PhD THESIS

The influence of the tillage system on the soil, quality and quantity of corn production in the Transylvanian Plain area

(Summary of the Phd thesis)

PhD student **Alin Daniel Popa**

Scientific coordinator **Prof. Univ. Dr. Teodor Rusu**

INTRODUCTION

The effects of global warming have led to food insecurity and global problems related to addressing them, with the aim of preventing, mitigating and adapting to the dangers that arise with climate change.

In some areas of the globe, the year-on-year variation in rainfall is very high and makes it impossible to efficiently manage water resources in increasing the productivity of agricultural crops, improving environmental conditions by implementing sustainable agriculture systems could be the solution to avoid a global food crisis.

Current agricultural practices have a major impact on soil properties, plant growth and development, and especially on the productivity of a crop, so in a region where the effects of climate change are beginning to become visible, improving technology is of real interest to both researchers and farmers.

The implementation of a tillage system must be done in accordance with all the aspects that can influence that system, so it involves a detailed knowledge of all the elements that contribute to increasing soil fertility. An insufficient analysis of the way in which the soil interacts with these high requirements can have negative consequences, which are degradation processes or even the destruction of production capacity (HAMZA et al., 2005).

The role of sustainable agriculture is to mitigate the effects of climate change and to maintain or even improve crop productivity at the lowest possible production costs.

Irrationally applied tillage, especially classic tillage (ploughing) has caused over time a degradation of soil characteristics, a strong decrease in organic matter content and subsequently in its productive potential. The influence of the soil tillage system on soil properties is proven by important indices in the conservation of soil fertility and for the evaluation of the sustainability of the agricultural system (RUSU et al., 2006).

The influence of conservative tillage systems on water use efficiency and production depends on soil type, crop requirements, probability of rainfall and soil water storage capacity (HEMMAT and ESKANDARI, 2004).

According to LAMPURLANÉS et al., (2001), conservative tillage systems lead to an increase in soil water reserve by increasing infiltration and reducing evaporation, but depending on the type of soil and climatic conditions, this leads to higher, equal or even lower yields than conventional tillage systems.

The implementation of sustainable technological systems plays a vital role in adapting capacity and global food security in the context in which more and more agricultural lands are desertified or subject to erosion year after year.

Improving the technological system of maize cultivation through the adoption of conservative tillage systems, the rational use of fertilisers as well as the reduction of pressure exerted by diseases, weeds and pests can lead to a reduction in the vulnerability of agriculture to the effects of climate change.

The direct correlation between the global increase in food needs and population growth leads to the need to expand the land cultivated with corn, being the

second most important crop in the world, but also in productivity per unit area.

Corn (*Zea mays* L.) is one of the most cultivated plant species worldwide, along with wheat, rice and soybeans, due to its nutritional value, but also to its agrophytotechnical peculiarities. About 75–80% of the world's corn production is used in animal feed, ensuring a conversion of dry matter into meat, milk, etc., and about 15% of the production is used in human nutrition (SFETCU, 2021).

In this context of climate change and adaptation to these changes, the thesis entitled "**The influence of the tillage system on the soil, quality and quantity of corn production, in the Transylvanian Plain area**" has as its main purpose the knowledge of the links between the technological components on the elements of productivity, production but also on the influence of biotic and abiotic factors that intervene in the vegetative cycle of the plant.

Objectives of the research project

In order to achieve the main goal of the thesis, several objectives have been established through which all aspects of the study will be pursued and which, upon their completion, can provide the necessary information.

- establishing the influence of the tillage system on the emergence of corn and the degree of weeding;
- establishing the influence of the tillage system on the degree of disease and pests;
- research on the influence of tillage systems on soil water reserve and soil resistance to penetration;
- determining the influence of tillage systems, fertilization system and applied treatments on productivity elements and maize production;
- establishing the influence of the tillage system and cultivation technologies on the economic efficiency of maize crops.

Experimental factors

The research was carried out between 2018 and 2020, at the Turda Agricultural Research and Development Station (SCDA Turda).

The experiment carried out is a polyfactorial one, the method of placement used is that of subdivided plots, the surface of an experimental plot being 48 m2, arranged in 3 repetitions (Fig. 2.). During the experiment, the corn sowing was done with the MT 6 - Maschio Gaspardo machine. The sowing density was 65,000 plants/ha and the seed incorporation depth was 5 cm. The precursor plant to the corn crop was the winter wheat. The biological material used in the experiment was represented by the Turda 332 maize hybrid (Fig. 1.), created at ARDS Turda.

Fig. 1. Turda 332 corn hybrid
(Sources: https://www.google.ro/search?q=hibrizi+porumb+ turda&source=lnms&tbm=isch&sa=X&ved=)

Turda 332 is a simple semi-early hybrid, with a high waist, it has 16-17 leaves with a semi-erect habit, the cobs are cylindrical in shape, with 18-22 rows of grains on the cobs, the rachis is red, the grain is toothed and dark yellow, with an MMB (mass of 1000 grains) of 220-240 g.

The hybrid has good resistance to low temperatures in the first vegetation period and to plant fall, good tolerance to drought, heat and grain shale.

It is recommended to cultivate in zone I and II of favorability in Transylvania, Moldova and in the hilly areas in the west of the country. It lends itself to intensive cultivation, ensuring a density of 65-70,000 plants/ha.

Factor A - tillage:

- a1- Classic system (ploughing with furrow turning);
- a2- Unconventional system (chisel version);
- a3- Unconventional system (disc harrow version);
- a4- Unconventional system (direct seeding);

Factor B – fertilization:

- b1 – control – mineral fertilization;
- b2 - mineral fertilization + Haifa (19:19:19 + Mg + Microelements) (5 kg/ha);
- b3 - mineral fertiliser + Folimax Oil (12-04-24 + 2.0% MgO + 36.5% SO3 + Microelement) (1.5 kg/ha);
- b4 - fertilizare minerală + Folimax Gold (27,0% N + 1,5% MgO + 0,02% B + 0,2% Cu + 0,02% Fe + 1,0% Mn + 0,02% Mo + 0,02% Zn) (3 l/ha).

Factor C – climatic conditions of the years of study:

- c_1 – 2018

- c_2 – 2019
- c_3 - 2020

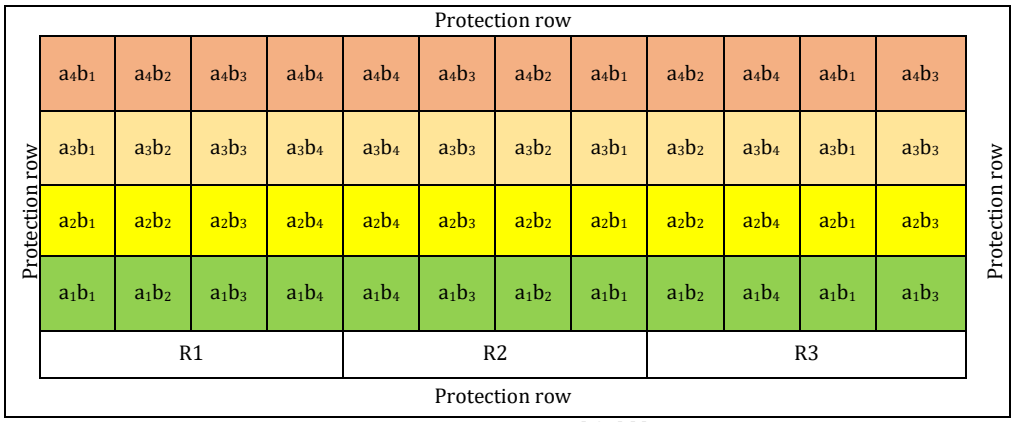

Fig. 2. Maize experimental field layout
(source: original)

Four variants of land tillage were included in the research: classic ploughing with a plough with furrow turning (Fig. 3); Conservative minimum tillage variant cizel, disc and no tillage.

In the conventional tillage system, the basic plowing is done immediately after the land is freed from the predecessor plant, at a depth of 30 cm, then the preparation of the seedbed is carried out with the rotary harrow for shredding and uniforming the land.

Fig. 3. Ploughing work with furrow turning (classic system)
(Sursa/source: Original)

In the case of the unconventional soil tillage system (chisel version, Fig. 4.), a loosening of the soil is carried out with a chisel at a depth of 40 cm, followed by a preparation of the seedbed with a rotary harrow for shredding and levelling the soil.

Fig. 4. Tillage in an unconventional system (chisel version)
(source: Original)

In the case of the unconventional tillage system (disc version, Fig. 5.), the soil is tilled with a disc harrow, at a depth of 10 cm, followed by a preparation of the seedbed with the rotary harrow for shredding and levelling the soil.

Fig. 5. Soil tillage in an unconventional system (disc harrow)
(Sursa/ source: Original)

In the unconventional farming system (no-tillage version, Fig. 6.) the sowing is done directly in the stubble of the previous crop without prior tillage, with the MT 6 maize seeder.

Fig. 6 Direct sowing
(source: Original)

The amount of seed per hectare was calculated using the formula:

Q= (D x MMB)/ (P x G) x100

D= number of germinable grains /m2

MMB= mass of 1000 grains

P = physical purity

G= germination capacity

The foliar fertilization was carried out by applying two foliar treatments, the first treatment was carried out in the phenophase of 8-10 leaves, and the 2nd treatment was carried out in the fezophase of 10-12 leaves.

The mineral fertilization was carried out in two phases: at the same time as sowing, a complex NPK fertilizer (27:13.5:0) was applied at a dose of 250 kg/ha, and on the vegetation in the phenophase of 6-8 leaves, a CAN fertilizer (27:7:5) was administered at a dose of 120 kg/ha, in all variants.

The technological work was carried out simultaneously (on the same date) in all systems, so that there were no changes to the experience.

In order to combat weeds, treatments were carried out that included combinations of herbicides that combat monocot and dicotyledonous species in the corn crop, namely Tender 1.2 l/ha, Merlin Flex 0.4 l/ha at a quantity of 260 l/ha water that were applied in pre-emergence and Starane 1.0 l/ha at a quantity of 260 l/ha water was used on vegetation.

Results and conclusions

1. The number of days from sowing to sunrise is influenced both by the tillage system where the difference from the classic system is smaller but 1-2 days in the case of minimum tillage systems and higher by 2-5 days in the case of direct sowing and by the environmental conditions of the 3 experimental years, in 2019, when the climatic conditions recorded immediately after sowing were not favorable for optimal fermentation and emergence.

2. Between the systems with minimal works and the classic system there are no significant differences in terms of density at sunrise.

Very significantly negative differences in the number of sprouted plants were observed in the case of the no-tillage system, where there was a decrease of 12/10m^2 compared to the classic system.

3. The spectrum of weeds determined in the period 2018-2020 is variable both in terms of the number of weeds/m^2 and the number of identified species, with the highest number of weeds/m^2 being recorded in 2018.

4. Of the 4 tillage systems, in the case of the classic tillage system and the conservative system, the cizel variant, a number of 13 species of weeds were found, most of which were from the category of annual dicotyledons.

5. In the case of the other two systems with minimal tillage, the disc and direct seeding variant, the number of weed species identified per m2 increased to 15, within the direct seeding system, several species in the perennial category were identified.

6. Both in the classic tillage system and in the conservative systems, the momentary soil water reserve was within normal limits until July, with values above the minimum ceiling of 503.1 m3/ha, except for 2019 when the decrease has been recorded since July.

7. With the decrease in the amount of precipitation between July and August, the water reserve decreases below the level of the minimum ceiling but not below the withering coefficient in all 4 tillage systems, but the largest decrease is observed in the case of the classic system.

8. The resistance of the soil to penetration, determined in the 4 tillage systems, shows an increase in its value immediately below the working depth, namely approx. 2888 kPa in the case of the classic system at a depth of 30 cm, 2439 kPa in the case of the chiseled version at 40 cm, 1972 kPa, in the case of disc harrow version, in the case of direct sowing in the first 10 cm a value of 877 kPa is recorded.

9. Corn sown in conservative tillage systems needs a longer time to reach certain technological stages, so in the case of the useful thermal degrees determined between sowing and the appearance of stigmas, about 10 – 18°C is needed in the case of minimum tillage and approx. 22 – 27°C in the case of direct sowing for the climatic conditions of 2018 and 2020 and 53°C more in systems with minimal tillage respectively 90°C at direct seeding in the case of 2019.

10. The root system of maize develops better in a deeper layer of soil when it is loosened with the help of ploughing and the penetration of the roots is not restricted and more superficial if the sowing is done directly in the untilled soil.

The size of the plants is generally correlated with the root system, so in the case of direct sowing the height of the plants is also lower than in the classic tillage system.

11. The average production achieved after the application of a classic tillage system reaches a value of over 8000 kg/ha, being higher than that obtained in the soil conservation systems in which the differences range from 600 kg/ha for disc tillage and up to 1780 kg/ha for direct sowing.

12. Foliar fertilization applied to corn brings very significant production increases between 317 kg/ha and 611 kg/ha, the largest increases being observed when applying Folimax Gold fertilizer.

13. Climatic conditions are the factor that most influences the productivity of a crop, so in 2019 when the rainfall regime was deficient, corn production was only 5581 kg/ha, with a very significantly negative difference of 2129 kg compared to the average of experience, and in 2018 it increased very significantly by 1261 kg/ha.

14. The interaction of the experimental factors fertilization and tillage systems highlights a variation of maize production where the best yields are recorded in the classic system when applying the Haifa product and the lowest production was achieved in the system with direct sowing at the variant where foliar fertilization was not applied.

15. The production results obtained from the interaction of tillage and fertilization systems are not positively influenced, the classic tillage system having the best results regardless of the fertilization variant applied.

16. The productions achieved in 2018 were higher regardless of the soil tillage, being between 7374 kg/ha and 9565 kg/ha and in 2019 they decreased to values between 3986 kg/ha and 6553 kg/ha.

17. The conditions of 2020 were also very well exploited by the conservative tillage systems, especially by direct sowing where a production of 8739 kg/ha was obtained, very close to the classic system.

18. The mass of 1000 grains was significantly influenced by the application of the foliar fertilizers Haifa and Folimax Gold, the differences being between 5.94 g and 6.19 g.

19. The unfavorable climatic conditions of 2019 are the cause of the decrease of the MMB by 21.79g compared to the average of the years, the difference being statistically ensured as very significant. The favorability of the climatic conditions of 2018 was also transposed into the mass of the 1000 grains analyzed in the study.

20. The tillage system does not have a very large influence on the MMB, the differences obtained compared to the classic system being statistically insecure and ranging from 2.56 g to 5.78g.

21. The interaction of fertilization with tillage systems does not have a very large influence on the MMB, significant differences being observed only in the case of the conservative system of the cizel variant when applying the Haifa and Folimax Oleo fertilizers.

22. Although increases or decreases in this parameter are observed, they are statistically assured only in the direct seeding version to which the Folimax Oleo product has been applied and where the difference of 12.33 g is significantly positive.

23. Very significant differences in the MMB were determined in the interaction between the tillage system and climatic conditions, where in 2018 the differences obtained were statistically ensured as very significant regardless of the tillage system.

24. From the interaction of the year factor with the tillage system, it emerges that in years with favorable conditions, the MMB increases with very significant differences in the cultivation of no-tillage corn and decreases in the case of unfavorable environmental conditions.

25. The main quality indices of maize, protein and starch are influenced by the tillage system, with very significant negative differences, respectively very significant

in the case of protein and positive in the case of starch on systems with minimal tillage.

26. Climatic conditions are the factor influencing the increase or decrease of the qualitative indices with differences statistically ensured as very significantly positive in the case of 2020 for both parameters and with very significant negative differences in 2019 for protein and in year 2018 for starch.

27. From the interaction of experimental factors on protein content, it emerges that foliar fertilization applied to maize contributes to its improvement and that the tillage system does not significantly influence the percentage in interaction with fertilization, but can influence depending on climatic conditions.

28. The hectoliter mass decreases with significant instinct values between 1.94 kg/hl and 2.14 kg/hl in systems with minimal tillage and with a very significant difference of 2.78 kg/hl in the case of direct sowing.

29. By applying foliar fertilization, the MH value is not significantly modified, but the climatic conditions modify this parameter very significantly, with negative differences of 2.67 kg/hl respectively 3.07 kg/hl in 2018 and 2019 and positive differences of 5.74 kg/hl in 2020.

30. The degree of attack of cob fusariosis was not significantly influenced by the tillage system, the differences obtained being statistically unensured.

31. The application of foliar fertilizers contributes to a small extent to reducing the degree of fusarium attack, but the negative differences of 0.06-0.04% are not statistically ensured.

32. The climatic differences between the 3 experimental years do not present a significant influence on the degree of attack of the cob fusariosis, the only statistically assured differences being identified in the interaction between foliar fertilizers with the conservative disc variant system where the differences are significant respectively distinctly significant.

33. The climatic conditions of 2018 significantly influenced the frequency of the attack on cobs of the pest *Ostrinia nubilalis*, compared to 2019 and 2020 when the frequency of the attack was reduced with very significant differences of 10.6 and 12.8% compared to the average of the years.

34. The working system has no influence on the frequency of the attack except in the interaction with the climatic conditions where in the first year there is an high frequency, statistically ensured as very significant and with negative differences from significant to very significant in the case of 2019 and 2020.

35. The length of the galleries produced by the larvae of *Ostrinia nubilalis* is higher in the conservative tillage systems, with differences statistically ensured as very significant.

36. The variation of climatic conditions significantly influences the length of

the galleries, in 2019 they are shorter than in the other 2 years.

37. The number of larvae of *Ostrinia nubilalis* is higher in conservative systems and is influenced by the other experimental factors only in their interaction, especially with climatic conditions.

38. The number of holes produced on the corn stalks is very significantly influenced by the way of tillage, in all 3 conservative systems lower values being obtained than in the classic system.

39. The economic efficiency of the implementation of conservative tillage systems does not derive specifically from the reduction of production costs in the short term, but rather from the long-term effects it has on the soil and the environment in the context of sustainable agriculture.

Originality

Current climate change and pollution reduction are among the main factors that require the reconsideration of tillage systems. Also, in the concept of sustainable agriculture, a concept accepted at EU level, soil tillage is an integrated part. In general, technologies specific to sustainable agriculture should ensure higher productivity over time than conventional agriculture.

In this context, tillage systems for corn cultivation become an important factor in achieving sustainable agriculture goals. Even if in the soil conditions specific to the Transylvanian Plateau there have been researches on the behavior of corn in different tillage systems, nevertheless the approach of such a large number of technological aspects and the interactions between them are elements of novelty and, at the same time, of originality.

Selective bibliography

1. HAMZA M.A., W.K. ANDERSON, 2005, Soil compaction in cropping systems: A review of the nature, causes and possible solutions, Soi land Tillage Research, vol. 82 issue 2, 121-145.
2. HEMMAT A., I. ESKANDARI, 2004, Conservation tillage practices for winter wheat-fallow farming in the temperate continental cli¬mate of northwestern Iran. Field Crops Research, 89, 123–133.
3. LAMPURLANÉS J., P. ANGÁS, C. CANTERO-MARTÍNEZ, 2001, Root growth, soil water content and yield of barley under different tillage systems on two soils in semiarid conditions. Field Crops Research, 69, 27–40.
4. RUSU T., P. GUŞ, ILEANA BOGDAN, I. OROIAN, LAURA PAULETTE, 2006, Influence of minimum tillage szstems on physical and chemical properties of soil, Journal of Food, Agriculture & Environment, vol 4(3-4), 262-265, Helsinki, Finlanda.
5. SFETCU I.C. 2021, Cercetări privind comportamentul unor hibrizi de porumb la aplicarea sistemului minim de lucrare a solului în zona de Sud-Est a României (Moara Domnească - Ilfov). Teză de doctorat. U.S.A.M.V.B Bucureşti.