Proceedings of the 11th International Scientific Conference Rural Development 2023
Edited by assoc. prof. dr. Judita Černiauskienė

ISSN 1822-3230 (Print)
ISSN 2345-0916 (Online)

Article DOI: https://doi.org/10.15544/RD.2023.001

THE EFFECT OF REDUCED TILLAGE, STRAW, AND GREEN MANURE ON COMPONENTS OF THE WINTER OILSEED RAPE AGROECOSYSTEM

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The research focuses on how reduced tillage, straw incorporation, and green manure application impact different elements of winter oilseed rape agroecosystem. The main objective is to investigate the impact of these practices on biometric parameters and the yield of winter oilseed rape. The specific research objectives are to investigate the effects of reduced tillage, straw incorporation, and green manure application on biometric parameters and yield of winter oilseed rape. In pursuit of these objectives, the study aims to reveal the potential positive and negative impacts of these agricultural practices on the wider efficiency and sustainability of winter oilseed rape cropping systems. The research contributes to the understanding of the complex interactions between cultivation practices and the health and productivity of winter oilseed rape agroecosystems.

Keywords: *winter oilseed rape, biometric parameters, yield*

INTRODUCTION

Tillage has a major impact on agroecosystems and their sustainability. Understanding soil ecosystem structure and function through different intensities of tillage or no-till seeding is a prerequisite for any future farming system. It is essential to understand not only the short-term but also the long-term effects of tillage on the soil ecosystem below and above the soil surface (Steponavičienė, 2018). Maintaining and improving soil fertility in permanent cropping systems is essential to maintain agricultural productivity and environmental quality. Soil degradation in Lithuania is occurring due to intensive agriculture and anthropogenic activities, which calls for new research. Soil potential, as well as crop productivity, depends directly on soil degradation and pollution, which determines soil organic matter and biodiversity (Bogužas et al., 2015, Steponavičienė et al, 2023).

Catch crops are also grown to restore soil fertility by improving soil structure, promote the formation and stability of soil aggregates, limit water loss and migration as well as the entry of nutrients into deeper soil layers, provide shade and cool the soil surface, protect the soil from wind and water erosion, promote soil microorganisms and increase soil biological activity (Wanic, et al, 2019, Morizet-Davis, et al, 2023).

Green manure crops can be sown throughout the growing season or after harvesting the main crop rotation. The first plants are grown for fertilizing winter crops, and the others – for fertilizing next year's summer crops. The purpose of the green manure and the selected type of plant depends on the amount of biomass, the accumulation of chemical elements in the biomass, and the decomposition processes taking place in the soil. All these factors affect the green manure yield and yield quality indicators (Tripolskaja et al., 2010). Soil is a dynamic source of plant nutrients. It has biological, chemical, and physical properties that respond differently depending on how the soil is cultivated (Sagines et al., 2019). A proper tillage system determines the availability of water and organic carbon in the soil, microbiological processes, and control of weeds, plant diseases, and pests. It can be said that proper tillage has great benefits for crop production and harvest (Deike et al., 2008), but improper tillage can alter soil structure, nutrient absorption, accelerate erosion, disrupt the water, and carbon cycles (Lal, 1993). Reduced tillage has many benefits, including the conservation of biological activity and soil fertility, as well as soil compaction and reduced soil erosion (Sangines et al., 2019). Soil fertility is greatly influenced by the amount of organic matter and its humification (Cardelli et al., 2012). To maintain the humus content of the soil, it is not enough to use only mineral fertilizers, to increase the humus content in the soil, we can use organic fertilizers which help to increase the fertility of the soil by enriching it with organic matter (Maikštėnienė et al., 2010). As catch crops have a positive impact on the soil environment and plant health, they are an important factor and element of agricultural technology. Catch crops inhibit the migration of nutrients (mainly N and P) to deeper soil horizons by up to 70%. Catch crops also promote atmospheric CO_2 sequestration and N_2 fixation (legumes) and increase the humic content of the soil. Catch crops reduce soil compaction (up to 20%), increase soil moisture, temperature, and porosity, and improve soil health. The incorporation of plant biomass into the soil increases the number of microorganisms living in the soil by as much as 20–80%, earthworms (1.4 to 2.6 times), and soil enzymatic activity (up to two times). It also stimulates the exchange of CO_2 between the soil and the atmosphere (Wanic et al., 2019). The study aimed to investigate the effects of no-tillage, straw, and green manure application on the germination, biometric parameters, and yield of a winter oilseed rape crop.

RESEARCH METHODS

The research was conducted at the Experimental Station of Vytautas Magnus University Agriculture Academy (54°52′50″ N latitude and 23°49′41″ E longitude) as a long-term field experiment established in 1999. This study took place in 2023 and cumulative differences in crop yields (2000-2023). The soil at the experimental site was classified as Planosol. The long-term experiment was carried out using a split-plot design with four replications, resulting in a total of 24 plots. Initially, each plot had a size of 102 m^2 (6 × 17 m), and the harvested area measured 30 m^2 (15 × 2 m).

In an agroecosystem crop rotation, winter oilseed rape (*Brassica napus* L.), winter wheat (*Triticum aestivum* L.), and spring barley (*Hordeum vulgare* L.), which are the most popular crops grown in Lithuania, were chosen. In a two-factor field experiment, the straw (Factor A) in spring barley was removed (R) from one part of the experimental field, and in the other part of the field, the entire straw yield was chopped and spread (S) at harvest. Three different tillage systems (Factor B) were investigated as subplots: (1) conventional deep ploughing (GA) in autumn at a depth of 23–25 cm; (2) catch crops for green manure with no-tillage (TS); and (3) no-tillage (TS). All the tillage systems were tested in both halves of the experiment with and without straw. After harvesting, the plots subjected to conventional ploughing were cultivated with disc implements and deep ploughing in autumn. White mustard (*Sinapis alba* L.), a catch crop for green manure on stubble, was sown only in the TS plots immediately after the harvest of winter wheat and spring barley.

Seedling density in the winter oilseed rape crop was determined twice: on the third and tenth days from the beginning of germination. In each field, the seedling density was counted in ten randomly selected places in a 1-meter-long row. Seedling density was recalculated in plants/m^{-2}. Biometric indicators, crop structure elements and seed yield of winter oilseed rape were determined the following way: after winter oilseed rape reached full maturity, 20 plants were taken from each variant in 4 replicates at different locations, and their biometric indicators were determined (the number of pods of the apical inflorescence and side branches, the number of seeds in a pod and the weight of 1000 seeds). The density of the winter oilseed rape crop (number of productive stems) was determined by growth stage, 50 x 50 cm frames, in 4 locations of the field and expressed as number/m_2. The crop in the test fields was harvested with a combine harvester, weighed, and expressed as 14% moisture, 100% clean grain mass. A pooled sample of 2 kg of grain was made from all replicates of each variant to determine cleanliness. Grains were poured into cloth bags and 3 samples were weighed from the combined sample of each variant. Impurities were separated from them, and clean grains were weighed.

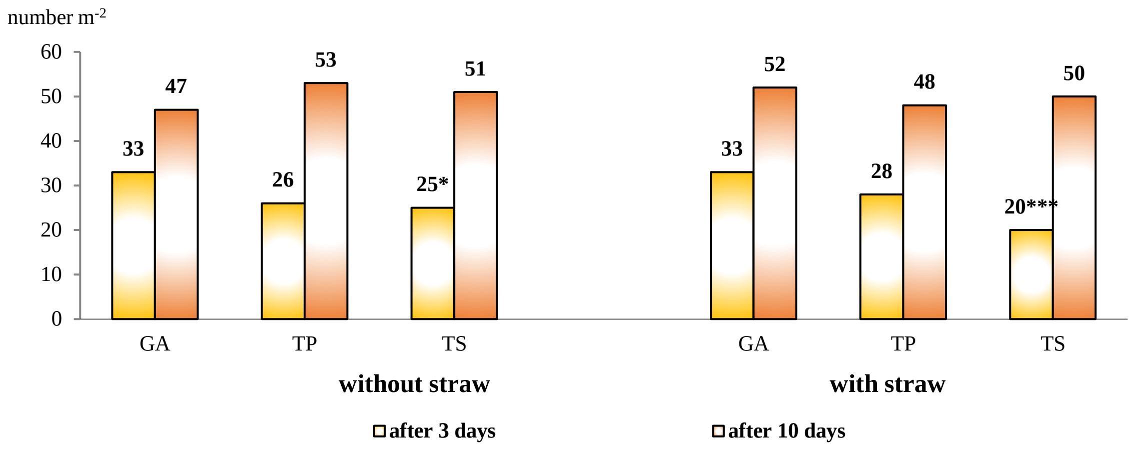
Experimental data were analysed using a two-factor analysis of variance (ANOVA) based on the methodology using the SYSTAT statistical software package, version 12 (SPSS Inc., Chicago, IL, USA). The significance of differences among the treatments was determined using the least significant difference (LSD) test. The probability levels indicating significant differences between specific treatments and the control treatment are denoted as follows: *—when $0.010 < p \leq 0.050$ (significant at the 95% probability level); **—when $0.001 < p \leq 0.010$ (significant at the 99% probability level); and ***—when $p \leq 0.001$ (significant at the 99.99% probability level).

RESEARCH RESULTS AND DISCUSSION

For winter oilseed rape, germination was determined after 3 days and 10 days after the appearance of the first seedling to assess the seed germination energy. It was found that in untilled soil without catch crops, both with and without straw, the number of winter oilseed rape seedlings 3 days after the appearance of the first seedling was significantly lower compared to deep ploughing, by 24% and 39%, respectively (Fig.1). However, no significant differences were found 10 days after the appearance of the first seedling.

Some researchers have also found that the lower germination of cereals under no-tillage is temporary, with the number of cereal seedlings levelling off after just one week under different tillage systems. Our studies confirm these findings. However, there is evidence that the number of plants in no-tillage remains lower after a few weeks than in autumn-tilled soils, but no significant differences are found (Wang et al., 2019).

The results obtained showed that plant weight, plant height, number of pods and weight of 1000 seeds were significantly higher in untilled soil, both with and without catch crops, compared to deep ploughing (Table 1) and where straw was chopped and spread compared to no straw.



Note. GA – deep ploughing (control), TP – no-tillage with catch crops, TS – no-tillage and no catch crops. The probability level of significant difference: * – P≤ 0.05; *** – P≤ 0.001. No interaction between factors established.

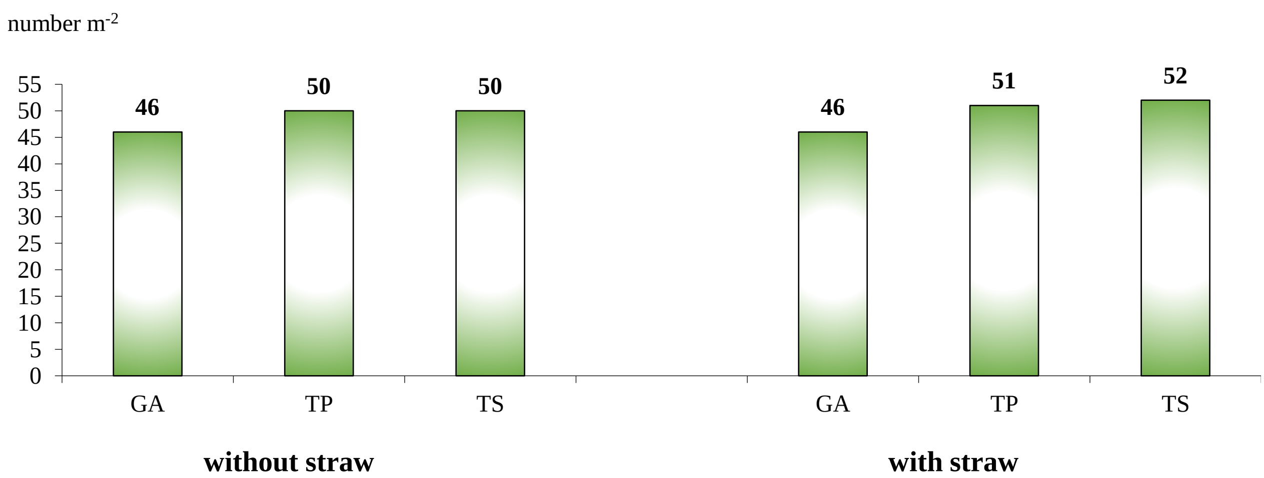
Figure 1. Germination of winter oilseed rape on the 3rd and 10th day after the appearance of the first seedling in2022

Table 1. Biometric indicators of winter oilseed rape in 2022

Tillage systems	Plant weight, g	Plant height, cm	Number of plant branches, number	Number of plant pods, number	Number of seeds in a pod, number	Weight of 1000 seeds
Without straw						
Deep ploughing (control)	19.6	97	6	122	27	4.31
No-tillage with catch crops	38.3***	132***	7	200***	33	4.68*
No-tillage and no catch crops	34.0***	128***	7	217***	32	4.83***
With straw						
Deep ploughing (control)	22.9	107	7	147	29	4.43
No-tillage with catch crops	41.4***	127***	6	188***	32	4.73*
No-tillage and no catch crops	46.6***	125***	7	220***	31	4.90***

Note. GA – deep ploughing (control), TP – no-tillage with catch crops, TS – no-tillage and no catch crops. The probability level of significant difference: * – *P*≤ 0.05; *** – *P*≤ 0.001. No interaction between factors established.

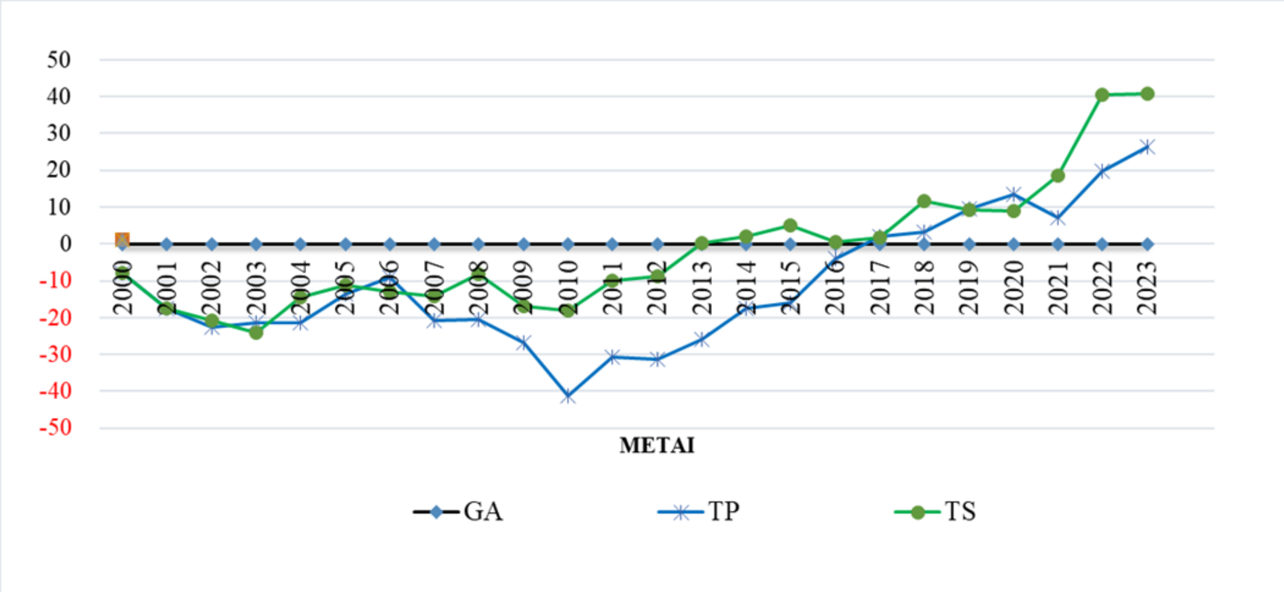
Number of productive stems and yield of winter oilseed rape. Deep ploughing tended to reduce the number of productive stems of winter oilseed rape, but no significant influence was found, compared to the variants without tillage (Fig. 2). The use of straw also had no effect.



Note. GA – deep ploughing (control), TP – no-tillage with catch crops, TS – no-tillage and no catch crops. No significant differences, *P* > 0.05. No interaction between factors established.

Figure 2. The number of crop density of winter rape in 2022

Sustainable agroecosystems are able to maintain their condition, productivity and biodiversity, as well as the integrity of all of them, over time and in the context of human activities and use (The dictionary of forestry, 1998). Good ecosystem health is one of the key conditions for the dynamic sustainability of an ecosystem. Stability is closely linked to the other two elements of ecosystem sustainability - productivity and biodiversity. When the links between them are weakened, ecosystem sustainability is reduced. The sustainability of agro-ecosystems is thus inextricably linked to the stability of their productivity. To illustrate the potential for sustainability of the tillage systems studied, the cumulative differences in % yields of the crops grown in the experiment since the beginning of the field experiment in 2000 compared to deep ploughing in that year are presented (Fig. 3).



Note. GA – deep ploughing (control), TP – no-tillage with catch crops, TS – no-tillage and no catch crops.

Figure 3. Cumulative differences in plant yield in % compared to deep ploughing in the following year in 2000-2023.

To summarise the findings of this research, the increasing exploitation of biological natural resources poses a major threat to the sustainability of ecosystems. In a consistent farming system, tillage should be simplified, mechanical tillage should be reduced and the use of biological means of maintaining soil fertility should be used as much as possible, in combination with improving soil quality. The use of crop residues and green manure, when combined with reduced tillage intensity and seeding in untilled soil, has a positive effect on soil properties and helps to maintain crop rotations and crop productivity.

CONCLUSIONS

For winter oilseed rape, germination was determined after 3 days and 10 days after the appearance of the first seedling to assess the seed germination energy. It was found that in untilled soil land without catch crops, both with and without straw, the number of winter oilseed rape seedlings 3 days after the appearance of the first seedling was significantly lower compared to deep ploughing, but no significant difference was observed 10 days after the appearance of the first seedling.

Plant weight, plant height, number of pods and weight of 1000 seeds were significantly higher in the untilled soil, both with and without catch crops, compared with deep ploughing. Straw abandonment significantly increased the yield and yield performance indicators of winter oilseed rape.

The long-term application (since 2000) of no-tillage technology with or without catch crops in the climatic conditions of 2022 significantly increased the yield of winter oilseed rape. Compared to conventional tillage – ploughing – yields were 1.3–1.5 times higher.

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