

The influence of soil management practices on biochemical characteristics of soil in plum orchard

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ABSTRACT

Soil management practices such as low or no tillage, mulching and grass cover significantly influence the biochemical characteristics of soil in plum orchards, generally by increasing soil organic carbon, humus and nutrients, enhancing soil aggregation, and improving water infiltration and storage. Research on the application of eco-schemes regarding permanent crops in fruit orchards in the context of ensuring biodiversity and environmental conservation was carried out in a plum field trial located at ICDP Pitesti-Maracineni. The following experimental variants were established: 1. For the interval between the rows of trees, three variants (V1 – clean soil; V2 – spontaneous grass cover; V3 – artificial grass cover (*Lolium perenne*, *Festuca rubra*, *Medicago sativa*, *Lotus corniculatus*); 2. On the row of trees, four variants (V1 – clean soil; V2 – grass cover with clover „Nanissimo”; V3 – herbicide; V4 – mulching). The following biochemical indicators were determined in 2024 and 2025 years: pH, organic carbon, humus, total nitrogen, mobile phosphorus and mobile potassium content. Compared with the results of soil chemical analyses performed before the installation of the experimental variants, it was observed: an increase in pH values, the soil going from an acidic reaction to a neutral one; an increase in soil content in humus, total nitrogen, mobile phosphorus and mobile potassium in the grass cover and mulching variants.

Keywords: soil, tillage, grassing, mulching, herbicides, chemical composition.

INTRODUCTION

In Romania, the plum is the dominant species, the area cultivated with plum is 66,740 ha, which ensures a production of 645,090 t. Romania holds the 2nd place in the world after China and the first one in Europe (FAO data, 2025).

Soil management practices in plum orchards are similar to those applied to other fruit species and are specific to a conventional system. Intensive practices like conventional tillage and monoculture often lead to soil degradation, causing reductions in organic matter and nutrients and stability due to increased erosion and oxidation (Bezabih *et al.*, 2016; Sinore *et al.*, 2022).

Soil is an important resource for sustainable agriculture that influences the ecosystem and orchard productivity (Herencia *et al.*, 2021; Prasad *et al.*, 2021; Rusu *et al.*, 2025). In fruit growing system, including plum orchards, soil quality and soil content in nutrients influence directly growth and yielding capacity (Naraine, 2022; Poonia *et al.*, 2024; Rusu *et al.*, 2025). Soil degradation due to improper practices is a priority goal in agriculture management in Europe and also in Romania (Bezabih *et al.*, 2016; Herencia *et al.*, 2021; Sinore *et al.*, 2022;

Haruna *et al.*, 2025). To avoid soil degradation, many countries have implemented a series of strategies, action plans, programs and rules to improve conservation practices. One of the conservation practices is the application of cover crops in agricultural culture (Haruna *et al.*, 2025).

Cover crops have been used in agriculture for many years ago to improve soil nutrient content. In the mid-twentieth century, these soil maintenance practices were less commonly used due to the excessive use of fertilizers (Haruna *et al.*, 2025). The grass cover (natural or artificial) between the rows in orchards can provide several benefits to the soil: improve the fertility; increase organic matter and the content in nutrients; reduce the erosion; improve the microbial activity (Hoagland *et al.*, 2008; Simoes *et al.*, 2014; Singh *et al.*, 2016; Xiaozhu *et al.*, 2016; Li *et al.*, 2022; Răduțoiu *et al.*, 2023; Ma *et al.*, 2024; Haruna *et al.*, 2025). Some species, such as clover (*Trifolium repens* L.), alfalfa (*Medicago sativa* L.), perennial ryegrass (*Lolium perenne* L.), and tall fescue (*Festuca arundinacea*) are frequently cultivated between the rows in the orchards, depending on the pedo-climatic conditions of the area (Răduțoiu *et al.*, 2023; Ma *et al.*, 2024).

In Romania, the Ministry of Agriculture and Rural Development, within the framework of the National Strategic Plan 2023-2027 (PNS), has implemented the PD-06 eco-scheme – „Grassing the interval between the rows in orchard, vineyard, nursery and hop crops”, which offers viable solutions to active farmers, who practice modern, but at the same time environmentally friendly fruit growing.

Another important conservation practice is mulching, which prevents soil erosion, improves soil structure, fertility and nutrients, controls weeds and microbial activity (Haruna *et al.*, 2025; Guo *et al.*, 2024).

Taking into account the ones presented above, this paper aims to evaluate the effect of different soil management practices on biochemical characteristics of soil in a plum field trial located at ICDP Pitesti-Maracineni.

MATERIALS AND METHODS

Field trial. Research was carried out in a plum field trial established in 2022 in the Genetic and Breeding Department of the Research Institute for Fruit Growing Pitesti, Romania (central part of Romania 44°53'56" Northern latitude, and 24°51'35" Eastern longitude). Soil is medium-textured, heavy-clay, with low humus content.

Experimental variants. In 2024 - 2025, the following experimental variants were applied:

1. On the interval between the rows of trees, three variants: V1 - clean soil; V2 - spontaneous grass cover; V3 - artificial grass cover (*Lolium perenne*, *Festuca rubra*, *Medicago sativa*, *Lotus corniculatus*);
2. On the row of trees, four variants: V1 – clean soil; V2 – grass cover with clover „Nanissimo”; V3 – herbicide; V4 – mulching.

Analysis of biochemical characteristics.

Before applying the experimental variants, soil samples collected at two depths (0 - 20 cm and 20 - 40 cm) were chemically analyzed according to the SR ISO 11464:1998 standard. The standard establishes the pretreatments required for soil samples before being subjected to chemical analyses and describes five types of sample pretreatment: drying, crushing, sieving, separation and grinding. The following analyses were performed on soil samples, both before and after the application of the experimental variants: soil pH was measured by potentiometric method in soil: water solution mixture=1:2.5 according SR ISO 7184-13: 2001; organic carbon according to the Walkley Black method, modified by Gogoasă, respectively humus by calculation using the formula $\text{Humus \%} = C_{\text{org}} \times 1.724$ (STAS 718/21-82); the total nitrogen was determined by the Kjeldahl method (Kjeldahl, 1983); the mobile phosphorus was determined spectrophotometrically, according STAS

7184/19-82; the mobile potassium was determined flamephotometrically from the same extract obtained for phosphorus determination, according STAS 7184/18-80.

Statistical analysis. The data were included in an Excel database and statistically interpreted with the SPSS 14.0 program, which uses the Duncan test (multiple t-tests) at a 0.05 level of probability.

RESULTS AND DISCUSSIONS

Chemical analyses before the installation of the experimental variants

Chemical analyses carried out before the experiments were set up revealed that the soil reaction was slightly acidic and the humus content was relatively low: 1.50% at the surface, decreasing to 1.27% at 40 cm depth. The soil had a low content of total nitrogen (0.180% at the surface and 0.153% at 40 cm depth). Also, the mobile phosphorus was low, 18.10 mg/100 g soil at the surface, decreasing to 4.10 mg/100 g soil at 40 cm depth. The content of mobile potassium was 33.2 mg/100 g soil in the superficial horizon and 16.60 mg/100 g soil at 40 cm depth (Table 1).

Table 1. The main chemical components of the soil before the installation of the experimental variants

No.	Horizon	Depth (cm)	pH	N (%)	P ₂ O ₅ mg/kg soil	K ₂ O mg/kg soil	Humus %
1	Aa	0-20	5.5	0.180	18,10	33,20	1,50
2	A1	20-40	6.0	0.153	4,10	16,60	1,27

Chemical analyses after the installation of the experimental variants

After the installation of the experimental variants, soil chemical analyses were performed to determine the influence of these soil maintenance variants on the agrochemical indicators of the soil. Soil samples were collected from the plum field trial at a depth of 20 cm, on each experimental variant.

Soil pH. Fruit trees grow and develop properly on neutral soils, with a pH between 6.3 and 7.5. The consumption of nutrients by fruit trees is influenced by the pH of the soil. Thus, at a pH between 7 and 8.5, fruit trees easily assimilate calcium and magnesium; at a pH between 6.0 and 6.8, nitrogen is assimilated; at a pH of 6.5 to 7.5, phosphorus is assimilated; at a pH higher than 6, potassium is easily assimilated (Nagy *et al.*, 2022).

In the plum field trial, the soil pH showed a significant difference between the experimental variants, both on the row and on the interval. On the row, pH average values ranged between 7.04 in variant 2 – grass cover with clover „Nanissimo” and 6.28 in variant 1 – clean field, with an average value of 6.57 (Table 2). On the interval between rows, pH had values ranging between 6.27 in variant 1 – clean soil and 6.53 in variant 3 – artificial grass cover, with an average value of 6.44 (Table 3).

Compared with the results of soil chemical analyses performed before the installation of the experimental variants, it is observed an increase in pH values of the soil going from an acidic reaction to a neutral one. The best results were obtained in the case of variant 2 - grassing with dwarf clover on the row and in the case of variants 2 - spontaneous grassing and 3 - artificial grassing on the interval between the rows.

It can be observed that in the two clean soil variants, both in the row direction and in the interval, the pH values were lower. It is known that the lowest pH values on the surfaces maintained as clean soil are due to soil erosion and the washing out of soluble basic cations, while the concentration of hydrogen ions increases in the soil solution, which leads to a decrease in pH. Our results are similar to those obtained by other researchers (Bezabih *et al.* 2016; Sinore *et al.*, 2022; Poonia *et al.*, 2024).

Humus and organic carbon. Humus is a fundamental constituent of soil that contributes to the formation of structure, water absorption, adsorption and exchange of cations, and the

provision of nutrients resulting from the mineralization of organic matter (Dumitru *et al.*, 2011).

The organic carbon and humus content of soil were significantly affected by soil management practices. On the row, the humus content of soil ranged between 2.64% in variant 2 – grass cover with clover „Nanissimo” and 1.88% in variant 3 – herbicide; the soil organic carbon ranged between 1.53% in variant 2 – grass cover with clover „Nanissimo” and 1.09% in variant 3 – herbicide (Table 2). On the interval between rows, the humus content ranging between 2.05% in variant 1 – clean soil and 2.43% in variant 3 – artificial grass cover; the soil organic carbon ranged between 1.19% in variant 1 – clean soil and 1.41% in variant 3 – artificial grass cover (Table 3).

Compared with the results of soil chemical analyses performed before the installation of the experimental variants, it is observed an increase of humus content of soil, from 1.50% to 2.14% on the row and 2.23% on the interval.

Both on the row direction and on the interval, the soil organic carbon and humus content were lower in the variants maintained as clean soil and herbicide and higher in the grassing and mulching variants.

The low values of humus and organic carbon in the herbicide variant can be explained by the fact that herbicides can hurt the soil. Thus, they can negatively influence the activity of soil microorganisms responsible for the decomposition of organic matter. They can also block the release of carbon, and in some cases, contribute to the accumulation of carbon by inhibiting mineralization or by incomplete decomposition of organic matter. All of this prevents the formation of humus on the long term with consequences on soil fertility. The same results regarding the influence of herbicides on soil fertility were also reported by Meena *et al.* in 2023 and by Ikioukenigha *et al.* in 2024.

The same explanation can be given in the case of variant 1 – clean soil, where the values of humus and organic carbon were low. Maintaining the soil as clean of weeds in orchards, although reducing competition for water and nutrients, can decrease humus content on the long term, as it removes organic matter from the surface and destroys the microorganisms that contribute to humus formation and affecting soil fertility (Bezabih *et al.* 2016; Sinore *et al.*, 2022).

On the other hand, the results regarding the high soil content in humus and organic carbon in the grassing and mulching variants can be explained by good interaction between biomass and grassing, respectively the cover crop can lead to an increase in the organic carbon content and implicitly in humus (Herencia *et al.*, 2021; McClelland *et al.*, 2021; Guo *et al.*, 2024; Haruna *et al.*, 2025; Rusu *et al.*, 2025).

Macronutrients (nitrogen, phosphorus, and potassium).

The content of soil in *total nitrogen* is generally low, being linked to soil organic matter and is important in plant nutrition (Dumitru *et al.*, 2011).

In both situations, in row and in interval, the content of soil in total nitrogen was low. On the row, the total nitrogen content ranged between 0.208% in variant 2 – grass cover with clover „Nanissimo” and 0.146% in variant 1 – clean soil (Table 2). On the interval between rows, the total nitrogen content ranged between 0.158% in variant 1 – clean soil and 0.213% in variant 3 – artificial grass cover (Table 3).

Compared with the results of soil chemical analyses performed before the installation of the experimental variants, it is observed a very small increase, from 0.180% to 0.185% on the row and 0.193% on the interval.

It is also noted that in the variants where grassing and mulching were practiced, the content of soil in total nitrogen was somewhat higher than in the clean soil and herbicide variants due to the poor nutrient management in the last two variants. The presence of vegetation accords soil adequate cover, thereby reducing soil loss and enhancing soil water storage would contribute to soil organic matter and nitrogen input in the soil.

Phosphorus is important in plant growth and fruiting. The solubility of phosphorus differs depending on the soil reaction and the chemical combinations in which it is found (Dumitru *et al.*, 2011).

The mobile phosphorus was significantly affected by practice management. On the row, the mobile phosphorus content ranged between 30.81 mg/kg in variant 2 – grass cover with clover „Nanissimo” and 21.19 mg/kg in variant 1 – clean soil (Table 2). On the interval between tree rows, the mobile phosphorus content ranged between 16.21 mg/kg in variant 1 – clean soil and 19.70 mg/kg in variant 3 – artificial grass cover (Table 3).

As in the case of the other chemical indicators analyzed, a slight increase in the soil content of mobile phosphorus is observed compared to the initial chemical analyses, from 18.10 mg/kg to 25.41 mg/kg on the row and 18.28 mg/kg on the interval.

In the variants where grassing and mulching were applied, the mobile phosphorus content was higher than in the clean soil variant, because these soil maintenance practices add minerals and organic matter to the soil and better phosphorus fixation.

Table 2. Influence of experimental variants (on tree row) on the main soil components in the plum field trial

Year	Variant	pH	Humus (%)	Organic carbon (%)	Total nitrogen (%)	Mobile phosphorus (mg/kg)	Mobile potassium (mg/kg)
2024	V1 – clean soil	6.24 c	1.86 c	1.08 c	0.135 c	20.56 c	50.20 c
	V2 – grass cover with clover	6.96 a	2.48 a	1.44 a	0.200 a	29.25 a	76.35 b
	V3 - herbicide	6.24 c	1.75 d	1.02 d	0.172 b	23.47 b	38.45 d
	V4 - mulching	6.42 b	2.03 b	1.18 b	0.198 a	23.82 b	105.84 a
2025	V1 – clean soil	6.32 d	1.95 c	1.13 c	0.157 d	21.83 c	70.49 c
	V2 – grass cover with clover	7.13 a	2.79 a	1.62 a	0.215 a	32.36 a	95.83 b
	V3 - herbicide	6.45 c	2.00 c	1.16 c	0.189 c	25.48 b	67.96 d
	V4 - mulching	6.76 b	2.27 b	1.32 b	0.209 b	26.51 b	117.34 a
2024-2025	V1 – clean soil	6.28 c	1.90 c	1.11 c	0.146 c	21.19 c	60.34 c
	V2 – grass cover with clover	7.04 a	2.64 a	1.53 a	0.208 a	30.81 a	86.09 b
	V3 - herbicide	6.35 c	1.88 c	1.09 c	0.181 b	24.48 b	53.07 c
	V4 - mulching	6.59 b	2.15 b	1.25 b	0.204 a	25.16 b	111.59 a
Average		6.57	2.14	1.25	0.184	25.41	77.77

*Duncan multiple ranges test. Numbers followed by the same letter within a column are not significantly different ($P \leq 0.05$).

Potassium, along with nitrogen and phosphorus, is one of the macroelements with an important role in plant nutrition. The part of potassium that becomes accessible to plants depends on the soil clay content, organic matter, soil reaction and soil water regime (Dumitru *et al.*, 2011).

In our experience, on the row, the mobile potassium content varied between 111.59 mg/kg in variant 4 – mulching and 53.07 mg/kg in variant 3 – herbicide (Table 2). On the interval between rows, the mobile potassium content varied from 71.49 mg/kg in variant 1 – clean soil to 84.95 mg/kg in variant 3 – artificial grass cover (Table 3). The addition of potassium by the cover crops was higher compared to the initial analyses carried out before the installation of the experiment and compared to the other chemical parameters analysed, from 33.20 mg/kg to 77.77 mg/kg on the row and 78.08 mg/kg on the interval.

Similar results regarding the content of soil in total nitrogen, mobile phosphorus and mobile potassium were found by Bezabih *et al.* (2016), Herencia *et al.* (2021), Sinore *et al.* (2022), Poonia *et al.* (2024), and Haruna *et al.* (2025).

From one year to the next (2025 compared to 2024), an increase in soil organic carbon, humus, total nitrogen, mobile phosphorus and mobile potassium content can be observed, which confirms that the continuous addition of biomass can improve the content of soil in biochemical indicators by prolonged practice.

Table 3. Influence of experimental variants (on the interval between the rows) on the main soil components in the plum field trial

Year	Variant	pH	Humus (%)	Organic carbon (%)	Total nitrogen (%)	Mobile phosphorus (mg/kg)	Mobile potassium (mg/kg)
2024	V1-clean soil	6.21 c	1.91 c	1.11 c	0.139 c	15.47 b	62.35 c
	V2-spontaneous grass cover	6.46 b	2.10 b	1.22 b	0.195 b	18.23 a	67.52 b
	V3-artificial grass cover	6.48 a	2.29 a	1.33 a	0.198 a	19.15 a	72.46 a
2025	V1-clean soil	6.33 b	2.19 c	1.27 c	0.176 c	16.95 b	80.63 c
	V2-spontaneous grass cover	6.56 a	2.34 b	1.36 b	0.220 b	19.61 a	88.09 b
	V3-artificial grass cover	6.58 a	2.57 a	1.49 a	0.227 a	20.24 a	97.44 a
2024-2025	V1-clean soil	6.27 b	2.05 b	1.19 b	0.158 b	16.21 b	71.49 a
	V2-spontaneous grass cover	6.51 a	2.22 b	1.29 b	0.208 a	18.92 a	77.81 a
	V3-artificial grass cover	6.53 a	2.43 a	1.41 a	0.213 a	19.70 a	84.95 a
	Average	6.44	2.23	1.30	0.193	18.28	78.08

*Duncan multiple ranges test. Numbers followed by the same letter within a column are not significantly different ($P \leq 0.05$).

However, taking into account the classification scale of the Research Institute for Pedology and Agrochemistry Bucharest (1976), the soil on which the experiments are located falls into class 2 – 3 in terms of humus and carbon content, respectively, low to medium supply (Dumitru *et al.*, 2011). According to the classification scale of Bogaci (1981), the soil is poorly supplied with total nitrogen and mobile phosphorus and medium supplied with mobile potassium (Dumitru *et al.*, 2011)..

Correlations between the main traits

The statistical analyses revealed significant correlations between pH, content of soil in humus, organic carbon and nutrients under varying management practices, which demonstrated that different maintenance practices play an important role in improving soil fertility and optimizing nutrient cycling (Tables 4 and 5). Similar trends are observed by Rusu *et al.* in 2025 in a plum orchard from the Moldavian Plateau.

Table 4. The Pearson Correlations between the characteristics studied (on the row)

Indicator	pH	Humus	Organic carbon	Total nitrogen	Mobile phosphorus	Mobile potassium
pH	1	0.976**	0.977**	0.786**	0.927**	0.581**
Humus	0.976**	1	1.000**	0.728**	0.903**	0.588**
Organic carbon	0.977**	1.000**	1	0.730**	0.903**	0.589**
Total nitrogen	0.786**	0.728**	0.730**	1	0.837**	0.738**
Mobile phosphorus	0.927**	0.903**	0.903**	0.837**	1	0.465*
Mobile potassium	0.581**	0.588**	0.589**	0.738**	0.465*	1

* Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed);

Significant correlations were observed between: pH and nitrogen ($r=0.786$ on the row and $r=984$ on the interval); pH and phosphorus ($r=0.927$ on the row and $r=875$ on the interval); pH and potassium ($r=0.581$ on the row and $r=724$ on the interval), the consumption of nutrients by fruit trees being influenced by the pH of the soil. It is known that at a pH above 6, nitrogen, phosphorus and potassium are easily assimilated. Significant correlations were also recorded between humus and organic carbon content, given that humus is a fraction of

organic carbon ($r=1.000$ both on the row and on the interval). Correlations between total nitrogen and mobile phosphorus ($r=0.837$ on the row and $r=0.896$ on the interval) and mobile potassium ($r=0.738$ on the row and $r=0.796$ on the interval) indicate a strong nutrient interdependence within the soil management practices. Recent studies by Rusu *et al.* (2025) further highlight that nitrogen availability supports the efficient utilization of phosphorus and potassium.

Table 5. The Pearson Correlations between the characteristics studied (on the interval)

Indicator	pH	Humus	Organic carbon	Total nitrogen	Mobile phosphorus	Mobile potassium
pH	1	0.867**	0.867**	0.984**	0.875**	0.724**
Humus	0.867**	1	1.000**	0.905**	0.832**	0.911**
Organic carbon	0.867**	1.000**	1	0.905**	0.835**	0.911**
Total nitrogen	0.984**	0.905**	0.905**	1	0.896**	0.796**
Mobile phosphorus	0.875**	0.832**	0.835**	0.896**	1	0.672**
Mobile potassium	0.724**	0.911**	0.911**	0.796**	0.672**	1

** Correlation is significant at the 0.01 level (2-tailed).

CONCLUSIONS

This study underscores the importance of different management practices in improving the soil fertility and the content in nutrients within the plum orchard from ICDP Pitesti-Maracineni.

Compared with the results of soil chemical analyses performed before the installation of the experimental variants, the following results were obtained: an increase in pH values (from 5.5 to 6.59), the soil going from an acidic reaction to a neutral one; an increase in soil content in humus (from 1.5% to 2.80%, respectively 2.57%), total nitrogen (from 0.180% to 0.215%, respectively 0.227%), mobile phosphorus (from 18.10 mg/kg soil to 32.36 mg/kg soil, respectively 20.25 mg/kg soil) and mobile potassium (from 33.20 mg/kg soil to 95.83 mg/kg, respectively 97.44 mg/kg) in the clover grassing variant on the row and respectively in the artificial grassing variant on the interval. Also, in the mulch variant, good results were recorded regarding soil pH (6.59), humus content (2.15%), organic carbon (1.25%), total nitrogen (0.204%), mobile phosphorus (25.16 mg/kg) and potassium (111.19 mg/kg).

The statistical analyses revealed significant correlations between pH, content of soil in humus, organic carbon and nutrients under varying management practices, which demonstrated that different maintenance practices play an important role in improving soil fertility and optimizing nutrient cycling.

ACKNOWLEDGEMENTS

This research was supported by a sectoral project ADER 6.1.9/18.07.2023 - The influence of the application of eco-schemes regarding permanent crops in fruit orchards in the context of ensuring biodiversity and environmental impact, supported by the Ministry of Agriculture and Rural Development.

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