AgroLife Scientific Journal - Volume 5, Number 1, 2016
ISSN 2285-5718; ISSN CD-ROM 2285-5726; ISSN ONLINE 2286-0126; ISSN-L 2285-5718

# INFLUENCE OF SOIL TILLAGE UPON WEEDS, PRODUCTION AND ECONOMICAL EFFICIENCY OF CORN CROP

**Felicia CHETAN[1], Teodor RUSU[2], Cornel CHETAN[1], Paula Ioana MORARU[2]**

[1]Agricultural Research and Development Station Turda, 27 Agriculturii Street, Turda, 401100, Cluj County, Romania, Phone: +4026.431.16.80, Fax: + 4026.431.17.92, Email: felice_fely@yahoo.com
[2]University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, 3-5 Manastur Street, Cluj-Napoca, 400372, Romania, Phone: +4026.459.63.84, Fax: + 4026.459.37.92, Email: rusuteodor23@yahoo.com

Corresponding author email: felice_fely@yahoo.com

***Abstract***

*The research of some alternative variants to conventional soil tillage (characterized by furrow ploughing) targeted the setup and promotion of some technologies adapted to concrete conditions from different agricultural areas, regarding especially the type of soil, the climate conditions, the land orography and the technical equipment available. The objectives were surveyed from an agronomical, ecological and economical point of view. The failure in putting into practice many of the alternative variants of soil tillage were related to crop weeds, cultural defects and lower productions. The paper presents the results of the research made under the conditions of a Phaeozem situated in the Transylvanian Plain, regarding the influence of soil tillage system conventional system and minimum tillage - with chisel) and the fertilization & herbicide system upon the degree of weeds, production and economical of corn crop, during 2011-2014. The soil tillage system and climate conditions of the agricultural year influenced the weeds in the corn crop. In the case of minimum tillage bigger weeds have been registered, of 33.67 weeds/$m^2$ compared to the conventional tillage, with 29.17 weeds/$m^2$. In a drought year, respectively 2012, weeds grew the most (35.50 weeds/$m^2$), they reduce during a normal climate year 2013, to 27.50 weeds/$m^2$, and in 2014 which was considered a rainy year, favorable to corn crop, weeds were 31.25 weeds/$m^2$. The soil tillage system hasn't influenced significantly corn productions, they were almost equal in the two systems. Corn production is influenced significantly by the climate conditions of the agricultural year, ranging between 5392-6102 kg/ha. The economic efficiency of the minimum tillage system is higher and it results from the reduction of fuel consumption to 84.4 l/ha compared to conventional system, which needs 101.5 liters/ha for all the soil tillage. Subtracting total expenses (material and fuel) from the value of the production made within each technological system it results a profit of 112.9 lei/ha, which overall minimum tillage technology means a reduction by 6.6%.*

***Key words****: conventional tillage, minimum tillage, weeds, corn, yields, climate conditions.*

## INTRODUCTION

Conventional soil tillage, the main characteristic of which is ploughing with mouldboard plough (for furrow), is applied worldwide, on almost 55% from the arable surface (Chetan et al., 2014). For the following 10-15 years, it is estimated to reduce the weight of this system under 40%, motivated mainly by ecological objectives, by the reduction of fuel consumption and by the growth of economical efficiency (Gus et al., 2003; Rusu, 2005; Domuta, 2008). The energophage technologies, with tough action on the soil are an initial factor for soil degradation, 35% of the damaged surface is due to human activity worldwide, and 28% to other forms of improper land administration.

The agricultural research and practice have promoted several alternative variants to the conventional soil tillage, variants adapted to the concrete conditions regarding especially the type of soil, the climate conditions, land orography and the technical equipment available (Hulpoi, 1970; Săndoiu, 1999; Gus et al., 2003; Fabrizzi et al., 2005). Expert literature quotes as alternative variants of soil tillage from sowing directly into raw soil to deep loosening without furrow. Between these extremes there are variants like (Rusu, 2001): reduced tillage (conventionally rationalized), minimum tillage (with coverage under 30%),

mulch tillage (with coverage over 30%), ridge tillage, strip till, zone till, no-tillage (direct drill). „*Grouping the tillage to the maximum in order to save energy, work and people*" is the definition given to the minimum tillage system by Săndoiu (1999).

The evolution of research in the field of soil tillage alternatives and the results gained are influenced by the variant chosen and the technology applied, both in terms of performance of the agricultural equipment and modelling new technologies.

The first experiences with minimum tillage system were made in Romania for corn crop, in 1962 at Fundulea and then in other research stations like: Lovrin, Oradea etc., and the first results are published in 1966 (Gus et al., 2003). The results obtained by Pintilie (1979) on the levigated chernozem from Fundulea and on the brown-red soil from Simnic-Dolj show that on the lands on which the ploughing hasn't been made, even if herbicides were applied, the weed number has grown and corn production dropped to a quarter (840 kg/ha). Bachthaller (1968) who experienced this method in Germany didn't obtain satisfactory results. The optimal climate conditions, especially humidity, contribute to the success of corn crop cultivated in minimum tillage (Hulpoi, 1970). Following the research made in corn crop under irrigation conditions (1967-1969), having as precursory plant lucerne, the corn had productions ranging between 8880-9960 kg/ha. The soil diversity in Romania makes the application of minimum soil tillage be practiced on 42% from the arable surface (15% under favourable conditions and 27% under moderate favourable conditions (Canarache, 1990).

Griffith et al., 1982, observes that the classical soil tillage system determines a profit 10% times higher than the minimum system on a poorly drained soil, on the other hand the profit is 8% higher in minimum soil tillage on a well-drained soil. Cardina et al., 1991, Feldman et al., 1997, show that the density and contents of the weed seed reserve in the soil varies according to the soil tillage system. The diversity of the seed reserve grows from the mouldboard plough, to disk, chisel and no-tillage, which had the biggest seed reserve (Rusu et al., 2013). In order to fight weeds one must state the importance of meeting the methods and agrotechnical measures which accompany the technology of cultivating an agricultural crop, which act upon weeds restrictively indirectly, reducing the risk of infestation with species existing in the respective land (Berca, 2011; Rusu et al., 2014) and in certain cases, decreasing the risk of infestation with certain weed species (crop rotation, the use of fertilizers and amendments, rational sowing, adequate phytosanitary methods).

Crop rotation and soil tillage system continue to remain one of the measures with high efficiency in fighting weeds (Cociu, 2011; Rusu et al., 2013). By specific agrotechnical measures applied to each plant from the crop rotation (for example: soy-wheat-corn) the growth and breeding of certain weed species is diminished. Thus, cane - *Sorghum halepense* (L.) Pers. - grows very well in weeding machine crops and creates difficulties in fighting it while it doesn't develop at all in the wheat crop, and thistles - *Cirsium arvense* (L.) Scop. - which damages the wheat crop is fought easily if weeding machines enter the rotation.

During the last years there are increasing problems with drought, that is why we must preserve soil water, and choosing the range of machine and technology is the most important issue (Rusu et al., 2009; Moraru et al., 2010; Chetan et al., 2014). Limiting the drought effects can be also made by agrophyto-technical measures to accumulate, preserve and value efficiently rain water. By protecting the soil with vegetable scraps (mulch), we avoid losing water by evaporation but also suffocating weeds emerged or under emerging (Rusu, 2005; Chetan et al., 2015).

Corn is very much studied due to crop requirements in minimum soil tillage and choosing the type of hybrid for this system has been a constant preoccupation of breeders (Lazureanu et al., 1997). For the corn hybrids destined to the crop in minimum soil system or no-tillage system, the following features are taken into account even more: the capacity to germinate at low temperatures, early vigor and vegetation period more reduced than the hybrids traditionally cultivated in the area,

resistance to disease and pests specific to the mulch system.
The paper presents the results of the research made at Agricultural Research Development Station Turda (ARDS Turda), situated in the Transylvanian Plain, the influence of the soil tillage system and the fertilization & herbicide system upon the degree of weeds, the production and economic efficiency in corn crop.

## MATERIALS AND METHODS

Research of the influence of the soil tillage system and the fertilization system in corn crop was made within a tri-factor experience during 2011-2014, in a 3 year rotation: soybean - wheat - corn.
The experimental factors were:
A - Soil tillage system: $a_1$ - Conventional System (CS); $a_2$ - Minimum Tillage (MT) System (with chisel).
B - Fertilization system: $b_1$ - $N_{40}P_{40}$ kg/ha in sowing; $b_2$ - $N_{40}P_{40}$ kg/ha in sowing + $N_{40}$ kg/ha on vegetation in corn phenophase 4-6 leaves.
C - Combined treatments: $c_1$, $c_2$ (Table 1) which comprise combinations of treatments with foliar fertilizers, fungicides and insecticides applied in 2 important phenological moments of corn: (i) phenophase 3-5 leaves with foliar fertilizers, insecticides, herbicides; (ii) phenophase 7-8 leaves with foliar fertilizers, insecticides and fungicides.
The biological material used was the corn hybrid Turda Star.
The degree of weeds of the crop and the weed spectrum present were determined: visually, by numbers with the help of a metric frame, gravimetrically by extracting weeds, separation by species, weighting and drying in the oven.
The production of corn crop was determined by weighting on the experimental parceling, after having eliminated the margins and transformed the production according to STAS humidity (14%).
The experimental data were processed by analyzing the variant and setting up the Least Significant Difference - LSD (5%, 1%, and 0.1%) (ANOVA, 2015).
The economic efficiency of the systems was determined according to the number of technological works applied, the fuel consumption (based on the features of the agricultural equipment and the machines used) and the materials used, reported on ha.
The experiment was placed on a Phaeozem soil with the following characteristics: pH 7.00; humus 3.40%; total nitrogen 0.226%; phosphorus 73 ppm; potassium 295 ppm, determined on the depth 0-30 cm.
The climate conditions from the experimental years are presented in Table 2 (thermal regime) and Table 3 (rainfall regime) (according to the Weather Station ARDS Turda).

## RESULTS AND DISCUSSIONS

In minimum tillage processing the land is made from autumn with chisel, and in spring before sowing a germinating bed was prepared by a milling. Destroying the weeds emerged earlier depends on the quality of this tillage which is not made when the soil is too humid (*Cirsium, Sonchus, Rubus* etc.).

Table 1. Treatments applied at corn, 2012-2014

| Variant | Application moment | | | | | |
|---|---|---|---|---|---|---|
| | Sprayers preemergent | | 3-5 leaves phenophase | | 7-8 leaves phenophase | |
| | Used product | Dose (l; kg/ha) | Used product | Dose (l; kg/ha) | Used product | Dose (l; kg/ha) |
| $c_1$ | Merlin Flex+Tender | 0.4 l/ha +1.5 l/ha | Cerlit + Astral | 1l/ha + 1.5 l/ha | - | - |
| | - | - | Agrofeed | 2.5 kg/ha | - | - |
| | - | - | Calypso | 0.1 l/ha | - | - |
| $c_2$ | Merlin Flex+Tender | 0.4 l/ha +1.5 l/ha | Cerlit + Astral | 1l/ha + 1.5 l/ha | - | - |
| | - | - | Agrofeed | 2.5 kg/ha | Agrofeed | 2.5 kg/ha |
| | - | - | Calypso | 0.1 l/ha | Fastac | 0.1 l/ha |

Table 2. The thermal regime ARDS Turda, 2012-2014

| Year/ month | Temperature – month average (°C) | | | | | | | | | | | | Average annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | |
| 2012 | -2.3 | -6.1 | 4.7 | 11.8 | 16.2 | 21.0 | 24.0 | 22.3 | 19.1 | 11.4 | 5.2 | -2.6 | 10.4 |
| 2013 | -2.4 | 2.0 | 3.5 | 12.3 | 16.8 | 19.4 | 20.9 | 22.1 | 13.8 | 11.2 | 7.1 | -1.7 | 10.4 |
| 2014 | 0.5 | 3.8 | 8.8 | 11.4 | 15.1 | 18.5 | 20.4 | 19.9 | 16.6 | 10.8 | 5.7 | 1.3 | 11.1 |
| Average 10 years | -2.1 | -0.4 | 5.2 | 12.2 | 17.3 | 20.8 | 23.0 | 22.5 | 17.4 | 11.0 | 4.8 | -0.8 | 9.8 |
| Average 57 years | -3.5 | -0.9 | 4.1 | 9.9 | 14.8 | 17.8 | 19.7 | 19.3 | 15.0 | 9.6 | 3.8 | -1.5 | 9.0 |

Table 3. The rainfall regime ARDS Turda, 2012-2014

| Year/ month | Rainfall – monthly amount (mm) | | | | | | | | | | | | Suma anuala |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII | IX | X | XI | XII | |
| 2012 | 26.2 | 30.7 | 5.3 | 78.4 | 89.2 | 67.4 | 52.4 | 28.0 | 30.2 | 42.0 | 9.6 | 45.0 | 504.4 |
| 2013 | 19.8 | 10.3 | 57.9 | 53.3 | 79.3 | 86.2 | 37.6 | 44.0 | 57.8 | 67.8 | 5.9 | 3.3 | 523.2 |
| 2014 | 51.6 | 15.5 | 23.1 | 72.0 | 66.2 | 48.4 | 144. 4 | 83.8 | 48.4 | 67.4 | 34.2 | 86.6 | 741.5 |
| Average 10 years | 26.0 | 21.3 | 30.6 | 55.3 | 78.9 | 111.7 | 94.2 | 76.8 | 49.1 | 49.1 | 21.6 | 29.0 | 598.2 |
| .Average 57 years | 21.4 | 18.8 | 23.4 | 45.4 | 68.3 | 84.2 | 75.6 | 55.2 | 40.4 | 32.8 | 28.0 | 26.8 | 520.4 |

In the conventional system the autumn ploughing was made followed by preparing the germinating bed in spring. Crop weeds arise even from the beginning of the vegetation period, annual and perennial dicotyledonous species infest early the land and the annual and perennial monocotyledonous species appear later in the field.

Before sowing corn, in order to fight weeds emerged or under emerging, herbicide on the soil was applied pre-emerging, by using the products: Merlin Flex 0.4 l/ha + Tender 1.5 l/ha in a volume of 250 l water/ha. This herbicides was made in both soil tillage systems: conventional and minimum tillage.

The post emerging fight against weeds from the corn crop was made in the 3-5 leave phase with the herbicides: Cerlit 1l/ha to fight dicotyledonous weeds (especially *Rubus*) + Astral 1.5 l/ha to fight monocotyledonous weeds.

Before post-emerging herbicides the spectrum of present weeds was determined. 20 weed species have been identified, of which: 17 species are annual (DA) and perennial dicotyledonous (DP), respectively 3 species annual (MA) and perennial monocotyledonous (MP) (Figure 1).

In minimum tillage system, starting with 2013, two weed perennial dicotyledonous species appeared, that is: *Lepidium draba* L. and *Rorippa austriaca* (Crantz) Besser, and in 2014 the species *Matricaria inodora* L., *Polygonum aviculare* L. Specific for 2014 is the presence in the corn crops and soy of the annual species *Capsella bursa pastoris* (L.) Medik. which has a predominant emerging in the autumn and ripe in early spring or the beginning of the summer.

The participation of weed species to the degree of weeds in the corn crop is presented in Figure 2, from which it results that the highest percentage was held by the DA weeds, 51% of the total of 29.51 t/ha, in CS and 48% of the total of 29.8 t/ha in MT. The DP weeds were mostly present in MT (20%) compared to CS (18%). The MT system determined an MA weed percentage of 31% compared to CS where weeds were 30%. The MP weeds (*Elymus repens* L. Goud) recorded a lower value in participation, of 1%, in both soil tillage systems.

The number and mass of weeds presented in corn crop is bigger in MT during the first experimental years 2012, 2013, but in 2014 the weed number decreased (30 weeds/$m^2$) compared to CS where the weeds present were 33/$m^2$ (Table 4). The weed species present MT, in 2012, were 45 weeds/$m^2$ with a height of 1212.5 g/$m^2$ and 12.1 t/ha. By ploughing with the mouldboard and furrow, the number of weeds determined in CS was influenced, in 2012, being 27 weeds/$m^2$, with a mass of 956.5 g/$m^2$ and 9.6 t/ha.

The year influences significantly the weed degree of the corn crop (Table 5). Thus, in 2012 (drought) it has determined a number of 35.50 weeds/$m^2$, the year 2013 recorded a value of 27.50 weeds/$m^2$, and the year 2014,

considered a year favorable to corn crop, distinct significant negative influence, the weed number present was 31.25 weeds/m$^2$. The favorability of this year for the corn crop also influences the development of weeds.

The soil tillage system influences the weed degree of corn crop (Table 6). The MT system recorded a growth of the weed degree, respectively 33.67 weeds/m$^2$, compared to the number of weeds present in CS, where 29.17 weeds/m$^2$ were determined.

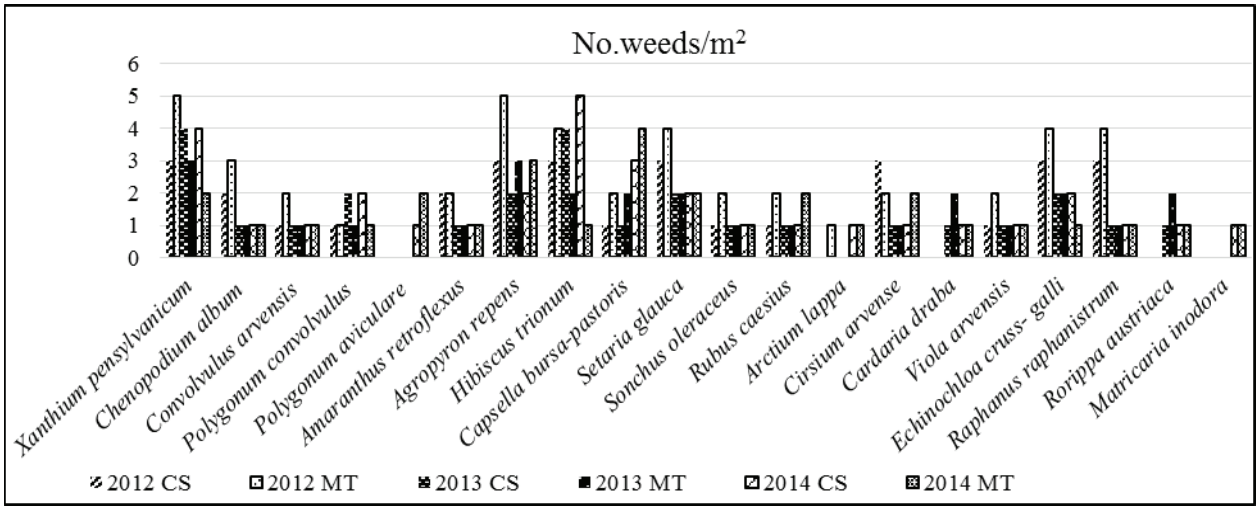


Figure 1. Weeds species presented in the corn culture during, 2012-2014

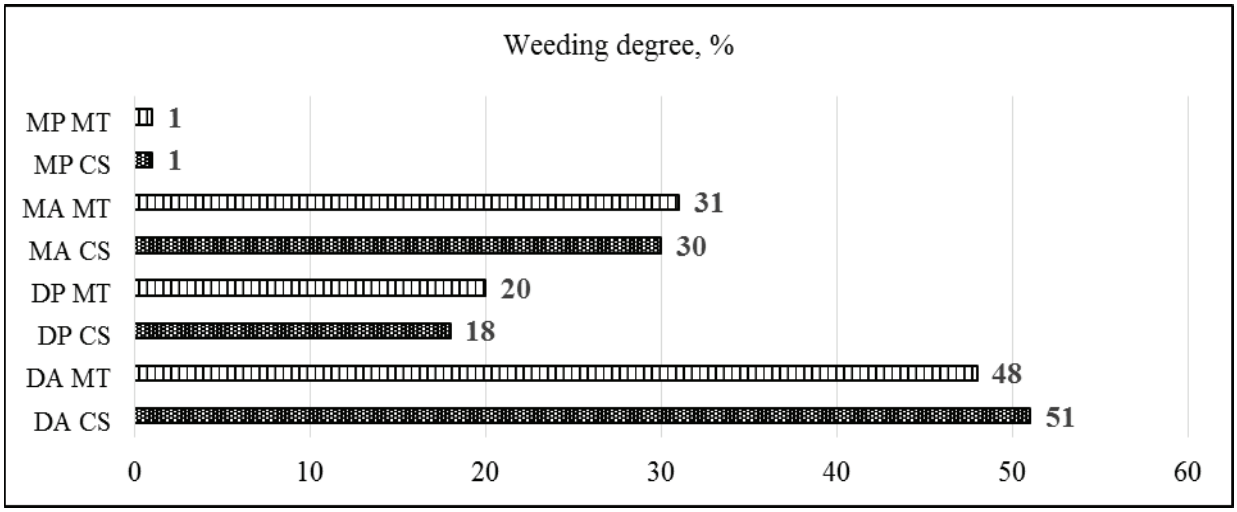


Figure 2. Participation of weed species in the crop weeds degree according to the soil tillage, 2012-2014

Table 4. Gravimetric determination of existing weeds in corn culture, 2012-2014

| System / Year | | DA | | | DP | | | MA | | | MP | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No/m$^2$ | g/m$^2$ | t/ha | No/m$^2$ | g/m$^2$ | t/ha | No/m$^2$ | g/m$^2$ | t/ha | No/m$^2$ | g/m$^2$ | t/ha |
| $a_1$ | 2012 | 13 | 441.7 | 4.4 | 5 | 143.4 | 1.4 | 6 | 363.7 | 3.6 | 3 | 7.7 | 0.07 |
| | 2013 | 18 | 518.3 | 5.2 | 5 | 131.2 | 1.3 | 4 | 298.5 | 3.0 | 2 | 6.8 | 0.07 |
| | 2014 | 21 | 556.9 | 5.6 | 6 | 259.9 | 2.6 | 4 | 221.2 | 2.2 | 2 | 7.5 | 0.08 |
| Total $a_1$ | | **52** | **1517** | **15.2** | **16** | **534.5** | **5.3** | **16** | **883.4** | **8.8** | **7** | **22** | **0.22** |
| $a_2$ | 2012 | 25 | 631.5 | 6.3 | 7 | 185.2 | 1.9 | 8 | 384.6 | 3.8 | 5 | 11.2 | 0.1 |
| | 2013 | 13 | 398.6 | 4.0 | 7 | 176.5 | 1.8 | 4 | 311.1 | 3.1 | 3 | 6.8 | 0.07 |
| | 2014 | 16 | 411.3 | 4.1 | 8 | 238.7 | 2.4 | 3 | 215.4 | 2.2 | 3 | 7.9 | 0.08 |
| Total $a_2$ | | **54** | **1441.4** | **14.4** | **22** | **600.4** | **6.0** | **15** | **911.1** | **9.1** | **11** | **25.9** | **0.26** |

Table 5. The influence of the year upon the weed degree in corn, 2012-2014

| Year | No. weeds/m$^2$ | % | Differences | Significance |
|---|---|---|---|---|
| 2012 | 35.50 | 100.00 | 0.00 | Mt. |
| 2013 | 27.50 | 77.50 | -8.00 | 000 |
| 2014 | 31.25 | 88.00 | -4.25 | 00 |
| LSD (p 5%) = 1.50; LSD (p 1%) = 2.48; LSD (p 0.1%) = 4.65 | | | | |

Table 6. The influence of soil tillage upon the weed degree in corn, 2012-2014

| Tillage system | No.weeds/m$^2$ | % | Differences | Significance |
|---|---|---|---|---|
| $a_1$- Conventional System (CS) | 29.17 | 100.0 | 0.00 | Mt. |
| $a_2$- Minimum Tillage (MT) | 33.67 | 115.4 | 4.50 | * |
| LSD (p 5%) = 2.12; LSD (p 1%) = 10.61; LSD (p 0.1%) = 106.10 | | | | |

The soil tillage system hasn't significantly influenced the productive potential of Turda Star hybrid, the average productions registered don't present statistically ensured differences, that is 5693 kg/ha in MT and 5671 kg/ha in CS (Figure 3). The corn crop is influenced by the climate conditions of the production year (Figure 4), therefore, compared to 2012 (a drought year, 5392 kg/ha), in 2013 the production is significantly positive (5552 kg/ha), and in 2014 the production is extremely significantly positive (6102 kg/ha).

A great contribution to the success of corn crop is the more abundent rain during winter accumulated in the soil, putting thus the water reserve in spring to the disposal of plants in the first phases of vegetation. The rain from the spring of 2012 (78.4 mm in April, 89.2 in May) and in 2013 (57.9 mm in March, 53.3 mm in April, 79.3 mm in May) managed to ensure corn a sufficient humidity during the sowing period and up to July. After this period the pedological drought came (52.4 mm in July and 28.0 mm in August in 2012, respectively 37.6 mm in July and 44.0 mm in August in 2013), this reflecting then in the productions made. The year 2014 characterized as a rainy year, the drought came in June (the monthly amount of rain was 48.4 mm) after which consistent rain followed, 144.4 mm in July and 83.8 mm in August, a climate situation which hasn't influenced the reduction of the production.

Fertilization system have a very significant positive influence on the yield difference between the two variants, a basic fertilizer ($N_{40}P_{40}$) and two fertilization ($N_{40}P_{40}$ + $N_{40}$) being 876 kg/ha (Table 7).

From the analysis of the economic efficiency of soil tillage system it results a reduction of the fuel consumption in the case of MT but this difference, in the end, mitigates by the high price of the agricultural inputs (1682.93 lei/ha), resulting still a decrease of expenses by 97.47 lei/ha (Table 8).

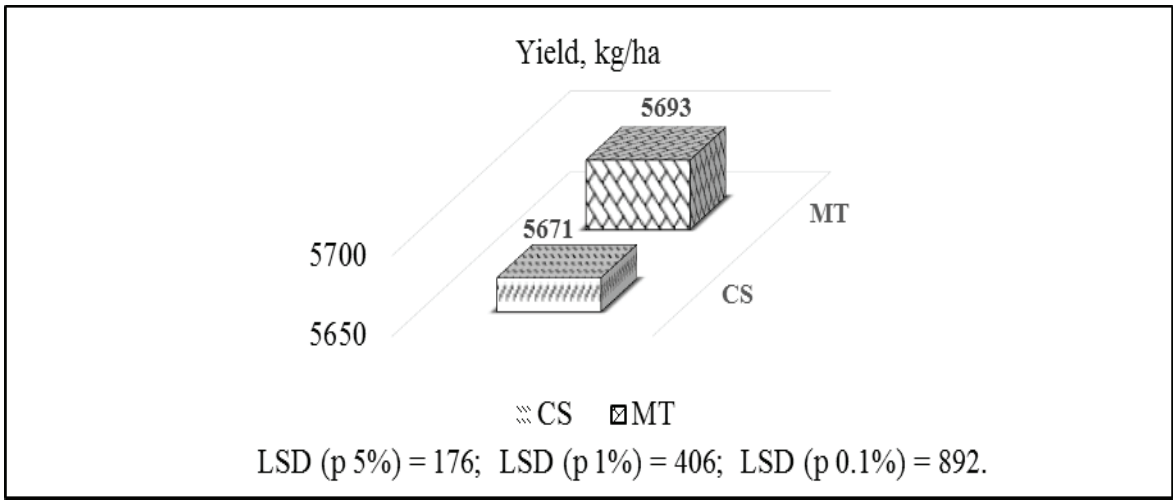


Figure 3. The influence of soil tillage upon corn production, kg/ha, 2012-2014

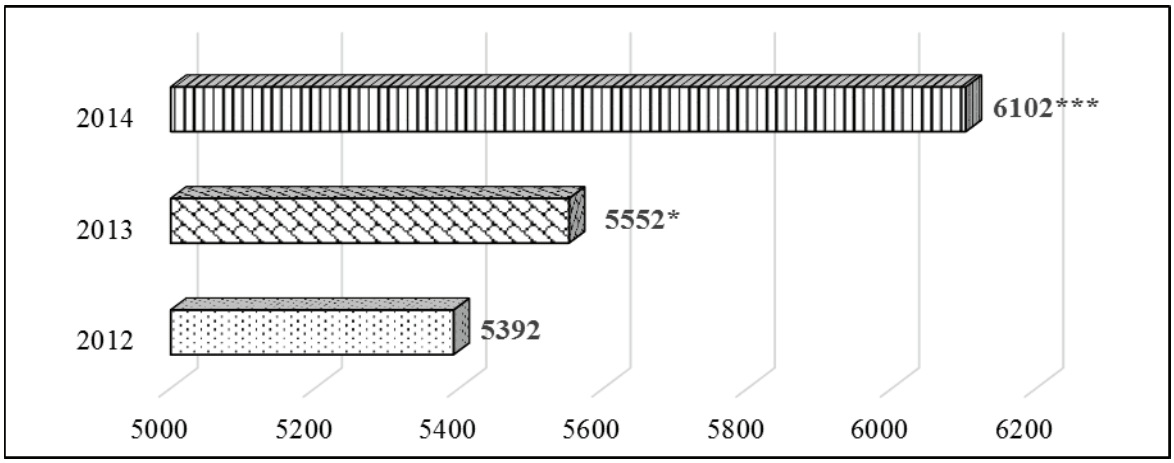


Figure 4. The influence of the year upon corn production, kg/ha, 2012-2014

Table 7. The influence of fertilization system upon corn production, kg/ha, 2012-2014

| B-fertilizing factor | Yield, kg/ha | % | Differences | Signification |
|---|---|---|---|---|
| $b_1$- $N_{40}P_{40}$ | 5244 | 100.0 | 0.00 | Mt. |
| $b_2$- $N_{40}P_{40}$ + $N_{40}$ | 6120 | 117 | 876 | *** |
| LSD (p 5%) = 157; LSD (p 1%) = 258; LSD (p 0.1%) = 484 | | | | |

Table 8. The economic efficiency of soil tillage in the corn crop

| Technological expenses | CS | MT |
|---|---|---|
| Consumption diesel fuel, l/ha | 101.5 | 84.4 |
| Lei/ha | 578.55 | 481.08 |
| Expenditure with materials, lei/ha | 1682.93 | 1682.93 |
| Total, lei/ha | **2261.48** | **2164.01** |

## CONCLUSIONS

The soil tillage system and the climate conditions influenced the weed degree of corn crop. The MT system recorded a growth of the weed degree to 33.67 weeds/$m^2$ compared to the number of weeds present in CS soil tillage which had 29.17 weeds/$m^2$. In a drought year, respectively 2012, the weed degree was the highest (35.50 weeds/$m^2$), it reduces in a normal climate year, 2013, to 27.50 weeds/$m^2$, and in 2014 considered a rainy year, favorable to corn crop, the weed degree is 31.25 weeds/$m^2$.

The soil tillage system hasn't significantly influenced the corn productions, they were almost equal in the two systems, but still with an increase of 0.4% in MT. The corn crop is influenced by the climate conditions of the agricultural year, thus compared to 2012, a drought year with a production of 5392 kg/ha, in 2013 the production is significantly positive with 5552 kg/ha, and in 2014 the production is extremely significantly positive, being 6102 kg/ha.

The economic efficiency of the MT system is higher and it results from the fuel consumption 84.4 l/ha at a price of 481.08 lei/ha compared to CS which needs 101.5 liters/ha at a price of 578.55 lei/ha. The economic efficiency of the MT system also results from the higher production obtained. Subtracting from the value of the production made in each technological system the total expenses (materials and fuel) it results a profit of 112.9 lei/ha, which overall MT technology means 6.6%.

## ACKNOWLEDGEMENTS

This work was supported by a grant of the Romanian National Authority for Scientific Research and Innovation, CNCS - UEFISCDI, project number PN-II-RU-TE-2014-4-0884.

## REFERENCES

Bachthaler G., 1968. Chemie oder Pflung. C.D.A. Crop field, 3.

Berca M., 2011. Agrotechnics, the modern transformation of agriculture. Ed. Ceres, Bucharest.

Cardina J., Regnier E. & Harrison K., 1991. Long-term tillage effects on seed banks in three Ohio soils. Weed Science, 39(2), p. 186-194.

Canarache A., 1990. Physics agricultural soils. Ed. Ceres, Bucharest.

Chetan C., Rusu T., Chetan F., Simon A., 2015. Influence of soil tillage systems and weed control treatments on root nodules, production and qualitative indicators of Soybean. Procedia Technology, 22, p. 457-464.

Chetan F., Rusu T., Chetan C., Simon A., Ignea M., 2014. Results obtained from maize production during the period 2012-2013 in minimum tillage, at ARDS Turda. Bulletin UASVM Cluj-Napoca, Series Agriculture, 71(2), p. 163-169.

Cociu A., 2011. Soil properties, winter wheat yield, its components and economic efficiency when different tillage systems are applied. Romanian Agricultural Research, 28, p. 121-130.

Domuta C., 2008. Agriculture cropping systems. Ed. Oradea University.

Fabrizzi K.P., Garcia F.O., Costa J.L., Picone L.I., 2005. Soil water dynamics, physical properties and maize and wheat responses to minimum and no-tillage systems in the southern Pampas of Argentina. Soil & Tillage Research, 81, p. 57-69.

Feldman S.R., Alzugaray C., Torres P.S. & Lewis P., 1997. The effect of different tillage systems on the composition of the seedbank. Weed Research, 37 (2), p. 71-76.

Griffith D.R., Mannering J.V., Mengel D.B., Parsons S.D., Bauman T.T., Scott D.H., Edwards C.R., Turpin F.T., Doster D.H., 1982. A guide to no-till planting after maize or soybean. Cooperative Extension Service Publication ID-154. Perdue University W. Lafayette, Indiana.

Gus P., Bogdan I., Rusu T., 2003. Conventional and unconventional soil tillage systems. Ed. Risoprint, Cluj-Napoca.

Hulpoi N., Picu I., Tianu A., 1970. Optimal plowing depth in terms of irrigation on leached chernozem from Fundulea. International Symposium of Soil Tillage, p. 24-29.

Lazureanu A., Manea D., Carciu Gh., 1997. Influence of soil tillage and chemical fertilization on maize yield, at Didactic Station Timisoara. Alternatives for soil tillage, Vol. I, p. 23-30.

Moraru P.I., Rusu T., Sopterean M.L., 2010. Soil tillage conservaton and its effect on erosion control, water management and carbon sequestration. ProEnvironment, 3, p. 359-366.

Pintilie C., 1979. Soil tillage system to reduce energy consumption. Crop production - cereal and technical crops, 9.

Rusu T., 2005. Agrotechnics. Ed. Risoprint, Cluj-Napoca.

Rusu T., Gus P., Bogdan I., Moraru P.I., Pop A.I., Clapa D., Marin D.I., Oroian I., Pop L.I., 2009. Implications of minimum tillage systems on sustainability of agricultural production and soil conservation. Journal of Food, Agriculture & Envir., 7(2), p. 335-338.

Rusu T., Bogdan I., Moraru P.I., Pop A.I., Oroian I., Marin D.I., Ranta O., Stanila S., Gheres M., Duda M., Mogosan C., 2013. Influence of minimum tillage systems on the control of *Convolvulus arvensis* L. on wheat, maize and soybean. Journal of Food, Agriculture & Environment, 11(2), p. 563-566.

Sandoiu I.D., 1999. Problems regarding introducing of alternative soil tillage in Romanian Plateau. International Symposion - Minimum soil tillage systems, UASVM Cluj-Napoca, p. 20-26.

***ANOVA, 2015. PC program for variant analyses made for completely randomized polifactorial experiences. UASVM Cluj-Napoca, Romania.