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COVER CROPS FROM WINTER WHEAT, TRITICALE AND PEAS CULTIVATED IN PURE STANDS AND MIXTURES – SOIL AND WEED SUPPRESSION BENEFITS

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ABSTRACT

Cover crops had shown a potential to improving carbon sequestration in soil and environmental quality, but these beneficial effects can be modulated by precipitation conditions. In this paper was evaluated the effectiveness of three cover crops on soil chemical properties and weed suppression.

The experiments were performed on cambic chernozem soil from NARDI Fundulea Romania in two contrasting years regarding the amount of precipitation. Three cover crops were studied. The cover crop consisting of peas + triticale has increased more soil carbon content and infestation with weeds were lower as compared with cover crop consisting of peas or triticale. The differences concerning carbon sequestration, soil organic carbon, carbon to nitrogen ratio, weed suppression were influenced also by level of precipitations from experimental site. Cover crops were slow to impact C/N ratio of soil. In contrast, the floristic composition, and the degree of weed infestation were very significantly influenced by the composition of the cover crops. The use of cover crop mixtures offered an additional benefit to weed suppression that of individual cover crops.

Keywords: cover crops, biomass, soil organic carbon (SOC), carbon to nitrogen ratio (C/N), weeds.

INTRODUCTION

Due to recent concerns about climate change, the importance of increasing the organic carbon content of the soil and the role of climate in carbon sequestration through plant biomass are unanimously accepted and increasingly studied (Lal, 2004; Chahal et al., 2020). Data from the literature have shown that increasing carbon sequestration in agricultural soils and transforming the soil into a reservoir for atmospheric carbon can be achieved by choosing the best crops, genotypes or technology measures (soil conservation, fertilizer application, organic amendments, crop rotations, proper waste management, etc.) (Lal, 2004). Currently, the global carbon sequestration capacity of the soil is estimated at 0.4-1.2 Gt C /year. Carbon is stored both in the organic matter of the soil and in the biomass above and in the soil.

Crops contribute to the increase in organic carbon content in the soil through underground biomass (ie the root system that remains in the soil), which seems to be the best predictor of long-term storage of carbon in the soil. This indicates that, in crop systems, compared to the application of high doses of N fertilizers, the selection of crops with high underground biomass is a more effective management practice for increasing C sequestration in soil (Kukal et al., 2009).

”In addition to C sequestration, C trading has gained attention globally. Carbon trading refers to market based financial incentives provided to practitioners for controlling greenhouse gas emissions and/or sequestering. Incentivising C storage enhances the economic

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value of the soil ecosystem services of soil organic content (SOC) provided by the agricultural management practices, and providing payments contributes to the financial well-being of the growers who invest in C sequestration strategies" (Chahal et al., 2020). There is the potential for producers to benefit financially from the additional C sequestration in Romania through a pricing policy of cross compliance that was implemented as a component of PAC (http://www.apia.org.ro).

Under this framework, adoption of cover crops (CC) in the cropping system is recommended as a management strategy for increasing SOC stores. In addition to providing C inputs, CCs offer numerous agroecosystem services such as reduction of soil compaction, (the most indicated crops are: radish, hybrid rape, turnip, sugar beet, sunflower, sorghum-sudan, sweet clover, alfalfa), nitrogen fixation, (peas, lentils, peas, soybeans, peas), waste recycling (canola, rape, radishes, turnips and mustard), recycle nutrients (sunflower, sugar beet, small grain).

The cover crops can sequester carbon, but the magnitude of their potential impact is debated (Zomer et al., 2017). Thus, this may vary with soil type, management, elevation, and soil climate (Poeplau and Don, 2015). The literature regarding the impacts of CCs on crop yields is also inconclusive, as there is considerable variability in results across studies, some studies have found that CCs positively affect subsequent crop yields (Maughan et al., 2009) while other studies have found no significant effect or even decreased yields (Acuna and Villamil, 2014).

Weeds compete with crops for light, nutrients, and water. Cover crops are increasingly being used for weed management, and planting them as diverse mixtures has become an increasingly popular strategy for their implementation. While ecological theory suggests that cover crop mixtures should be more weed suppressive than cover crop monocultures, few experiments have explicitly tested this for more than a single temporal niche (Smith et al., 2014).

The objectives of this study were to evaluate effects of cover crops consisting of winter/spring peas (for fixing atmospheric nitrogen), triticale (for recycling soil nutrients) and mixed of these on soil C sequestration, soil quality and weed suppression.

MATERIAL AND METHODS

The experiment was carried out at the experimental field of National Agricultural Research and Development Institute from Fundulea on cambic chernozem soil, during two vegetation periods (2019-2020 and 2020-2021). Three cover crops were studied, winter peas, triticale and a mixture of 50% triticale (Utrifun variety) and 50% winter pea (Spectral variety) and no cover crop as control. The sowing date was September 25 in both years and the sowing depth was 4-5 cm.

To quantify organic carbon sequestration, biomass was sampled in the end of spring, using 0.50 m^2 quadrates combined in each plot.

The soils samples were collected randomly from each replicated plot using a soil of 20 cm depth. Soil samples from each plot were then homogenized into a composite sample and sieved at 2 mm. Plant debris and roots were removed. Soil relative moisture was determined by drying 10 g of fresh soil at 105°C for 24 h. The physical and chemical soil characteristics were measured for all samples according to SR ISO 11464:1998.

The following two methods were used for the chemical characterization of the soil:

• organic matter: determined volumetrically by the wet oxidation method after Walkley Black modified by Gogoaşă - STAS 7184 / 21-82.

The soil organic carbon content was obtained with the formula: SOC = organic matter/1.724, where 1.724 is the amount of humus, in g, corresponding to 1 g of organic carbon:

• total nitrogen (N%): Kjeldahl method, disintegration with H_2SO_4 at 350°C.

The effect of cover crop species on soil properties and weed suppression was determined by analysis of variance.

RESULTS AND DISCUSSION

The evolution of the climatic conditions in the agricultural years 2019-2020 and 2020-2021 indicated in Fundulea significant differences from the normal conditions, both in terms of thermal regime and in terms of rainfall.

The analysis of these conditions in relation to the requirements for the climatic factors of the winter crops showed, in general, the assurance within the optimal limits of the thermal factor during the autumn period (Table 1). It is observed that the temperatures were above the multiannual average, the months of October and December being much warmer in both years of experimentation compared to the multiannual average (11.7°C in October, respectively, 0.1°C in December).

Table 1. Average temperature (°C) and monthly distribution of rainfall (mm) during the experimental years

Month	X	XI	XII	I	II	III	IV
Temperature 2019-2020	12.8	10.2	4	0.9	5.2	8.3	12.3
Temperature 2020-2021	14.7	6.1	3.9	1.6	3.2	5.1	9.7
Multianual average	*11.7*	*5.8*	*0.1*	*-1.8*	*0.8*	*5.8*	*11.6*
Rainfall 2019-2020	38.0	33.2	16.2	2.0	16.6	29.8	14.0
Rainfall 2020-2021	28.6	20.0	77.6	77.0	16.2	59.0	31.0
Multianual average	*42.4*	*41.7*	*48.4*	*32.7*	*26.5*	*38.8*	*44.9*

Winters were relatively mild, with temperatures above the multi-year average, while in the spring of 2021 April temperatures were below the multi-year average. The cover crops had passed well over the winter period in both years, as can be seen in the figure below.

Figure 1. Aspect with cover crops (spring 2021)

From October to the end of April, the amount of precipitation in Fundulea amounted to 149.8 mm in the first year and 309.4 mm in the second year of experimentation, compared to the multiannual average of 282.4 mm, a deficit of 132.6 mm, respectively, a surplus of 27 mm compared to the normal area (Table 1).

Under these conditions, the cover crop consisting of triticale and peas contributed to the increase of the organic carbon content in the soil through aerial biomass with values of 4260 g FM/m^2 in 2021 compared to only 2840 FM/m^2 (Table 2).

Table 2. Contribution of cover crops to organic carbon sequestration

Experimental variants	Biomass (g fresh matter/m^2)	
	2020	2021
Triticale + pea	2840	4260
Triticale	1540	2400
Winter pea	1020	1650

Effects of cover crop on biomass accumulations were analysed using the analysis of variance which showed the very significant effect of both the analysed factors and their interaction (Table 3).

Table 3. Analysis of variance for organic carbon sequestration

Source of variance	DF	Mean square	F value
A Factor: year	1	4370939	5011.26***
Error A	2	0.022872	
B Factor: cover crops	3	7671606	529.85***
Interaction AxB	3	259505	8.79***
Error B	12	29522	

*** 0.1% level of significance.

The analysis of variance for soil organic carbon content indicated a significant effect of year and cover crops at the 0.1% level of significance and for the C/N ratio the main source of variation is the experimental years (Table 4).

Table 4. Analysis of variance for soil organic carbon content

Source of variance	DF	Soil organic carbon content		Ratio of C/N	
		Mean square	F value	Mean square	F value
A Factor: year	1	1.435	94.379***	60.166	19.16*
Error A	2	0.015		3.16	
B Factor: crop	3	0.134	15.692***	6.38	0.55 ns
Interaction AxB	3	0.018	2.14 ns	1.05	0.09 ns
Error B	12	0.008		2.53	

* 5% level of significance; *** 0.1% level of significance; ns - insignificant.

Soil analyses carried out to see if the cover crop contributes to the improvement of the organic carbon content of the soil showed the positive effect of the mixture of peas and triticale on it, which was 1.96% compared to 1.75% carbon content in no cover field under the conditions of 2021. The contribution brought by winter pea was higher than that made by triticale, where the values of the carbon content were lower or equal than those from the no cover field (Table 5).

Table 5. The effect of different cover crops on organic carbon and soil C/N ratio

Experimental variants	Soil depth (cm)	Organic carbon (%)		C/N ratio	
		2020	2021	2020	2021
Triticale + pea	0-20	1.59	1.96	9.69	11.95
Triticale	0-20	1.10	1.75	6.70	10.62
Winter pea	0-20	1.46	1.86	9.24	12.63
No cover	0-20	1.30	1.75	8.38	11.23

In all cover crops, organic carbon had higher values compared to no cover soil (Table 4).

Other research conducted at the Fundulea Institute has shown that reducing the organic matter content of soils by cultivation is not an irreversible process, Cecilia Neagu (2006) states that the percentage of organic carbon increases in proportion to the dose of nitrogen fertilizer (Table 2). The increase refers to the carbon extractable in dilute alkaline solutions and to the carbon of humic acids.

The C/N ratio is better in 2021 for the variants of winter peas and mixture of winter peas + triticale (12.63 and 11.95, respectively), indicating a quality organic matter, well humified.

The studies of Romdhane et al. (2019) have sown that total nitrogen and soil organic carbon were higher when cover crops were naturally (by frost) and/or mechanical eliminated compared to rolling and glyphosate termination treatments, while cover crop biomass was positively correlated to soil carbon and C:N ratio. Other studies shown that cover crop species showed, in general, different abilities to accumulate nitrogen fractions in the soil as a result of their chemical characteristics and the C/N ratio was the main characteristic that differentiated the abilities of cover crops to accumulate N in the soil (Veras et al., 2016).

The results in the literature show that cover crops can be used to conserve and improve soil quality, create biodiversity, break down pest and disease cycles, and suppress weeds (Snapp et al., 2005; Blanco-Canqui et al., 2015).

Cover crops that contain mixtures of different species have become popular because combining species with different properties creates a culture that can perform several functions (Finney and Kaye, 2017)

The results obtained by us on the influence of cover crops on the evolution of diseases, pests and weed suppression highlighted the beneficial effect of the cover crop consisting of the mixture of two species, which confirms the data in the literature presented above.

Thus, in Table 6 we highlighted the presence of diseases, pests and weed species in the experimental variants. It is obvious that the mixture of triticale and winter peas had the effect of reducing the weeding. Only the ephemeral species of Veronica was present, compared to the species of *Apera spica venti*, *Papaver rhoeas* and *Cirsium arvensae* present in the cultivation of triticale, respectively, winter peas (Table 6).

Table 6. The diseases, pests and weed species in the years of experimentation

Experimental variants	Diseases		Pest		Weed species and weed suppression (1-10 scale; 10 = best)	
	2020	2021	2020	2021	2020	2021
Triticale + pea	Zero	Zero	Zero	Zero	*Veronica spp.* 8	*Veronica spp.* 9
Winter pea	Pea rust	Pea rust (Puccinia)	Zero	Zero	*Veronica spp.* *Polygonum convolvulus* *Cirsium arvensae* 4	*Veronica spp.* *Cirsium arvensae* 5
Triticale		*Erisiphe graminis*	Zero	Zero	*Veronica spp.* *Apera spica venti* *Papaver rhoeas* 5	*Veronica spp.* *Apera sica venti* 6

The analysis of the variant highlights the very significant effect of the cover crops in the weed suppression (Table 7).

Table 7. Analysis of variance for suppress weeds

Source of variance	DF	Mean square	F value
A Factor: year	1	5.667	3.98 ns
Error A	2	1.421	
B Factor: cover crops	2	23.327	47.315***
Interaction AxB	2	0.051	0.102
Error B	8	0.493	

*** 0.1% level of significance

Concerning positive effect of cover crop mixture in terms of weed suppression, biomass stability, and next crop productivity compared with the best-performing single species the results are not clear. Smith et al. (2014) found no benefits of growing a cover crop mixture while that Finney et al. (2016) demonstrated that increasing the number of species increased weed suppression and reduced nitrate (NO_3^-) leaching but negatively affected crop yield in the subsequent cropping season. In our case, the superiority of the cover crop consisting of the mixture of triticale and peas in weed control, can be explained by the ability to develop a closed canopy, but also by the well-known allelopathic properties of triticals.

CONCLUSIONS

The results obtained highlighted the importance of the component of the cover crop and the climatic conditions on the carbon sequestration and the organic carbon content of the soil. Thus, the cover crop consisting of a mixture of 2 species (triticale and peas) and higher rainfall have been shown to have a beneficial effect on the accumulation of biomass and organic carbon content in the soil. While the carbon-nitrogen ratio is more influenced by climatic conditions. The floristic composition and weed infestation were different in the years of experimentation and the cover crops studied. In the cover crop consisting of a mixture of triticale and peas, weed species and weeding were lower compared to the individual cover crops studied.

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