosphor-soluble microorganisms; variant 2 - treatment with microbiological fertilizer Micro - Vita II containing azotobacter, nitrifying microorganisms, phosphor-soluble microorganisms and iron.From the morphological characteristics were measured the weight of whole plant,which ranged from 73,17 g in the control to 84,00 gin variant 1,root weight,which ranged from 63,83 g in the control to 74,67 g in variant 1, lengthwhich ranged from 17,69 cm in the control to 18,28 cmin variant 1, widthwhich ranged from 2,22 cm in the control to 2,39 cm in variant 1 and index of the rootwhich ranged from 7,65 in variant 1to 7,99 gin the control. According to the results statistically significant differenceswere determined between the variants in weight of whole plant and rootweight. The highest yield was obtained in variant 1from 53,77 t/ha, in variant 2 the yield was 46,32 t/ha, while the lowest yield was obtained in the control from 45,96 t/ha. Also statistically significant difference was determined in the yield between the variants.

**Keywords:** carrot, yield, morphological characteristics, sustainable agriculture, microbialfertilizers.

## Introduction

In modern agriculture primary goal is the intensification of all food production and improving foods quality. Vegetable production, which is an important branch of the agricultural sector includes production of many kinds of vegetables including carrot (*Daucuscarota* L., fam. *Apiaceae*), which is one of the most important root vegetables, because it features high nutritional value, and also it has a great economic importance in the agricultural sector. In addition, production is focused on getting a high yield, high quality and health safety vegetables, which are essential in the daily diet because of the high content of vitamins, minerals and secondary biologically active substances, especially antioxidants that are important in the prevention of different diseases (Лазић, 2011). However, besides the nutritional value of vegetables in recent decades more frequent application of synthetic fertilizers, pesticides, hormones, etc. in conventional vegetable production, in some cases results in reduced quality and safety of the vegetables, and with disruption of natural relationships in ecosystems (Ковачевић и Ољача, 2005). Therefore the production systems which exclude the application of synthetic preparations are becoming increasingly popular models of sustainable agriculture and are extremely important in the agriculture.

Directions in which sustainable agriculture is moving, with notably limiting of the application of synthetic fertilizers are opening more opportunities for the use of

microbiological fertilizers, whose main component are the microorganisms that through their activity in the soil are providing food for the plants in available forms (Matotan, 2004; Најденовска и Ѓорѓевиќ, 2009). The application of these fertilizers will result with a positive effect if they are with appropriate composition according to the needs of the crops and if their application is in optimal quantities and at a certain period of the vegetation (Lešić et al., 2004). The type of fertilizers, their composition and the manner and timing of their application is extremely important in the production of carrot, because of their ability to accumulate nitrates and nitrites, which are harmful to human health (Vukashinovic et al. 1991; Boskovic-Rakocevic et al., 2012). According to Kazimierczak et al. (2011), Szopińska et al., (2013) and Wrzodak et al., (2013) higher levels of minerals and vitamin C, and less nitrates and lower content of some heavy metals were found in vegetables produced without the use of artificial fertilizers.

**Materials and methods**

Experiment was set on open field, on soil type aluvium in the village of Jurumleri, Skopje, during 2013. As research material was used carrot (Daucus carota L.), from the hybrid Maestro. The Maestro hybrid is suitable for cultivation during the main season and is good for longer storage. It is appropriate for the production because of the resistance to disease and mechanical damages, and because of the strong green mass, which allows easy removal from the soil.

For treatment of the carrot ware used two types of microbial fertilizers, Micro - Vita I, organic fertilizer containing several groups of azotobacter, nitrifying microorganisms and phosphor-soluble microorganisms and Micro - Vita II, organic fertilizer containing azotobacter, nitrifying microorganisms, phosphor-soluble microorganisms and iron. Microbiological fertilizers Micro - Vita are stimulating the development of the root system, improve the blooming and also help to stimulate photosynthesis. Significantly improve the utilization of cations and anions from the soil, improve fertility, microbiological composition and water-air regime of soil. Also improve the resistance of plants against bacterial and fungal diseases, which leads to reduced application of chemical preparations.

The sowing of the carrot was on 22 April in the experimental plots with a size of 2 $m^2$, arranged in random block system in three variants with four repetitions. The sowing was in rows, with distance between the plants in the rows of 5 cm, while between the rows the distance was 25 cm.

The variants were set according the type of microbiological fertilizer:

1. Ø control - not applied microbiological fertilizer;
2. variant 1 - treatment with microbiological fertilizer Micro - I Vita containing several groups of azotobacter, nitrifying microorganisms and phosphor-soluble microorganisms;
3. variant 2 - treatment with microbiological fertilizer Micro - Vita II containing azotobacter, nitrifying microorganisms, phosphor-soluble microorganisms and iron.

The application of the fertilizers was foliar during the vegetation, with dorsal spray pump, with a solution with concentration of 100 ml/10 L water, every 7 days. The application of both fertilizers began on May 25 and the last application was made on 24 August.

During the vegetation was irrigated according to the needs of the crop with a system of metal pipes and sprayers.

The effect on the morphological characteristics and yield of carrots, with application of microbiological fertilizer, was analyzed trough the monitoring of following parameters: weight of whole plant, root weight, root length, root width, index of the root and yield.

The obtained results of the studies concerning the morphological characteristics and yield of carrot are processed by descriptive statistical methods and analysis of variance.

**Results and discussion**

The carrot is grown for the tasty roots with yellow, orange, red or purple color, which can have different forms: spindle, cylindrical or conical, even globular, with a length of 25 cm, which depends from the variety and growing conditions. According to the weight, the roots can be small with weight up to 60 g, medium from 60 to 150 g and large from150 to 250 g. The consumptive part, thickened hypocotyl or real root in the diet can be used fresh, as spice, dried, frozen, marinated and like juice. The

best part of the carrot is the crust because it contains the most nutrients, less nitrates and greater amount malic and citric acid, as opposed to the middle part (core). Quality carrot has the same color of the crust and the core, and a higher proportion of peel marrow(Лазиќ, 2011).

Table 1 shows the results of our study concerning the morphological characteristics of the carrots. According to the results the lowest average weight of whole plant was obtained in the control from 73.17 g, then 74.67 g in variant 2, and the highest invariant 1 from 84.00 g. The coefficient of variation (CV%) was lowest in variant 1, wherein is 14.90%, then in variant 2 - 19.34% and highest coefficient of variation was obtained in the control of 20.03%. Statistically significant difference with the LSD test on level 0.05, was determined between the control and variant 1 (10.83 g) and between variant 1 and variant 2 (9.33 g).

The average weight of the root or the consumptive part of the carrot ranged from 63.83 g in the control, then 64.33 g in variant 2 and the highest was in variant 1 from 74.67 g. The coefficient of variation was lowest in variant 1 from 16.44%, then in variant 2 - 21.26% and in the control was highest from 22.32%. Statistically significant difference on level of 0.05 was defined between: the control and variant 1 (10.84 g) and between variant 1 and variant 2 (10,34 g). Vithwel and Kanaujia (2013) in their research for determining the effect of integrated nutrition on the productivity of carrot, found the root weight of 41.29 g with the use of cow manure, 43.04 with use of manure from pigs, 90.37 g with application of the combined nutrition with NPK, cow manure and bio fertilizers, then a weight of 86.07 g with utilisation of NPK, manure from pigs and biofertilizers and weight of 79.00 g with integrated nutrition with NPK, vermicompost and biofertilizers.

According to the average values for the length of the root, the smallest length of the root of 17.69 cm was observed in the control, followed by variant 2 with 17.84 cm, while the largest value for this parameter was determined in variant 1 of 18.28 cm. The lowest coefficient of variation (CV%) was calculated in variant 2 of 6.78%, then in the control of 7.60%, while the highest coefficient of variation was calculated in variant 1 of 7.93%. Statistically significant difference between the variants for this parameter has not been determined. Vithwel and Kanaujia (2013) in their research for determining the effect of integrated nutrition on the productivity of carrot, determined root length of 15.69 cm withapplying cow manure, 16.04 cm with application of manure from pigs, 18.88 cm using combined nutrition with NPK, cow manure and biofertilizers, then a length of 18.60 cm with use of NPK, manure from pigs and biofertilizers and length of 18.23 cm with integrated nutrition with NPK, Vermicompost and bio fertilizers.

According to the data in Table 1, the highest average value for the width of the root was obtained in variant 1 of 2.39 cm, then in variant 2 – 2.29 cm and lowest in the control of 2.22 cm. The coefficient of variation was highest in variant 1 - 6.69%, then in the control - 5.86% and the lowest was in variant 2 - 5.68%. Statistically significant difference between the variants for this parameter was not determined. Vithwel and Kanaujia (2013) in their research for determining the effect of integrated nutrition on the productivity of carrot, found the root diameter of 3.53 cm with the use of cow manure, 3.42 cm with usage of manure from pigs, 4.14 cm with application of combine nutrition with NPK, cow manure and biofertilizers, then a width of 4.13 cm with application of NPK, manure from pigs and biofertilizers and a width of 4.13 cm with integrated nutrition with NPK, vermicompost and biofertilizers.

Table 1. Morphological characteristics of the carrot

| Variant / Parameter | | Control | Variant 1 | Variant 2 |
|---|---|---|---|---|
| Weight of whole plant (g) | Average | 73,17 | 84,00 | 74,67 |
| | Difference between the control and the variants | | 10,83* | 1,47 |
| | Difference between variant 1 and variant 2 | | | 9,33* |
| | SD | 14,66 | 12,52 | 14,44 |
| | CV% | 20,03 | 14,90 | 19,34 |
| | $LSD_{0,05}$= 7,646 | | | |
| Root weight (g) | Average | 63,83 | 74,67 | 64,33 |
| | Difference between the control and the variants | | 10,84* | 0,50 |
| | Difference between variant 1 and variant 2 | | | 10,34* |
| | SD | 14,25 | 12,28 | 13,68 |
| | CV% | 22,32 | 16,44 | 21,26 |
| | $LSD_{0,05}$= 7,323 | | | |
| Root length (cm) | Average | 17,69 | 18,28 | 17,84 |
| | Difference between the control and the variants | | 0,59 | 0,15 |
| | Difference between variant 1 and variant 2 | | | 0,44 |
| | SD | 1,35 | 1,45 | 1,21 |
| | CV% | 7,60 | 7,93 | 6,78 |
| Root width (cm) | Average | 2,22 | 2,39 | 2,29 |
| | Difference between the control and the variants | | 0,17 | 0,07 |
| | Difference between variant 1 and variant 2 | | | 0,10 |
| | SD | 0,13 | 0,16 | 0,13 |
| | CV% | 5,86 | 6,69 | 5,68 |
| Index of the root | Average | 7,99 | 7,65 | 7,79 |
| | Difference between the control and the variants | | 0,34 | 0,20 |
| | Difference between variant 1 and variant 2 | | | 0,14 |
| | SD | 0,88 | 0,95 | 0,66 |
| | CV% | 11,01 | 12,42 | 8,47 |

The index is the ratio between the height and the width of the root. The average value for this parameter in our study ranged from 7.65 in variant 1, 7.79 in variant 2 and 7.99 in the control. The highest coefficient of variation was calculated in variant 1 of 12.42%, then in the control of 11.01%, and the lowest in the variant 2 of 8.47%. Statistically significant difference in terms of this parameter was not determined.

The carrot is mature and ready for removal from the soil when the leaves are starting to became yellow. At this time the digest accumulation in the root is completed and the root is richest with sugars, β-carotene, and has the best taste. The time of removal should be carefully determine when the tissue root is firmly enough (100 more days of sowing) to avoid shooting and breaking of roots while extracting and processing. The yield of carrots depends from the way of sowing, from the way of cultivation, from the choice of variety or hybrid and from the climatic conditions. Depending on the above factors, the yield of carrot ranges from 20 to 60 t / ha (Lesić et al., 2002). Table 2 shows the average yield in t / ha for the three variants in our study.

Table 2. Yield of the carrot (t / ha)

| | Control | Variant 1 | Variant 2 |
|---|---|---|---|
| Average yield | 45,96 | 53,77 | 46,32 |
| Difference between the control and the variants | | 7,81* | 0,36 |
| Difference between variant 1 and variant 2 | | | 7,45* |
| Index % | 100,00 | 116,99 | 100,78 |
| SD | 0,38 | 2,44 | 6,59 |
| CV% | 0,83 | 4,54 | 14,23 |
| $LSD_{0,05}$= 6,51 | | | |

The average yield of the carrot in our study ranged from 45.96 t / ha in the control, then 46.32 t / ha in variant 2, and the highest yield was obtained in the variant 1 from 53.77 t / h. The yield in variant 1 where it was applied microbiological fertilizer with azotobacter, nitrifying microorganisms and phosphor-soluble microorganisms, was 16.99% higher compared with the control, while the yield in variant 2, where it was applied microbiological fertilizer with azotobacter, nitrifying microorganisms, phosphor-soluble microorganisms and iron,compared to control was minimal above from the control - 0.78%. The lowest coefficient of variation was calculated in the control of 0.83%, then in variant 1 was 4.54% and in variant 2 was highest from 14.23%. After the statistical analysis, it was determined a significant difference at the level of 0.05 between the control and variant 1 (7.81 t / ha) and between variant 1 and variant 2 (7.45 t / ha). Vithwel and Kanaujia (2013) in their research for determining the effect of integrated nutrition on the productivity of carrot, determined yield of 13.73 t / ha with application of cow manure, yield of 14.31 t / ha with the use of manure from pigs, then yield of 30.08 t / ha with application of combined nutrition with NPK, cow manure and biofertilizers, then yield of 28.66 t / ha with utilization of NPK, manure from pigs and biofertilizers and yield of 26.31 t / ha with applying integrated nutrition of NPK, vermicompost and biofertilizers.

## Conclusions

According to the results obtained in our study considering the morphological characteristics of the carrot, statistically significant difference between the variants was determined for the weight of whole plant (g) and weight of the root (g). Statistically significant difference for the weight of whole plant with LSD test on level of0.05 was determined between the control and variant 1 from 10.83 g, and between variant 1 and variant 2 from 9.33 g, while for to the weight of the root statistically significant difference was determined between the control and variant 1 from 10.81 g and between variant 1 and variant 2 from 10.34 g.

The highest yield of carrot was obtained in variant 1, where it was applied microbiological fertilizer containing azotobacter, nitrifying microorganisms and phosphor-soluble microorganisms,16.99 % higher compared with the control, while in the variant 2, where it was applied microbiological fertilizer with azotobacter, nitrifying microorganisms, phosphor-soluble microorganisms and ironthe yield was 0.78% higher compared with the control. Statistically significant difference was determined between the control and the variant 1 of 7.81 t / ha and between variant 1 and variant 2 of 7.45 t / ha.

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