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# ASSESSMENT OF THE POSSIBILITIES OF ARTIFICIAL INTELLIGENCE FOR AGROCHEMICAL SOIL ANALYSIS WITH FERTILIZATION RECOMMENDATIONS

*Research paper*

**Milana Drašković[1*], Željko Eremić[2]**
[1,2]Technical College of Applied Sciences, Zrenjanin, Serbia

**Abstract:** Various artificial intelligence models exist today. This paper examines the capabilities these models offer in the field of agrochemical soil analysis and fertilizer recommendations. We leveraged internet technologies to evaluate the potential of several artificial intelligence models within agricultural technology. The outputs obtained were compared against official recommendations. The paper presents a comparison between soil fertilization recommendations based on agrochemical analysis results provided by professional services and those generated by various artificial intelligence models. The results of this comparison and the associated conclusions are presented and subsequently discussed in terms of the reliability of the tested models.
**Key words:** AI models, Internet technologies, Agrochemical soil analysis, fertilization

## INTRODUCTION

Agrochemical soil analysis is a basic prerequisite for successful agricultural production in vegetable, arable and fruit growing (Dinkins & Jones, 2013; Varga, 2015). Every year, plants take out a certain type and amount of nutrients from the soil, which must be returned to the soil by fertilizing (Kızılkay,et al. 2022; Paolo &Rinaldi, 2008).
Agrochemical soil analysis is a key step for achieving high and stable yields in agriculture. It provides a precise insight into the current state of nutrients in the soil.
The main benefits of regular soil testing include:

- **Economic savings:** Fertilizer is introduced specifically and in the correct quantities, which avoids unnecessary expenditure on nutrients that are already in abundance.
- **Environmental protection:** Prevents excessive fertilization that can lead to groundwater pollution and soil structure degradation.
- **Proper plant development:** Plants receive balanced nutrition, which directly affects better fruit quality and greater resistance to diseases and drought.
- **Long-term planning:** The received recommendation for fertilization is valid for the next four years, which enables optimal planning of crop rotation and investments.

Hazelnut plantations in Serbia(Fig.1.) are becoming more and more important, primarily because of the price that hazelnuts have reached on the market. Hazelnuts represent a very important type of stone fruit whose fruits are highly valued on the domestic and world markets.
Good yields of hazelnuts can be expected on soils of medium fertility, light, sandy loam, humus-carbonate and moderately moist. According to the reaction of the soil, hazelnut is tolerant, because it thrives well on soil with a pH value of 5 to 8.
Mineral nutrition of young trees should be in accordance with their development. As the tree grows, so do the fertilizer rates, (Korać M., et al. 2020). If necessary, other corrections are made during this period, such as correction of the pH value, because the hazelnut root absorbs nutrients more easily when the pH is from 6.8 to 7.3.

[1]Corresponding author, milana.draskovic@gmail.com., ORCID: 0009-0002-2085-4356
[2]zeljko.eremic@gmail.com, ORCID: 0009-0003-3310-3081



***Fig.1*** *Hazelnut plantations*

Different AI models have different capabilities. We have decided on several of the most popular free versions of the model. We asked each of them the same question, gave them the same input data set, and the same desired output format. These results are compared and discussed.This paper examines what recommendations for soil fertilization are provided by the AI models used based on the results of agrochemical analysis of soil under hazelnut plantations.

## MATERIAL AND METHODS

### Agrochemical soil analysis

Average soil samples, consisting of an appropriate number of individual samples (20-25), were taken from a plot of land with an area of 1.7 ha. The depth from which samples are taken for the purpose of soil fertility control for fruit species is 0-30 cm, and 30-60 cm. The samples were taken using hand-held soil sampling probes. Agrochemical soil analysis was performed in the accredited laboratory of the Agricultural Expert Service (PSS) in Zrenjanin.

### AI models

In our research, we used several artificial intelligence models, providing them with the same input data and the same question. The desired response format was also specified within the question. The models are listed:

- GPT, Version GPT-5.6, https://chatgpt.com
- Google Gemini, Version 3, https://gemini.google.com
- Perplexity, N/A, https://www.perplexity.ai
- DeepSeek, DeepSeek-V3, https://chat.deepseek.com
- Meta, Spark 1.1., https://www.meta.ai
- Claude, Claude Sonnet 5, https://claude.ai

The question sent to each of the models is: Based on the results of the agrochemical analysis of the soil in the hazelnut orchard, provide a recommendation regarding fertilization for the next 4 years. The soil analysis results are presented in Tables 1 and 2. The recommendation should be provided in the format of Table 3. Can I send you Tables 1 and 2 in the first image as input data, and then Table 3—which you need to fill out—in the second image?Each of the models then asked to load the first image with tables 1 and 2 (input data), and then the second image with table 3 (desired output format). These images have been loaded successfully in each model.

Our research is a continuation and extension of research (Drašković&Eremić, 2024) where the same input data were used, but the communication channel was textual and only one artificial intelligence model was used.
Results of agrochemical analysis of the soil under hazelnut planting with fertilization recommendation for cadastral plot number 2348, cadastral municipality of Žitište, area of 1.7 ha.The results of testing the agrochemical properties of the soil for the average sample taken at a depth of 0-30 cm are shown in Table 1.

***Table 1.*** *Results of agrochemical soil analysis for an average sample taken from a depth of 0-30cm*

| Parameter | Unit | Value | Method |
|---|---|---|---|
| Soil reaction (pH) in 1M KCl | | 7,70 | SRPS ISO 10390:2007 |
| Soil reaction (pH) in water | | 8,41 | SRPS ISO 10390:2007 |
| $CaCO_3$ content | % | 9,72 | SRPS ISO 10693:2005 |
| Easily accessible phosphorus as $P_2O_5$ | mg/100 gr | 67,21 | MZ 10 05 |
| Easily accessible potassium as $K_2O$ | mg/100 gr | 36,60 | MZ 10 06 |
| Humus content | % | 2,93 | MZ 10 04 |
| Total nitrogen content$_{(calculation)^*}$ | % | 0,15 | |

($Note^*$:refers to the requested part of the examination that is not in the scope of accreditation)

The results of testing the agrochemical properties of the soil for the average sample taken at a depth of 30-60 cm are shown in Table 2.

***Table 2.****Results of agrochemical soil analysis for an average sample taken from a depth of 30-60cm*

| Parameter | Unit | Value | Method |
|---|---|---|---|
| Soil reaction (pH) in 1M KCl | | 7,91 | SRPS ISO 10390:2007 |
| Soil reaction (pH) in water | | 8,56 | SRPS ISO 10390:2007 |
| $CaCO_3$ content | % | 12,52 | SRPS ISO 10693:2005 |
| Easily accessible phosphorus as $P_2O_5$ | mg/100 gr | 48,98 | MZ 10 05 |
| Easily accessible potassium as $K_2O$ | mg/100 gr | 25,20 | MZ 10 06 |
| Humus content | % | 1,95 | MZ 10 04 |
| Total nitrogen content$_{(calculation)^*}$ | % | 0,10 | |

($Note^*$ : refers to the requested part of the examination that is not in the scope of accreditation)

The soil contains excessive amounts of phosphorus and optimal amounts of potassium, so it is not recommended to introduce fertilizers containing phosphorus into the soil in the next four years.

Template for the desired response format is shown in Table 3

***Table 3.*** *Template for the desired response format*

| Year | Basic fertilization (until December 15) | | 1. Nitrogen supplementation (in the middle of January) | | 2.Nitrogen supplementation (in the middle of March) | |
|---|---|---|---|---|---|---|
| | Type of fertilizer | Quantity per hectare | Type of fertilizer | Quantity per hectare | Type of fertilizer | Quantity per hectare |
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## RESULTS AND DISCUSSION

The recommendation for the introduction of nutrients based on the results of the agrochemical properties of the soil under the hazelnut plantation is shown in Table 4.andTables 5-10 show the responses of different artificial intelligence models.

***Table 4.*** *Fertilization recommendation for hazelnut (13 years old)*

| Year | Basic fertilization (until December 15) | | 1. Nitrogen supplementation (in the middle of January) | | 2.Nitrogen supplementation (in the middle of March) | |
|---|---|---|---|---|---|---|
| | Type of fertilizer | Quantity per hectare | Type of fertilizer | Quantity per hectare | Type of fertilizer | Quantity per hectare |
| Year 1 | SOP-51%+18% potassium sulfate-200kg/ha | | UREA 46% | 150 kg/ha | AN 33% | 150 kg/ha |
| Year 2 | SOP-51%+18% potassium sulfate-200kg/ha | | UREA 46% | 150 kg/ha | AN 33% | 150 kg/ha |
| Year 3 | SOP-51%+18% potassium sulfate-200kg/ha | | UREA 46% | 150 kg/ha | AN 33% | 150 kg/ha |
| Year 4 | SOP-51%+18% potassium sulfate-200kg/ha | | UREA 46% | 150 kg/ha | AN 33% | 150 kg/ha |

***Table 5.*** *Model response: GPT*

| Year | Basic fertilization (until December 15) | | 1. Nitrogen supplementation (in the middle of January) | | 2.Nitrogen supplementation (in the middle of March) | |
|---|---|---|---|---|---|---|
| | Type of fertilizer | Quantity per hectare | Type of fertilizer | Quantity per hectare | Type of fertilizer | Quantity per hectare |
| Year 1 | No mineral fertilizer required | 0 | CAN (27% N) | 185 | CAN (27% N) | 185 |
| Year 2 | No mineral fertilizer required | 0 | CAN (27% N) | 185 | CAN (27% N) | 185 |
| Year 3 | No mineral fertilizer required | 0 | CAN (27% N) | 185 | CAN (27% N) | 185 |
| Year 4 | No mineral fertilizer required | 0 | CAN (27% N) | 185 | CAN (27% N) | 185 |

***Table 6.*** *Model response: Google Gemini*

| Year | Basic fertilization (until December 15) | | 1. Nitrogen supplementation (in the middle of January) | | 2.Nitrogen supplementation (in the middle of March) | |
|---|---|---|---|---|---|---|
| | Type of fertilizer | Quantity per hectare | Type of fertilizer | Quantity per hectare | Type of fertilizer | Quantity per hectare |
| Year 1 | / (Not required due to extremely high $P_2O_2$ and $K_2O$) | 0 kg/ha | Ammonium Sulfate (21% N) | 150 kg/ha | KAN (27% N) | 150 kg/ha |
| Year 2 | / (Not required) | 0 kg/ha | Ammonium Sulfate (21% N) | 150 kg/ha | KAN (27% N) | 150 kg/ha |
| Year 3 | Organic fertilizer (Manure / Compost)* | 15–20 t/ha | Ammonium Sulfate (21% N) | 150 kg/ha | KAN (27% N) | 150 kg/ha |
| Year 4 | / (Not required) | 0 kg/ha | Ammonium Sulfate (21% N) | 150 kg/ha | KAN (27% N) | 150 kg/ha |

*Note: Applying well-rotted organic manure in Year 3 will help preserve soil structure, lower active pH slightly, and improve micronutrient availability (especially Iron/Zinc) in alkaline soils without over-supplying phosphorus.

***Table 7.*** *Model response: Perplexity*

| Year | Basic fertilization (until December 15) | | 1. Nitrogen supplementation (in the middle of January) | | 2.Nitrogen supplementation (in the middle of March) | |
|---|---|---|---|---|---|---|
| | Type of fertilizer | Quantity per hectare | Type of fertilizer | Quantity per hectare | Type of fertilizer | Quantity per hectare |
| 1 | No phosphorus or potassium fertilizer; optional mature compost/manure | 10–15 t/ha* | Ammonium sulfate (21% N) | 180 kg/ha | Ammonium sulfate (21% N) | 180 kg/ha |
| 2 | No phosphorus or potassium fertilizer; optional mature compost/manure | 10–15 t/ha* | Ammonium sulfate (21% N) | 180 kg/ha | Ammonium sulfate (21% N) | 180 kg/ha |
| 3 | No phosphorus or potassium fertilizer; optional mature compost/manure | 10–15 t/ha* | Ammonium sulfate (21% N) | 180 kg/ha | Ammonium sulfate (21% N) | 180 kg/ha |
| 4 | No phosphorus or potassium fertilizer; optional mature compost/manure | 10–15 t/ha* | Ammonium sulfate (21% N) | 180 kg/ha | Ammonium sulfate (21% N) | 180 kg/ha |

*Apply compost or well-rotted manure only if available and if the orchard's organic-matter management requires it; do not treat this as a substitute for a measured mineral-N requirement

***Table 8.*** *Model response: DeepSeek*

| Year | Basic fertilization (until December 15) | | 1. Nitrogen supplementation (in the middle of January) | | 2.Nitrogen supplementation (in the middle of March) | |
|---|---|---|---|---|---|---|
| | Type of fertilizer | Quantity per hectare | Type of fertilizer | Quantity per hectare | Type of fertilizer | Quantity per hectare |
| Year 1 | Mature compost/manure[1] | 20–30 t/ha | KAN (27% N)[2] | 150 kg/ha | KAN (27% N) | 150 kg/ha |
| Year 2 | Mature compost/manure | 20–30 t/ha | KAN (27% N) | 150 kg/ha | KAN (27% N) | 150 kg/ha |
| Year 3 | Mature compost/manure + $K_2SO_4$[3] | 20–30 t/ha + 100 kg/ha | KAN (27% N) | 150 kg/ha | KAN (27% N) | 150 kg/ha |
| Year 4 | Mature compost/manure + $K_2SO_4$ | 20–30 t/ha + 100 kg/ha | KAN (27% N) | 150 kg/ha | KAN (27% N) | 150 kg/ha |

***Table 9.*** *Model response: Meta*

| Year | Basic fertilization (until December 15) | | 1. Nitrogen supplementation (in the middle of January) | | 2.Nitrogen supplementation (in the middle of March) | |
|---|---|---|---|---|---|---|
| | **Type of fertilizer** | **Quantity per hectare** | **Type of fertilizer** | **Quantity per hectare** | **Type of fertilizer** | **Quantity per hectare** |
| 1 | Well-rotted cattle manure (no mineral P,K) | 20 t/ha | Ammonium sulfate 21% N | 250 kg/ha = 52.5 kg N | KAN 27% N | 250 kg/ha = 67.5 kg N |
| 2 | **SKIP** - No basic (P,K extremely high) | 0 | Ammonium sulfate 21% N | 200 kg/ha = 42 kg N | KAN 27% N | 200 kg/ha = 54 kg N |
| 3 | Well-rotted cattle manure | 20 t/ha | Ammonium sulfate 21% N | 250 kg/ha = 52.5 kg N | KAN 27% N | 250 kg/ha = 67.5 kg N |
| 4 | **SKIP** - Repeat soil analysis | 0 | Ammonium sulfate 21% N | 200 kg/ha = 42 kg N | KAN 27% N | 200 kg/ha = 54 kg N |

***Table 10.*** *Model* response*: Claude*

| Year | Basic fertilization (until December 15) | | 1. Nitrogen supplementation (in the middle of January) | | 2.Nitrogen supplementation (in the middle of March) | |
|---|---|---|---|---|---|---|
| | **Type of fertilizer** | **Quantity per hectare** | **Type of fertilizer** | **Quantity per hectare** | **Type of fertilizer** | **Quantity per hectare** |
| 1 | Well-rotted farmyard manure | 30 t/ha | Urea (46% N) | 90 kg/ha | Urea (46% N) | 130 kg/ha |
| 2 | Not required (P, K reserves very high) | - | Urea (46% N) | 90 kg/ha | Urea (46% N) | 130 kg/ha |
| 3 | Not required (P, K reserves very high) | - | Urea (46% N) | 90 kg/ha | Urea (46% N) | 130 kg/ha |
| 4 | Well-rotted farmyard manure | 30 t/ha | Urea (46% N) | 90 kg/ha | Urea (46% N) | 130 kg/ha |

None of the used artificial intelligence models gave an adequate recommendation for fertilizing a plot of 1.7 ha under hazelnut planting in relation to the agrochemical analysis of the soil. Deviations are significant both in the recommended amount of mineral fertilizers and in the selection of the type of fertilizer.The most similar fertilization recommendations to those obtained from PSS, only for Nitrogen supplementation(in the middle of January)were given by the artificial intelligence model Claude.

## CONCLUSION

In our work, we showed one application of the artificial intelligence model in the field of agrochemical soil analysis with fertilization recommendations. Several free versions of artificial intelligence models were used. Models were sent questions, input data, and output format. Later, the results of the model were discussed. The conclusion is that all the used models are not reliable to give recommendations for fertilizing hazelnut plantations, based on the given results of agrochemical soil analysis.
Directions for further research refer to the possibility of using some other models, new versions of existing models when they become available, as well as application in some other areas.

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