Application of Reduced Corn Cultivation Technology in Agro-Ecosystem of Cazin Municipality

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Summary

Intensive corn cultivation is predominant in current agriculture of the Una-Sana Canton. One of the corn cultivation methods in agro-ecosystem is reduced cultivation. The paper presents the experiment of "Osmak žuti" (eight-row yellow) corn cultivation on two control sites with application of reduced and intensive cultivation in Cazin municipality. The objectives of this research were to examine the possibility of application of reduced corn cultivation; analyze statistical variation elements (length, circumference and weight of corn cob); and determine cost effectiveness of reduced relative to intensive production. The results indicate extremely high statistically significant difference ($p<0.001$) for all parameters in both cultivation methods. The cost effectiveness of reduced relative to intensive cultivation of *Osmak žuti* corn is higher by 36%. The experiment encourages introduction of reduced corn cultivation practice.

Key words

Una-Sana Canton, intensive cultivation, reduced cultivation, corn

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Received: September 12, 2010 | Accepted: February 21, 2011

Introduction

Replacement of human labor in the process of soil cultivation has hastily increased detrimental effects on soil, and this trend coincides with the invention of steam engines and development of metallurgy. Use of matching tools increases the number of operations and depth of intervention, which represents a turning point in soil cultivation development (Mihalić, 1968). Nowadays, huge efforts are made in order to maintain large yields and reduce harmful effects of soil cultivation through reducing the intervention and introducing various technical/technological innovations (Derpesh, 2005). The term reduced or conservation tillage comes from English »*conservation*« that means preserve or protect. The reduced tillage is a type of soil preparation that includes performance of multiple operations at the same time, or avoidance of certain operations. Reduced cultivation is often referred to as minimum tillage and/or no-till (Milojić, 1968). The possibility of applying some types of reduced tillage in cultivation of corn in Slavonija was examined (Komljenović, 1990).

The advantages of reduced cultivation in corn production are based on environment-production, energy and economy related reasons. The energy related reasons that support reduced tillage are tied to a large consumption of energy in conventional soil tillage (Tebrügge and Böhrnsen, 1997). According to the Western European statistics, 38% of total energy used in agriculture is consumed by soil tillage (Milojić et al., 1971) of which 75-85% by ploughing alone (Mihalić, 1968). The economic reasons for introducing the reduced tillage lead to reduced energy consumption, reduced production costs and better productivity, which eventually reflect in a higher profit for the household (Sorrenson et al., 1997). When it comes to crop production, in many countries or in certain regions, the organization-technical reasons lead to the emergence of so called »work rush«. By applying reduced soil tillage in the sense of skipping certain work processes or combining them into one passage, the work interventions become fast and simple. The environment related reasons supporting reduced soil tillage pertain to a reduced passage of heavy machinery that results in reduced risk of disturbed soil structure, degradation, soil compaction, disturbed water-air relation and change of ratio between detrimental and beneficial micro fauna (Badalikova and Hryby, 2006; Birkas et al., 2002; Jug et al., 2007). Conventional type of farming causes hydro erosion on sloped terrains and wind erosion in the areas with arid climate. Application of some of the reduced tillage methods reduces or even stops the occurrence of the effects caused by conventional farming (Milojić, 1971).

»Osmak žuti« is an old corn cultivar still used by the rural population of the Šturlićka Platnica settlement in Cazin municipality. "Osmak žuti" is primarily utilized in mill industry. Fine grinding provides flour (white or yellow), while coarse grinding produces semolina or pearl-corn. Special processing is used to produce corn flakes. Dishes made of corn are tasty, healthy and digestible. Additionally, corn has some medicinal properties: it stimulates appetite, improves sexual potency, reduces the level of blood sugar, prevents formation of bladder stone, reduces the breast and prostate cancer risk, etc. The corn germs oil reduces the level of cholesterol in blood. Thermal processing (cooking) activates antioxidant molecules that protect organism from cancer. When cooked (or roasted) corn releases ferulic acid that is considered to have anti-cancerous properties.

Corn has to be cultivated in crop rotation, although it is tolerant of single-crop farming. Good preceding crops for corn include annual and perennial legumes, potato, sugar beet, sunflower and stubble **cereals.** Fertilization of corn has to be properly planned. In order to achieve high yields on medium fertile soils, usually 150-200 kg N, 120-130 kg P_2O_5 and 130-150 kg K_2O per hectare are added (Todorović et al., 2003). Combining legume and filed crops cultivation has a great importance in sustainable organic production. Global benefits of nitrogen fixation are addressed in many papers (Vance, 1998; Graham and Vance, 2000). We are familiar with the practice of planting beans between the rows of corn, as well as the positive effects of nitrogen fixation in bean roots on overall corn yields (Pineda et al., 1994). Nodule bacteria take juices from the legumes and nitrogen gas from the atmosphere to be converted into nitrogen compounds and stored in their organisms. At the end of vegetation period, bacteria die leaving nitrogen compounds in the soil. The quantity of such compounds ranges between 30-550 kg/ha, depending on the type of legume. White clover leaves around 150-200 kg/ha of nitrogen in the soil (Veladžić et al., 2003).

The purpose of these examinations were to determine the possibility of applying reduced corn cultivation; identify eventually significant statistical difference between the two applied cultivation methods; and, analyze the cost effectiveness of reduced cultivation relative to the intensive one.

Materials and methods

The experiment was carried out in the municipality of Cazin, settlement of Šturlićka Platnica, in the period from fall 2008 to 10 October 2009. The old corn cultivar Osmak žuti (commonly known as "Sitni žutac") was planted in the same type of soil on two control parcels of 100 m^2 in area. One control parcel was used for reduced, and the other one for intensive tillage. Both parcels were treated with the same quantities of organic fertilizer - 20 t/ha. The fertilizer was spread in early fall of 2008, and followed by basic ploughing (around 25 cm deep), disc-harrowing and harrowing. On the reduced tillage parcel, white clover *(Trifolium repens)* was planted as a preceding crop, which in addition to supplying the soil with nitrogen also served to control the weeds. The clover made hoeing and chemical treatments of planted corn unnecessary. The sowing of corn was done in the spring time, i.e. on 20 April 2009, on both parcels and at the depth of 8-10 cm. The inter-row spacing averaged 70 cm, while the inter-plant spacing ranged from 25 to 30 cm. On the intensive cultivation parcel, we applied hoeing (at the stage of 3-5 leaves), hilling (at the stage of 7-9 leaves) and top dressing with NPK mineral fertilizer in the quantity of 30 kg/100m^2 whose nutrient ratio was NPK 13:10:12. On the reduced cultivation parcel these measures

Table 1. Parameters for length, volume and weight of maize of intensive and reduced production

Production	Lenght (cm)	Volume (cm)	Weight (g)
Intensive	12.0 – 19.0	11.0 – 14.5	70.0 – 225.0
Reduction	8.0 – 16.5	10.5 – 13.5	30.0 – 125.0

Table 2. Statistical – variation parameters of corn (length, volume, weight)

Measurements	Production	X_{sr}	SD	C_V	S_X	X_{min}	X_{max}
Lenght [cm]	Intensive	16.15	1.962	0.121	0.358	15.448	16.852
	Reduced	11.98	2.184	0.182	0.399	11.200	12.76
Volume [cm]	Intensive	13.05	1.0043	0.0778	0.1834	12.691	13.409
	Reduced	12.35	1.0196	0.0825	0.1862	11.985	12.715
Weight [g]	Intensive	141.16	44.038	0.312	8.040	125.40	156.92
	Reduced	78.16	27.453	0.351	5.012	68.34	87.98

X_{sr} – mean, SD – standard deviation, C_v – variation coefficient, S_x – assessment of error, X_{min} and X_{max} - interval of variation (error risk α=0.05)

were left out. Once the corn reached full technological maturity, it was manually harvested on both parcels while taking care that cobs are not mixed. The bulk was sampled and representation samples of "Osmak žuti" were taken (30 pieces) for testing. The samples were used to measure length, circumference and weight of the cobs with grains. Obtained results were processed by statistical analysis methods . The (Žižić et al., 2001) statistical analysis included utilization of the Microsoft Office Excel 2007 software package. As for the applied technologies, we analyzed the cost of corn production and cost effectiveness of the reduced cultivation production relative to the intensive one.

Results

The average yield of the Osmak žuti cultivar on the control parcel of reduced tillage reached 21 kg/100 m², while the yield of the intensive cultivation parcel was 40.5 kg /100 m². The measuring results for the Osmak žuti cultivar parameters are shown in Table 1. On the reduced tillage parcel, cobs were rather smaller than those on the intensive tillage one. The analysis of statistical-variation parameters of length, circumference and weight of the "Osmak žuti" corn cultivar cobs with grains was made for both intensive and reduced tillage production (Table 2). The testing was conducted by the Student test (n≥30). The testing confirmed an extremely high statistically significant difference (p<0.001) for length, circumference and weight of the "Osmak žuti" cobs with grains between the two applied cultivation methods (Table 3). The cost analysis of reduced and intensive cultivation showed the following results (Table 4). Values of the Osmak žuti cultivar produced in both cultivation methods are presented in Table 5. The calculated cost effectiveness of reduced cultivation method is by 36% higher than the intensive production regardless of smaller yields. This is justified by higher cost of the final product on the market.

$$E_i = \frac{UV_{rp} - UV_{ip}}{UV_{rp}} \times 100\% \text{ (Andrić, 1998)}$$

E_i – economic cost effectiveness
UV_{rp} – total value of reduced production
UV_{ip} – total value of intensive production

Discussion

We believe that the reasons of low yield on the control parcel with reduced tillage lie in lack of top dressing and competition with white clover over the soil moisture. Corn partially benefited from white clover in terms of weed competition, as it was our objective to avoid inter-row cultivation and application of herbicides. Although the effects of nitrogen-fixation were not examined in this paper, but taking into account the fact that beans in combined cultivation with corn contribute to achieving better yields (Pineda et al., 1994), a positive impact of white clover could be expected. The effects of nitrogen fixation represent an elaborate subject and receive global attention of agro-ecologists and agro-economists in the context of environment preservation and sustainable agricultural production, which is evident in a number of scientific papers (Vance, 1998; Graham and Vance, 2000). The effects of sowing corn in white clover

Table 3. Statistical parameters of corn for length, volume and weight

Parameters of corn	t_{value}
Lenght	7.78***
Volume	2.68***
Weight	6.65***

*** extremely high statistically significant difference (p<0.001)

Table 4. The costs of intensive and reduced corn production per hectare

Operation	Production		The cost analis (KM)	
	Reduced	Intensive	Reduced	Intensive
With barnyard manure (20 t)	Yes	Yes	375.00	375.00
With mineral manure (300 kg)	No	Yes	—	234.00
Tillage (basic and suplementary)	Yes	Yes	300.00	300.00
Clower planting (Trifolium repens)	Yes	No	377.00	-
Hoeing	No	Yes	-	150.00
Hilling	No	Yes	-	150.00
Harvest	Yes	Yes	400.00	400.00
Total			1,452.00	1,609.00

Table 5. The value of corn produced by reduced production and intensive production

Production	Yield (kg)	Costs (KM)	Product value (KM)	Total value (KM)
Reduced	2,100	1,425.00	1.00	648.00
Intensive	4,050	1,609.00	0.50	416.00

could be particularly tangible in the second year following the sowing of white clover, as the quantity of nitrogen deposited in soil could then reach around 150-200 kg/ha (Veladžić et al., 2003). The stated methods of reduced soil tillage and further technical and technological innovations should certainly contribute to the reduction of harmful effects of many soil cultivation interventions, as well as the application of chemicals that affect the environment (Derpesh, 2005). In our process of reduced soil tillage for corn production, the total number of cultivation operations was reduced (hoeing and hilling), as well as top dressing and application of herbicides to remove weeds, which can be linked with the definition of minimum tillage system (Milojić, 1968). The testing confirmed a high statistically significant difference ($p<0.001$) in length, circumference and weight of cob of Osmak žuti cultivar between the two applied cultivation methods. The financial effects of these two production types are almost identical, however, the reduced cultivation is more significant in terms of high market price of the Osmak žuti cultivar grains which reaches 1 KM (flour 1.50 KM), whereas the prices of intensive cultivation produces are way smaller (grain 0.50 KM). The cost effectiveness of reduced cultivation is by 36% higher relative to the intensive one regardless of smaller yield that is justified and compensated by higher price of the end product and readiness of the consumers to pay it since this is a product free of chemical treatments.

Conclusions

- Reduced cultivation technology in case of Osmak žuti corn cultivar has a perspective in further application, provided there is additional improvement of cultivation technology.
- Total yield on the area of 100m^2 of corn sown into white clover amounted 21 kg/100 m^2, that is 2,100 kg of corn grains per hectare, while the intensive corn cultivation yield amounted 40.5 kg /100 m^2, i.e. 4,050 kg/ha.
- Higher yield of the intensive cultivation was reached thanks to the stated agro-technical measures (hoeing, hilling) and additional top dressing, which contributed to a better condition of the plants during the cultivation.
- Measuring confirmed that the corn cobs from reduced tillage were rather smaller relative to those from intensive tillage.
- Testing established a high statistically significant difference ($p<0.001$) for length, circumference and weight of cobs with grains between the two applied cultivation methods.
- Economic cost effectiveness of reduced cultivation of the Osmak žuti corn cultivar is by 36% higher than the intensive one.
- Continue conducting experiments with various time frames for sowing white clover in order to determine the most optimal time for corn sowing so that it could make the most of the white clover's nitrogen-fixation process (most likely in the second year).

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