SOIL TILLAGE AS INFLUENCED BY CLIMATE CHANGE

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Abstract:
A long-term field trial was set up in order to define the effects of autumn or spring primary tillage upon the physical characteristics and yields of spring row crops – maize and soybean. The objectives were to assess and recommend the most effective tillage method. In the first trial year, the year factor had a stronger influence on maize yields compared to the tillage factor. In the second trial year, however, the situation was quite contrasted. The tillage factor had a stronger impact on soybean yields compared to the year factor. The two-year investigation period was only allowed to draw some preliminary conclusions. For this reason the research will be continued.

Keywords: autumn and spring tillage, maize, soybean, climate change

Introduction

As much as it may seem unreal, climate change has been ensued over last decade going with extreme incidences. According to data, agricultural activity is among the causes of the climate change at the same time being one of the human activities is most susceptible to climate change (Várallyay, 2006). This fact is evidenced by three extreme dry years (2000; 2003 and the autumn of 2006) in the last decade both in Croatia and in Hungary. It is common knowledge that agriculture is an open, roofless factory, which means that weather conditions of a certain region often have a decisive influence on yields of crops grown. Man can change and influence soil tillage, sowing time, cultivars and hybrids but he has to adapt to climate conditions. For these reasons, perseveration of moisture from the period of its abundance (winter) and its utilization by crops in the period of its deficiency (summer) is of the utmost importance.

Materials and Methods

The experience so far and investigations of many years (Birkas et al., 2007; Jolankai and Birkas, 2007, Jug et al., 2006) show that coincidence of adverse effects of the "year factor" and/or "tillage factor" may drastically reduce crop yields. It is, however, clear that the opposite also holds, viz. the beneficial effect of the year factor and the tillage factor may lead to memorable yields. The problem is the increasing prevalence of climatically unfavourable years over the last period of time (Dobo et al., 2006). The project that will be partially presented in this paper was conceived for these reasons. Special attention will be paid to changes in soil physical properties, moisture content, and yields of the crops grown. Investigations involve spring row crops of low plant density: maize (*Zea Mays* L.) and soybean (*Glycine hyspida* L.). The experimental field was set up on arable areas of the College of Agriculture at Krizevci in Central Croatia on the soil type Stagnic Luvisol. Tillage treatments included in the trial are shown in Table 1.

Table 1. Tillage treatments

A	Spring ploughing to 30 cm + surface preparation with seedbed preparation implement
B	Spring ploughing to 30 cm + surface preparation with rotary harrow
C	Autumn ploughing to 30 cm + winter furrow closing with spike-tooth harrow, surface preparation with rotary harrow
D	Autumn ploughing to 30 cm + winter furrow closing with spike-tooth harrow
E	Autumn ploughing to 30 cm + winter furrow + disc-harrowing

Each treatment has an area of 280 m^2 (20 x 14 m) and is laid out in 4 replications, which makes a total trial area of 0.8 ha. Soil samples for the analyses was taken prior to sowing, upon emergence, during silking (maize) or flowering (soybean) and after crop harvesting. On average, 48 soil samples were taken during the growing period from the plough layer of each treatment. Maize was represented by the hybrid Pioneer PR 38A24 (FAO group 380), soybean cultivar Visnja was used with seed rate of 130 kg ha^{-1}.

Results and discussion

The first research objective is to define the effects of time and soil tillage method, as well as climate parameters, upon changes in soil physical parameters and yields achieved. Climate indicators for the region under study were calculated on the basis of a long-term period (1976-2005) and the years in which investigations were conducted in 2006 and 2007 (Figure 1, 2). Although a two-year period is clearly short for drawing any significant science-based conclusions, the factors influenced the year effect are given here. Climate conditions in the first spring (2006) corresponded to the long-term average, while a perceptible precipitation deficit was recorded in the autumn-winter period (Figure 1). This water deficit and the higher temperature (Figure 2) in the winter-spring season of 2007 had a significant influence on the given tillage methods and the soybean yields. Table 2 shows the mean values of the soil physical parameters in relation to the different tillage methods. In the first trial year we found a statistically significant difference between treatments regarding to the effective moisture, soil bulk density and porosity. During maize phase, treatment B had on average the highest moisture and bulk density while the highest value of total porosity was recorded in treatment A. In the second trial year, significant differences were recorded between treatments only for soil water capacity, while no significant differences were stated for other parameters.

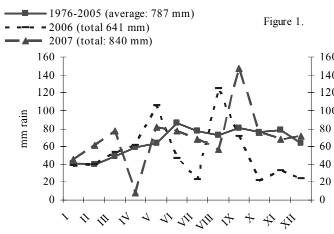

Figure 1. Monthly precipitation

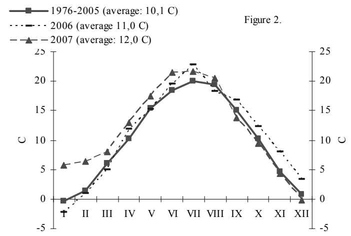

Figure 2. Average monthly temperature

Table 2. Physical analyses of soil according to the tillage methods and crops studied

Treatment	Effective moisture, % vol.	Bulk density, Mg m^{-3} q_v	q_c	Total porosity, % vol.	Water capacity, % vol.	Air capacity, % vol.
2006, Maize						
A	28.15± 38.8*	1.35 ± 9.9	2.61 ± 2.4	48.19 ± 10.8	41.31 ± 7.3	6.88 ± 78.1
B	28.78 ± 39.1	1.45 ± 6.6	2.60 ± 2.2	46.59 ± 10.1	41.20 ± 6.2	5.39 ± 93.4
C	28.16 ± 38.4	1.36 ± 8.1	2.60 ± 2.5	47.55 ± 8.7	41.67 ± 8.6	5.88 ± 73.0
D	27.05 ± 41.8	1.36 ± 8.9	2.61 ± 2.9	47.84 ± 9.5	40.70 ± 8.8	7.14 ± 68.8
E	28.03 ± 38.9	1.38 ± 6.3	2.61 ± 2.0	47.51 ± 8.4	41.22 ± 6.0	6.29 ± 60.9
2007, Soybean						
A	29.95 ± 12.5	1.38 ± 7.5	2.61 ± 0.97	47.17 ± 8.6	40.81 ± 4.2	6.36 ± 72.0
B	29.33 ± 16.6	1.39 ± 6.1	2.60 ± 0.87	46.21 ± 7.2	41.01 ± 3.9	5.20 ± 74.5
C	29.41 ± 13.9	1.37 ± 5.6	2.61 ± 0.90	47.25 ± 6.5	39.98 ± 3.6	7.27 ± 52.8
D	29.70 ± 10.9	1.36 ± 7.2	2.61 ± 0.83	46.73 ± 15.9	40.57 ± 5.0	6.16 ± 65.2
E	29.16 ± 18.4	1.39 ± 6.3	2.60 ± 0.87	46.35 ± 7.6	40.04 ± 5.3	6.31 ± 61.0

**Relative Standard Deviation (RSD, %)*

In the first trial year, in the autumn ploughing variants (C, D and E), a statistically higher plant density was determined upon emergence (in the maize 5 leaf stage) compared to treatments involving spring ploughing (Table 3). However, surprising changes occurred during maize growth in statistically significant differences. In the treatments of spring ploughing (A and B), a statistically higher value of hectolitre mass was recorded compared to treatments involving autumn ploughing. This fact can be explained by soil management used in the preceding period of the trial. The area on which the trial was set up used to be uncultivated fallow for 4 years. In the autumn of 2005, a vetch and oats mixture was mistakenly sown on the area foreseen for treatments with spring ploughing, while the planned autumn ploughing was applied on the remaining part of the trial area. In the spring of 2006, the crop remains were incorporated into soil as green manure by means of the foreseen spring ploughing practices. This probably had a decisive influence on the yields attained in the first year.

Table 3. Yield and some yield components of the studied crops

	Maize, 2006				Soybean, 2007			
Treatment	Plant density, 10 m^{-2}	1000 grain mass, g	Hectolitre mass, kg	Grain yield, t ha^{-1}	Plant density, 1 m^{-2}	1000 grains mass, g	Hectolitre mass, kg	Grain yield, t ha^{-1}
A	74	397.03	84.93**	10.79**	50	164.41	68.39	1.71
B	75	398.83	84.50**	12.67**	59	165.06	68.82	2.09**
C	98**	388.20*	83.58	11.86**	53	161.50	69.13	1.99**
D	98**	400.26	83.62	10.14	64**	166.34	69.04	1.99**
E	98**	397.52	82.96	9.93	75**	166.49	69.23	2.24**

In the other hand, the tillage factor had no decisive influence on yield in the first trial year. If the year climatic factors were within the limits of the long-term average (especially the winter-spring part of the year), the autumn ploughing had slight efficiency on yields compared to the spring ploughing practices. In treatments involving spring ploughing (A and B) as well as in a variant with autumn ploughing (C) a statistically higher yields were recorded compared to the other two autumn ploughing variants. This indicates that the tillage factor had less influence in that year whereas the impact of the year factor on yields was stronger. Following the planned methodology, soybean was sown in the trial field in 2007. Counts of soybean plants at its full emergence stage and immediately prior to harvest showed a significantly larger number of plants per square metre in treatments (D and E) involving autumn ploughing, as well as in treatment B with spring ploughing, compared to the remaining two variants with spring ploughing. This had a decisive influence on the obtained yield. As regards absolute and hectolitre mass, there were no statistically significant differences between the treatments. Compared to treatment A, statistically higher yields were recorded in all other treatments. Accordingly, the year factor had a stronger influence in given year compared to the tillage factor. This is confirmed by the climate conditions determined during the autumn of 2006 and the spring of 2007. Drought started as early as in June 2006. That drought had no strong reflection on the preceding crop (maize) because in August above-average rain was fallen. But, all months from that month to February 2007 had much lower precipitation compared to the average. At the same time, all those months were warmer than the average (Figures 1 and 2), and unfavourable situation continued also in 2007.

Although January, February, March and May of 2007 had above-average rainfall, precipitation deficit was recorded again in April, June and July. We think that for these reasons the precipitation deficit could have been alleviated only by autumn tillage, i.e., by accumulation of precipitation water from the winter period. The results for the given year, climatically very unfavourable for spring crops growing that pointed to the advantages of autumn ploughing. Although the two years investigation may provide preliminary information, the presented data are used as the bases to the time and method of soil tillage in future investigations.

Conclusions

The applied soil tillage variants had no significant influence on the studied soil physical parameters that is effective moisture, soil densities, total porosity, soil water capacity and air capacity. In the first trial year, the year factor had a stronger influence on maize yields compared to the tillage factor. In the second trial year, however, the situation was quite contrasted due to extreme climate. The tillage factor had a stronger impact on soybean yields compared to the year factor. Considering the probable climate extremes role of the soil tillage through water conservation and yield establishment will be widened in the near future.

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