VALORIZATION OF ACIDIC SOILS BY TESTING, INTRODUCING AND EXPANDING THE CULTIVATION OF NEW SPECIES WITH HIGH PRODUCTION POTENTIAL IN THE CONTEXT OF CLIMATE CHANGE IN NORTH-WEST ROMANIA

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https://doi.org/10.71066/FTTMK.2.20

Introduction

The introduction and expansion of new plant species (mustard, fava beans, chickpeas, buckwheat, lentils, sorghum) that are not native to the ecological framework of a humid climate and acidic soils will enable the selection of species with the greatest ecological plasticity to ensure a sufficient supply of plant biomass for use as green manure (cover crops), animal feed, human food, and biomass (Aka Sağlıker & Şahin, 2018; Csabai et al., 2019, 2022a, 2022b, 2023, 2025; Vágvölgyi & Kosztyuné Krajnyák, 2025). The pedological context of the project is characterized by the fact that acidic soils account for more than 30% of the arable land in northwestern Transylvania. In these soils, the presence of a more or less developed B horizon, with a clay content ranging from 30–35%, combined with low hydraulic conductivity values, causes water to stagnate at the surface during periods of heavy precipitation, which adversely affects plant growth.

Apparent density values suggest that the soil is relatively compacted; the pH ranges from slightly acidic to acidic, with a trend toward acidification due to fertilization, primarily with nitrogen-based fertilizers.

The humus content (which was formed predominantly from fulvic acids) is low, indicating that the humus is quite depleted. The trend in soil organic matter content shows a quantitative and qualitative decline in humus in these soils.

The presence of aluminum ions, due to the increase in potential acidity, strictly requires periodic soil amendment.

Literature review

Legume crops ensure food, feed, and industrial security. Legume crops are an important source of high-quality plant protein. These plants help enhance soil fertility and contribute to energy security. They are excellent preceding crops in crop rotations. (Kosztyuné Krajnyák et al., 2023; INTERNET 1, Szabó et al., 2018, Szabó et al., 2019).

Chickpeas are rich in protein, minerals (phosphorus, potassium, magnesium, calcium, iron), and B vitamins. With a high protein content (24%), combined with a substantial percentage of carbohydrates and fats, chickpeas have exceptional nutritional value and can largely replace the protein found in meat.

In 1793, ground and roasted chickpeas were mentioned by a German writer as a substitute for coffee in Europe, a practice that continues today. During World War I, chickpeas were cultivated for this purpose in some parts of Germany (INTERNET 2).

Lentils are a rich source of fiber, folate, and potassium, nutrients essential for heart health.

According to the American Heart Association (AHA), increased fiber intake can reduce LDL cholesterol (the "bad" cholesterol). Not only is fiber associated with a lower incidence of cardiovascular disease, but it may also slow the progression of the disease in people at high risk (INTERNET 3).

Voican et al. (2002) state that the cultivation of cereal crops began in the Late Neolithic. The culture spread from the Middle East in 4 directions: in Europe, crossing the Balkans, the North African coast, to Spain, in Ethiopia - on the Nile, in Mesopotamia and India. About 4,000 years ago, garden grain was cultivated in Greece and southern Italy (INTERNET 4).

Farmers growing buckwheat in Romania do not have as many varieties as farmers in Russia, where over 60 varieties of buckwheat are grown. Russia is also the largest exporter of buckwheat in the world.

Archaeological excavations in the Indus Valley have revealed that mustard was cultivated there as early as 1800 BC (INTERNET 5).

One benefit of sorghum cultivation is its role in preventing land desertification (Antohe, 2002; Drăghici, 2023).

In areas with acidic, humus-poor soils, lupin—grown for grain, including within a rational crop rotation scheme, and used as green manure—plays a significant role in making agriculture profitable; at the same time, it can provide a substantial amount of protein for feeding monogastric animals (INTERNET 6; Szabó et al., 2025).

Red clover is a perennial forage legume important for animal nutrition; it efficiently utilizes humid, hilly areas and acidic to moderately acidic soils, playing a role in soil improvement and pollution reduction (Moisa & Smit, 2018).

Wheat is of great importance as a food product, providing a large share of the carbohydrates and proteins required by humans and accounting for more than half of the calories consumed by humanity (INTERNET 7).

Among cereal crops, triticale represents one of humanity's major achievements in the field of theoretical and applied genetics; it offers significant potential for increasing yield per unit area—producing crops for both human consumption and animal feed—particularly in regions where growing conditions are less favorable for other cereals (Ittu et al., 1986, 1990, 2001; Ittu and Săulescu, 1988, 2000; Kosztyuné Krajnyák et al., 2024).

Material and Method

The research was conducted in 2024 and 2025, under the soil and climate conditions at the Livada Agricultural Research and Development Station in Satu Mare County, on a white luvisol with a pH of 5.1 in the topsoil, a clay content of 20.9%, and a humus content of 1.8%.

The research aims to optimize the use of acidic soils by introducing new crop species—buckwheat, chickpeas, mustard, sweet sorghum, fava beans, and lentils—alongside established crops in the area—clover, lupine, triticale, and wheat—all of which are acid-tolerant varieties.

By selecting the composition of the new species based on the area's specific characteristics and developing technologies tailored to each species and the ecological context—given that each species prefers certain soil types (lupine and red clover tolerate acidic soils; chickpeas and fava beans prefer neutral to slightly alkaline soils), conducting experiments on these soil types leads to relevant conclusions regarding the ecological plasticity of different species and varieties and the possibility of expanding cultivation areas even to regions considered less favorable.

Agroclimatic Resources at SCDA Livada During the Agricultural Year:

The Northern Pannonian subprovince, which encompasses the plain area of the SCDA Livada territory, is influenced by a temperate climate with a sub-Atlantic character, according to the Köppen classification, with the climate code cfbx. To characterize the agroclimatic conditions, thermal resources, as well as the characteristics and fluctuations of moisture resources, are analyzed.

Thermal Resources

Average annual temperatures range from 8°C to 11.6°C. The sum of effective temperatures (>10°C) in the plain area ranges from 1,200 to 1,450°C.

The multiannual average temperature recorded at the Livada station over the past 63 years is 9.9°C. The temperatures recorded during the study period are shown in Figure 1.

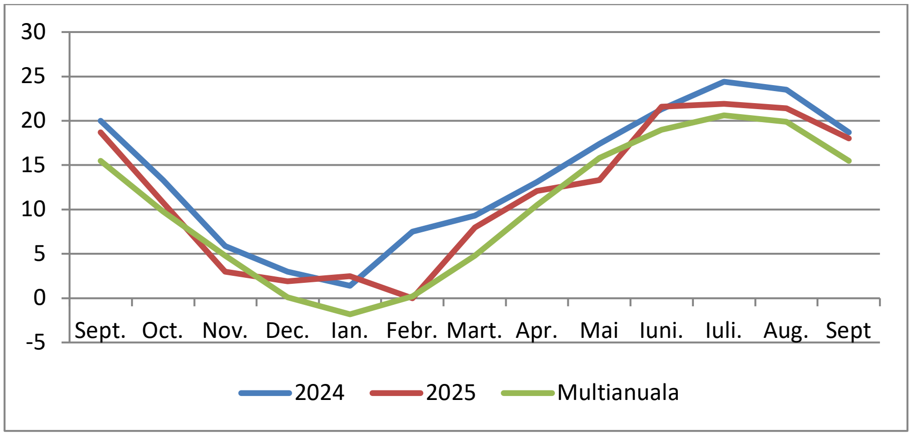

Figure 1. Monthly temperatures (°C) recorded at SCDA Livada

At Livada, the 63-year multi-year average precipitation is 751.4 mm, with an uneven and erratic distribution during the growing season.

The precipitation recorded during the study period is shown in Figure 2.

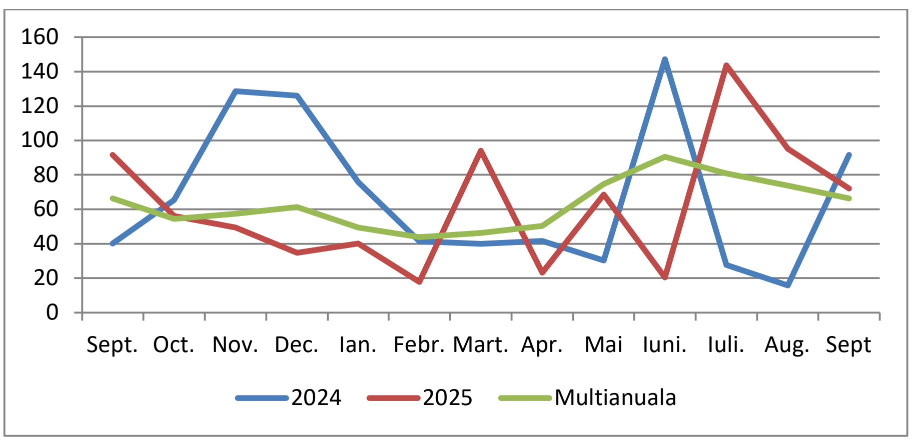

Figure 2. Monthly precipitation (mm) recorded at SCDA Livada

For the experimental years 2024 and 2025, a plot was designated for cover crops that allowed for early land preparation (wheat, sorghum).

The experimental design included two factors: factor A with two levels (a1 – amended and a2 – unamended) and factor B with two levels (D1 – density 1, D2 – density 2).

For factor A, the field was divided into two sections, one of which was amended with 1.0 t/ha of Teracalco, applied annually using a fertilizer spreader.

Crops were arranged perpendicular to factor A, with each crop having two variants representing factor B with two density levels.

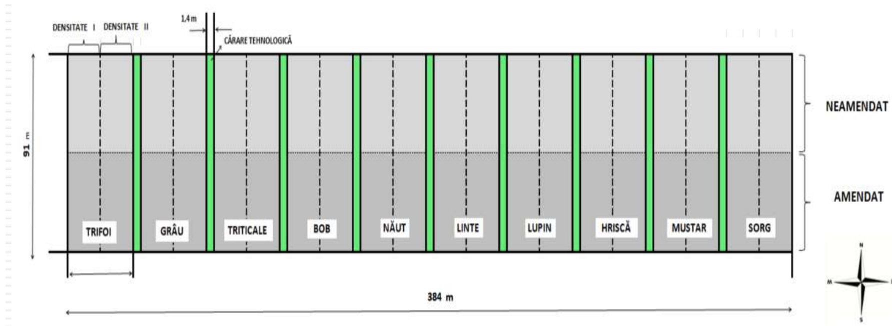

Figure 3. Sketch of the experimental setup

Prior to sowing, as part of seedbed preparation, a compound fertilizer (18-46-0) at a rate of 500 kg/ha was applied to the fall crops, while a compound fertilizer (18-46-0) at a rate of 200 kg/ha was applied to the spring crops.

In September–October, fall sowing (red clover, wheat, triticale) was carried out, and in March–May, spring sowing was carried out using a seed drill (Wintersteiger Plotseed TC) for the experimental plots.

Figure 4. Sowing of crops under the ADER 1.2.1 project

1. Red clover

The red clover variety sown as part of the project was "David Liv," developed at SCDA Livada. It is a synthetic diploid variety approved in 2015; an early-maturing variety with good resistance to lodging, winter hardiness, drought, and foliar diseases. It is suitable for both spring and fall planting. Red clover was planted between August and September during each phase of the project. The treatment combinations were as follows:
V1 – fertilized at two densities
D1 – 674 seeds/m² (15 kg/ha)
D2 – 1,124 seeds/m² (25 kg/ha)
V2 – unamended with two seeding rates
D1 – 674 seeds/m² (15 kg/ha)
D2 – 1,124 seeds/m² (25 kg/ha)

The seeding depth was 1 cm, and the row spacing was 12.5 cm.

2. Wheat

To establish the wheat crop, “Biharia” was sown—a new Romanian variety developed at SCDA Lovrin and registered in 2021. It has a medium growing season, is short in stature (approximately 80 cm), is resistant to winter and drought, has good tolerance to lodging and heat stress, is resistant to specific diseases, and has high tolerance to soil acidity. Wheat was sown in October, the optimal time for northwestern Romania, with the following treatments:

V1 – amended, with two seeding rates
D1 – 423 seeds per square meter (180 kg/ha)
D2 – 587 seeds per square meter (250 kg/ha)
V2 – unamended with two seeding rates
D1 – 423 seeds/m² (180 kg/ha)
D2 – 587 seeds/m² (250 kg/ha)

The seeding depth was 4 cm, and the row spacing was 12.5 cm.

3. Triticale

The triticale variety sown was Negoiu, developed at INCDA Fundulea and registered in 2012. Negoiu has high resistance to low temperatures, a rapid growth rate, thick, elastic straw that is resistant to lodging, moderate resistance to brown rust, and moderate susceptibility to powdery mildew and yellow rust; it is also resistant to sprouting in the head. The triticale was planted at the same time as the triticale.

The variants include the two factors—agrochemical fertilization and seeding rate—each with two levels:

V1 – amended, with two seeding rates
D1 - 323 seeds/m² (150 kg/ha)
D2 - 538 seeds/m² (250 kg/ha)
V2 – unamended with two seeding rates
D1 – 323 seeds/m² (150 kg/ha)
D2 – 538 seeds/m² (250 kg/ha)

The seeding depth was 4 cm, and the row spacing was 12.5 cm.

4. Chickpeas

The chickpea variety planted as part of the project was “BURNAS,” developed at SCDA Teleorman. It is a variety approved in 2006 that is highly drought-tolerant and has very good resistance to anthracnose. The chickpea crop was planted in March. The treatment combinations were as follows:

V1 – amended, with two seeding rates
D1 - 35 seeds/m² (140 kg/ha)
D2 - 45 seeds/m² (180 kg/ha)
V2 – unamended at two densities
D1 – 35 seeds per square meter (140 kg/ha)
D2 – 45 seeds per square meter (180 kg/ha)

The seeding depth was 4 cm, and the row spacing was 25 cm for both treatments.

5. Fava Beans

For the fava bean crop, the “SUPERAGUADULCE” variety was sown; it is a large-seeded variety (no small or medium seeds were found), has moderate heat requirements, but is sensitive to moisture. Like the fava bean crop, the broad bean crop was sown in mid-March, with the variants being V1—amended and V2—unamended; in both cases, two seeding densities were used. The seeding densities were:

V1 – amended, with two seeding rates
D1 - 30 seeds/m² (450 kg/ha)
D2 - 40 seeds/m² (675 kg/ha)
V2 – unamended at two densities
D1 – 30 seeds/m² (450 kg/ha)
D2 – 40 seeds/m² (675 kg/ha)

The seeding depth was 8 cm, and the row spacing was 25 cm.

6. Lentils

Lentils were sown in early spring, as was the case with the legume crops in the project, since delaying sowing results in uneven emergence. The variety sown was the green lentil "VELVET." The treatment variants for the lentil crop were:

V1 – amended, with two seeding rates
D1 – 250 seeds per square meter (75 kg/ha)
D2 – 300 seeds per square meter (89 kg/ha)
V2 – unamended with two seeding rates
D1 – 250 seeds per square meter (75 kg/ha)
D2 – 300 seeds per square meter (89 kg/ha)

The seeding depth was 4 cm, and the row spacing was 12.5 cm for both variants.

7. Buckwheat

The buckwheat variety sown was "PANDA," a variety noted for its high disease resistance; it survives cold spring periods well and withstands drought even during the flowering period. The variants were as follows:

V1 – amended, with two seeding rates
D1 – 200 seeds per square meter (60 kg/ha)
D2 – 250 seeds per square meter (80 kg/ha)
V2 – unamended with two seeding rates
D1 – 200 seeds/m² (60 kg/ha)
D2 – 250 seeds/m² (80 kg/ha)

The seeding depth was 3 cm, and the row spacing was 25 cm for both variants.

8. Mustard

To establish the mustard crop, the "MARYNA" variety was sown, and sowing took place in early March.

The treatments were: V1—amended and V2—unamended, with both sown at two seeding rates.

V1—amended, with two seeding rates
D1—200 seeds/sq m (14 kg/ha)
D2—300 seeds/sq m (21 kg/ha)
V2 – unamended with two seeding densities
D1 – 200 seeds/m² (14 kg/ha)
D2 – 300 seeds/m² (21 kg/ha)

The seeding depth was 1.5 cm, and the row spacing was 25 cm.

9. Lupin

The “MIHAI” variety, approved by ISTIS in 2015 and patented in 2017, was developed through a breeding program at the Faculty of Agriculture of USAMV Iași. This variety was sown as part of the project in mid-March, along with the other spring crops, and included the following treatments:

V1 – amended, with two seeding rates
D1 – 50 seeds/m² (150 kg/ha)
D2 – 70 seeds/m² (210 kg/ha)
V2 – unamended with two seeding rates
D1 – 50 seeds/m² (150 kg/ha)
D2 – 70 seeds/m² (210 kg/ha)

The seeding depth was 5 cm, and the row spacing was 25 cm.

10. Sweet Sorghum

In early May, sorghum was planted using the “ALIZE” hybrid, a semi-early hybrid with excellent tolerance to lodging, drought, shattering, and Fusarium. The varieties planted were:

V1 – amended, with two seeding rates
D1 - 11 seeds/m² (4 kg/ha)
D2 - 17 seeds/m² (6 kg/ha)
V2 – unamended with two seeding rates
D1 – 11 seeds/m² (4 kg/ha)
D2 – 17 seeds/m² (6 kg/ha)

The seeding depth was 4 cm, and the row spacing was 50 cm.

Weed Control

Weed control in the crops included in this study was carried out using the following herbicides:

Red clover was treated post-emergence with a grass-killing herbicide, Gramin, at 1.5 L/ha (active ingredient: 50 g/L quizalofop-P-ethyl) and with the broadleaf herbicide Basagran at 2 L/ha (active ingredient: bentazone 480 g/l) + the adjuvant Break Thru at 100 ml/ha.

Weed control in the wheat and triticale crops was carried out using the herbicide Sekator Progress OD at 0.150 L/ha (amidosulfuron 100 g/L + iodosulfuron-methyl-Na 25 g/L + mefenpyr diethyl 250 g/L (safener)), applied post-emergence in the spring.

The mustard crop was treated with a pre-emergence herbicide immediately after sowing; the herbicide applied was Metax 500 SC at 1.5 L/ha (active ingredient: 500 g/L metazachlor). It is a selective herbicide for controlling annual monocotyledonous and dicotyledonous weeds.

To control monocotyledonous and dicotyledonous weeds in the field bean crop, the herbicide Challenge was applied pre-emergence at a rate of 4 L/ha (active ingredient: aclonifen 600 g/L).

The weed species (present prior to harvest) that were not controlled in the bean crop by the Challenge herbicide at 4 l/ha were: *Ambrosia artemisiifolia* and *Apera spica-venti*.

The buckwheat crop was not treated with herbicides because no selective and effective herbicide was found, and no herbicides are registered for this crop. Although it was not treated with herbicides, the buckwheat plants competed well with the existing weeds and were maintained through manual weeding.

Weed control in the chickpea, lentil, and lupin crops were carried out using the herbicide Challenge at 4 l/ha (active ingredient: aclonifen 600 g/l), applied pre-emergence. Challenge is registered for controlling annual dicotyledonous weeds and certain annual monocotyledonous weeds.

In lupin crops, as in the other legume crops included in the study, *Ambrosia artemisiifolia* poses the greatest problem in terms of weed infestation, since this weed is not controlled by the Challenge herbicide or by other herbicides.

The sorghum crop was treated pre-emergence with the herbicide Stomp Aqua at 3 l/ha (active ingredient: 455 g/l pendimethalin). During the early part of the growing season, a post-emergence herbicide application was carried out using Dicopur Top at 1 L/ha (344 g/L 2,4-D acid as dimethylamine salt and 120 g/L dicamba), a systemic herbicide, to control dicotyledonous weeds. These herbicides were highly effective, keeping the crop weed-free until harvest.

Monitoring and Controlling Specific Diseases and Pests

The fight against pests, which continue to significantly impact agricultural production, is an ongoing effort. Measures to control diseases and pests should be implemented as part of an integrated system based on knowledge of the specific characteristics of the disease or pest, the biology of the harmful agent, and the plant's phenological stage, in correlation and interdependence with environmental factors.

In clover cultivation, prevention of attacks by highly damaging pathogens in our region (*Sclerotinia trifoliarum*, Erikss), which are transmitted through soil and seed, was achieved by treating the seed with the fungicide Dividend M 030 FS (difenconazole 30 g/L) at a dose of 1.0 L/t (in a 1:10 dilution).

Prevention of soil- and seed-borne diseases (dowry and smut) in wheat was achieved by chemically treating the seed with the fungicide AMIRAL PROFFY 6FS at a dose of 0.5 L/t, in a 1:10 dilution. To combat the foliar pathogen complex, preventive and curative treatments were applied during phenophase BBCH 35–37 using the fungicide FALCON 460 EC at a dose of 0.8 L/ha diluted in 150 L/ha, and during the BBCH 55 growth stage using the fungicide Nativo PRO 325 SC at a dose of 0.6 l/ha.

Systemic diseases in triticale that are transmitted through seed and soil were controlled by applying preventive seed treatment with the fungicide AMIRAL PROFFY 6 FS (tebuconazole 60 g/L) at a dose of 0.5 L/t in a 1:10 dilution. The treatment was highly effective, with no ears showing symptoms of smut or bunt. Foliar disease infestation was very severe from the time of emergence, necessitating foliar treatments applied at BBCH stage 36 with the fungicide FALCON PRO at a dose of 0.8 L/ha, diluted in 150 L of water per hectare, and during the BBCH 55 phenological stage with the fungicide NATIVO PRO 325SC at a dose of 0.6 L/ha in 150 L of water per hectare.

The fava bean crop at the Livada Agricultural Research and Development Station enjoyed a remarkable growing season, characterized by optimal plant health. The seeds were treated preventively before sowing with the fungicide DIVIDEND M030 FS at a dose of 0.5 L/t, using a 1:10 dilution. This treatment provided effective protection against potential fungal diseases, preventing the emergence of any pathogens in the crop throughout the entire growing season.

Results and Discussion

The study did not record any instances of fungal or bacterial diseases throughout the entire growing season. Pathogens commonly found in fava bean crops, such as Ascochyta rabiei or Fusarium oxysporum, were not identified in the monitored plots, underscoring the effectiveness of the seed treatment and favorable agrotechnical conditions. The absence of any disease symptoms allowed healthy and vigorous plant growth, resulting in a fava bean crop that was free of phytosanitary issues.

However, the presence of a specific pest, Helicoverpa armigera, known for its impact on legume crops, including fava beans, was observed. Infestation by this pest was observed throughout the experiment, but it did not cause significant damage.

The bean crop in this area was significantly affected by a complex of pathogenic factors. Prior to sowing, the seeds were treated with the fungicide DIVIDEND M030 FS as a preventive measure against potential soil- or seed-borne pathogens. The crop was infested by the black beet aphid (Aphis fabae) at a 100% infestation rate. As a result of this massive infestation, multiple insecticide treatments were applied, including MAVRIK 2F at a dose of 0.2 L/ha in 150 L of water per hectare, MOSPILAN at 150 g/ha, and CIPERGUARD MAX at a dose of 40 mL/ha.

Figure 5. Image from the Bob experimental field

(Aphis fabae infestation)

The lentil crop at the Livada Agricultural Research and Development Station was in exceptional phytosanitary condition, due both to favorable agroclimatic conditions and to the phytosanitary measures implemented. Before sowing, the seeds were treated with the fungicide DIVIDEND M030 FS at a dose of 0.5 L/t, using a 1:10 dilution. This treatment played a key role in preventive protection against fungal diseases, ensuring optimal crop health throughout the entire growing season.

Throughout the growing season, no significant symptoms of fungal or bacterial infections were observed, and common pathogens such as Colletotrichum truncatum (anthracnose) or Fusarium spp. were absent from the lentil crop. The effectiveness of the fungicide treatment and continuous monitoring of plant health played a decisive role in preventing the development of pathogens, maintaining the lentil crop in optimal plant health.

The buckwheat crop was notable for its exceptionally favorable plant health status. The seeds were subjected to a preventive treatment with the fungicide DIVIDEND M030 FS, at a dose of 0.5 L/t and a dilution ratio of 1:10, ensuring the necessary protection against potential fungal infections that could affect the crop during its early stages of development.

Throughout the entire growing season, no problems related to fungal or bacterial diseases were reported. Buckwheat, known for its natural resistance to pathogens, showed no symptoms indicating the presence of specific pathogens, such as Alternaria or Botrytis, which frequently affect other crops. The complete absence of these diseases is due both to effective seed treatment and to favorable growing and maintenance conditions, which supported the plants' overall health.

Mustard was affected by the pathogens *Erysiphe communis*, which causes powdery mildew in cruciferous plants, and *Alternaria brasicae*, which causes black pod spot. Powdery mildew infection was observed on the leaves and flower stalks. The maximum level of infection was observed during the flowering stage of the plants, with a frequency of 100% and a severity ranging from 15.3% to 25.2%. Variations in plant density and agrochemical treatment did not result in differences in infection levels. Alternaria infection was more severe on the fruit clusters, with infection levels ranging from 7.3% to 10.1%, with no significant differences based on agrochemical treatment or plant density.

The crop was protected against pest attacks by applying three insecticide treatments designed to protect the leaves and flower clusters. The first treatment was carried out using MAVRIK 2F at a dose of 0.2 L/ha in 150 L of water per hectare. The treatment was intended to control leafhoppers (*Phyllotetra atra* and *Phyllotetra nemorum*), which cause damage to the leaves. Adults gnaw through the upper epidermis, creating small holes (1.5–2 mm in diameter); in the event of a severe infestation, the leaves dry out. At the time of treatment, there were 7–10 insects per plant.

The second treatment was aimed at controlling the pests mentioned in the first treatment, as well as the pest *Melighetes aenus*, which affects flower buds. MOSPILAN was applied at a rate of 150 g/ha. The number of insects per plant prior to treatment was 5–10. The staggered flowering of the plants and conditions favorable to the pest necessitated a new treatment with CIPERGUARD MAX at a dose of 40 ml/ha. No differences in pest infestation were observed based on the levels of plant density or agrochemical application.

Figure 6. Image from the Muștar experimental field

(Pest infestation)

In the field of plant health, a preventive seed treatment was applied to the lupin seeds to control soil- and seed-borne pathogens using the fungicide DIVIDEND M 030 FS (difenconazole 30 g/L) at a dose of 1 L/t in a 1:10 dilution. In the experimental plot treated with the seed treatment, lupin mosaic—a disease caused by Lupinus Virus 1, Mastenbroek—was observed. The percentage of virus-infected plants was 0.2–0.3%; no differences in infection rates were observed based on agrochemical treatment or plant density. Infected plants are smaller than healthy ones and have a stiff growth habit. The upper leaves are small, stiff, erect, and wrinkled, and exhibit light green (yellow) spots or streaks alternating with areas of normal color. The flowers of these plants abort at a rate of 70–80%. A large number of spindly, thread-like shoots form on the upper part of the stem, giving infected plants a bushy appearance. Brown necrotic spots appear along the shoots and on the leaf petioles. The disease is transmitted through seeds, and infection occurs via aphids. Control consists of removing plants showing mosaic symptoms from the crop.

Among the diseases caused by pathogenic fungi, fusarium wilt and anthracnose have been observed. Fusarium wilt, caused by the pathogen Fusarium spp., causes fusarium wilt in plants by attacking the roots, collar, and base of the stem, which rot, leading to the whitening and drying out of the plants. The disease is transmitted through seeds and soil, and the obvious wilting symptom manifests during the budding and flowering stages. The incidence of infection was below 0.3% (sporadic), with no difference observed based on plant density or the use of agrochemicals. The most dangerous disease affecting sweet white lupine—which in some years can compromise the entire crop—is anthracnose, caused by *Ascochyta lupinicola*. The disease initially manifests as circular, oval, or slightly elongated gray spots with reddish-brown margins. The most severe form occurs on flowering shoots, where the spots measure 15–30 mm, are brick-red in color, and result in tissue destruction at the site of infection and the bending or curving of the shoot.

Figure 7. Image from the Lupin experimental field

(Symptoms of anthracnose)

Fungicide treatment is highly effective only when applied preventively (before the disease appears). The treatment was applied in the pre-budding stage using MERPAN 80 WP at a dose of 1.5 kg/ha. With the fungicide treatment, the disease incidence rate was 1–2%, with no differences observed based on agrochemical application or plant density. No pest infestations affecting the crop were observed.

Grain sorghum is frequently attacked by the pathogen *Sphaceloteca sorghi*, which causes panicle smut. The infection is seed-borne and spreads via chlamydospores in the soil or on the seed. Control of this pathogen is only effective through preventive seed treatment. The treatment was carried out using the fungicide DIVIDEND M030 FS at a dose of 0.5 L/t in a 1:10 dilution. No smut infection was observed. During the growing season, primarily after the emergence of panicles, characteristic symptoms specific to a bacterial infection caused by *Xanthomosa holcicola* in association with *Pseudomonas anthropogoni* appeared on the leaves and leaf sheaths.

No foliar fungicide treatments were applied (the disease severity exceeded the PED only toward the end of the growing season). No differences in the degree of infection were observed based on agrochemical amendments or plant density.

The yields obtained for the crops studied are presented in Table 1,2:

Table 1. Yields obtained during the experimental period

Nr. Crt.	**Crop**	**Yield kg/ha $\bar{x}$ 2024, 2025**							**Yield difference ($\bar{x}$ Amended – $\bar{x}$ Unamended)%**
		Amended		**Unamended**		**Production difference (Amended – Unamended)**		**Yield difference ($\bar{x}$ Amended – $\bar{x}$ Unamended)**	
		D1	**D2**	**D1**	**D2**	**D1**	**D2**		
1	Wheat	6922	7002	4664	5045	2258	1957	2107	43,4
2	Triticale	6657	8108	6407	6994	250	1114	682	10,2
3	Mustard	158	249	101	299	57	-50	4	1,5
4	Broad bean	522	543	639	715	-117	-172	-144	21,3
5	Lentil	547	633	476	624	71	9	40	7,2
6	Buckwheat	676	768	592	748	84	20	52	7,8
7	Chickpea	740	836	652	861	88	-25	31	4,0
8	Lupin	1966	2545	1443	1754	523	791	657	41,1
9	Red clover (green fodder)	47250	56600	45050	54300	2200	2300	2250	4,5
10	Grain sorghum	4767	5833	4695	5602	72	231	151	2,9

D1 – density 1

D2 – density 2

Table 2. Yields obtained during the experimental period

Nr. Crt.	**Crop**	**Yield kg/ha $\bar{x}$ 2024, 2025**							**Yield difference ($\bar{x}$ D2- $\bar{x}$ D1) %**
		Amended		**Unamended**		**Yield difference (D2-D1)**		**Yield difference ($\bar{x}$ D2- $\bar{x}$ D1)**	
		D1	**D2**	**D1**	**D2**	**Amended**	**Unamended**		
1	Wheat	6922	7002	4664	5045	80	381	231	3,9
2	Triticale	6657	8108	6407	6994	1451	587	1019	15,6
3	Mustard	158	249	101	299	91	198	144	111
4	Broad bean	522	543	639	715	21	76	48	8,4
5	Lentil	547	633	476	624	86	148	117	23,0
6	Buckwheat	676	768	592	748	92	156	124	19,5
7	Chickpea	740	836	652	861	96	209	153	21,9
8	Lupin	1966	2545	1443	1754	579	311	445	26,1
9	Red clover(green fodder)	47250	56600	45050	54300	9350	9250	9300	20,1
10	Grain sorghum	4767	5833	4695	5602	1066	907	987	20,8

D1 – density 1

D2 – density 2

The current acidity of the soil samples was determined after the end of the growing season specific to each crop, using the 1:2.5 (m/v) soil-to-solution aqueous suspension method.

Current acidity, which is determined by the free hydrogen ions in the soil solution, has a direct influence on plant growth; however, it can serve only as a qualitative indicator and not for calculating the amendment dose. To quantitatively determine the amendment dose, potential acidity is used, which is determined by hydrogen (H^+) and aluminum (Al^{3+}) ions adsorbed onto the surface of colloidal particles (0.0002 mm).

Soil treatment with calcium amendments is carried out not as a source of nutrient ions, but to improve the ionic composition of the soil solution and the physicochemical and biological conditions in the soil, to increase the readily assimilable forms of certain nutrients, and to eliminate the toxic effects of certain components of the soil solution (Fe, Al).

Acidic agricultural soils in Romania cover approximately 5,700,000 ha (excluding forested areas), of which 30% is arable land. These soils formed on sedimentary rocks (loam, clay, alluvium) in areas of deciduous and coniferous forests with average annual precipitation ranging from 600 to 900 mm, of which over 30% falls in May and June, and the average annual temperature ranges from 6 to 10°C.

Figure 8, which presents the results of the chemical analyses, shows that lime application (1 t/ha in 2024 and 1 t/ha in 2025) causes the pH value to increase from 5.03 to 5.31.

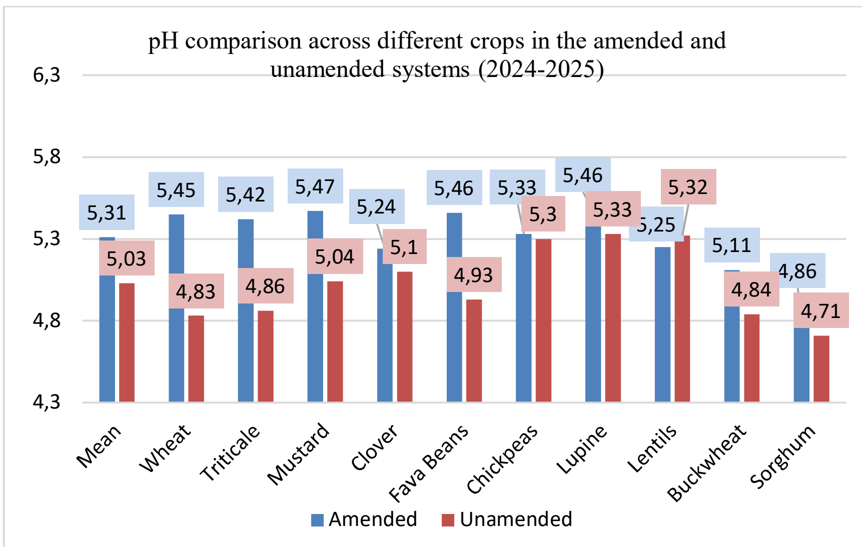

Figure 8. Comparison of pH levels for different crops in the amended and unamended systems

In the untreated plots, the soil reaction was classified as strongly acidic for wheat, triticale, fava beans, buckwheat, and sorghum, and as moderately acidic for mustard, clover, chickpeas, lupine, and lentils.

The application of Teracalco at a rate of 1 t/ha in 2024 and 2025, intended as a moderate corrective measure, partially neutralizes the acidity, causing the pH value to increase by an average of 0.28 units and changing the soil classification from strongly acidic to moderately acidic for wheat, triticale, fava beans, and buckwheat, with the exception of fields where sorghum was grown, which remain classified as strongly acidic soils.

Crops, in interaction with the soil's mineralogy and organic matter, result in small pH differences, with positive values for lupine, chickpeas, mustard, and lentils, and negative values for buckwheat and sorghum (Figure 9)

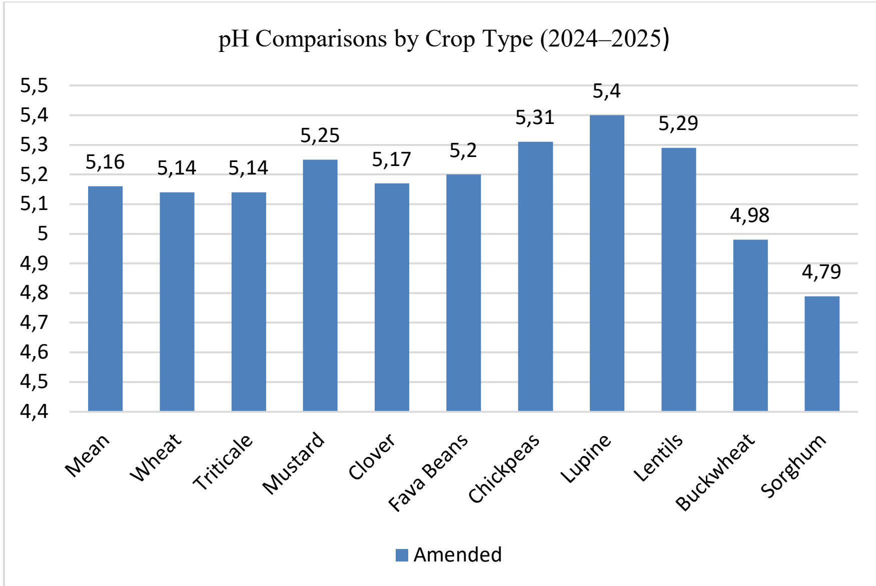

Figure 9. Comparison of pH across different crops

X-ray diffraction analysis (Crăciun, 1987) revealed that the soils at Livada are dominated by minerals with low cation exchange capacity, such as illite (20–50) and chlorite (10–40), accompanied by kaolinite (3–15).

The effect of soil amendment on clay minerals is more pronounced than that of fertilization. Depending on the pH, variations in the content of these minerals influence the evolution of illite/chlorite in the soil, in correlation with the ionic nature of the environment as expressed by the pH.

Conclusions

Under the conditions of acidic, white luvisol soils in northwestern Romania, due to the high level of infestation and successive accumulation of seeds from weeds that pose a problem for all legume crops, the limiting and problematic factor is weed control, particularly of the species *Ambrosia artemisiifolia*, for which the range of herbicides is very limited or completely absent.

The results obtained confirm the need to continue this type of study, as they provide a solid scientific basis for technological recommendations aimed at increasing resource efficiency, improving soil fertility, and supporting sustainable agricultural practices.

Summary

The Livada Agricultural Research and Development Station is located in northwestern Romania, on the Someș Plain, a fluvial alluvial plain, and is bounded by the geographic coordinates 47° 51' 34" north latitude and 23° 07' 31" east longitude, at an elevation of 133 m.

The research focused on optimizing the use of acidic soils by introducing new crop species—buckwheat, chickpeas, mustard, sweet sorghum, fava beans, and lentils—alongside established crops in the area—red clover, lupine, triticale, and acid-tolerant wheat varieties.

Establishing crop management practices specific to each species to enable the optimal realization of production potential on acidic soils. Reducing weed infestation, diseases, and pests, as well as increasing nutrient content through the use of new crop species: This is possible due to their fungicidal and nematicidal effects (mustard with a high hydrocyanic acid content, sorghum for *Diabrotica virgifera virgifera*, as well as improved competition with area-specific weeds). We

believe that this objective will lead to a reduction in the costs of controlling diseases, weeds, and pests, as well as a reduction in the need for chemical fertilizers.

Keywords: acidic soil, new species, technological links, yields

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