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The Role of Green Manures on Weed Control and Sunflower Production on the Poorly Fertile Soils

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ABSTRACT

The cultivation of acidic soils presents a major challenge for agriculture, as it obstructs crops productivity due to mineral toxicity, nutrient deficiency, and poor water uptake. The identification of new methods to improve the agricultural properties of the poorly productive acidic soils requires the development of research to increase quantitative and qualitative of production. Organic fertilizers can ameliorate soil quality. The aim of this study was to investigate how different green manures influence quantity and quality of production, as well as weed control of the sunflower crop under acidic soil conditions. The research was conducted in 2023 and 2024 on an albic luvisol in northwestern Romania (Livada, Satu Mare County), using various plants as green manure and evaluating their effects individually and in interaction with chemical fertilizers to increase sunflower crop yields.

The experiments were set up at the Livada Agricultural Research and Development Station using the split-plot method with two factors: Factor A - green manure with six levels (sunflower, triticale, soybean, pea, rapeseed, and control) and Factor B - two levels (chemical fertilization and no chemical fertilization).

Results indicated that highest number of weeds/sqm was recorded on the plot with peas as green manure with 46% higher that the control. Also results show that the level of dicotyledonous weed infestation was reduced by 32% by using green manures. As for the sunflower yield, there was clearly a positive result especially on the plots with peas as green manure, with 1036 kg/ha over the control unit, without green manure.

As a conclusion we can declare that on the poorly fertile and acidic soils from the region, green manures had a clear benefic effect on the sunflower crop, from both the weed infestation and the crop production aspects.

Keywords: sunflower, green manure, weed infestation, production.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is a globally important oilseed crop, valued for its versatile applications in food, feed, and industrial sectors. Ensuring sustainable and efficient sunflower production is crucial to meet the growing global demand for vegetable oils. Conventional weed control methods, often reliant on synthetic herbicides, can have detrimental environmental impacts, including soil and water contamination, disruption of beneficial soil organisms, and the development of herbicide resistance in weeds (Brumă et al., 2021; Furey and Tilman, 2021; Li et al., 2021). Furthermore, the long-term sustainability of agricultural systems hinges on practices that enhance soil health and fertility, moving away from sole reliance on synthetic fertilizers (Javed et al., 2022). In this context, the integration of green manures into sunflower cropping systems presents a promising and sustainable approach to address both weed management and soil fertility enhancement.

Green manures, defined as crops grown specifically to be incorporated into the soil, offer a multitude of benefits for agricultural systems (Rani et al., 2021; Gerke, 2022; Iderawumi and Kamal, 2022; Prajapati et al., 2023). They contribute to improved soil structure, increased organic matter content, enhanced nutrient cycling, and improved water infiltration and retention (Javed et al., 2022; Gerke, 2022; Prajapati et al., 2023). The incorporation of green manures also stimulates soil biological activity, fostering a

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healthy and resilient soil ecosystem (Javed et al., 2022; Fall et al., 2022). Specifically, the increase in soil organic matter from green manure incorporation serves as a food source for beneficial soil microbes, including fungi, which play a crucial role in nutrient cycling and disease suppression (Fall et al., 2022). This enhanced biological activity can contribute to improved nutrient availability for the subsequent sunflower crop, promoting healthy growth and potentially increasing yields (Mitkov, 2021; Gerke, 2022; Iderawumi and Kamal, 2022).

Beyond their soil-enhancing properties, green manures offer a valuable tool for weed suppression (Mitkov, 2021; Prikhodko et al., 2021; Rudska, 2021; Gerke, 2022; Petcu et al., 2022; Yang et. al., 2022; Gürbüz and Alptekin, 2024). Several mechanisms contribute to the weed suppressive ability of green manures. Firstly, rapidly growing green manure crops can compete with weeds for resources such as light, water, and nutrients, effectively suppressing weed growth (Rudska, 2021; Gerke, 2022; Gürbüz and Alptekin, 2024). Secondly, certain plant species used as green manure release allelochemicals, natural compounds that can inhibit the germination and growth of other plants, including weeds (Gerke, 2022; Yang et al., 2022). This allelopathic effect can provide an additional way of weed control, reducing reliance on herbicides. Thirdly, the incorporation of green manure biomass into the soil can create a physical barrier that hinders weed seed germination and seedling emergence (Prikhodko et al., 2021).

The integration of green manures into sunflower cropping systems has the potential to provide a dual benefit: effective weed suppression and improved sunflower yield. By reducing weed pressure, green manures can minimize yield losses caused by weed competition. Furthermore, the enhanced soil fertility and improved nutrient availability resulting from green manure incorporation can create a more favorable environment for sunflower growth and development, leading to increased yields (Mitkov, 2021; Gerke, 2022; Iderawumi and Kamal, 2022). However, the specific effects of green manures on weed suppression and sunflower yield can vary depending on several factors, including the type of green manure species used, the timing of green manure incorporation, soil type, climate conditions, and the specific weed community present (Mitkov, 2021; Rudska, 2021; Gürbüz and Alptekin, 2024). Due to the multilateral action, green manures increases the production not only in the first crop that is sown after it, but also in the following two or three crops. A very important aspect in the use of green manures resides in the very low cost and the possibility of being applied on a large scale, especially on lands that require organic fertilization and that have difficulties in providing and transporting manure (Mondici, 2022).

Brown luvisols and albic luvisols occupy a percentage of over 35% of the arable land of the counties in northwestern Romania (Boieriu et al., 1987). Based on the ratio between humus (%) and total nitrogen (N.%), which serves for the indicative assessment of the need for nitrogen fertilizers or organic fertilizers, which on these soils is below 20%, clearly showing the requirement for fertilization with manure as being high compared to nitrogen fertilization (Davidescu and Davidescu, 1981). In this context the objectives of this study were to established the influence of some green manuring on the quantity and quality of production, as well as on the weed degree infestation in the sunflower crop cultivated in acidic soil. In order of implementation green manuring techniques as remedy for acidic soil as well as to reduce the reliance on chemical fertilizers.

MATERIAL AND METHODS

The research was carried out in the pedoclimatic conditions at ARDS Livada, Satu Mare County, on a luvisol albic with a pH of 5.1, a clay content of 20.9% and a humus content of 1.8. Green crops (sunflower, triticale, soy, peas, rapeseed) were sown immediately after the wheat harvest, thus ensuring the vegetal carpet for the following crops.

The influence of green manure and the interaction of green manure and chemical

fertilizer on the sunflower crop were done by setting up a split-plot experiment with two factors. Factor A - green fertilizer with six grades (sunflower, triticale, soybean, pea, rapeseed, control) and factor B - two grades (chemically fertilized and chemically non-fertilized). The variants of the experimental field are presented below (Table 1).

Table 1. Sketch of the experimental field

Vegetable carpet											
Sunflower		Triticale		Peas		Soybean		Rape		Control (without vegetation)	
N	F	N	F	N	F	N	F	N	F	N	F
Sunflower	Sunflower	Sunflower	Sunflower	Sunflower	Sunflower	Sunflower	Sunflower	Sunflower	Sunflower	Sunflower	Sunflower

N - unfertilized; F - fertilized;

Figure 1. The Incorporation of pea vegetal carpet

The phenophases of the cover crops at incorporation was flowering and the first pods formed in the case of the pea crop (Figure 1).

In order to facilitate the decomposition of the plant mass, the vegetal carpet was previously disked, after which the plowing was carried out. This procedure was also applied to the control variant (without vegetation).

The sunflower hybrid sown was P 64 LP 99, a semi-late hybrid, chosen following the production results from the demonstration plots established in the institution. Land preparation: autumn plowing was carried out after disking the vegetal carpet. In the spring, a work was carried out with the disc harrow as soon as it was possible to enter the field with the machines. The preparation of the germinal bed was done with a complex tillage machine (Solaris).

Sowing density: 62000 plants/ha.

960 g/l S-metolachlor was applied in a dose of 1.5 l/ha, and the product tribenuronmethyl (50%) was applied to the vegetation to control the spectrum of weeds, in a dose of 0.030 kg/ha quizalofop-P-ethyl (50 g/l) in a dose of 1 l/ha.

The degree of weed infestation was determined by counting the weeds by species per 1 m² in each plot, repeated before the post-emergence herbicide

Regarding climatic data, an increase in monthly temperatures was observed during the experimental years, compared cu average multiannual temperature. Rainfall distribution was uneven, with more frequent extreme events, including excessive rainfall and prolonged drought periods (Figure 2).

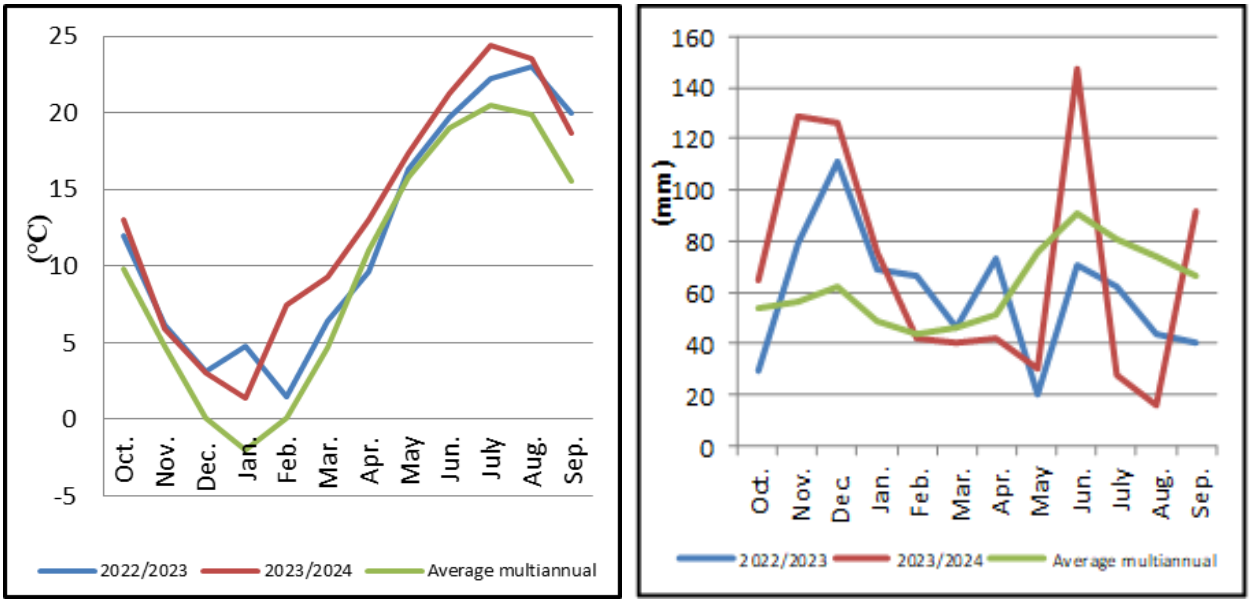

Figure 2. Annual and multiannual temperature (°C) and precipitation (mm) recorded at ARDS Livada

RESULTS AND DISCUSSION

Despite all the progress made in agriculture in the last century, weeds are still present in cultivated lands (Chirilă, 2001).

The dicotyledonous weeds were: the *Chenopodium album* species (73%) and *Ambrosia artemisiifolia* (8%). In the years of study in sunflower culture, monocotyledon weeds were less dominant, highest percentage of 12% was represented by the species *Echinochloa crus - galli* (Figure 3).

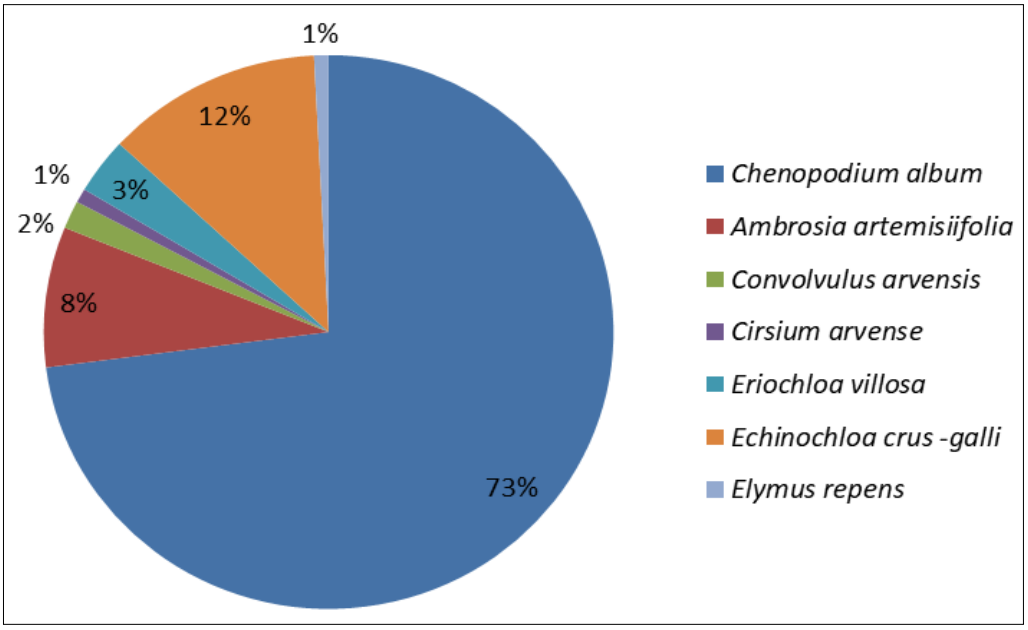

Figure 3. The frequency of dominant weed species existing in the culture of Sunflower (control variant)

In Table 2, the significance of the differences in the total number of weeds compared to the control is analyzed both on the basis of the limit differences calculated on the basis of the variance of the error and on the basis of the variance of the interaction variant x years.

The total number of weeds in the variant with green pea fertilizer registers a highly significant superior difference compared to

the control, while the level of weeding in the other variants is insignificant (Table 2).

Climatic conditions and green manure made the weeding level not significant in any variant compared to the interaction (Table 1).

The highest number of weeds of 176.6 plants/m^2 that was registered in variant 5 is found in class A, after which variants 1,2,3,4 and 6 are placed in class B after Duncan test (Table 2 and 3).

Table 2. Influence of green manure on weed degree infestation in sunflower crop

No.	Variant	No. weeds/sqm	No. weeds %	Difference ± No. weeds/sqm	Significance		The Duncan test
					Compared terror	Compared to Interplay	
1	Control	120.7	100	-	-	-	B
2	Rape	98.16	81	-22.54	-	-	B
3	Sunflower	124.0	103	3.3	-	-	B
4	Soybean	97.16	80	-23.54	-	-	B
5	Peas	176.6	146	55.9	***	-	A
6	Triticale	97.6	80	23.1	-	-	B
LSD	**5% 1% 0.1%**				**26.76 36.37 49.30**	**59.54 93.37 158.94**	

Table 3. Analysis of weed degree infestation determined by green manure by the Duncan multiple comparison system in sunflower crop

No.	Variant	No. weeds/ sqm	The difference from the version on the spot				
			6	5	4	3	2
			97.2	97.6	98.2	120.7	124.0
1	Peas	176.6	79.4 29.8 *	79.0 29.5 *	78.4 28.9 *	55.9 28.0 *	52.6 26.7 *
2	Sunflower	124.0	26.8 29.5	26.4 28.9	25.8 28.0	3.3 26.7	
3	Control	120.7	23.5 28.9	23.1 28.0	22.5 26.7		
4	Rape	98.2	1.0 28.0	0.6 26.7			
5	Triticale	97.6	0.4 26.7				
6	Soybean	97.2					

The total number of monocotyledonous weeds in the version with pea and triticale green manure registers a highly significant superior difference compared to the control, while the level of monocotyledonous weeds on rape green manure is significantly negative (Table 4).

Climatic conditions and green manure made the level of weeding with monocotyledons to have a distinctly positive significance on triticale green manure, and significantly positive on pea green manure compared to the interaction (Table 4).

In the case of infestation with monocotyledon weeds, the highest number of weeds of 23 plants/m^2 was achieved in variant 6 (Triticale) and is found in class A. Also in class A without a significant difference compared to the triticale green fertilizer variant are the variants: 5 (Peas), 4 (Soybean) and 1 (Control). In class B based on the significant difference are the variants: 3 (Sunflower) and 2 (Rapeseed) (Table 4 and 5).

Table 4. Influence of green manure on monocotyledonous weeding in sunflower crop

No.	Variant	No. weeds/sqm	No. weeds %	Difference ± No. weeds/sqm	Significance		The Duncan test
					Compared terror	Compared to Interplay	
1	Control	16.5	-	-	-	-	A
2	Rape	8.3	50	-8.2	O	-	B
3	Sunflower	13.8	84	-2.7	-	-	B
4	Soybean	19.0	115	2.5	-	-	A
5	Peas	19.6	119	16.5	***	*	A
6	Triticale	23.0	139	19.9	***	**	A
LSD	**5% 1% 0.1%**				**6.6 8.9 12.1**	**11.5 18.1 30.7**	

Table 5. Analysis of green manure-induced monocot weeding by Duncan multiple comparisons system in sunflower crop

No.	Variant	No. weeds/ sqm	The difference from the version on the spot				
			6	5	4	3	2
			8.3	13.8	16.5	19.0	19.6
1	Triticale	23.0	14.7 7.3 *	9.2 7.2 *	6.5 7.1	4.0 6.9	3,4 6.5
2	Peas	19.6	11.3 7.2 *	5.8 7.1	3.1 6.9	0.6 6.5	
3	Soybean	19.0	10.7 7.1 *	5.2 6.9	2.5 6.5		
4	Control	16.5	8.2 6.9 *	2.7 6.5			
5	Sunflower	13.8	5.5 6.5				
6	Rape	8.3					

In the analysis of weeding with dicotyledons compared to the control, based on the limit differences calculated on the basis of the error variance, significantly negative differences are recorded in the soybean and triticale green manure variants, and in variant 5 with green manure, peas, the difference is distinctly significant negative. Regarding the significance of the variant x years interaction, no significant differences were recorded, demonstrating that the climate factor does not significantly interact with green manure in changing the number of emerged weeds (Table 5).

In the case of weeding with dinocotyledons, the highest number of weeds of 102 plants/m^2 was achieved in control. Variants 3 (Sunflower), 2 (Rapeseed), and 4 (Soy), no have a significantly different level of weeding. The level of weeding in variants 5 and 6 (Peas and Triticale) is significantly higher reduced (Table 6 and 7).

Table 6. Influence of green manure on dicotyledonous weeding in sunflower crop

No.	Variant	No. weeds/sqm	No. weeds %	Difference ± No. weeds/sqm	Significance		The Duncan test
					Compared terror	Compared to Interplay	
1	Control	102	100	-	-	-	A
2	Rape	89	87	-13	-	-	A
3	Sunflower	93	91	-9	-	-	A
4	Soybean	78	76	-24	0	-	A
5	Peas	69	68	-33	00	-	B
6	Triticale	75	74	-27	0	-	B
LSD	**5% 1% 0.1%**				**24,29 32.88 44.58**	**60.93 95.55 162.65**	

Table 7. Analysis of weeding of dicotyledons induced by green manure by the Duncan multiple comparison system in sunflower crop

No.	Variant	No. weeds/ sqm	The difference from the version on the spot				
			6	5	4	3	2
			69	75	78	89	93
1	Control	102	33 27.0 *	27 26.7 *	24 26.1	13 25.4	9 24.1
2	Sunflower	93	24 26.7	18 26.1	15 25.4	4 24.1	
3	Rape	89	20 26.1	14 25.4	11 24.1		
4	Soybean	78	9 25.4	3 24.1			
5	Triticale	75	6 24.1				
6	Peas	69					

The sunflower yield achieved in the experimental years evidentiated highly significant increases if soybean and pea were used as green manure, distinctly significant increases in case of sunflower green manure, and significant increases for rapeseed and triticale (Table 8).

Table 8. The influence of vegetation on sunflower production (Average of 2023 and 2024)

Factor A - Green manure		Production (kg/ha)	Difference from Control	%	Significance
Control		1932	0	100	-
Rape		2363	431	122	*
Sunflower		2566	634	133	**
Soybean		2727	795	141	***
Peas		2968	1036	154	***
Triticale		2490	558	129	*
LSD	**5% 1% 0.1%**				**379 567 772**

Through chemical fertilization, on the average of the green manure factor, distinctly significant yield increases are achieved compared to the experiment's average. In contrast, under unfertilized conditions, distinctly significant production decreases are observed compared to the same control (experiment average) (Table 9).

Table 9. The influence of fertilization on sunflower production regardless of the vegetation cover (Average of 2023 and 2024)

Factor A - Green manure		Production (kg/ha)	Difference from Control	%	Significance
Average		2507	0	100	-
Fertilized		2804	297	112	**
Unfertilized		2211	-296	88	00
LSD	**5%** **1%** **0.1%**				**190** **267** **377**

Note: ****** - significantly positive at the 0.1 level; 00 - significantly negative at the 0.1 level.

Through the interaction of the gradations of the green manure factor with the gradations of the chemical fertilization factor, compared to the chemically fertilized control, distinctly significant increases are achieved in the chemically fertilized sunflower, soybean and pea variants. Significant negative differences compared to the chemically fertilized control are achieved only in the non-chemically fertilized control variant. All other variants of factor A in interaction with factor B do not achieve significant differences compared to the chemically fertilized control.

Production differences compared to the chemically non-fertilized control are achieved at a very significant level in the chemically fertilized sunflower, chemically fertilized soybean, chemically fertilized and chemically unfertilized peas, and chemically fertilized triticale variants. There are also distinctly significant increases in production in the chemically fertilized rapeseed and chemically non-fertilized soybean variants. Spores at a significant level are achieved on canola and triticale not chemically fertilized and in the chemically fertilized control (Table 10).

Table 10. The influence of the interaction of the studied factors on the production of sunflower (Average of 2023 and 2024)

Factor A		Factor B	Production (kg/ha)	Difference ± (Ct. 1)		Difference ± (Ct. 2)	
				kg/ha	Signif.	kg/ha	Signif.
Control		F (Ct. 1)	2274	0	-	685	*
		N (Ct. 2)	1589	-685	0	0	-
Rape		F	2533	259	-	944	**
		N	2193	-81	-	604	*
Sunflower		F	3087	813	**	1498	***
		N	2045	-229	-	456	-
Soybean		F	3051	777	**	1462	***
		N	2402	-128	-	813	*
Peas		F	3143	869	**	1554	***
		N	2792	518	-	1203	***
Triticale		F	2735	461	-	1143	***
		N	2245	-29	-	656	*
LSD	**5%** **1%** **0.1%**						**520** **736** **1054**

CONCLUSIONS

The soil type used in the experiment exhibits a very low fertility level and a significantly reduced microbiological activity related to the mineralization of organic matter. As a result, positive production differences can only be achieved through the application of chemical fertilizers.

During the study years, the dominant weed species in sunflower crops were Chenopodium album, Ambrosia artemisiifolia, and Echinochloa crus-galli. Peas used as green fertilizer caused an increase in the degree of weeding of the sunflower crop, while rapeseed, sunflower, soybean, and triticale reduced it.

On the green manure background, significant production increases were observed in sunflower yield, specifically in interactions involving sunflower green manure with soybean and peas.

In contrast, the use of rapeseed and triticale as green manures did not yield significant production differences, even with fertilizer application.

Notably, the production obtained on pea green manure, even without chemical fertilization, exceeded the yields obtained from chemically fertilized rapeseed and triticale.

The results confirm that the combined approach of green manure and chemical fertilizers represents a viable solution for sustainable agriculture. This method enables efficient soil resource management, contributing to biodiversity conservation and the sustainable growth of agricultural production.

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