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# THE EFFECT OF SOIL MULCHING ON THE QUALITY OF THE BULB AND THE YIELD OF DIFFERENT AUTUMN GARLIC GENOTYPES

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## Abstract

The effect of soil mulching (covering) on the quality of the bulb and the garlic yield was tested. The experiment served to test the properties of five genotypes (four population and Bosut sort) originating from the Institute of Field and Vegetable Crops, Novi Sad, Serbia. The tested garlic was grown on black polyethylene sheeting, wheat straw and non mulch soil (control). The field experiment was set up in a randomized complete block design in four replications (Mačva, Serbia). The following factors were analyzed: number of cloves per bulb, weigh of clove (singl), weight of bulb and bulb yield. Mulch significantly affected the analyzed garlic properties, specifically the quality and yield of the bulb. In this regard, the emphasis is on the polyethylene sheeting where the values of the above mentioned factors were the most favourable ones. Significant differences were recorded between the tested genotypes. The differences between them were significantly expressed in the mulching varieties. The results accomplished in this experiment indicate that by mulching the soil and with the appropriate genotype selection, the yield achieved in the garlic production can be significantly increased with quality bulbs.

**Key words:** *garlic, bulb, yield, soil mulching*.

## Introduction

The production of garlic (*Allium sativum* L.) in Serbia is based on the autumn and spring subtypes of garlic. Spring garlic is planted early in the spring (March) and it has smaller bulbs, higher number of cloves, higher dry matter content. Because of these properties, the spring garlic bulbs can be kept longer in comparison to the autumn subtype of garlic. Autumn garlic has an attractive, larger bulb, which is primarily caused by the length of the growing season (October-July).

At the territory of Serbia, garlic is grown on around 9 thousand hectares. Average yields are about 4 t $ha^{-1}$ (FAO, 2014). The production technology is conditioned by its biological specificity, vegetative method of reproduction, resistance to low temperatures and other requirements according to agroecological conditions. Because of these characteristics, it is particularly taken into account the introduction of planting material, which must originate from a similar geographic area (similar agroecological conditions). Selection of local garlic genotypes in Serbia is small and the level of production technology is low (Kamenetsky et al., 2004; Gvozdanović-Varga et al., 2009; Moravčević et al., 2011b). When selecting the planting material one takes into account the aforementioned particularities that limit its production, there is an answer to the question of why our garlic yield is several times lower (about 3 times) when compared to the global yield (around 13 t $ha^{-1}$).

A variety of natural and industrial materials for mulching (covering) the soil are being used in the plant production. Harvest residues of certain plants (wheat, corn, soybean) and various foils, mainly polyethylene (PE) are dominant. The advantage of mulching is reflected primarily in the easy maintenance of optimal moisture and soil temperature, weed control, as well as reducing the incidence of diseases and pests on cultivated plants. Even though this agrotechnical measure mainly positively affects the cultivated plant, it has not found its application in the production of garlic in Serbia. In particular, we emphasize the fact that no domestic science is not going towards this direction even though a large number of foreign research showed that garlic mulching gave a positive effect (Haque et al., 2003a; Jamil et al., 2005; Najafabadi et al., 2012).

For all the above mentioned reasons, and for the purpose of increasing the volume of domestic garlic production, this team of researches chose the testing that will answer the question of the extent that the soil mulching in the autumn garlic production has on its quality and the yield. The paper also shows the behavior of different genotypes of the autumn garlic.

## Material and methods

Autumn garlic testing in the agroecological conditions of Mačva (Western Serbia) was performed during the vegetation seasons of 2011/12 and 2012/13. Thereby, we used a method of field experiments that were set in a random block system in four recurrences. The size of the elementary plot size was 4 $m^2$ (2x2 m).

Table 1 shows the following meteorological parameters: average monthly air temperatures and the amount of monthly rainfall for the years in which the experiment was conducted (RHMSS, 2014).

Table 1 Mean monthly temperature and monthly rainfall, Sremska Mitrovica, Serbia

| Month/Year | Temperature [ºC] | | | | Rainfall [mm] | | | |
|---|---|---|---|---|---|---|---|---|
| | 2011 | 2012 | 2013 | 2000-2013 | 2011 | 2012 | 2013 | 2000-2013 |
| Jan | 0.10 | 1.50 | 3.10 | 0.40 | 32 | 41 | 55 | 39 |
| Feb | 0.10 | -4.50 | 4.40 | 1.72 | 32 | 53 | 48 | 35 |
| March | 6.30 | 7.90 | 6.50 | 7.01 | 16 | 4 | 64 | 41 |
| April | 13.20 | 12.90 | 13.40 | 12.58 | 20 | 86 | 32 | 50 |
| May | 16.60 | 17.10 | 18.10 | 17.77 | 63 | 71 | 113 | 68 |
| June | 20.60 | 22.70 | 20.20 | 20.74 | 70 | 27 | 60 | 80 |
| July | 22.20 | 24.90 | 22.00 | 22.39 | 94 | 40 | 44 | 52 |
| Aug | 22.40 | 23.70 | 23.20 | 22.03 | 6 | 0 | 18 | 51 |
| Sept | 20.30 | 19.50 | 16.10 | 16.81 | 19 | 13 | 61 | 54 |
| Oct | 10.40 | 12.80 | 14.70 | 12.11 | 27 | 48 | 71 | 59 |
| Nov | 3.00 | 9.10 | 9.00 | 7.06 | 6 | 30 | 34 | 45 |
| Dec | 3.80 | 0.40 | 1.70 | 1.69 | 45 | 40 | 5 | 41 |
| Average/Sum | 11.58 | 12.33 | 12.70 | 11.86 | 430 | 453 | 605 | 615 |

The crop preceding the garlic was broccoli in both tested years. The primary type of tillage (plowing) was performed in both tested years, at the end of September at a depth of 30 cm. Together with the seedbed preparation, we performed a basic fertilization with 500 kg $ha^{-1}$ mineral fertilizer of formulation 8:24:16 +4% S. At the beginning of April, we also performed a top dressing of 300 kg $ha^{-1}$ of nitrogen fertilizers KAN (27%). Regular weed, disease and pest control was performed. The experiment was conducted without irrigation. The soil was of cambisol type, with the following chemical properties: pH -5.60 (KCl), humus content 2.1%, total nitrogen content - 0.2%, phosphorus 13 mg and potassium - 24 mg per 100 g of soil.

The experiment tested the properties of five autumn garlic genotypes (Bosut variety and four other populations) that originate from the Institute of Field and Vegetable Crops of Novi Sad, Serbia. Garlic is grown on black polyethylene foil, wheat straw and soil without mulch (control). Polyethylene mulch foil is set just prior to planting while mulch of wheat straw (3 cm layer thickness) is placed immediately after planting the garlic.
Garlic was planted by hand in mid-October in the density of about 250 thousand plants $ha^{-1}$ (30x13 cm). Garlic harvest (removal), was carried out, in both years, in July ($1^{st}$ and $6^{th}$), when it was observed that the false tree completely softened, while the plants have not yet begun to massively lodge. Immediately before planting garlic (three months after the removal), the following parameters were analyzed: the number of cloves in the bulb, clove weight (individual, in grams), bulb weight (g) and the bulb yield (t $ha^{-1}$).
The results were statistically analyzed according to the model of two-factor analysis of variance (ANOVA) and the LSD test (Excel 2007, DSAASTAT 2011).

## Results and discussion

The highest number of cloves in the bulb was noticed at the soil that was mulched with a black PE foil (11.37) while the lowest number was noticed in the variant without mulch (8.53). Statistically, mulched variants had the significantly higher number of cloves when compared to the controlled variant (without mulch). Statistically, significant differences in regards to the number of cloves were also noticed in the genotypes. The highest number of cloves, in all variants, had the genotype B (16.45), while the lowest number of cloves in a bulb was noticed in the genotype D (8.33). Slight variations of this parameter (maximum stability) were observed in the bosut variety. In our agroecologic conditions, the autumn garlic forms a smaller number of cloves when compared to the spring garlic form. According to the number of cloves we can distinguish genotypes with low (3-6), medium (7-15) and strong branching (more than 15). The number of cloves in a bulb depends on the genotype, growing conditions, ways of preserving the bulbs (IPGRI, 2001; Rahim and Fordham, 1988; Moravčević et. al., 2011a, Mathew et al., 2011).
The average weight of an individual clove had values that ranged from 3.26 g (genotype B) to 10.27 g (bosut). The first value was achieved in the controlled variant (without mulch) while the second, which is the largest in the experiment, was achieved in the soil that was mulched with black PE foil. The average clove weight that was obtained on the black PE foil was statistically significantly higher only when compared to the weight of cloves that was obtained in the controlled variant. When compared to other two variants, the differences achieved in the variants where the soil was mulched with straw were not significant. When observing genotypes, we can state that the average weight of cloves in the variety Bosut, varied the most (from 4.70 to 10.27 g), while the least variation was observed in the genotype C (5.07 to 5.78 g). This parameter directly depends on the bulb weight and the number of cloves in the bulb (positive correlation), and therefore the conditions that lead to the development of larger bulbs have a positive impact on the weight of a single clove (Moravčević, 2012). Also, the clove weight also represents a varietal characteristic, while the separation of cloves from bulbs (before planting) is a lot faster if they are composed of a small number of larger cloves (Stahlschmidt et al., 1997; Gvozdanović-Varga et al., 2004; Stavelikova, 2008).
The bulb weight ranged from 29.23 to 87.80 g. The first value was achieved in the controlled variant (genotype C), while the second value was observed in the variant where the soil mulching was performed with PE foil (Bosut variety). Statistically, we achieved significantly higher values of the bulb weight on the mulched soil when compared to the ones that were achieved in the controlled variant (without mulch). Besides, it is necessary to pint out that the values achieved for the bulb weight from the soil mulched with PE foil, when compared to

the soil with straw, were statistically also significantly higher. Statistically significant differences in the values of bulb weight were observed in the genotypes. Since this parameter represents the most important productive characteristic of the garlic which defines the yield and determines its market value, it is necessary to point out that soil mulching positively affected that characteristic. Similar results, but in different agroecologic conditions, were obtained by a number of other researches (Haque et al., 2003b; Karaye and Yakubu, 2006; Mirzaei et al., 2007; Faradonbeh et al., 2012).

Table 2. The effect of soil mulching on the quality of the bulb and the yield of different autumn garlic genotypes

| Mulching system (A) | Genotype (B) | Number of cloves per bulb | Weight of clove (singl) (g) | Weight of bulb (g) | Bulb yield (t $ha^{-1}$) |
|---|---|---|---|---|---|
| Black polyethylene sheeting | Bosut | 8.33 | 10.27 | 87.80 | 16.9 |
| | A | 10.00 | 7.26 | 74.67 | 14.6 |
| | B | 18.67 | 4.05 | 78.33 | 15.3 |
| | C | 8.33 | 5.50 | 48.33 | 9.4 |
| | D | 13.33 | 4.95 | 68.13 | 13.4 |
| Average | | 11.73 | 6.41 | 71.45 | 13.9 |
| Wheat straw | Bosut | 10.00 | 8.20 | 84.17 | 15.8 |
| | A | 13.00 | 5.52 | 74.53 | 14.1 |
| | B | 15.00 | 4.75 | 73.33 | 13.8 |
| | C | 9.00 | 5.07 | 47.60 | 8.8 |
| | D | 7.67 | 5.25 | 42.30 | 8.1 |
| Average | | 10.93 | 5.76 | 64.39 | 12.1 |
| Non mulch soil (control) | Bosut | 10.00 | 4.70 | 48.70 | 9.2 |
| | A | 8.33 | 5.91 | 51.70 | 9.8 |
| | B | 15.67 | 3.26 | 53.37 | 9.9 |
| | C | 4.67 | 5.78 | 29.23 | 5.7 |
| | D | 4.00 | 6.85 | 29.40 | 5.6 |
| Average | | 8.53 | 5.30 | 42.48 | 8.0 |
| | LSD | | | | |
| A | 0.05 | 1.18 | 0.72 | 4.06 | 0.7 |
| | 0.01 | 1.59 | 0.97 | 5.46 | 0.9 |
| B | 0.05 | 1.53 | 0.93 | 5.23 | 0.9 |
| | 0.01 | 2.05 | 1.25 | 7.05 | 1.2 |
| A x B | 0.05 | 2.64 | 1.61 | 9.07 | 1.6 |
| | 0.01 | 3.56 | 2.17 | 12.21 | 2.1 |

The average bulb yield, in the whole experiment, was 13.3 t $ha^{-1}$. The lowest yield was achieved by genotype D (5.6 t $ha^{-1}$), while the highest was achieved by the Bosut variety (16.9 t $ha^{-1}$). The first value was observed in the controlled variant (without mulch), while the second value was observed in the variant where the soil mulching was performed with PE foil. The average yield achieved at the soil mulched with PE foil was the highest one (13.9 t $ha^{-1}$), while the lowest yield was achieved at the soil without mulch (8.0 t $ha^{-1}$). These achieved differences are statistically very significant. Differences between tested genotypes were also demonstrated in the same manner. In average, in all mulching variants, the highest yield was achieved by the Bosut variety (13.9 t $ha^{-1}$), while the lowest was achieved by the genotype C (8.0 t $ha^{-1}$). Manifesting the genetic potential of the garlic, through achieved yield, is directly connected to the agroecological conditions and applied agrotechnics (Mirzaei et al., 2007). Due to the favorable water regime, in both tested years, mulching has made a significant positive effect. This effect is mainly caused by the influence of mulch on the soil water regime, wherein the thermal conditions were significantly enhanced. This has directly influenced the increase of the soil microbial activity, and thus its fertility (Bhuiya et. al., 2003; Kabir et al., 2013).

## Conclusion

Soil mulching (covering) favorably affected the quality and the bulb yield of the autumn garlic in the agroecological conditions of the western Serbia (Mačva). The increase in yield of some genotypes, at the mulched soil, compared to the one without mulch, was even up to 140% (genotype D). Bosut variety, which demonstrated the greatest yield stability, had the yield increase of 83% which was caused by mulching. From the above mentioned, we can conclude that the autumn garlic should be preferably grown at the mulched soil and that further research should focus on the variety of materials which can be implemented by this agrotechnical measure.

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