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RESULTS REGARDING THE INFLUENCE OF GREEN MANURE USAGE ON MAIZE CROP ON ACIDIC SOILS IN THE NORTHWEST OF THE COUNTRY

Ács Peter-Balázs[1,2'], Andraș Beniamin-Emanuel[1,2], Ursan Patrick-Andrei[1,2], Mondici Susana[1] Păcurar Ioan[2], Butnar Lucian[3], Liviu Giurgiulescu[4]

[1] Livada Agricultural Research-Development Station, 7 Baia Mare St., Livada
[2]The University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, 3-5 Calea Mănăștur St, Cluj-Napoca
[3]Technical University of Cluj-Napoca, Faculty of Engineering, 62A Dr. Victor Babeș St, Baia Mare, Romania
[4]Technical University of Clu-Napoca, Faculty of Science, Victoriei Street 76, Baia Mare, Romania
**Corresponding author e mail:* acsbalazs24@gmail.com

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ABSTRACT

This paper presents the efficacy of green manures in raising soil fertility and enhancing crop productivity, on the Albic Luvisols in northwestern Romania.Green manures are cover crops that provide various benefits when added to the soil. Peas are especially effective at increasing organic nitrogen in the soil, leaving behind a significant amount of 471.74 kg N(a.s.) per hectare. Regardless of the pressure from the pathogen Fusarium spp. and the pest Ostrinia n. the maize yield was not affected. The incorporated green manures especially peas, significantly raises maize yield surpassing the control with almost 3000 kg. The quality of the maize crop, specifically starch content and hectoliter weight, was not influenced by either green manure or chemical fertilization.

INTRODUCTION

Corn (Zea mays), also known as maize, is one of the most significant crops globally, serving as a staple food for humans, a primary feed for livestock, and a crucial raw material for various industrial products (Shiferaw et al., 2011). Its versatility and high yield make it indispensable in both developed and developing countries. However, the intensive cultivation of maize often leads to soil degradation and a decline in soil fertility, necessitating sustainable agricultural practices to maintain productivity.

One such practice is the use of green manures, particularly legumes, which offer numerous benefits over conventional chemical fertilizers. Green manures are crops grown specifically to be incorporated into the soil to improve its organic matter content and nutrient availability (Thorup-Kristensen et al., 2003). The plants used as green manure should produce a rich vegetative mass in as short a time as possible and should not be demanding in terms of soil. The plants used for this purpose are mostly legumes, but other plants can also be used as well. (Dumitru et al., 2003). This technique involves growing plants, such as and subsequently incorporating them into the soil before they reach maturity. The decomposition of these plants enriches the soil with organic matter, nutrients, and beneficial microorganisms (Drinkwater et. al. 2007).

Leguminous green manures, such as clover and vetch, are especially valuable due to their ability to fix atmospheric nitrogen through symbiotic relationships with Rhizobium bacteria (Peoples et al., 2009). This natural process enriches the soil with nitrogen, a critical nutrient for plant growth, reducing the need for synthetic nitrogen fertilizers (Peoples et al., 2009). Decomposing green manure residues release essential nutrients like nitrogen (N), phosphorus (P), and potassium (K) that become readily available for succeeding crops (Dong et al., 2021)

Moreover, green manures have a lower environmental impact compared to chemical fertilizers. They enhance soil health by improving soil structure, increasing microbial activity, and preventing erosion (Drinkwater et al., 1998). Brown luvic soils and albic luvisols occupy a percentage of over 35% of the arable land of the counties in NW Romania (Boieriu, 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, it is on these soils below 20%, clearly showing the requirement for fertilization with manure to be high compared to nitrogen fertilization (Davidescu, 1981; Alexandrescu, et al. 2023). Research carried out at Livada ARDS, in the interval 1991-1993, demonstrated that the contribution of green fertilizers (lupine) to the improvement of the agrochemical indices of the soil and to the realization of productions is at the level of the use of fertilization with 20 tons/ha of animal manure (Sîrca, 1997) .

Unlike chemical fertilizers, which can lead to nutrient leaching and water pollution, green manures release nutrients slowly, ensuring a more sustained and balanced nutrient supply (Crews & Peoples, 2004). Naz et al. (2023) states that green manuring crops are comprised of above- and below-ground biomass. They have the ability to capture solar energy and convert it into carbon flux, which is useful for releasing macro and micronutrients to the soil biota.

MATERIAL AND METHODS

The experiment is located in Livada, Satu Mare county, Romania, more precisely the experimental fields of Livada A.R.D.S., on an albic luvisol. Albic Luvisol, classified under the World Reference Base for Soil Resources (WRB), is a type of soil found in various regions around the world. It is characterized by a distinctive horizon known as the albic horizon, which is typically light in color due to leaching of minerals and organic matter. This horizon often exhibits a higher clay content compared to underlying horizons, contributing to its unique properties. (IUSS Working group, 2015) (Fao, 2006). In the upper horizon, there is a low humus content, with a moderate supply of mobile phosphorus, low mobile potassium, and a strongly acidic reaction, with the pH in water of around 5.2. (Boeriu et al., 1987). Soil pH is the most important indicator measured for estimating soil health especially in mine soils, since it has a great influence on key soil processes. (Buta et al., 2019) The pronounced acidification, low supply of humus and potassium, and the defective air-water regime impose serious restrictions on crop cultivation. (Kurtinecz et al., 2022). Additionally, Albic Luvisolsplay a role in carbon sequestration, helping to mitigate climate change. (Arrouays et al., 2002).

The crust formation index has values between 1.8-2.2 (Canarache et al. 1987), often leading to the compromise of crops with epigeic germination, an aspect that can only be improved through the addition of organic matter, which facilitates soil structure. Additionally, the addition of organic matter improves water permeability, soil warming, and intensifies microbiological activity, which are deficient aspects in these types of soils, where surface puddles or erosions are frequent.

Table 1.

The main physico-chemical parameters of Albic Luvisol at Livada ARDS

Horizon Horizon depth Sample depth	UM cm cm	Ap 0-18 0-15	Ao 18-40 20-30	 30-40	AB 40-55 40-55	Bt1w 55-70 55-70	Bt2w 70-110 80-95
Humus(Cx1,72)	%	1,82	1,44	0,90	0,90	0,84	3,24
N total	%	0,168	0,102	0,072	0,068	0,064	-
C : N	-	8,21	9,15	10,14	10,34	10,57	-
pH (H_2O)	-	5,19	6,24	6,65	6,53	5,62	5,28
SB	me/100g soil	5,20	6,26	6,53	8,85	10,23	11,02
Ca^{2+}sch	me/100g soil	4,22	5,46	5,41	6,70	7,07	7,25
Mg^{2+}sch	me/100g soil	0,77	0,63	0,96	1,91	2,84	3,49
K^{+}sch	me/100g soil	0,18	0,12	0,12	0,20	0,25	0,23
Na^{+}sch	me/100g soil	0,03	0,05	0,04	0,04	0,06	0,06
V%	% din T	53,5	73,2	77,8	79,8	71,1	69,5
P- AL	ppm	13,6	24,0	10,2	-	-	-
K-AL	ppm	100	87	87	-	-	-
Clay(< 0,002 mm)	% g/g	20,9	21,1	23,1	27,0	32,4	33,1
Apparent density	g/cm^3	1,35	1,54	1,49	1,48	-	1,48
Hydraulic conductivity	mm/h	1,3-4,0	5,87	3,11	0,35	-	1,04

In terms of temperatures during the vegetation period, a warming trend can be observed with temperatures of even 3 degrees Celsius compared to the multi-year. (Figure 1). The region experiences an average annual temperature range of 8˚C to 10˚C. The accumulation of heat units above the threshold of 10˚C in the plain area varies between 1200 and 1450˚C. Over the past six decades, the Livada station has recorded an average temperature of 9.9˚C.

Recently, climate changes are becoming more and more evident, and this is perfectly reflected by the lack of precipitation, the installation of the phenomenon of excessive heat and the increase in the average annual temperature. Temperature variations, positive or negative, are reflected in the evolution of the vegetation state of agricultural crops and implicitly in the production capacity.

These climate data stretch us towards new ways of approaching agriculture. Green manures or also called cover crops are beneficial to retain moisture in the soil.

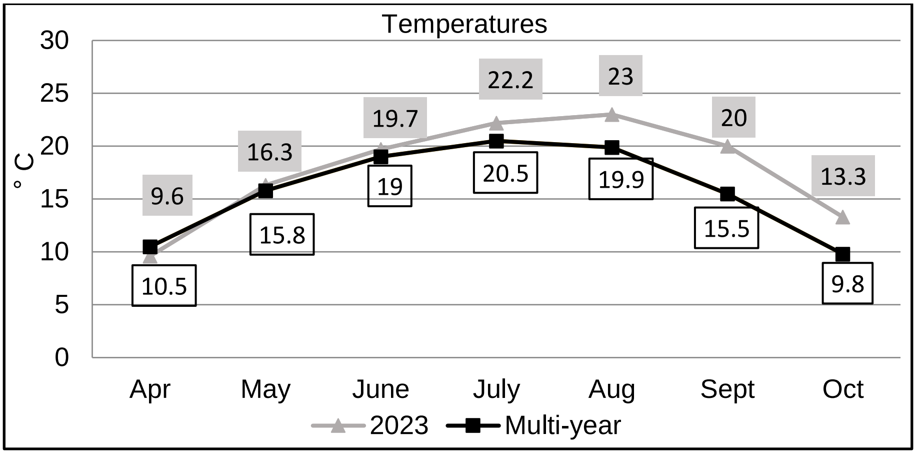

Figure 1. Comparison of maize vegetation period temperature ranges with multi-year trends

In this area, the level of annual precipitation reaches a level of approximately 740-750 liters per square meter, precipitation that in recent years is distributed more and more unevenly. As can be seen from the graph below (Figure 2), the level of precipitation during the maize vegetation period suffered anomalies, especially in May when the level was 19.7 liters and August-September where the deviation from the multi-year average was significant.

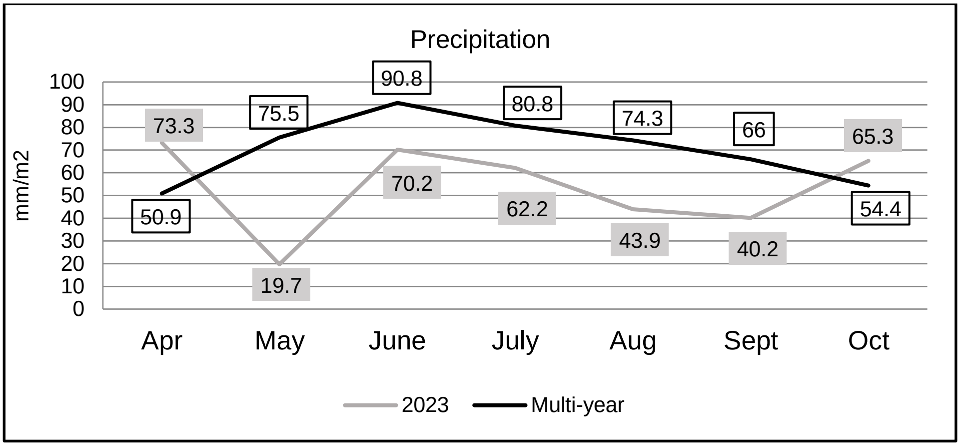

Figure 2.Comparison of maize vegetation period precipitation with multi-year averages

The experimental design incorporates tworeplications and employs a split-plot configuration (Figure 3), featuring two distinct experimental factors. These factors are denoted as Factor A, pertaining to the type of green manure utilized; Factor B, concerning the application of chemical fertilizers; The five selected plant species, namely triticale, peas, soybeans, sunflower, and rapeseed, were sown during the summer season and subsequently integrated into the soil at the green growth stage, strategically timed prior to the optimal period for sowing wheat.

In terms of chemical fertilization, Calcium ammonium nitrate characterized by a nitrogen content of 27% was employed, administered at a rate of 450 kilograms per hectare (kg/ha) in the spring.

This detailed experimental design seeks to shed light on the complex interactions between green manures and chemical fertilizers, combined with fungicide treatments, and their collective impact on maize cultivation performance and results.

Table 2

The variants of the experiment

Variant	Factor A	Green manure crop	Factor B	Chemical fertilization
1	A1	Control (No green manure)	B1	Fertilized
2	A1		B2	Unfertilized
3	A2	Rapeseed	B1	Fertilized
4	A2		B2	Unfertilized
5	A3	Sunflower	B1	Fertilized
6	A3		B2	Unfertilized
7	A4	Soybean	B1	Fertilized
8	A4		B2	Unfertilized
9	A5	Peas	B1	Fertilized
10	A5		B2	Unfertilized
11	A6	Triticale	B1	Fertilized
12	A6		B2	Unfertilized

	A1	**A2**	**A3**	**A4**	**A5**	**A6**
R1	B1	B2	B1	B2	B1	B2
	B2	B1	B2	B1	B2	B1
R2	B1	B2	B1	B2	B1	B2
	B2	B1	B2	B1	B2	B1
R3	B1	B2	B1	B2	B1	B2
	B2	B1	B2	B1	B2	B1

Figure 3.Field layout

Figure 4.Drone picture of the experiment

RESULTS AND DISCUSSIONS

Green manures were incorporated by plowing into the soil in the autumn of 2022. Before incorporation, the quantity biomass of each plant species per hectare was quantified using sampling quadrants. (Figure 5). This method allowed us to determine the exact amount of plant material being added to the soil. Additionally, the amount of bioavailable nitrogen, the specific form of nitrogen usable by plants, contributed by each cover crop species was determined. The largest amount of green mass was obtained in the sunflower crop (over 22.7t), followed by peas and then rapeseed.

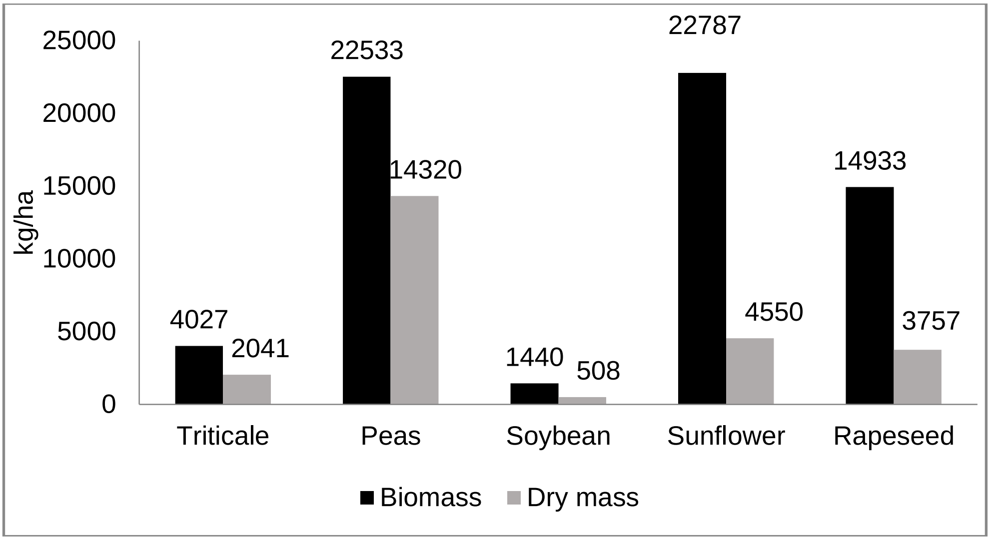

Figure 5. Quantity of biomass incorporated by plant species

The determination of proteins is carried out by the *Kjeldahl* method, in which the samples are subjected to mineralization in a strongly acidic environment which determines the transformation of protein nitrogen into ammonium ion; after a distillation step, the titration (Figure 5) is carried out with a strong acid. By obtaining the amount of protein, the amount of active substance nitrogen incorporated per hectare was calculated (Table 2). (Pacurar Luana et. al. 2016)

Table 3

The amount of active substance nitrogen per hectare

	Biomass kg/ha	Dry mass kg/ha	Proteine %	Proteine kg ha	N (a.s.) kg ha
Triticale	4027	2041	13.56	276.81	44.29
Peas	22533	14320	20.59	2948.4	471.74
Soybean	1440	508	21.55	109.54	17.53
Sunflower	22787	4550	12.33	560.98	89.76
Rapeseed	14933	3757	12.95	486.57	77.85

Figure 6. Distilled samples

When it come to the diseases of the maize cropin 2023 the most common in the experimental region is the pathogen *Giberellaroseum sp. cerealis, Giberellazeae, f.c. Fusariumroseum, f.sp. cerealis graminear*. It occurs more frequently in temperate areas, with high humidity, on numerous plants. Maize can be infected at all stages of growth. This attack comes either from infected seed or from infected soil. *Fusarium* is a genus of fungus that poses a serious threat to maize crops worldwide (Tiru et al 2022). It's not just one species, but a complex of fungal pathogens that can infect various parts of the maize plant, leading to significant yield losses and contamination with harmful toxins (Bryla et al 2022). *Fusarium* infection can cause diseases like ear rot, stalk rot, and seedling blight (Tiru et al 2022). Plants may die before emergence, their roots and cotyledons being invaded by the yellowish-white or pink mycelial sheath. This not only reduces grain yield but also affects the quality of the maize.

The major culprits are *Fusarium verticillioides* (previously known as F. moniliforme) and *Fusarium graminearum* species complex (FGSC) (Bryla et al 2022) (Zhou et. al, 2018). These fungi can infect the maize plant through wounds, insect damage, or naturally occurring openings.

A major concern with *Fusarium* is its ability to produce mycotoxins – toxic secondary metabolites that can harm humans and animals if consumed (Bryla et al 2022). *F. verticillioides* primarily produces fumonisins, while FGSC produces trichothecene mycotoxins (Zhou et. al, 2018).

Controlling *Fusarium* is challenging. Fungicides can be used, but their effectiveness is limited (Tiru et al 2022). Researchers are exploring sustainable approaches like using resistant maize varieties, crop rotation, and biological control agents (Tiru et al 2022).

Figure 7. Infection of *Fusarium* spp. on the maize cob on the *Ostrinia* n. attack

The influence of the green manure factor on the degree of *Fusarium* attack in maize fluctuated between the values of 0.87 in the case of pea green manure and 1.36 in the case of soybean. Even if there were differences between the variants compared to the control, these differences did not reach significance levels.

Table 4

The influence of Factor A on the degree of attack of *Fusarium*

Variant	Degree of attack (%)	Difference from the control	Significance
Control	1.18	Control	-
Rapeseed	1.08	-0.10	-
Sunflower	1.18	0	-
Soybean	1.36	0.17	-
Peas	0.87	-0.32	-
Triticale	1.08	-0.11	-
	CL (p 5%)	1,19%	
	CL (p 1%)	1,69%	
	CL (p 0.1	2,44%	

The application of chemical fertilizers did not influence the degree of attack of the *Fusarium* pathogen at the two grades of fertilized and unfertilized.
Regarding the influence of factor B, there are no significant differences between the fertilized and non-fertilized variants.

Table 5

The influence of Factor B on the degree of attack of *Fusarium* spp.

Variant	Degree of attack (%)	Difference from the control	Significance
Fertilized	1,20	0,08	-
Unfertilized	1,05	-0,08	-
Average	1,13	0	
	CL (p 5%)	0,54%	
	CL (p 1%)	0,75%	
	CL (p 0.1%)	1,06%	

In the case of the interaction of the green manure and chemical fertilizer factors on the degree of *Fusarium* attack on the maize crop, there are no significant differences in any variant, the values are between -1.02 and 0.05 in the case of fertilized variants and -0.05 and 1.37 in the case of chemically fertilized variants.

Table 6a

The interactions of factors A and B on the degree of attack of *Fusarium*

Variant	Degree of attack (%)	Difference from the control	Significance
Control F	1,72	0	-
Rapeseed F	0,90	-0,82	-
Sunflower F	1,77	0,05	-
Soybean F	0,70	-1,02	-
Peas F	0,72	-1,00	-
Triticale F	1,40	-0,32	-

Table 6b

The interactions of factors A and B on the degree of attack of *Fusarium*

Variant	Degree of attack (%)	Difference from the control	Significance
ControlUF	0,65	0	-
RapeseedUF	1,27	0,62	-
SunflowerUF	0,60	-0,05	-
SoybeanUF	2,02	1,37	-
PeasUF	1,02	0,37	-
Triticale UF	0,75	0,10	-
	CL (p 5%)	1,51%	
	CL (p 1%)	2,13%	
	CL (p 0.1%)	3,05%	

F – fertilized
UF – Unfertilized

The European corn borer (*Ostrinia nubilalis*) is a major pest in maize, causing significant yield losses globally. Larvae feed on various parts of the plant, including stems and ears, leading to physical damage and secondary infections. (Hutchison et al., 2010). The larvae bore into the plant, weakening its structure and making it susceptible to diseases. (Siegfried & Hellmich, 2012).In Europe, control strategies focus on crop rotation, biological control using natural predators, and the careful application of insecticides to manage pest populations (Meissle et al., 2011).This pest of maize, quite frequently encountered in the experience area.


Figure 8. *Ostrinia* n. larvae in the maize plant

From the given table, the green manure factor did not influence the frequency of *Ostrinia nubilalis* in the maize crop. The highest frequency was observed on the green manure soybean with 55% and the lowest being the triticale green manure with 47,5 %, with no significant differences compared to the control variant

Table 7

The influence of factor A on the frequency of *Ostrinia* n.

Variant	Freq. %	Difference from the control	Significance
Control	49,72	0	-
Rapeseed	48,33	-1,38	-
Sunflower	50,45	0,73	-
Soybean	55,00	5,28	-
Peas	40,00	-9,72	-
Triticale	47,50	-2,22	-

CL (p 5%) 20,69%
CL (p 1%) 29,41%
CL (p 0.1%) 42,58%

The chemical fertilization did not bring any significant differences on the frequency of the *Ostrinia*. The difference compared to the average being of 6,5 %

Table 8

The influence of factor B on the frequency of *Ostrinia* n.

Variant	Freq. %	Difference from the control	Significance
Fertilized	55,00	6,50	-
Unfertilized	42,00	-6,50	-
Average	48,50	0	

CL (p 5%) 11,81%
CL (p 1%) 16,57%
CL (p 0.1%) 23,39%

Table 9a

The interactions of factors A and B on the frequency of *Ostrinia* n.

Variant	Freq. %	Difference from the control	Significance
Control F	53,33	0	-
Rapeseed F	63,33	10,00	-
Sunflower F	68,33	15,00	-
Soybean F	56,67	3,33	-
Peas F	43,33	-10,00	-
Triticale F	45,00	-8,33	-

Table 9c

The interactions of factors A and B on the frequency of *Ostrinia* n.

Variant	Freq. %	Difference from the control	Significance
Control UF	46,10	0	-
Rapeseed UF	33,33	-12,77	-
Sunflower UF	32,57	-13,53	-
Soybean UF	53,33	7,23	-
Peas UF	36,67	-9,43	-
Triticale UF	50	3,90	-

CL (p 5%) 29,09%
CL (p 1%) 41,09%
CL (p 0.1%) 58,76%

Figure 8. *Ostrinia n*. attack on the maize

Regarding the correlation between the attack of *Fusarium* and the frequency of *Ostrinia*, a linear increase can be observed, so we can say that the damage produced by *Ostrinia* creates optimal conditions for the installation of *Fusarium* on the maize cobs**.**

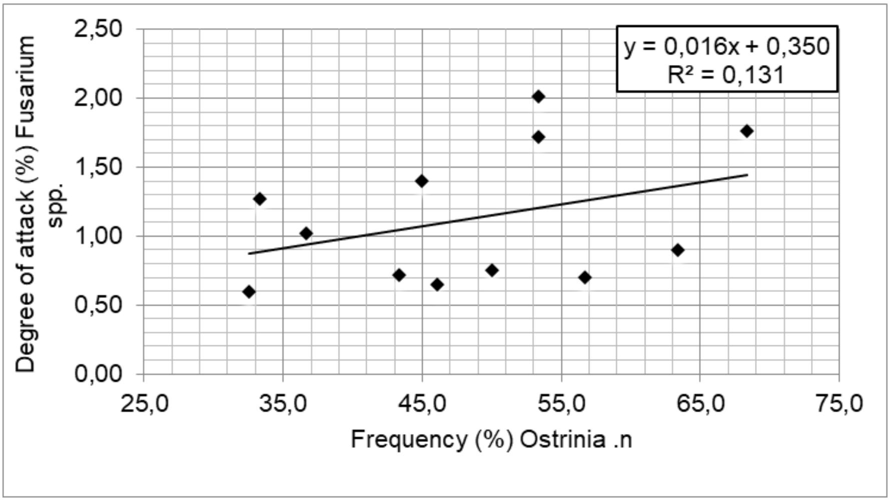

Figure 9. Correlation between the frequency of *Ostrinia* n. and the degree of attack of *Fusarium* spp.

The influence of factor A (green manure) on maize production was significant, with increases in production recorded in all tested variants. Production gains varied from distinctly significantly positive in the case of triticale green manure with an increase of 643 kg/ha, to very significantly positive in the version with pea green manure with a difference compared to the control of 2967 kg/ha.

The results obtained demonstrate a positive impact of factor A on maize production, with a particular efficiency in the case of green pea fertilizer, the variant in which production reached the level of 8264 kg/ha.

Table 10

The influence of factor A on the maize yield

Variant	Average kg/ha	Difference from the control	Significance
Control	5464	-	-
Rapeseed	8002	2358	***
Sunflower	7280	1816	***
Soybean	7789	2324	***
Peas	8264	2967	***
Triticale	6107	643	**

CL (p 5%) 372 kg
CL (p 1%) 528 kg
CL (p 0.1%) 765 kg

Factor B (chemical fertilizer) influenced lead production as expected with a difference from the average between chemically fertilized and unfertilized, of 1307 kg/ha

Table 11

The influence of factor B on the maize yield

Variant	Average kg/ha	Difference from the control	Significance
Fertilized	8486	1307	***
Unfertilized	5872	-1307	OOO
Average	7179		

CL (p 5%) 321kg
CL (p 1%) 450 kg
CL (p 0.1%) 635 kg

The experiment demonstrated that using green manures significantly impacts maize yield. Fertilized variants like Rapeseed, Sunflower, Soybean, Peas, and Triticale showed substantial yield increases, with Rapeseed F achieving the highest increase of 3488 kg/ha. Unfertilized variants also improved yields, notably Peas UF with a 3286 kg/ha increase. However, Sunflower UF and Triticale UF did not show significant improvements. These results highlight the potential of green manures to enhance crop productivity, especially when fertilized

Table 12a

The interaction of factors A and B on the maize yield

Variant	Average kg/ha	Difference compared to the control	Significance
Control F	6137	0	-
Rapeseed F	9625	3488	***
Sunflower F	9298	3161	***
Soybean F	8714	2577	***
Peas F	8786	2649	***
Triticale F	8357	2220	***

Table 12b

The interaction of factors A and B on the maize yield

Variant	Average kg/ha	Difference compared to the control	Significance
Control UF	4791	0	-
Rapeseed UF	6379	1587	***
Sunflower UF	5262	470	-
Soybean UF	6863	2071	***
Peas UF	8077	3286	***
Triticale UF	3857	-934	O

CL (p 5%) 688 kg
CL (p 1%) 942 kg
CL (p 0.1%) 1340 kg

Maize production quality index and they were influenced by both A factor green manures and chemical fertilization as well. The amount of starch fluctuates between 74.68% in the case of the pea variety and 75.75 in the control variant, without green manure. Differences are insignificant, except for the pea variant where we have a very significant negative difference with a value of -1.07 % starch compared to the control.

Table 13

The influence of factor A on the starch content

Variant	Starch (%)	Difference compared to the control.	Significance
Control	75,75	0	-
Rapeseed	75,68	-0,07	-
Sunflower	75,72	-0,03	-
Soybean	75,65	-0,10	-
Peas	74,68	-1,07	OOO
Triticale	75,53	-0,22	-

CL (p 5%) 0,46
CL (p 1%) 0,66
CL (p 0.1%) 0,95

The amount of starch was not influenced by chemical fertilization, the obtained difference of only 0.18% compared to the average of the fertilized and non-chemically fertilized variants.

Table 14

The influence of factor B on the starch content

Variant	Starch (%)	Difference compared to the control.	Significance
Fertilized	75,32	-0,18	-
Unfertilized	75,68	0,18	-
Average	75,5	0	

CL (p 5%) 0,31%
CL (p 1%) 0,44%
CL (p 0.1%) 0,62%

From the influence of factors A and B, a significantly negative difference is observed in the case of the fertilized pea variant and a significantly negative difference in the non-fertilized pea variant, so we can draw the conclusion from all the data that chemical fertilization does not influence the amount of starch in maize at all.

Table 15a

The interaction of factors A and B on the starch content

Variant	Starch (%)	Difference compared to the control.	Significance
Control F	75,77	0,00	-
Rapeseed F	75,40	-0,37	-
Sunflower F	75,80	0,03	-
Soybean F	75,47	-0,30	-
Peas F	74,37	-1,40	OO
Triticale F	75,13	-0,63	-

In reference to the hectoliter weight of maize, as shown in the table below, the observed differences between the variants and the control unit are statistically insignificant. Although each variant exhibits a negative deviation, only the pea green manure variant displays a statistically significant negative difference with -1,40%.

Table 15b

The interaction of factors A and B on the starch content

Variant	Starch (%)	Difference compared to the control.	Significance
Control UF	75,73	0	-
Rapeseed UF	75,97	0,23	-
Sunflower UF	75,63	-0,10	-
Soybean UF	75,83	0,10	-
Peas UF	75,00	-0,73	O
Triticale UF	75,93	0,20	-

CL (p 5%) 0,71%
CL (p 1%) 1,01%
CL (p 0.1%) 1,44%

Table 16

The influence of factor A on hectoliter weight

Variant	Hectoliter weight kg/hl	Difference compared to the control.	Significance
Control	69,43	0	-
Rapeseed	69,27	-0,17	-
Sunflower	69,28	-0,15	-
Soybean	69,03	-0,40	-
Peas	68,03	-1,40	OO
Triticale	69,08	-0,35	-

CL (p 5%) 0,97 kg/hL
CL (p 1%) 1,38 kg/hL
CL (p 0.1%) 2,00 kg/hL

In terms of the impact of chemical fertilization on the maize crop, no significant differences were observed in the hectoliter weight, with a difference between them of 0,22 kg/hl

Table 17

The influence of factor B on hectoliter weight

Variant	Hectoliter weight kg/hl	Difference compared to the control.	Significance
Fertilized	68,80	-0,22	-
Unfertilized	69,24	0,22	-
Average	69,02	0,00	

CL (p 5%) 0,37kg/hl
CL (p 1%) 0,51kg/hl
CL (p 0.1%) 0,72kg/hl

The impact of green manures and chemical fertilizers on maize crop hectoliter weight in 2023 was investigated. Results indicate that the interaction between these two factors did not significantly influence the hectoliter weight. However, a slight negative difference of -1.40 kg/hl was observed in the fertilized pea variant.

Table 18a

The interaction of factors A and B on the hectoliter weight

Variant	Hectoliter weight kg/hl	Difference compared to the control.	Significance
Control F	69,60	0,00	-
Rapeseed F	68,97	-0,37	-
Sunflower F	69,33	0,03	-
Soybean F	68,47	-0,30	-
Peas F	67,67	-1,40	OO
Triticale F	68,77	-0,63	-

Table 18b

The interaction of factors A and B on the hectoliter weight

Variant	Hectoliter weight kg/hl	Difference compared to the control.	Significance
Control UF	69,27	0,00	-
Rapeseed UF	69,57	0,30	-
Sunflower UF	69,23	-0,03	-
Soybean UF	69,60	0,33	-
Peas UF	68,40	-0,87	-
Triticale UF	69,40	0,13	-

CL (p 5%) 1,16 kg/hl
CL (p 1%) 1,64 kg/hl
CL (p 0.1%) 2,36 kg/hl

CONCLUSIONS

The present study investigated the impact of green manure usage on maize crop performance on acidic soils in the northwestern region of Romania. Specifically, the experiment evaluated the effects of five different green manures (rapeseed, sunflower, soybean, peas, and triticale) and their combinations with chemical fertilizer on maize yield, disease incidence, and grain quality.

The results demonstrated that the incorporation of green manure significantly enhanced maize yield compared to the control. Among the green manures tested, peas exhibited the most substantial positive effect, increasing yield by 2967 kg/ha compared to the control. While all green manures yielded significantly higher maize crops than the control, the magnitude of the yield increase varied among species.

Disease incidence, as measured by the frequency of *Ostrinia nubilalis* and the degree of Fusarium attack, was not significantly influenced by either green manure type or chemical fertilization. However, a correlation was observed between the frequency of *Ostrinia nubilalis* and the degree of Fusarium attack, suggesting that the presence of *Ostrinia* may facilitate the establishment of *Fusarium*. Regarding grain quality, neither green manure nor chemical fertilization had a significant impact on starch content or hectoliter weight. This indicates that the positive effects of green manure on maize yield were not accompanied by changes in grain quality.

In conclusion, the findings of this study provide compelling evidence for the benefits of green manure usage in maize production on acidic soils. Green manures can effectively increase maize yield without compromising grain quality, while also offering significant environmental advantages over chemical fertilizers. By reducing reliance on synthetic fertilizers, green manure practices can help mitigate greenhouse gas emissions, improve soil health, and promote sustainable agriculture.

Furthermore, green manures are often more readily available and can be significantly cheaper than chemical fertilizers, making them a viable and cost-effective option for farmers. Future research should explore the long-term effects of green manure use on soil health, nutrient cycling, and the resilience of maize crops to environmental challenges.

REFERENCES

Alexandrescu, I.M., Cotetiu, R.I., Alexandrescu, I.L., 2023. The Influence of The Spindle Speed on the Damping Capacity of the Oil Film for a Radial Bearing with the Ratio L/D= 1 as a Function of the Static Loading of the Bearing. Scientific Bulletin, Serie C, Fascicle: Mechanics, Tribology, Machine Manufacturing Technology, Vol. 2023 Issue 37, pp.3-5.

Arrouays, D., et al., 2002. Global soil map: Toward a fine-resolution global grid of soil properties. Advances in Agronomy, pp. 125-178.

Boieriu I., Brădișteanu M., Codrean I., Kereszturi I., Tibil A., Săsărean G., Rotaru A, Szilagyi C., 1987. Solurile județului Satu Mare și posibilități de sporire a capacității lor de producție, Volum omagial 1962-1987 Livada. Editura București.

Bryła, M., Pierzgalski, A., Zapaśnik, A., Uwineza, P.A., Ksieniewicz-Woźniak, E., Modrzewska, M. and Waśkiewicz, A., 2022. Recent research on *Fusarium* mycotoxins in maize. A review. Foods, 11(21), pp. 3465.

Buta, M.; Blaga, G.; Paulette, L.; Păcurar, I.; Roșca, S.; Borsai, O.; Grecu, F.; Sînziana, P.E.; Negrușier, C., 2019. Soil Reclamation of Abandoned Mine Lands by Revegetation in Northwestern Part of Transylvania: A 40-Year Retrospective Study. Sustainability, 11, pp. 3393.

Canarache A., 1987. Însușirile fizice ale solurilor agricole din județul Satu Mare (Caracterizare sintetică) și ameliorarea lor. Lucrări științifice – Volum omagial 1962-1987. Livada. Editura București.

Crews, T. E., & Peoples, M. B. 2004. Legume versus fertilizer sources of nitrogen: Ecological tradeoffs and human needs. *Agriculture, Ecosystems & Environment*, 102(3), pp. 279-297.

Davidescu, D., Davidescu, V., 1981. Agrochimia moderna. Editura Academiei Republicii Socialiste România, pg. 394.

Dong, N., Hu, G., Zhang, Y. et al. 2021. Effects of green-manure and tillage management on soil microbial community composition, nutrients and tree growth in a walnut orchard. Sci Rep 11, pp. 16882.

Drinkwater, L. E., & Snapp, S. S. 2007. Nutrients in agroecosystems: Rethinking the management paradigm. Advances in agronomy, 92, pp. 163-186.

Drinkwater, L. E., Wagoner, P., & Sarrantonio, M. 1998. Legume-based cropping systems have reduced carbon and nitrogen losses. *Nature*, 396(6708), pp. 262-265.

Dumitru M., Șimota C. ,Doreanu E, Geambașu N., Stanciu P., Țigănaș L., Iliescu H., Țogoe I., Munteanu I., Dumitru E., Mitroi A., 2003. Cod de bune practice agricole, Vol. 1, Editura Expert.

Hutchison, W. D., et al. 2010. "Areawide suppression of European corn borer with Bt maize reaps savings to non-Bt maize growers." Science, 330(6001), pp. 222-225.

Kurtinecz P., Ursan P.A., 2022. Experențe staționare cu amendarea și fertilizarea solurilor acide la Stațiunea de Cercetare și Dezvoltare Agricolă Livada, Cercetare și performanță în agricultură, Broșura SCDA Livada, Nr. 7

Meissle, M., et al. 2011. "Pests, pesticide use and alternative options in European maize production." *Pest Management Science*, 67(8), pp. 885-900.

Naz, A.; Rebi, A.; Naz, R.; Akbar, M.U.; Aslam, A.; Kalsom, A.; Niaz, A., Ahmad, M.I.; Nawaz, S.; Kausar, R., et al. 2023. Impact of Green Manuring on Health of Low Fertility Calcareous Soils 2023. Land, 12, pp. 546.

Pacurar, L., Ceclan, A., Muntean, E., 2016. Controlul calității cerealelor prin spectrofotometrienir. Revista Agricultura Transilvana nr.24, SCDA Turda, pp. 71-75.

Peoples, M. B., Herridge, D. F., Ladha, J. K. 2009. Biological nitrogen fixation: An efficient source of nitrogen for sustainable agricultural production? *Plant and Soil*, 174(1-2), pp. 3-28.

Peoples, M.B., Brockwell, J., Herridge, D.F., et al., 2009. The contributions of nitrogen-fixing crop legumes to the productivity of agricultural systems. Symbiosis 48, pp. 1–17.

Shiferaw, B., Prasanna, B. M., Hellin, J., Bänziger, M. 2011. Crops that feed the world 6. Past successes and future challenges to the role played by maize in global food security. *Food Security*, 3(3), pp. 307-327.

Siegfried, B. D., Hellmich, R. L. 2012. Understanding successful resistance management. *GM Crops & Food*, 3(3), pp. 184-193.

Sîrca, C., 1997. Cercetări privind cultura lupinului (Lupinus albus) pe solurile brunluvice din nord-vestul țării. Teză de doctorat, ASAS, București.

Şugar, I.R., Gaspar, F. , Chiver, O., 2024. Study on theAerodynamic and Dimensional Properties of Corn used to Obtain Biofuel. Carpathian Journal of Food Science and Technology, Volume: 16 (3), Baia Mare, pp. 61-67.

Thorup-Kristensen, K., Magid, J., Jensen, L. S., 2003. Catch crops and green manures as biological tools in nitrogen management in temperate zones. *Advances in Agronomy*, 79, pp. 227-302.

Tiru, Z., Mandal, P., Chakraborty, A.P., Pal, A. Sadhukhan, S., 2022. Fusarium Disease of Maize and its management through Sustainable Approach. Fusarium: An Overview of the Genus, pp.61.

Zhou D, Wang X, Chen G, Sun S, Yang Y, Zhu Z, Duan C. 2018. The Major Fusarium Species Causing Maize Ear and Kernel Rot and Their Toxigenicity in Chongqing, China. Toxins; 10(2):90.

***FAO. 2006. Guidelines for Soil Description (4th Edition). Food and Agriculture Organization of the United Nations, Rome.