# THE EFFECT OF MINIMUM STRIP-TILLAGE COVER CROP SYSTEM ON QUALITY SOIL INDICATORS IN VEGETABLE CROPS

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**Absract.** *This study compares a few agro-physical and chemical soil features submitted to influences of minimum strip-tillage cover crop system and conventional tillage system in cabbage, carrot, garden bean and sweet corn crops. From 2005 to 2008 comparative tests have been performed by the two tillage systems in Apahida (Cluj-Napoca), situated in an area of temperate continental climate (average annual temperature of 8 to 10°C, average annual rainfall of 590 mm; the soil is alluvial, sandy-clay, slightly plastic, moderately developed, mildly alkaline pH = 7.7, humus content of 3.4% and good potassium, phosphorous and nitrogen content). Soil reaction values and the high organic matter and nitrogen content have been measured before the experiment. Not too deep changes were recorded in the chemical soil reaction (pH), being still mildly alkaline. After three years of tests, in 2007 a 7.15 pH was recorded with conventional tillage and a 7.24 pH with minimum tillage. Total nitrogen content was medium in both crop variants (0.198% total N with conventional tillage and 0.192% total N with minimum tillage). P mobile content in the soil was also good: 125 ppm P with conventional tillage and 136 ppm P with minimum tillage. K mobile soil supply was high to very high – 210 ppm K mobile with conventional tillage, 232 ppm K mobile with minimum tillage. The humus level in the soil recorded a significant increase. At the beginning of the tests as of 2005, the humus in soil was of 3.40%; after two years of experimenting a 3.90% increase was recorded; after three years of testing the humus content was of 4.5% with the minimum strip-tillage cover system. The soil texture is medium, with a high degree of plasticity and adherence, water and air permeability, with a good water and nutrient retention. Following analyses soil structure modification was recorded, rates increasing from 78% to 83% with the minimum strip-tillage cover crop system, being noted that the higher the soil structuring level, the more increased the fertility.*

**Keywords**: minimum tillage, cover crop, vegetable crop, agro-physical and chemical soil features.

## INTRODUCTION

In the European Union countries and recently in Romania as well, organic agriculture is increasingly encouraged. Therefore this work intends to emphasize the influence of minimum strip-tillage cover crop system on soil quality indicators, quality and quantity of cabbage, carrot, bean and sweet corn production. Soil quality indicators are sensitive to changes, depending on soil type, tillage works that accelerate organic matter decomposition by microorganisms through soil humidity changes, aeration and temperature regime, state of aggregation and nutritional environment (Gus & Co., 2003; Rusu, 2005). With non-conventional tillage the soil generally contains great quantities of organic C and N and a greater microbial mass than with conventional tillage. The difference between nutrient distribution and

cations exchange capacity in superficial soil layers is also noticed with the non-conventional tillage, even in the absence of turning over and furrow ploughing by heavy equipment. Good tillage type and frequency management may stop soil degradation and improve its quality.In spite of recent concerns on soil preservation agriculture, few researches have been performed in this area of Romania, especially with vegetable crops. As non-conventional tillage causes different reactions to different types of soil – weather conditions to soil quality, the purpose of this study was to assess the influence of the non-conventional strip-tillage cover crop system in a few vegetable crops. Cover crops like oat and vetch are cultivated in the first spring shot, for the planting of summer vegetables. This cover crop has been weed-killed and left on the soil as mulches. Organic mulch systems imply chemical or mechanical killing of cover crops and have been successfully used in vegetable crops and field crops (Morse and Seward, 1986; Luna and McGrath, 1996; Groff, 2001; Luna and Tim O'Brien, 2004).

## MATERIAL AND METHOD

Experimental plots have been placed in a moderate temperate continental climate (average annual temperature of 8-10°C, annual rainfall 590 mm). The soil is representative for the experimental area, being of alluvial soil type (SRTS, 2003), sandy clay, slightly alkaline (pH = 7.7), with a humus content of 3.4%, and good potassium, phosphorous and nitrogen content). Agro-physical and chemical soil features have been determined in the two tillage systems, both at the beginning and through the experiment.

In the non-conventional strip-tillage cover crop system, the spring fodder (oat and vetch in a 2:1 ratio) was weed-killed by a total herbicide (Glyphosat 2 l/ha), vegetable wastes were left on the surface of the soil, and seeding was done into 10-15 cm wide trenches. Conventional tillage used furrow ploughing at 25 cm depth as well as soil loosing and breaking up, vegetable wastes of the previous crop being removed from soil surface. Biological material used in this experiment was represented by four species of vegetables, namely: cabbage, carrot, garden bean and sweet corn, used with both tillage systems. Remarks on the evolution of agro-physical and chemical soil features were made 2 and 3 years following the application of the two tillage systems.

## RESULTS AND DISCUSSION

Overall fertility of an agricultural soil has always been related to its organic matter content. Maintaining the corresponding levels of this parameter into the soil is of great agricultural significance, as it occurs into all soil improvement processes and connects the soil structure to plant growth and macro and microorganisms support into the soil.

The two tillage systems (non-conventional strip-tillage cover crop system and the conventional furrow ploughing system) compared in this experiment show major differences in soil quality 2 and 3 years following the experiment. Analyses made after three years of experiments (Table 1) revealed no major changes in soil

reaction (pH), the soil's reaction still being mildly alkaline (pH of 7.15 with conventional tillage and pH of 7.24 with minimum tillage).

Concerning the soil nutritive elements (N, P, K), a better supply has been detected. A very good nutritive elements supply may be the consequence of cover crop, which at the end of vegetation period (fall) was incorporated into the soil in case of monitored vegetable species. At the beginning of the experiment (fall 2004) organic fertilizers (very well fermented manure) were used.

**Table 1**

**Evolution of soil acidity (pH) and N, P, K contents in the two tillage systems, during 3 years, Apahida, 2005-2007**

| Years | Conventional tillage system | | | | Non-conventional tillage system | | | |
|---|---|---|---|---|---|---|---|---|
| | pH | N % | P ppm | K ppm | pH | N % | P ppm | K ppm |
| 2005 | 7.7 | 0.280 | 110 | 250 | 7.7 | 0.280 | 110 | 250 |
| 2006 | 7.8 | 0.280 | 110 | 250 | 7.8 | 0.315 | 132 | 280 |
| 2007 | 7.15 | 0.198 | 125 | 210 | 7.24 | 0.192 | 136 | 232 |

Total nitrogen soil content is medium with both crop variants (0.198% total N with the conventional tillage, 0.192% total N with the non-conventional tillage), being included in the range 0.141-0.270% total N. Mobile phosphorus soil content is also good: 125 ppm P with the conventional tillage, 136 ppm P with the non-conventional tillage, being included in the range 108.1-144 ppm mobile P, respectively good supply. Mobile K soil supply is high to very high, respectively 210 ppm mobile K in the conventional variant and 232 ppm mobile K in the non-conventional tillage variant. Nitrogen and potassium content decrease 3 years after the experiment in conventional tillage variant is due to the fact that no organic matter has been put into the ground during this time interval.

**Table 2**

**Evolution of humus content influenced by the tillage system, Apahida, 2005-2007**

| Years | Humus content % | |
|---|---|---|
| | Conventional tillage system | Non-conventional tillage system |
| 2005 | 3.40 | 3.40 |
| 2006 | 3.40 | 3.90 |
| 2007 | 3.90 | 4.50 |

The humus soil level recorded a significant increase in the strip-tillage cover crop system (Table 2). At the beginning of the experiments, in 2005, the humus quantity in the soil was of 3.40%; two years after the tillage systems implementation a 3.90% increase was recorded, and three years following the experiments a humus content of 4.50% was reached with the minimum strip-tillage cover crop system.

Soil texture is clay-like (Table 3). Clay and sand contents are high in both tillage variants. These data indicate a highly plastic and adherent texture, water and air permeability, and good water and nutrient retention capacity.

**Table 3**

**Evolution of soil texture, Apahida, 2005-2007**

| Particle categories | Soil texture | |
|---|---|---|
| | Conventional tillage system | Non-conventional tillage system |
| Clay (<0.002mm), % | 51.1 | 51.0 |
| Dust (0.02-0.002mm), % | 15.8 | 16.4 |
| Sand (2-0.02mm), % | 33.1 | 32.6 |

Soil is the more degradation-resistant the more organic matter it contains, the larger the clay quantity has, the colloidal complex is more calcium and magnesium ions saturated, and the biological activity in the soil is more intense, contributing to a spongy soil structure. After three years of experiments a change in grades of soil structure was recorded, the values increasing from 78% to 83% with the minimum tillage, the higher the structure grade the higher the fertility level (Table 4). In 2006 hydrostability of the aggregates was determined, with higher values being found in the minimum tillage variant.

**Table 4**

**Structure and hydrostability aggregate values influenced by two tillage systems, Apahida, 2005-2007**

| Years | Grades of soil structure | | | |
|---|---|---|---|---|
| | Conventional system Grade of: | | Non-conventional system Grade of: | |
| | Structure (%) | Hydrostability (%) | Structure (%) | Hydrostability (%) |
| 2005 | 79 | - | 79 | - |
| 2006 | 79 | 59 | 85 | 68 |
| 2007 | 78 | - | 83 | - |

**Table 5**

**Commercial production obtained in four vegetable crops with two tillage systems: conventional (CV) and non-conventional (NCV), Apahida 2005-2008**

| Year | Vegetable crops | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Cabbage | | Sweet corn | | Carrot | | Garden beans | |
| | CV | NCV | CV | NCV | CV | NCV | CV | NCV |
| 2005 | 4.8 | 4.0°° | 1.21 | 1.10 | 6.3 | 5.3°° | 0.46 | 0.41 |
| 2006 | 5.3 | 4.3°° | 1.28 | 1.15 | 6.0 | 5.0°° | 0.52 | 0.48 |
| 2007 | 4.9 | 4.7 | 0.76 | 0.78 | 3.9 | 3.6 | 0.65 | 0.60 |
| 2008 | 5.9 | 5.8 | 1.28 | 1.29 | 5.5 | 4.9° | 0.53 | 0.50 |
| **Average** | **5.22** | **4.70** | **1.13** | **1.08** | **5.42** | **4.70** | **0.54** | **0.50** |
| Difference % | 100.0 | 90.00 | 100.0 | 95.4 | 100.0 | 86.6 | 100.0 | 92.3 |
| DL (5%) | 0.36 | | 0.22 | | 0.43 | | 0.08 | |
| DL (1%) | 0.63 | | 0.43 | | 0.83 | | 0.13 | |

The apparent density values preferred by most of crop plants may vary between 1.0 and 1.4 g/cm³. Values of apparent density modify by tillage works. As in experimental crops, in microplots works have not been performed by mechanical

means, using heavy equipment as in large-scale production, soil compacting degree in conventional tillage was not much different from the non-conventional tillage variant. Regarding commercial production obtained by the four vegetable crops (Table 5), distinctly significant negative differences were noticed in cabbage and carrot during the first two years of the non-conventional tillage system.

Comparison of cabbage production in minimum tillage (non-conventional system) to the conventional tillage variant reveals a clearly significant decrease only in the first two years (2005, 2006). In the following two years (2007 and 2008) the production was almost equal, differences being of little and without statistic support. Carrot yield obtained via minimum tillage as compared to conventional tillage variant reveals that each year it was more reduced, in the first two years by clearly significant difference and the fourth years by just significant difference.

## CONCLUSIONS

Following the minimum strip-tillage cover crop system applied for 4 years, the following remarks have been made on agro-physical and chemical soil indicators and commercial production in the four studied vegetable crops: Soil reaction (pH) has not significantly changed, the soil still having a mildly alkaline reaction. With the minimum tillage systems soil supply of nutritive elements (N, P, K) was better. Humus level in the soil recorded an increase with the strip-tillage cover crop system; at the beginning of the experiments in 2005, the humus rate quantity in the soil was of 3.40%, after two years of tillage works an increase of 3.90% was recorded, and after three years of experiments the humus content rate reached 4.50 %. It was noticed that soil recorded a change in its grade of structure, values increasing from 78% to 83% with the minimum tillage variant, the higher the grade of soil structure the higher the fertility levels. Apparent density values range between 1.0 and 1.4 g/cm$^3$, which are preferred by most vegetables. Production registered clearly significant differences in cabbage and carrot in the first two years of culture, while in sugar corn and garden bean production registered approximately equal values by the minimum tillage works.

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