THE INFLUENCE OF TILLAGE SYSTEMS ON NUTRIENTS SUPPLY IN SOIL ON CORN CROP AT THE EZARENI FARM, IASI COUNTY

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Abstract*. The level and quality of crop production is determined to a great extent by the soil fertility. The level of supply with nutrients depends on many factors, but the most important element is the tillage system. In order to study the impact of soil tillage on nutrients content, research was carried out on the Ezareni farm, where conventional (CT) and no-tillage (NT) systems were observed. The soil of the investigated plots is cambic chernozem with a specific clay-loamy texture. The soil cores for analysis of macronutrients (N, P, K), soil reaction (pH) and humus content (H%) were taken from the 0 – 40 cm soil layer, from the corn crop. The results revealed a higher content of the main mineral nutrients at the soil surface and a significant decrease in deeper layers in no-tillage compared to a slight decrease with depth in the conventional system. Soil reaction (pH) values were between slightly acid to neutral, with a minimum of 6.2 in NT and a maximum value of 7.2 in CT. Humus content analysis showed a variation from 3.46 % to 0.73 % with the highest percentage in the topsoil in NT and in deeper layers in CT. In the no-tillage system, the macronutrients supply status is higher at the soil surface due to undisturbed microbiological activity of plant residues decomposing. In CT, ploughing determines a uniform distribution of nutrients content throughout the depth, but incorporation of plant residues causes humus to disperse into deeper soil layers. For the maintenance and permanent improvement of soil fertility, researchers are looking for the most suitable tillage system correlated with the physical properties. Therefore, the present paper aimed to highlight the impact of no-tillage system and conventional system on soil chemical properties.*

Keywords: *tillage systems, macronutrients, humus content, soil reaction*

INTRODUCTION

The agricultural sector is in a continuous transformation and the directions of that are multiple. Nowadays the climate, economic and social changes require new ways to approach so that the food needs, the quality of products be at the highest standard and the environment should be protected.

Maize (*Zea mays* L.) is one of the most important crops worldwide, ranking first in terms of production (LOBULU ET AL., 2019) due to its multiple uses (DABIJA ET AL., 2021): food, animal feed, production of alcohol, starch, dextrin, glucose, and maize oil (CHETAN ET AL., 2022).

Soil tillage can change the chemical, physical, and biological properties of the soil, whereby plant, development and yield are influenced. Soil nutrient status is an important indicator of fertility as it not only coordinates and supplies the nutrients required for plant growth, but also facilitates the decomposition of soil humus and biogeochemical cycles (CONDIT ET AL., 2013).

Soil fertility is related to the amount of humus contained by the soil, but also by its quality (GILMOUR, 2020). Furthermore, is defined by its reaction and the degree of supply of nutrients (nitrogen, phosphorus and potassium) and by the ratio between these in soil (BUCUR, LIXANDRU, 1997).

Nitrogen (N) is a constituent element of proteins, nucleic acids (DNA and RNA), and chlorophyll in chloroplasts and other compounds in plants, which plays a significant role in plant growth and development (YU ET AL., 2021; MIAO ET AL, 2019). Phosphorus (P) is an essential mineral nutrient for plant growth with important nutritional and physiological functions and in addition to nitrogen (N), is crucial in soil ecosystems (FU ET AL., 2020). Phosphorus (P) is a constituent element of many compounds in plants, such as nucleic acids (DNA and RNA), proteins, and enzymes, which promote plant growth and enhances the cold and drought resistance of crops (FRESNE ET AL., 2021). Potassium (K) can promote photosynthesis so that cellular osmotic pressure can use water uptake and enhance the plant's ability to tolerate various adverse conditions (BELOV ET AL., 2021; ZHAO ET AL., 2017; ALEXANDRUSAVA ET AL., 2011).

Soil reaction (pH) is the key to detecting changes in soil acidification or soil alkalinity. Strong associated relationships have been proved between soil pH and soil quality, e.g., physical structure and microorganism structure, crop yields via impacting the effectiveness of nutrients, and soil health, e.g., the buffer capacity in the heavy metal (NEINA DORA, 2019).

Major environmental deterioration can be caused by soil erosion, soil compaction, soil structural damage due to human activities, loss of organic matter as well as due to extreme climatic conditions influenced by human activity (AKKER ET AL., 2001). Different tillage systems induce different changes in the soil properties (e.g., physical, chemical, and biological characteristics) (HUANG ET AL., 2018).

The deficiencies of the conventional tillage system have been well researched often leading to serious soil and water loss, resulting in the depletion of soil nutrients, deterioration of the ecological environment, and unsustainable productivity of agricultural system (HUANG ET AL., 2018). Using conservative tillage systems as a substitute for plow-based methods of seedbed preparation, may provide a sustainable way for using soil resources (BURTAN ET AL., 2020). In general, compared to CT, conservation tillage improves the chemical environment of soil in croplands (LIGANG ET AL., 2022).

MATERIAL AND METHOD

The research was carried out on the northeast part of Romania, at the Ezareni farm, the Didactic Station belonging to "Ion Ionescu de la Brad" Iasi University of Life Sciences.

The climate of the experimental area is temperate – continental with an annual average of temperature of 9.4℃ and rainfall in 2020 of 587 mm and 691.8 mm in 2021. The experimental plots are located on cambic chernozem, with a clay-loamy texture.

The field experiment was based on two tillage systems: conventional, with ploughing at 28-30 cm and conservative by direct seeding with Fabimag FG – 01, each covering an area of 2 ha.

In order to analyze the soil chemical properties, the soil samples were collected from 0-10 cm, 10-20 cm, 20-30 cm and 30-40 cm depth layers, using an agrochemical auger, at the harvest of the maize crop. On each of the two plots, corresponding to NT and CT, the composite soil samples consisted of 20 randomly collected soil subsamples.

Agrochemical samples were prepared for the analytical flow by drying, removal of plant residues and grinding the soil. The determination were carried out at the Iasi Research Institute for Agriculture and Environment, in the chemistry laboratory.

The following determinations were performed:

1. Soil reaction (pH_{H_2O}) using the potentiometric method in aqueous suspension at a ratio 1:2,5 soil: distilled water; limits for soil pH values are given in Table 1.

Table 1

Soil reaction characterization limits (ICPA Bucuresti, 1981)

pH	Soil reaction status
≤ 5.0	strongly acid
5.01 – 5.80	moderately acid
5.81 – 6.80	slightly acid
6.81 – 7.20	neutral
7.21 – 8.40	slightly alkaline
> 8.40	strongly alkaline

2. Humus content (H%) by titrimetric dosing with Walkley-Black method in the Gogoasa modification; Table 2 represents the limits of humus content assessment.

Table 2

The limits for humus content in mineral soils (VINTILA ET AL., 1984)

H%	Characterization of humus content
≤1.0	extremely low
1.1 - 2.0	low
2.1 - 4.0	medium
4.1 - 8.0	high
> 8.0	very high

3. Nitrogen content (nitrogen index – NI%) established by calculating the nitrogen index, from the humus input; the description of the N content is shown in Table 3.

Table 3

Soil nitrogen status (ICPA Bucuresti, 1981)

NI%	Characterization of nitrogen supply
≤ 2,0	low
2,1 - 4,0	medium
4,1 - 6,0	good
> 6,0	very good

4. Mobile phosphorus content (P ppm) by the Egner-Riehm-Domingo method consisting of extraction with ammonium acetate lactate solution at pH 3,75; determination was carried out colorimetrically with molybdenum blue by the Murphy-Riley method - reduction with ascorbic acid (STAS 7184/19-82); characterization of the P status supply status is presented in Table 4.

Table 4

Soil phosphorus status (ICPA Bucuresti, 1981)

P ppm	Characterization of phosphorus status
< 8.0	very low
8.1 – 18.0	low
18.1 – 36.0	medium
36.1 – 72.0	good
72.0 – 144.0	very good

5. Mobile potassium content (K ppm) in ammonium lactate acetate and determined by the Egner-Riehm-Domingo method using the atomic absorption apparatus, flame technique - CONTR AA 700 (STAS 7184/18-80); Table 5 shows the characterization values of the K content.

Table 5

Soil potassium status (ICPA Bucuresti, 1981)

K ppm	Characterization of potassium status
< 66.0	low
66.1 – 132.0	medium
132.1 – 200.0	good
200.1 – 265.0	very good

RESULTS AND DISCUSSIONS

The aim of this research was to determine the dynamics of soil agrochemical properties from conventional to no-tillage system (Table 6).

Table 6

Influence of tillage systems on soil agrochemical properties

Sampling depth (cm)	pH	P (ppm)	K (ppm)	Humus (%)	CEC (meq/100g soil)	V (%)	NI (%)
No-tillage system (NT)							
0 - 10	6.2	28	285	3.46	23.4	87.96	3.03
10 - 20	6.5	14	178	2.38	24.4	88.1	2.10
20 - 30	6.5	11	182	1.28	25.3	88.9	1.14
30 - 40	7.1	4	114	0.73	-	-	0.73
Conventional system (CT)							
0 – 10	6.8	30	200	3.25	25.6	88.5	2.85
10 - 20	6.8	25	210	3.13	25.4	89.0	2.74
20 – 30	6.8	16	213	2.47	25.0	89.7	2.21
30 - 40	7.2	3	187	1.65	-	-	1.65

The results reveal a slightly acid reaction at the surface in NT (6.2) with a slight increase with depth due to the application of fertilizers without incorporation over 7 years. Up to 30 cm the pH remains in the slightly acid class, but changes suddenly under 30 cm. In deeper layers, the soil reaction is neutral to slight alkaline (7.1), influenced by the presence of $CaCO_3$ from the C horizon. In the CT, the soil reaction state is slightly acid, with a constant value of 6.8 down to 30 cm depth (fig. 1). Values in the range 6.0 – 6.5 are optimal for the solubility and accessibility of nutrients in the soil, and the plants receive the necessary nutrient doses (RUSU ET AL., 2007).

High humus content in the upper layer (3.46 %) and decreasing with depth is noticeable in NT. Absence of incorporation and retention of plant residues at the soil surface results in accumulation of organic matter in the 0-15 cm range and a diminished level to extremely low in deeper layers. Different humus contents are observed in the CT, with small differences between the values, due to the decomposition of organic matter occurring at different depths, the supply level is low to medium, between 3.25 – 1.65 % (fig.2).

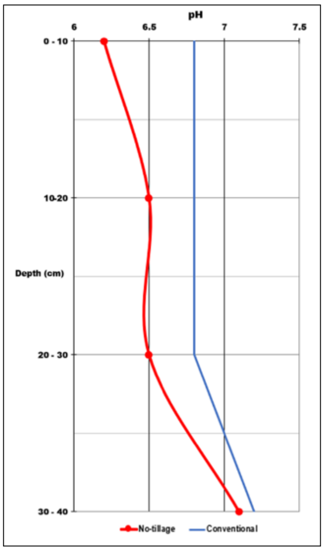

Fig. 1 Soil reaction

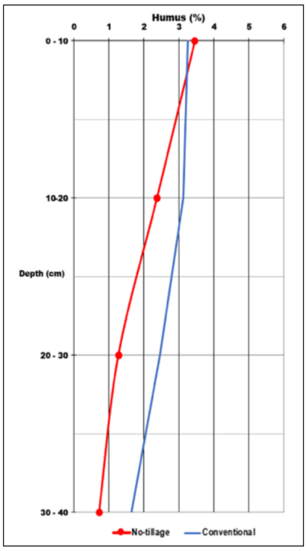

Fig. 2 Humus content

The nitrogen supply status of the soil in the investigated area was determined by calculating the nitrogen index (NI) using humus content (H%) and cation exchange capacity (CEC meq/100 g soil).

The medium nitrogen supply predominates in the upper soil layer (0-20 cm), in both tillage systems, between 3.03 – 2.85 % (fig. 3). In the case of reduced tillage, crop residues and organic matter accumulated at topsoil can immobilize nitrogen fertilizers and diminish their availability to crops (JITAREANU ET AL., 2007). At high nitrogen rates, yields can be equal or higher with no-tillage (HABTEGEBRIAL ET AL., 2007).

The degree of mobile phosphorus supply under NT is higher at the soil surface (28 ppm) cause to annual fertilizer application. Values decrease significantly with depth, reaching 14 ppm in the 10 – 20 cm range, mainly because of the very slow mobility of this nutrient. In CT, test results show smaller differences between sampling depths as a result of inverting, and the values are at the medium supply level (fig. 4).

Soil potassium content varies from medium to very good. In the NT, mobile K concentration is 285 ppm in the upper soil layers, but decreases substantially at the next depth (fig. 5). In the case of CT the close values of potassium concentration on soil depth are explained by ploughing and fertilizer incorporation.

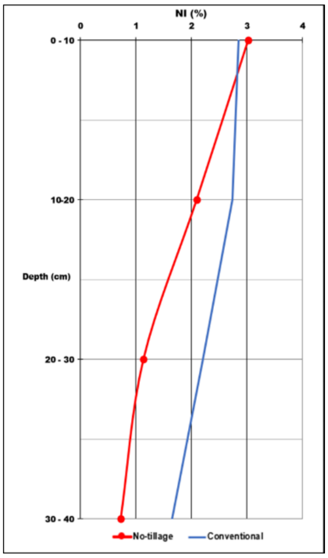

Fig. 3 Nitrogen index

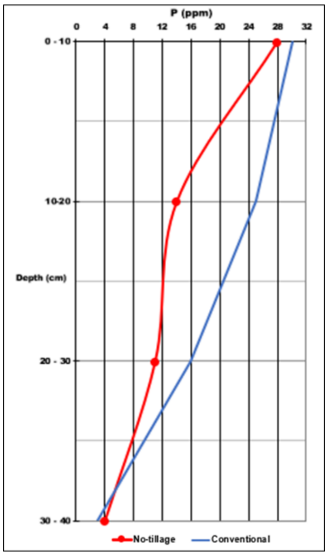

Fig. 4 Phosphorus content

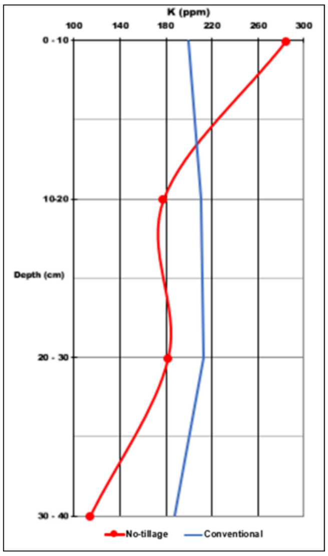

Fig. 5 Potassium content

CONCLUSIONS

Agrochemical analysis investigated in this study revealed a good soil supply of macronutrients, a high humus content related to organic matter and a soil reaction favorable to crop plants in NT. In the direct seeding system, the macronutrients supply status is higher at the soil surface due to undisturbed microbiological activity of plant residues decomposing. However, lower soil pH can negatively affect the availability of soil nutrients, leading to lower yields.

In CT, ploughing determines a uniform distribution of nutrients content throughout the depths, but incorporation of plant residues causes humus to disperse into deeper soil layers. Neutral soil reaction in all ranges supports optimal crop growth and micro-organisms perform their activity in the best conditions. N, P and K reserves are medium to good level through the sampling depth.

The results of this research once again highlight the benefits of the unconventional tillage system, in particular the no-tillage system. In order to choose the appropriate tillage system, it is necessary to consider all the elements that can affect both the yield and the environment. The no-tillage system is suitable for the climatic and soil conditions specific to the research area, but for more conclusive results the study will be extended.

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