Doi: 10.46793/MAK2026.175L

THE EFFECT OF SELECTED WEED CONTROL MEASURES IN ANGELICA (*ANGELICA ARCHANGELICA* L.) CROP ON SOIL pH

Jovan Lazarević*, Dragana Stevanović, Isidora Knežević, Aleksa Đukić, Helena Todorović

Research and Development Institute “Tamiš”, Pančevo, Serbia,
***Corresponding author: lazarevic@institut-tamis.rs**

Abstract: A two-year field experiment evaluated the effects of different weed control measures (organic and synthetic mulches, herbicides, and controls) on soil pH in angelica (*Angelica archangelica* L.) cultivation. Most treatments did not significantly affect soil pH at the 0 - 30 cm depth. However, sawdust mulch consistently caused the greatest reduction in soil pH in both experimental seasons, indicating a pronounced acidifying effect. In addition, silver-brown polyethylene mulch foil resulted in a statistically significant pH decrease, likely due to enhanced organic matter decomposition and accumulation of organic acids. These findings highlight the importance of mulch selection, as certain materials can alter soil chemical properties and should be considered in sustainable angelica production systems.

Keywords: Soil pH, *Angelica archangelica*, Mulches, Herbicides

INTRODUCTION

Angelica (*Angelica archangelica* L.) is a biennial or perennial medicinal and aromatic plant belonging to the family *Apiaceae*, originating from Iceland and Greenland (Kišgeci, 2002; Stepanović and Radanović, 2011). It is characterized by a highly developed root system, in which the largest amount of essential oil is concentrated, making this plant primarily cultivated for that purpose (Stepanović and Radanović, 2011). It is planted in autumn from transplants, and the root is harvested in the autumn of the following year. If cultivated for seed production, exploitation lasts two years, as the flowering stem is formed in the spring of the second year (Kišgeci, 2002; Stepanović and Radanović, 2011). The essential oil is an ingredient in various cosmetic products, pharmaceuticals, strong alcoholic beverages, and others (Bhat et al., 2011), and is highly valued and in demand on the market. Plantation production of angelica faces numerous challenges, one of the most significant being effective weed control. Given the limited possibilities for herbicide application in such crops, the potential use of mulches as a non-chemical weed control measure was also investigated. In addition to their effects on weeds, mulches can have both direct and indirect effects on the crop through their influence on the soil.

These weed control methods can be useful on multiple aspects: mulching enacts a direct mechanical pressure on the ground (Ferguson et al., 2008) and prevents or postpones weed’s seed germination and emergence, thus providing crops with a competitive advantage, by creating favorable conditions for their development. Meanwhile, it indirectly regulates the soil pH and humidity, prevents temperature oscillations, and reduces pest and disease incidence (Kader et al., 2017; Xianchen et al., 2020; Pavlů et al., 2021). Also, mulch usage is recognized as an effective crop production cultivation strategy used in the face of climate change-related extreme weather conditions (increasing air temperatures, relatively little precipitation, heavy rainfalls) (Lalljee, 2013; Iriany et al., 2018). Its efficiency in weed control and effect on soil properties depends on the type of material used for mulching (organic or synthetic) and its thickness and durability within the application period (Kasirajan and Ngouajio, 2012; Lazarević et al., 2020; Dragumilo et al., 2023), so two organic (wheat straw and sawdust) and two synthetic (black agrotextile water permeable and silver-brown waterproof foil) mulches were included in this study, as well as two herbicides: metamitron and aclonifen. Bearing in mind the fact that these weed control measures may also affect the cultivated plant, this study aimed to examine their effect on soil pH, as this is one of the most important parameters that determines and influences many processes in the soil and, consequently, in the cultivated plant.

MATERIAL AND METHODS

The field trial was conducted in Kujavica village (N: 4947855; E: 404266), near the city of Šabac (Vladimirci municipality, North-West Serbia), on semi-clay soil (chemical analysis was conducted before planting, Table 1). The experiment was carried out during two consecutive years: the first experimental season (I season: November 29, 2019 - October 27, 2020), and the second experimental season (II season: November 27, 2020 - November 03, 2021). The closest weather station provided monthly means meteorological data, Sremska Mitrovica (<50 km), and it is shown in Table 2.

Table 1. Soil chemical analysis results before planting

pH		$CaCO_3$	Hummus	N	P_2O_5	K_2O
H_2O	KCl	(%)	(%)	(%)	(mg/100g)	(mg/100g)
6.20-6.35	5.10-5.50	0.00	2.24-2.45	0.15-0.17	58.00-63.10	128.00-131.00

Table 2. Meteorological data during the period of field trials

Month	Temperature (°C)		Rainfall (mm)		Relative humidity (%)	
	2019/2020	2020/2021	2019/2020	2020/2021	2019/2020	2020/2021
October	13.2	12.5	8.6	71.6	72	82
November	10.8	6.7	9.4	13.3	80	90
December	4.1	4.9	18.0	74.1	87	89
January	0.5	2.7	23.9	37.7	89	88
February	5.8	4.7	56.1	49.1	75	81
March	7.5	5.5	39.1	38.0	71	72
April	12.5	9.3	5.9	38.2	54	72
May	15.9	16.2	66.3	49.0	70	66
June	20.1	22.7	70.5	7.2	76	60
July	21.8	24.5	44.1	105.9	72	66
August	22.9	21.4	104.1	30.1	74	67
September	18.7	17.5	33.4	7.8	68	67
Oktober	12.5	10.2	71.6	71.6	82	77
November	6.7	7	13.3	163.1	90	87

A total of eight treatments were included in the two-year field experiments (2019-2021) (Picture 1): two synthetic mulches, two organic mulches, two herbicides, and two controls.

The treatments were as follows:
T1: Black, agrotextile, water-permeable mulch foil (applied layer thickness: 1 mm; specific weight: 90 g m^{-2}; manufacturer: Ginegar Plastic Products Ltd., Israel),
T2: Silver - brown plastic, water-impermeable mulch film (applied layer thickness: 25 μm; manufacturer: Ginegar Plastic Products Ltd., Israel),
T3: Sawdust (mixture of black locust and oak; applied layer thickness: approximately 7-8 cm),
T4: Wheat straw (applied layer thickness: approximately 10 cm),
T5: Herbicide metamitron (product: "Metak 700 SC", Galenika Fitofarmacija; application rate: 4 L ha^{-1}),
T6: Herbicide aclonifen (product: "Challenge 600 SC", Bayer; application rate: 1 L ha^{-1}),
T7: Regularly hand-weeded control,
T8: Weedy (untreated) control.

Picture 1. Experimental field assay

The tested mulches were applied manually in early spring, at the onset of vegetation. Herbicides were applied foliarly, also in spring, when the weeds were at the 2-4 leaf growth stage. Application was carried out using a backpack battery-powered sprayer of the "AGM" brand, with a water volume of 300 L ha^{-1} at a pressure of 4 bar. The positive control was regularly maintained weed-free, while the negative control was left weedy throughout the entire duration of the field experiment. At the end of the growing season, after harvesting the angelica roots, soil samples were taken from a depth of 0-30 cm to determine pH values and to identify potential differences among treatments. The analysis was conducted as follows: after drying at a temperature not exceeding 40°C, soil samples were ground in a mill to a particle size of 2 mm. Subsequently, 5 mL of the ground soil was transferred into a sample bottle, with the addition of 25 mL of KCl or distilled H_2O, depending on which pH value was being measured. Then, the suspension was mixed for 60 minutes, after which pH was measured using a previously calibrated pH-meter with buffer solutions at a temperature of 20°C ± 2°C. Once equilibrium was established, the values were read and recorded to two decimal places.

Field trials were set up according to the experimental design completely randomized block system, in three replications. All statistical analysis was performed using IBM SPSS Statistics version 25.0 for Windows. Logarithmic transformation of the raw data was used for checking the homogeneity of the analyzed groups. One-way ANOVA was applied to the data and was performed to test the effect of four mulch treatments and two controls, and their interactions. Multiple comparisons were made using Duncan's test to detect significant differences between the arithmetic means of weed biomasses and root yields ($p < 0.05$).

RESULTS AND DISCUSSION

Based on the results of soil pH measurements at the end of the growing seasons (Table 3), conducted to record potential changes compared with the values obtained before the start of the experimental seasons, it can be observed that soil pH was very similar across all tested treatments, except for treatment T3 (sawdust), where the lowest pH values were recorded in both experimental seasons (Figure 1, 2). Depending on whether the measurements were performed in KCl or H2O, pH values in the first year ranged from 4.95 (KCl) to 5.69 (H_2O), and in the second year from 4.87 (KCl) to 5.56 (H_2O).

Table 3. Soil pH at the end of the first (A) and the second (B) experimental season

	A			B	
Treatments	**pH (KCl)**	**pH (H2O)**	**Treatments**	**pH (KCl)**	**pH (H2O)**
T1	6.12	6.84	**T1**	5.77	6.41
T2	5.92	6.54	**T2**	5.86	6.53
T3	4.95	5.69	**T3**	4.87	5.56
T4	6.09	7.04	**T4**	5.91	6.8
T5	6.17	6.85	**T5**	6.35	6.88
T6	6.25	7.03	**T6**	5.87	6.45
T7	6.28	6.00	**T7**	6.21	6.20
T8	6.24	6.99	**T8**	5.82	6.25

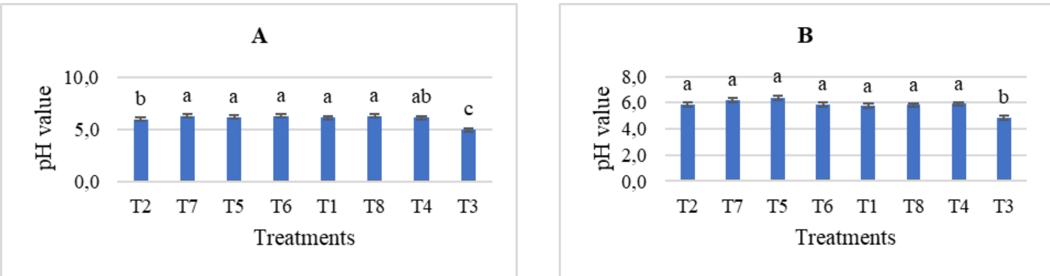
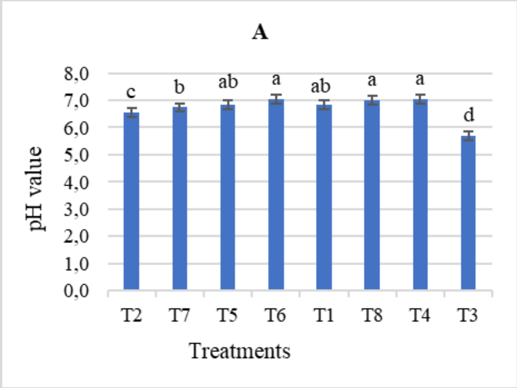


Figure 1. Soil pH reaction (KCl) in the first (A) and second (B) experimental season

At the end of the first experimental season, pH values in the other treatments ranged from 5.92 (T2) to 6.28 (T7) when measured in KCl, while the values obtained by measuring pH in H_2O ranged from 6.54 (T2) to 7.04 (T4). When the second experimental season is considered, the results are very similar to those at the end of the first season; thus, soil pH measured in KCl ranged from 5.77 (T1) to 6.35 (T5), while pH measured in H_2O ranged from 6.20 (T7) to 6.88 (T5).



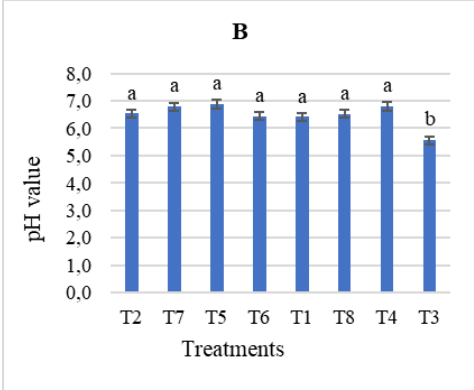


Figure 2. Soil pH reaction (H2O) in the first (A) and second (B) experimental season

Numerous authors have reported results indicating changes in soil pH under the influence of mulches (Chan et al., 2010; Alharbi, 2015; Sharma and Bhardwaj, 2017). The results of our study show that sawdust mulch had the greatest effect on reducing soil pH at the 0 - 30 cm soil depth. The impact of sawdust on lowering soil pH is also confirmed by Mohiuddin et al. (2022), who state that sawdust, unlike lime and gypsum, decreases soil pH, and that soils amended with sawdust have a statistically significantly lower pH compared with the control. Similarly, González-Orozco et al. (2018) point out in their study on the effects of sawdust in nurseries that soil pH decreases but returns to its pre-application level very quickly.

In addition to sawdust, a statistically significant change in soil pH was also observed with the application of silver-brown polyethylene (PE) film. Sharma and Bhardwaj (2017) report that the decrease in soil pH under PE film occurs because a greater number of organic acids accumulate beneath the film as a result of faster organic matter decomposition. Wang et al. (2017) determined that after five years of consecutive PE film application, soil pH decreased by 0,4 units.

CONCLUSION

The results of the two-year field experiments indicate that the applied weed control measures did not significantly affect soil pH in most of the tested treatments. However, the organic sawdust mulch exhibited a pronounced acidifying effect, with the lowest soil pH values recorded at the 0-30 cm soil depth in both experimental seasons. In addition, the application of silver-brown polyethylene film resulted in a statistically significant decrease in soil pH, which can be associated with more intensive organic matter decomposition and the accumulation of organic acids beneath the film. The obtained results are consistent with findings reported in the literature and indicate that the choice of mulch can have an important impact on soil chemical properties, particularly soil pH, which should be taken into account when planning sustainable angelica production.

ACKNOWLEDGMENT

This research is financially supported by the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia, under grant number: 451-03-136/2025-03/200054.

REFERENCES

Alharbi, A. (2015). Effect of mulch on soil properties under organic farming conditions in center of Saudi Arabia. Journal of American Science, 11(1), 108-115.

Bhat, Z.A., Kumar, Dinesh., Shah, M.Y. (2011). *Angelica archangelica* Linn. is an angel on earth for the treatment of diseases. International Journal of Nutrition, Pharmacology, Neurological Diseases, 1, 36-50.

Chan, Y., Fahey, J., Newell, M., Barchia, I. (2010). Using composted mulch in vineyards - effects on grape yield and quality. International Journal of Fruit Science, 10(4), 441-453.

Dragumilo, A., Marković, T., Vrbničanin, S., Prijić, Ž., Mrđan, S., Radanović, D., Božić, D. (2023). Weed suppression by mulches in *Mentha x piperita* L. Journal of Applied Research on Medicinal and Aromatic Plants, 35.

Ferguson, J., Rathinasabapathi, B., Warren, C. (2008). Southern red cedar and southern magnolia wood chip mulches for weed suppression in containerized woody ornamentals. Horticulturae Technology, 18, 266-270.

González-Orozco, M.M., Prieto-Ruíz, J.Á., Aldrete, A., Hernández-Díaz, J.C., Chávez-Simental, J.A., Rodríguez-Laguna, R. (2018). Nursery Production of Pinus engelmannii Carr. with Substrates Based on Fresh Sawdust. Forests, 9, 678.

Iriany, A., Chanan, M., Djoyowasito, G. (2018). Organic mulch sheet formulation as an effort to help plants adapt to climate change. International Journal of Recycling of Organic Waste in Agriculture, 7, 41-47.

Kader, M.A., Senge, M., Mojid, M.A., Ito, K. (2017). Recent advances in mulching materials and methods for modifying soil environment. Soil & Tillage Research, 168, 155-166.

Kasirajan, S., Ngouajio, M. (2012). Polyethylene and biodegradable mulches for agricultural applications: a review. Agronomy for Sustainable Development, 32, 501-529.

Kišgeci, J. (2002): Lekovito bilje: gajenje, sakupljanje, upotreba. Partenon, Beograd.

Lalljee, B. (2013). Mulching as a mitigation agricultural technology against land degradation in the wake of climate change. International Soil and Water Conservation Research, 3, 68-74.

Lazarević, J., Dragumilo, A., Marković, T., Savić, A., Božić, D. (2020). Suzbijanje korova u usevu angelike (*Angelica archangelica* L). Acta herbologica, 29, 129-139.

Mohiuddin, M., Hussain, Z., Abbasi, A., Ali, J., Irshad, M., Tariq, M., Intisar, A., Hina, A., Zaman, Q.U., Ng, A.W.M. (2022). Sawdust Amendment in Agricultural and Pasture Soils Can Reduce Iodine Losses. Sustainability, 14(20), 13620.

Pavlů, L., Kodešová, R., Fér, M., Nikodem, A., Němec, F., Prokeš, R. (2021). The impact of various mulch types on soil properties controlling water regime of the Haplic Fluvisol. Soil and Tillage Research, 205.

Sharma, R., Bhardwaj, S. (2017). Effect of mulching on soil and water conservation-A review. Agricultural Reviews, 38(4), 311-315.

Stepanović, B., Radanović, D. (2011). Tehnologija gajenja lekovitog i aromatičnog bilja. Institut za proučavanje lekovitog i aromatičnog bilja "Dr Josif Pančić", Beograd.

Wang, L., Li, X., Lv, J., Fu, T., Ma, Q., Song, W., Wang, W., Li, F. (2017). Continuous plastic-film mulching increases soil aggregation but decreases soil pH in semiarid areas of China. Soil and Tillage Research, 167, 46-53.

Xianchen, Z., Huiguang, J., Xiaochun, W., Yeyun, L. (2020).The effects of different types of mulch on soil properties and tea production and quality. Journal of the Science of Food and Agriculture, 100, 5292-5300.