

## THE EFFECTS OF DIFFERENT COVER CROPS ON YIELD AND YIELD COMPONENTS OF SWEET MAIZE

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### Abstract

The objective of the study was to determine the effect of different winter grown cover crops and legume-cereal based mixtures on yield of sweet maize. Growing fall sown cover crops is an approach for environmental protection through decreasing weed populations and increasing grain yield of sweet maize. The experiment includes two control treatments: dead organic mulch - soil covered with straw in autumn and winter time, and conventional (traditional) variant - bare soil uncovered during fall and winter time. Sweet corn was grown on slightly calcareous chernozem (locality Zemun Polje) after winter wheat as a previous crop. The experiment was in factorial setting with two factors (growing season - 2010/11 and 2012/13 and cropping system) the factor in RCBD with four replicates (the basic plot 16.8 m<sup>2</sup>). Along legume species, favorable effect on grain yield of sweet maize had been recorded on winter hairy vetch, as well on a kind of non-legume species based organic mulch. Depending on the treatment, yields of sweet corn in 2011 were from 8.09 t ha<sup>-1</sup> (conventional system) to 10.00 t ha<sup>-1</sup> (organic mulch), and 7.80 to 10.20 t ha<sup>-1</sup> in the year 2013.

**Key words:** *cover crops; sweet maize; yield components; grain yield.*

### Introduction

Unlike the standard hybrids of maize in which they conducted extensive research on the impact of different agricultural practices on yield (Khaldun et al., 2010; Tonk et al., 2011), growing conditions on yield and yield components (Beyene et al., 2011) and the effect of intercropping with other species (O'Leary and Smith, 1999) the results of investigation for grain yield of sweet maize are quite scarce (Bachiredy et al., 1992, Haas and Haas, 2009). The situation is such, not only in relation to standard hybrids of maize, but also in relation to other types of vegetables, most likely due to the very low economic importance of this crop. Sweet maize is a crop with much shorter vegetation period, in which it is very sensitive to the weather conditions, especially during germination and emergence as compared to the other subspecies of maize. The optimum time of sowing or planting could last longer, because of the possibility of growing this subspecies also from seedlings. Growing sweet maize from seedlings with cover crops significantly shortens the growing period (Orosz, 2013), but in years with pronounced drought without irrigation it is very difficult to practice this growing technology. Particularly are unfavorable very high air temperatures and lack of precipitation during and immediately after transplanting. Early sowing is also recommended by Aldrich (1970) for the reason that the roots will penetrate deeper in the soil this way, from where they can get water even in periods of drought. The more intensive vegetative growth also takes place during the period of shorter daytime and this way the plants will be smaller and will be less prone to lodge. Several techniques are known in the art for the purpose of early fresh market shipments: seedling growing or direct seeding with temporary plant cover (Hodossi, 2004 cit. Orosz, 2013). Some of the ways to mitigate the negative effects of later sowing are

sowing in optimum densities and growing of cover crops which soothe the effects of drought by the decreases of weed infestation and keeping moisture reserves. Sowing in optimum densities of some dwarf cultivars can give 3-4 ears per plant, but generally the number of ears in our conditions should be 1-2. Sweet maize likes warm weather, but for proper growth it needs a lot of moisture and it is an important way of irrigation. The worst results are obtained by artificial irrigation rain, because in the beginning they increased the number of fungal infections and pests, and at the time of pollination and fertilization could lead to a lack of pollen or its fertility. Productivity of sweet maize is quite dependent on the amount of nitrogen, whereas it is recommended every three to six weeks to add a certain amount of nutrients.

Previous studies of sweet maize were mainly focused on the sensitivity of yield to drought, especially in specific phases of the crop (Claassen and Shaw, 1970; Swan et al., 1990, Orosz, 2013). Sweet maize is different from the common maize in many important aspects, in particular by traits taste. The traits that affect the appearance of kernels and the normal appearance (condition) of kernels after cutting, as well as, the kernel colour, width and depth, are the most important properties of sweet maize hybrids that are used for industrial processing, i.e. for kernel cutting (Pajic and Radosavljevic, 1987). The sweet maize plant habitus is shorter and poorly developed. As maize hybrids of standard grain quality, these hybrids have a smaller or greater leaf area, depending on a hybrid, hence they differently response to a sowing density (Morris et al., 2000; Rangarajan et al., 2000; Simic and Stefanovic, 2007). Factors driving yield loss varied among sweet maize hybrids - more competitive hybrids established canopy dominance, restrained weed growth and experienced less yield loss (Williams et al., 2008).

Having in mind the above facts, the aim of this study was to determine the effect of different cover crops to the reduction of weed infestation and keeping moisture reserves for the period when there is not enough in soil, and the effects on yield of grain and yield components of sweet maize hybrid grown from transplants (2011 year) and direct sowing of seeds (2013) on chernozem soil type in Zemun Polje.

### **Materials and methods**

The experiment have included two kinds of winter cover crops in the *Fabaceae* family, a variant in which soil was covered with dead organic mulch and traditional, classical variant: plowing in the fall and bare soil which was left uncovered during the winter time. Investigated types of winter legumes were common vetch and hairy vetch and its mixture with oats, all varieties originated from Novi Sad Institute for Field Crops and Vegetables (Neoplanta, NS Vilosa and NS Jadar). Crops were grown in rain-fed conditions.

Field experiments were conducted in 2010/11 and 2012/13 at Maize Research Institute, Zemun Polje, in the vicinity of Belgrade in Serbia (44°52'N 20°20'E). The soil was slightly calcareous chernozem with 47% clay and silt and 53% sand. The soil properties in a surface layer (0-30 cm) were: 3.22% organic matter, 0.19% total N, 1.9% organic C, 16.2 and 22.4 mg per 100 g soil of available P and extractable K, respectively, 1.38% total CaCO<sub>3</sub> and pH 7.3. Eventhough experiments were located in different fields in each year, the winter wheat was the previous crop. Considering both plant nutrition and nitrogen fixation in legumes, we came up to the required amount of macronutrients for sweet maize (120 kg ha<sup>-1</sup> N, 90 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> and 60 kg ha<sup>-1</sup> K<sub>2</sub>O). In the fall, before planting of cover crops we have entered the entire amount of P and K in the form of monopotassium phosphate and 50 kg ha<sup>-1</sup> N in the form of ammonium nitrate, and on the two control variants, also all of P<sub>2</sub>O<sub>5</sub> i K<sub>2</sub>O and 40 kg ha<sup>-1</sup> N in the form of AN. In the spring time (April 07 2011 and April 19 2013) on a leguminous cover crops we have added another 30 kg ha<sup>-1</sup> N in the form of AN (the remaining 40 kg ha<sup>-1</sup> considered to have provided by nitrogen fixation), and control plots another 80 kg ha<sup>-1</sup> N, also

in the form of AN. The experimental plots were ploughed in autumn, followed by one pass of a disk harrow and a field cultivator prior to sowing.

Sowing of cover crops was carried out manually, on October 10-th, 2010 and November 02-nd, 2012. Cutting and measuring the above-ground biomass of cover crops was performed 7-10 days before planting of sweet maize. Planting of the main crop, after the production of seedlings, was done on May 26-th, 2011, and direct sowing on April 25-th, 2013. Crops were harvested approximately 22-24 days after pollination. In 2011. harvesting was performed on August 18. while in the year 2013. it was done on August 06.-th at the milky stage of kernel maturity which is considered optimal technological maturity.

#### Experimental design

The plant stand was created to contain 65.000 plants per hectare, according to the recommendations of the breeder of the variety, at a spacing of 70x22 cm in twin rows. Each plot consisted an area of 2,8x6m (4 parallel rows and 27 seeds sown in each row). Sowing depth was 3 cm. The new Zemun Polje (ZP) sweet maize hybrid in FAO 400 maturity group ZP 424su was grown. This hybrid belongs to a short season maize hybrids and it was evident that its yield increased continuously up to the highest sowing density. In other hybrids, the higher sowing density was reflected with lower yield (Paji and Radosavljevi, 1987).

#### Measurements and statistical analysis

Ears were harvested together with the husks, from the two central twin rows, 25 days after silking. Ten ears were selected from each row and the following measurements were carried out: weight of husked ears (g), total ear length (cm) and ear diameter (mm). The grain yield and yield components data were underwent to ANOVA for the factorial trials design according to the plan for two years, six variants, and differences between means were tested by the least significant difference (LSD) test (Gomez and Gomez, 1984).

#### Meteorological conditions in the period of investigations

Table 1. The average monthly air temperatures and monthly precipitation sums from April to September at Zemun Polje

| Months             | Temperature (°C) |             | Precipitation (mm) |            |
|--------------------|------------------|-------------|--------------------|------------|
|                    | 2011             | 2013        | 2011               | 2013       |
| April              | 14,6             | 14,9        | 11                 | 22         |
| May                | 17,3             | 19,8        | 63                 | 104        |
| June               | 22,4             | 21,7        | 40                 | 49         |
| July               | 24,1             | 24,1        | 107                | 3          |
| August             | 24,7             | 25,4        | 9                  | 44         |
| September          | 23,2             | 17,3        | 49                 | 59         |
| <b>Average/Sum</b> | <b>21,1</b>      | <b>20,5</b> | <b>279</b>         | <b>281</b> |

The meteorological conditions during the maize growing season were presented in the Table 1. The weather conditions, especially in the first investigated year were extremely unfavorable. Regarding precipitation in 2013 their distribution was, as well in 2011 quite unfavorable, but the average air temperature for the growing period of sweet maize was significantly lower than in the first year. This fact did not have a positive impact on the growth and development of the main crop, we cannot say for sure, because in this year, maize was grown by direct sowing seeds in the field.

## Results and discussion

Grain yield results and yield components data of sweet maize for the analyzed samples have presented in Table 2. By growing sweet maize from transplants, the length of the growing season in the first year of the experiment was 83 days, while in the second year of this study, when the main crop was grown by direct sowing, the length of the season was 90 days. With the first method of growing by transplanting small plug plants, cover crops had longer vegetation period, which was quiet preferable in terms of increasing organic matter in the soil, less weed infestation of main crop, and acquiring certain reserves of soil moisture, etc. Furthermore, much faster maturity of sweet maize in the first year of our study, certainly was contributed by severe drought during August (Table 1). From the aspect of the length of growing period, the priority should be given to this type of cultivation, but increased risk under rain-fed conditions, due to the lack of potential precipitation immediately after planting bring in certain limits. Orosz (2013) have emphasized that the growing period was significantly shortened with the transplantation of sweet corn youngplants compared to the direct seeded crop. Harvesting time occurred 17 days earlier in the case of transplantation and floating row cover application compared to direct sowed, uncovered treatment, and 13 days earlier compared to direct sowed, covered treatment. At the same time the floating row cover produce 4 days shortening in the growing season between P2 (direct sowing of plants with floating row cover) and P3 (direct sowing of plants with no row cover) treatments. The fleece covering had favourable effect on studied morphological characteristics of plants that are transplanted and floated with row cover. In case of direct sowed treatment (P2) the effect of covering had positive effect on total diameter of ears, number of seeds and length of seeds. In our research, studied yield components of sweet maize had a higher value if the crop is grown from seedlings. On the other hand, Dolijanovi et al., 2012 stated that because of the extreme conditions of drought and high temperatures in the growing season 2012.-th there was a crop failure. Therefore, in 2013 we have changed method of growing, switching to a direct sowing of seeds.

Tab. 2. The cropping system effects on yield components and grain yield of sweet maize

| Cropping system     | Weight of husked ears (g) |                  | Total ear length (cm) |                    | Ear diameter (mm)  |                    | Yield of grain (t ha <sup>-1</sup> ) |                    |
|---------------------|---------------------------|------------------|-----------------------|--------------------|--------------------|--------------------|--------------------------------------|--------------------|
|                     | 2011                      | 2013             | 2011                  | 2013               | 2011               | 2013               | 2011 <sup>**</sup>                   | 2013               |
| Common vetch        | 178 <sup>c</sup>          | 176 <sup>c</sup> | 16,3 <sup>b</sup>     | 16,2 <sup>ab</sup> | 34,3 <sup>cd</sup> | 34,1 <sup>bc</sup> | 8,84 <sup>b</sup>                    | 8,71 <sup>b</sup>  |
| Hairy vetch         | 184 <sup>b</sup>          | 183 <sup>b</sup> | 16,4 <sup>b</sup>     | 16,2 <sup>ab</sup> | 34,7 <sup>c</sup>  | 34,4 <sup>b</sup>  | 9,98 <sup>a</sup>                    | 9,17 <sup>b</sup>  |
| Common vetch+oats   | 181 <sup>b</sup>          | 183 <sup>b</sup> | 16,0 <sup>bc</sup>    | 15,8 <sup>c</sup>  | 34,5 <sup>c</sup>  | 34,5 <sup>b</sup>  | 8,72 <sup>b</sup>                    | 8,12 <sup>b</sup>  |
| Hairy vetch+oats    | 187 <sup>a</sup>          | 185 <sup>b</sup> | 16,6 <sup>b</sup>     | 16,4 <sup>ab</sup> | 35,1 <sup>b</sup>  | 34,9 <sup>a</sup>  | 8,61 <sup>b</sup>                    | 7,97 <sup>c</sup>  |
| Organic mulch       | 188 <sup>a</sup>          | 190 <sup>a</sup> | 17,1 <sup>a</sup>     | 16,7 <sup>a</sup>  | 35,5 <sup>a</sup>  | 35,0 <sup>a</sup>  | 10,00 <sup>a</sup>                   | 10,20 <sup>a</sup> |
| Conventional system | 174 <sup>d</sup>          | 171 <sup>d</sup> | 15,9 <sup>c</sup>     | 15,6 <sup>c</sup>  | 34,0 <sup>cd</sup> | 33,9 <sup>c</sup>  | 8,09 <sup>c</sup>                    | 7,80 <sup>c</sup>  |
| <b>Average</b>      | <b>182,0</b>              | <b>181,3</b>     | <b>16,4</b>           | <b>16,2</b>        | <b>34,7</b>        | <b>34,5</b>        | <b>9,05</b>                          | <b>8,66</b>        |

Values of means followed by the same letter are not significant;

As well as yield components, grain yield in the second year of examined period was lower than in the first one, the year 2011. Grain yield in the second year (10.20 t ha<sup>-1</sup>) compared to the yield in the first year of investigation (10.00 t ha<sup>-1</sup>) was higher only in the variant "dead mulch"- straw and the reason was hidden in the fact that such cover laid down shorter in the soil surface, it was not completely decomposed and thus prevented a complete waste of the reserves of moisture and intense occurrence of weeds in the spring.

The lowest yield was obtained following the traditional cultivation (8.09 t ha<sup>-1</sup> and 7.80 t ha<sup>-1</sup>). In addition, at least achieved yields probably the balance of nitrogen in the soil after harvest, at least, will be a subject of a subsequent paper. The yield of sweet maize achieved in this study was below average yields in similar experiments (Dolijanovi et al., 2012, 2013;

Simi et al., 2012), and the main reason was the way of growing. Between two of investigated vetch species which was grown as cover crops, both as a sole crop or in mixture with oats, the favorable effect on grain yield of the main crop have had with hairy vetch in both years and in both methods of growing.

### Conclusion

According to the presented results of two-year studies on the response of ZP sweet maize hybrids to different growing methods under agroecological conditions of Zemun Polje, the following can be concluded:

The observed traits of sweet maize (weight of husked ears, total ear length, ear diameter and grain of yield) significantly varied over the years. This means that the stated traits depends to a great extent on meteorological conditions and growing system.

The highest yield components and grain of yield of hybrid ZPSC 424su, for the average of both years, was recorded on the variant with organic mulch.

Generally speaking, growing of cover crops consisting legumes or mixtures of legumes and grasses have an advantage over the conventional system of growing, both in terms of yield components and grain yield, but also in terms of the protection and conservation of agroecosystem, which is now a very important part of research in agriculture.

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