Chemical analysis of soil and determination of its fertility

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Abstract: Soil chemical composition plays a fundamental role in determining agricultural productivity, influencing both crop growth and yield. Soil fertility is a critical factor influencing crop productivity, and its assessment through chemical indicators such as pH and macronutrients (nitrogen, phosphorus, potassium) provides insight into its suitability for cultivation. This study investigates the chemical properties of soil samples in order to evaluate their fertility status and provide appropriate fertilization recommendations. Four samples were analyzed in an accredited agrochemical laboratory to determine key parameters: pH (in water and KCl), organic matter content, total nitrogen, available phosphorus and potassium and calcium carbonate. The results indicate significant variability in soil pH, ranging from strongly acidic (pH 5.12) to alkaline (pH 8.25), and varying levels of macronutrients. Phosphorus and potassium levels were found to be low to moderate, while organic matter content was generally low. Based on these results, site-specific recommendations for fertilizer application were proposed to optimize crop productivity and restore soil fertility.
Keywords: chemical analysis, soil fertility

1. Introduction

Soil fertility is a critical factor influencing agricultural productivity and sustainability. It is primarily determined by the chemical, physical, and biological properties of soil, with chemical composition playing a vital role in nutrient availability and plant growth [1]. Essential nutrients such as nitrogen (N), phosphorus (P), and potassium (K) must be present in adequate quantities, along with favorable pH and organic matter content, to support optimal crop development [2].

In Serbia, like in many agricultural regions, variability in soil fertility necessitates regular testing to ensure balanced fertilization and sustainable land use. The present study focuses on the chemical analysis of soil from agricultural plots. Aim of this study is to assess fertility status, identify limiting factors, and provide scientifically grounded fertilization recommendations based on laboratory findings.

2. Methodology

Four samples were taken from agricultural plots identified as A, B, C, and D, each representing different micro-locations with a surface area of 1,000 m^2. Sampling was conducted at two depth intervals (0–30 cm and 30–60 cm), using standard soil probes. Each sample was air-dried, sieved (2 mm), and stored under controlled conditions before laboratory testing.

Chemical parameters were analyzed according to Serbian national standards (SRPS) [3]:

- pH (in H_2O and KCl) - measured potentiometrically using SRPS ISO 10390:2007;
- Organic Matter (OM, %) - determined by Kotzman method LM03;
- Total Nitrogen (N, %) - computational method based on the content of organic matter LM03;
- Available Phosphorus (P_2O_5, mg/100mg) - Egner-Riehm method
- Available Potassium (K_2O, mg/100mg) - Egner-Riehm method
- Calcium Carbonate ($CaCO_3$, %) - volumetric method (SRPS ISO 10693:2005)
- Water Content (H_2O, %) - gravimetric method (SRPS ISO 11465:2002) [7]

Laboratory instruments were calibrated according to ISO (International Organization for Standardization) procedures, and quality control measures were applied throughout.

3. Results and Discussion

The chemical characteristics of the analyzed soil samples are presented in Table 1. Different soil samples exhibited a wide pH range, from strongly acidic (5.20) to alkaline (8.30). Organic matter (OM) content varied from 2.72% to 4.02%, with most samples falling into the low to moderate fertility range [3]. Total nitrogen levels were relatively low (0.14-0.20%), and phosphorus and potassium levels showed significant variation among samples.

Table 1. Summary of soil chemical properties

Sample ID	pH (H_2O)	pH (KCl)	OM (%)	N (%)	P_2O_5 (mg/100mg)	K_2O (mg/100mg)	$CaCO_3$ (%)	Water content (%)	Soil sampling depth (cm)
A	5.20	4.15	2.72	0.14	7.43	14.36	<0.42	2.19	0-30
B	5.92	4.83	3.19	0.16	6.78	9.18	<0.42	1.72	30-60
C	8.30	7.34	3.23	0.16	>40.00	16.96	5.67	1.65	0-30
D	8.25	7.28	4.02	0.20	>40.00	24.74	5.67	3.61	30-60

Fertility classification based on national agronomic standards is summarized in Table 2. [7]

Table 2. Fertility assessment based on key parameters

Sample ID	Soil acidity	OM content	N content	P content	K content	Carbonates content
A	very acidic	moderate	moderate	low	low	very low
B	acidic	moderate	moderate	low	low	very low
C	alkaline	moderate	moderate	high	moderate	moderate
D	alkaline	moderate	high	high	moderate	moderate

The pH range of observed soil indicates a need for targeted management. Sample A displayed strong acidity (pH 5.20), which negatively affects the availability of phosphorus and can lead to aluminum toxicity [4]. Conversely, samples C and D were alkaline, which can immobilize micronutrients like iron and zinc, though favorable for leguminous crops [5].

Organic matter levels across all samples were relatively moderate, suggesting insufficient input of organic residues or limited biological activity. Organic matter plays a key role in nutrient retention, soil structure, and microbial health; [6] thus, increasing organic input (e.g., through manure or cover crops) is recommended.

Phosphorus availability was the lowest in sample B (6.78 mg/100mg), slightly higher in sample A (7.43 mg/100mg) and highest in samples C and D (with their levels being the same, >40.00 mg/100mg). Potassium levels were fairly uniform but below optimal for high-demand crops [2].

Total nitrogen was suboptimal in all samples (<0.25%), indicating the need for supplemental nitrogen fertilization. Nitrogen deficiencies can lead to poor vegetative growth and yield reduction [7].

Calcium carbonate was detected in higher quantities in samples C and D (5.67%), confirming their alkaline nature and influencing nutrient solubility. Soil water content is the highest in sample D (3.61%) which means that, compared to other samples, this one can hold more nutrients [1].

Fertilization recommendations included application of complex NPK fertilizers, with formulations such as 6:12:24 and quantities ranging from 300–400 kg/ha, as specified in the laboratory's advisory section.

4. Conclusions

The chemical analysis of aforementioned soil samples reveals heterogeneity in fertility status across the site. Strongly acidic soils with low phosphorus and nitrogen content (e.g., sample A) require corrective measures including liming and balanced fertilization. Alkaline samples, though higher in phosphorus, still exhibit moderate deficiencies in nitrogen and organic matter.

Overall, it is concluded that soil fertility levels aren't satisfactory, indicating the necessity of improved nutrient management practices. A combination of organic amendments, targeted NPK fertilization, and soil pH correction is recommended to restore soil fertility and support sustainable crop production.

Regular monitoring and site-specific fertilization planning will be essential to maintain soil health and productivity in the long term.

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