

COVER CROPS EFFECTS ON THE YIELD OF SWEET CORN

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Abstract

Sweet corn (*Zea mays saccharata* Sturt.; the hybrid ZP 424su of FAO 400 maturity group) was grown for two growing seasons (2011 and 2012) on slightly calcareous chernozem (locality Zemun Polje) after winter wheat as a previous crop. The cover crops were as follows: a = *Vicia sativa* L., b = *Vicia vilosa* Roth., c = *Pisum sativum ssp. arvense* L., d = organic mulch, e = conventional system. The experiment was in factorial setting with two factors (A = growing season, B = cropping system) the factor in RCBD with four replicates (the basic plot 16.8 m²). Because of extremely unfavorable weather conditions of the 2012 growing season (drought and hot stress: precipitation in July-August 43 mm accompanied with 26.7 °C mean air-temperature), maize yield was realized only in the first year of testing. Depending on the treatment, yields of sweet corn in 2011 were from 8.09 t ha⁻¹ (conventional system) to 10.00 t ha⁻¹ (organic mulch).

Keywords: *cover crop; organic farming; yield of grain; sweet corn*

Introduction

Cover crops are crops grown for managing soil fertility, soil quality, water, weeds, pests, diseases and for increasing biodiversity in agroecosystem (Lu *et al.*, 2000), which is the key role of sustainable and organic farming system.

Cover crops improve the sustainability and quality and sustainability of both natural systems and agroecosystems. Farmers choose the kinds of cover crops on the basis of their needs and goals, influenced by biological, social, cultural and economic factors (Snapp *et al.* 2005). Legume cover crops are typically rich in nitrogen and are often able to provide the exact amount of nitrogen required for crop production. In conventional farming system, this nitrogen is usually introduced into the soil in the form of chemical fertilisers. This property of cover crops is called a fertiliser replacement value (Thiessen-Martens *et al.*, 2005). Some scholars (Bohlool *et al.* 1992; Peoples and Craswell 1992; Giller and Cadisch 1995) consider that the extended biological nitrogen fixation achieved by growing cover plants is the only alternative to industrial nitrogen fixation in terms of maintaining and increasing food production in the future. Industrial nitrogen fixation has been criticised as an unsustainable source of nitrogen for the production of food due to its reliance on fossil fuel energy and environmental impacts associated with the use of chemical fertilisers in agriculture (Jensen and Hauggard-Nielsen 2003).

At the same time with the introduction of nitrogen in agroecosystems through biological nitrogen fixation, there are some sorts of cover crops, known as "catch crops" that can retain and recycle nitrogen, which is already present in the soil. These crops use excess of nitrogen that is left over after the fertilisation of the previous crops, preventing its loss through leaching, denitrification or evaporation (Thorup-Kristensen *et al.*, 2003). Catch crops are

usually fast-growing annual types of wheat adapted to efficiently collect available soil nitrogen (Ditsch and Alley, 1991).

Cover crops can also improve soil quality by increasing soil organic matter levels through the input of cover crop biomass over time. Increased soil organic matter enhances soil structure, as well as the water and nutrient holding and buffering capacity of soil (Patrick *et al.*, 1957). It can also lead to increased soil carbon sequestration, which has been promoted as a strategy to help offset the rise in atmospheric carbon dioxide levels (Sainju *et al.*, 2002, Lal, 2003).

Although cover crops can perform multiple functions in an agroecosystem simultaneously, they are often grown for the sole purpose of preventing soil erosion. Dense cover crop stands physically slow down the velocity of rainfall before it contacts the soil surface, preventing soil splashing and erosive surface runoff (Romkens *et al.*, 1990). Additionally, vast cover crop root networks help anchor the soil in place and increase soil porosity, creating suitable habitat networks for soil macrofauna (Tomlin *et al.* 1995). Erosion control, cover crops, improving the speed and volume of water that passes through the topsoil layer, which can decrease the salinity of the soil and how soil pollution and water courses.

Just before cover crops are killed (by such practices including mowing, tilling, discing, rolling, or herbicide application) they contain a large amount of moisture. When the cover crop is incorporated into the soil, or left on the soil surface, it often increases soil moisture. In agroecosystems where water for crop production is in short supply, cover crops can be used as a mulch to conserve water by shading and cooling the soil surface. While cover crops can help to conserve water, especially in years of deficient rainfall, may also affect the drying if too much moisture from heavy rain during the winter.

Thick cover crop stands often compete well with weeds during the cover crop growth period, and can prevent most germinated weed seeds from completing their life cycle and reproducing. If the cover crop is left on the soil surface rather than incorporated into the soil as a green manure after its growth is terminated, it can form a nearly impenetrable mat. This drastically reduces light transmittance to weed seeds, which in many cases reduces weed seed germination rates (Teasdale, 1993). Some cover crops suppress weeds both during growth and after death (Blackshaw *et al.*, 2001), and in addition to competition-based or physical weed suppression, certain cover crops are known to suppress weeds through allelopathy (Creamer *et al.*, 1996, Singh *et al.*, 2003). This occurs when certain biochemical cover crop compounds are degraded that happen to be toxic to, or inhibit seed germination of, other plant species. Some well known examples of allelopathic cover crops are *Secale cereale* L. (rye), *Vicia villosa* Roth. (hairy vetch), *Trifolium pratense* L. (red clover), and species in the *Brassicaceae* family, particularly mustards (Haramoto and Gallandt, 2004). In one study, rye cover crop residues were found to have provided between 80% and 95% control of early season broadleaf weeds when used as a mulch during the production of different cash crops such as soybean, tobacco, corn, and sunflower (Nagabhushana *et al.*, 2001). In the same way that allelopathic properties of cover crops can suppress weeds, they can also break disease cycles and reduce populations of bacterial and fungal diseases (Everts 2002), and parasitic nematodes (Vargas-Ayala *et al.*, 2000). Species in the *Brassicaceae* family, such as mustards, have been widely shown to suppress fungal disease populations through the release of naturally occurring toxic chemicals during the degradation of glucosinolate compounds in their plant cell tissues (Lazzeri and Manici, 2001). Some cover crops are used as so-called "trap crops", to attract pests away from the main crop of value and toward what the pest sees as a more favorable habitat (Shelton and Badenes-Perez, 2006).

The consequence of all these positive aspects of growing cover crops is the indirect effect on increasing the yield of crops that are grown after them on arable land. The combinations of main crop and cover crop were based on a combination of legume and non-

legume. This was specially achieved with the oats–vetch mixture as maize preceding cover crop and with grasses as soybean preceding crops (Restovich *et al.*, 2012). Uchino *et al.*, 2009 found that the largest increase in soybean yield determined if the cover crops were rye and corn following hairy vetch. However, the cover crop sowing time is very important for achieving high yields of major crops, especially corn. So in treatments where cover crops actions for spreading the 20 or so days after sowing maize main crop recorded the highest grain yield. Hiltbrunner *et al.*, 2007 found that the growing of cover crop from August to planting winter wheat in October had a very positive impact on the quality of planting, weed and later on grain yield per unit area.

The aim of this study was to evaluate the impact of different types of growing winter cover crops on yield of sweet maize from traditional cultivation of this crop with conventional practice.

Materials and methods

The experiment included three kinds of winter cover crops in the family *Fabaceae*, a variant in which the land was covered with dead organic mulch and traditional, classical variant-plowing in the fall and land bare, uncovered during the winter. Investigated types of winter legumes (common vetch and hairy vetch, and field pea) varieties belonging to Novi Sad (Neoplanta, NS Vilosa and Pionir). Crops are grown in rainfed conditions.

Field experiments were conducted in 2010/11 and 2011/12 at Maize Research Institute, Zemun Polje, in the vicinity of Belgrade (44°52'N 20°20'E). The soil was slightly calcareous chernozem with 47% clay and silt and 53% sand. The soil properties at 0-30-cm layer 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 CaCO₃ and pH 7.3. The experiments were located in different fields in each year and winter wheat was the previous crop. Plant nutrition and nitrogen fixation in legumes, we came up to the required amount of macronutrients for sweet corn (120 kg ha⁻¹ N, 90 kg ha⁻¹ P₂O₅ and 60 kg ha⁻¹ K₂O). In the fall, before planting of cover crops have entered the entire amount of P and K in the form monopotassium phosphate and 50 kg ha⁻¹ N in the form of ammonium nitrate, and the two control variants, also all of P₂O₅ i K₂O and 40 kg ha⁻¹ N in the form AN. In the spring (April 07 2011 and April 09 2012) is a leguminous cover crops added another 30 kg ha⁻¹ N in the form of AN (for the remaining 40 kg ha⁻¹ is considered to be provided nitrogen fixation), and control plots another 80 kg ha⁻¹ N, also in the form of AN. The experimental area was ploughed in autumn, followed by one pass of a disk harrow and a field cultivator prior to sowing.

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

Months	Temperature (°C)		Precipitation (mm)	
	2011	2012	2011	2012
April	14.6	14.4	11	67
May	17.3	17.9	63	128
June	22.4	24.6	40	14
July	24.1	27.1	107	39
August	24.7	26.2	9	4
September	23.2	22.0	49	31
Average/Sum	21.1	22.0	279	283

Sowing cover crops is carried out manually, October 10 2010 and October 14 2011, and measuring and cutting the above-ground biomass of cover crops was performed 7-10 days

before planting sweet maize. Planting of the main crop, after the production of seedlings, was the May 26 2011, and May 21 2012 year. Crops were harvested 22-24 days after pollination, in 2011 harvest was performed on August 18. and because of the extreme conditions of drought and high temperatures in the growing season 2012th there was a crop failure. The climatic conditions during the maize growing season were presented in the Table 1.

Experimental design

The experiment was in factorial setting with two factors in RCBD with four replications. Sweet corn was sown in densities: 65.000 plants ha⁻¹ The inter-row distance was 70 cm for all plant densities, while the within-row plant distance was 22 cm. The two new Zemun Polje (ZP) sweet corn hybrids in FAO 400 maturity group ZP 424su. The main plot size was 16.8 m² (2.8 m by 6.0 m).

Measurements and statistical analysis

All ears in two inner rows of each subplot were harvested and weighed directly from the field, 25 days after silking. Furthermore, a shelling percentage, as a kernel weight to cob weight ratio, was determined in a sample of 10 randomly selected ears.

The yield data were underwent to ANOVA for the factorial trials set up according to the plan for two years, five variants, and differences between means were tested by the least significant difference (LSD) test (Gomez and Gomez, 1984).

Results and discussion

Results of yield of grain and shelling of sweet corn in the investigated sample are presented in Table 2. Meteorological conditions in the investigated years were extremely unfavorable (Table 1), both leguminous cover crops, and for main crop – sweet corn. Yields above-ground biomass of cover crops were higher in 2011. year, and of the crop species significantly highest yields are obtained by growing pea in both years (Table 2). At least above ground biomass yields are achieved by growing winter common vetch (34.6 and 33.9 t ha⁻¹).

Analyzing the yield of sweet corn was determined that he was not positively correlated with the yield of above ground biomass of cover crops. The highest yield was obtained in the variant with dead organic mulch (10.00 t ha⁻¹), primarily due to the fact that for its decomposition was significantly more time alone and the planting of corn was thus greatly facilitated. The lowest yield was obtained following the traditional cultivation (8.09 t ha⁻¹). 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. Yield of sweet corn in the study year were below average yields in similar experiments (Simic *et al.*, 2012), and the reason is mainly in the way of growing this crop. Specifically, in order to meet the goal of preserving the land and cover crops to enable it to adhere to the land, we decided to planting sweet corn from previously produced seedlings. However, the weather conditions in which they were the 2012th years, this method of cultivation have failed despite the fact that at the time of planting moisture conditions were highly favorable (Table 1). It is a known fact that agronomic plants from seeds are generally quite resilient, how to extreme drought conditions, and the conditions of high air temperatures during the growing season. The estimates of the shelling percentage were at level for observed hybrid. The hybrid has been the best seller for years among ZP sweet maize hybrids, and a recent result of breeding of maize hybrids with specific properties of increased sugar.

Table 2. The growing season and cropping system effects on yield and shelling

Cropping system	The growing season (2011 and 2012) and cropping system effects					
	Yield (t ha ⁻¹)**				Percent	
	ABCC		Sweet corn (SC)		SC Shelling	
	2011*	2012*	2011*	2012	2011*	2012
<i>Vicia sativa</i> L.	34,6 ^a	33,9 ^a	8,84 ^a	-	62,58 ^a	-
<i>Vicia villosa</i> Roth.	36,8 ^{ab}	35,9 ^{ab}	9,98 ^b	-	74,69 ^b	-
<i>Pisum sativum</i> ssp. <i>arvense</i> L.	40,1 ^b	39,7 ^b	9,55 ^a	-	67,82 ^{ab}	-
Organic mulch	-	-	10,00 ^b	-	68,09 ^{ab}	-
Conventional system	-	-	8,09 ^{ab}	-	60,79 ^{abc}	-
Average	37,2	36,5	9,29	-	66,79	-

*P=0.05; Values of means followed by the same letter are not significant;

** ABCC = above ground biomass of cover crops

Conclusion

Meteorological conditions during the trial had an important impact on all the cropping systems. Perceived benefits of the alternative technology over conventional in terms of grain yield of the main crop. This breeding system is extremely important for the appropriate management of weeds for long-term weed control in organic agriculture. Since examination of weeds was not included in this study, particulare research should be continued and focused it the direction of precise examination of the floristic composition of weed sinuzuza depending on the cropping system of sweet corn.

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