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Chemical monitoring of soil as a basis in technology production of*Primalba* and *Willamette* raspberry varieties

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Abstract
In raspberry production technology, the choice of land is important, ie. the soil quality for raising Primalba and Willamette varieties. Raspberry varieties are perennial herbs, in the form of a bush or semi-shrub, with several annual roots and annual or biennial shoots from the Rosaceae family.Raspberry irrigated with a drip system, through soil is rehabilitated and the appropriate fertilizers are added. Examination of the chemical composition of the soil was in three laboratories in deferent periods. Results obtained in the first period of examination shows that nitrogen is the element with greatest movement in the soil itself and its content is 0.08 - 0.14%. The pH value affects the content of calcium, which plays an important role in the hardness of the fruit, the sensitivity to physiological disorders, and it amounts to 1113.0-3745.0 ppm. Phosphorus is an important element for the properties of fruit during storage and it amounts to 14.77 – 40.36 P_2O_5 kg/da. Potassium plays a role in producing good yields and the amount is about 14.0 –50.49.7 K_2O kg/da. Magnesium does not have the most important role which is 74.58 -220.9 ppm. The main role of magnesium is in the ratio of potassium (K / Mg) and should range from 2: 1 to 3: 1. From the data obtained of the soil analysis, in addition to the climatic conditions, the species and the structure, which are equally important for raspberry cultivation, we get a complete picture of soil processes and instructions for suitable conditions for growing raspberries.
Keywords*: soil, raspberry, planting, chemical elements, soil acidity.*

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I. INTRODUCTION

Raspberries can be classified in the group of the most important and profitable types of berries in terms of quantity and value of production. Raspberries are very adaptable to different climatic and soil conditions. The specificities of the raspberry are multiple and are reflected primarily in its favorable biological properties, the agroecological growing conditions it requires, the market value of the production itself, the economic effects of the production, etc. Raspberries bear fruit in the first or second year after planting, and already in the third year they reach full fertility. Raspberry yields can be extremely high if a balance is established between favorable agroecological conditions for cultivation, the application of modern agrotechnical measures and the use of certified seedlings [1, 14, 15].

Soil is one of the most important factors to consider before planting raspberries. Raspberries require well-drained soil. Most of the roots are located in the top 20 cm of soil and are easily damaged by overwatering. Before planting, organic matter should be added to improve soil drainage and nutrient holding capacity. In heavy soils, planting raised beds can also help improve water drainage from the top of the bed. A bed about 10 to 12 cm high is sufficient. Soil amendments can be made to help manage alkaline soils. Weed control before planting is critical [2].

Raspberries prefer environments with moderate summer temperatures lower than 30°C, but most cultivated varieties tolerate down to -30°C [3]. The optimal temperatures of the leaves are from 18°C to 22°C. Raspberries grow best in well-drained loam soil with organic matter greater than 3% and a pH of 5.5 to 6.5. Soil temperatures of 22° to 27°C are best for roots. Raspberry light requirements are a minimum of 6-8 hours of sunlight, the plants tolerate light shade, while high light intensity can result in sun damage to the plant [4]. General raspberry water requirements are approximately 2.5 cm of water per week per plant. This varies by cultivar, stage of growth, soil type, temperature and wind exposure. Raspberries need a period of dormancy and cooling on an annual basis [5].

A soil test is the first step in determining the needs of the planting site. Soil test results indicate what nutrients are available in the soil for the plant to receive and whether any changes or recommendations are needed to obtain the desired crop. Factors affecting nutrient availability are temperature, soil aeration, nutrient concentration, plant growth rate, and soil moisture. In contrast, plant tissue analysis is used to measure the nutrients that are taken up and found in different plant parts. Tissue analysis has the benefit of alerting the

grower to nutrient levels approaching deficiency and if the fertilizer is more concentrated. Corrective action can be taken before plant symptoms are visible [6, 17].

Primary macronutrients Nitrogen (N), Phosphorus (P) and Potassium (K) are the nutrients needed in the greatest quantity by raspberries. Secondary nutrients Calcium (Ca), magnesium (Mg) and sulfur (S) are primary nutrients. The requirements of raspberries for Ca and Mg are medium and the demand for S is low. Micronutrients Boron (B), Copper (Cu), Iron (Fe), Manganese (Mn), Molybdenum (Mo) and Zinc (Zn) are used in small amounts by the plant, but they still play an important role in plant development. B and Cu requirements are medium, Fe and Mn are high, and Mo and Zn requirements are low. It is important to have soil test results before applying these nutrients, as nutrient overload can be harmful to the plant and the environment. Nitrogen (N) is the most important nutrient required for plant growth and is generally required in large quantities. Nitrogen (N) is necessary for plant growth, formation of amino acids and is directly involved in photosynthesis [7, 8, 18].

Excess N at planting can potentially lead to moderate vegetative growth of the plant and, consequently, root system suffering. Nitrogen (N) should be applied based on soil test recommendations and the amount of organic matter in the soil. Organic matter consists of living organisms, fresh and decomposed residues such as animal manure, cover crops and green manures. Animal manure adds organic matter and nutrients directly to the soil. Cover crops add organic matter and N to the soil, reduce soil erosion and provide habitat for beneficial insects. Green manures are cover crops that grow during winter and spring and are plowed in early spring. Fertilization refers to a method in which the fertilizer is applied 5 to 10 cm from the side of the plant. After application, the soil is easily broken down and fed. Direct contact with plant tissue may result in burn-related damage to plant tissue. Nitrogen (N) is mobile in the soil and soil levels will change depending on biological activity and soil conditions. Phosphorus (P) is a major component of plant DNA and plays a key role in numerous plant functions. P is critical for root development, plant growth and maturity, seed production, energy transfer, photosynthesis, sugar and starch transformation, nutrient movement, and transmission of genetic traits. P is immobile in the soil and should be mixed into the top 4-6 inches of the soil. Potassium (K) is required for the activation of eighty or more enzymes in the plant and is responsible for increasing the efficiency of using water and converting sugars into starch. Adequate K levels improve fruit quality and increase stress tolerance. Potassium (K) is immobile in soil and should only be applied if a soil test indicates a low level [9]. Recommended K rates for all crops are based on equation and soil test recommendations [10].

II. MATERIAL AND METHODS

The test crop is a stand of Primalba and Willamette raspberry varieties. For this purpose, three soil tests were done in two different periods of time [11, 16].

For the first test carried out in laboratory 1 (PROANALİZ Laboratory, Professional laboratory for the analysis of water, soil, plants Proagrogold Group dooel, Strumica, Republic of North Macedonia) 4 soil samples were taken in the amount of 1 kg of soil sample in order to initially examine the land for plantation. .e. what is the soil composition of that land. The initial examination period is between 11th and 12th of 2018.

The second tests are in the period of the 3rd month in 2023, they were done in laboratory 2 (University "Cyril and Methodius", Faculty of agricultural sciences and FOOD - Skopje, Republic of North Macedonia, Laboratory for Soil and Fertilizer Analysis). Samples were taken at a depth of 30 to 60 cm in different places on the same plot to get a better picture of that land. The plant, in the case of raspberry species, was irrigated with a drip system. The samples were taken, packed in black nylon bags and taken to the accredited laboratory by own transport. First, the laboratory gave instructions: exactly how to take samples and how far the sampling should be from each other. Thus, within the period of 2 hours, the samples are transferred to the appropriate laboratory 2 and left for further examination.

Parallel to these tests, third tests were carried out in laboratory 3 (PROANALİZ Laboratory, Strumica, Republic of North Macedonia, accredited by the TURKAK Accreditation Agency) in the period from the 2nd month of 2023, which are quite different from the actual situation on the ground. During this test, 5 soil samples were taken from the entire surface at a location of their own choosing, but of course the established distance between all samples was considered. It was also pointed out that the samples were not taken from a water surface or covered mud per 1 kg soil sample [12].

Appropriate accredited methods were used for each examined element from the respective laboratory, which are described in detail in the following table (Table 1)[13].

Table 1. Method/instrument used for soil analyses

Parameters	**Laboratory 1** Methods	**Laboratory 2**Methods	**Laboratory 3**Methods
Soil preparation		MKC ISO 11464:2015	
Hummus		*Determination of organic C and humus according to the method of Tyurin, modified	
pH	TS ISO 10390/Satureortamda (H_2O)	MKC ISO 10390:2015	TS ISO 10390/Satureortamda (H_2O)
Calcium carbonate ($CaCO_3$) /%	TS 8335 ISO 10693 / Kalsimetrik	Volumetrically ISO 10693	TS 8335 ISO 10693 / Kalsimetrik
EC / (ds/m)	TS ISO 11265 / Satureortamda		TS-155
Salt(NaCl) /%			
Saturation (Texture)	TS 8333/ Saturasyon		TS 8333/ Saturasyon
Organic substances	TS 8336/ Walkley Black		TS 8336/,Walkley Black
Total Nitrogenium(N) / %	TS 8337 ISO 11261 / Kjeldahl	ISO -11261	TS 8337 ISO 11261 / Kjeldahl
ApsorbedPhosphorus(P) / P_2O_5 kg/da	TS 834 Olsen / Spektrofotometrik	AL MethodValidated onFZNH-Skopje	TS 834 Olsen / Spektrofotometrik
ApsorbedPotasium (K) as K_2O / kg/da	TS 8341 / 1N Amo. ASE / 1CP – 0ES	AL MethodValidated onFZNH-Skopje	TS 8341 / 1N Amo. ASE / ICP – 0ES
ApsorbedCalcium (Ca) / ppm	TS 8341 / N Amo. ASE / ICP		TS 8341 / N Amo. ASE / ICP
Absorbed Magnesium (Mg) / ppm	TS 8341 / N Amo. ASE / ICP		TS 8341 / N Amo. ASE / ICP
Absorbed iron(Fe) / ppm	TS ISO 14870 DTPA / ICP – 0ES		TS ISO 14870 DTPA / ICP – 0ES
ApsorbedManganese (Mn) / ppm	TS ISO 14870 DTPA / ICP		TS ISO 14870 DTPA / ICP
ApsorbedZink (Zn) / ppm	TS ISO 14870 DTPA / ICP		TS ISO 14870 DTPA / ICP
ApsorbedCooper(Cu) / ppm	TS ISO 14870 DTPA / ICP		TS ISO 14870 DTPA / ICP

III. RESULTS

3.1 First experimental trials in Laboratory 1

The initial chemical analysis was done in laboratory 1 (PROANALİZ Laboratory) in four soil samples with three repetitions each in 2018. The obtained results were calculated and their average value is shown in Table 2.

Table 2.First Soil analyses results in Laboratory 1

Parameters	Sample 1		Sample 2		Sample 3		Sample 4	
	Results	Conclusion	Results	Conclusion	Results	Conclusion	Results	Conclusion
pH	7,7	Slightly alkaline	6,28	Slightly acidic	6,35	Slightly acidic	6,11	Slightly acidic
Calcium carbonate ($CaCO_3$) /%	1,0	Calcareous	1,3	Calcareous	1,6	Calcareous	2,1	Calcareous
EC / (ds/m)	0,287 (21,7^{0}C)	Without salt	0,237 (20,7^{0}C)	Without salt	0,215 (21,16^{0}C)	Without salt	0,225 (21,1^{0}C)	Without salt
Salt(NaCl) /%	0,01	Without salt	0,007	Without salt	0,006	Without salt	0,009	Without salt
Saturation (Texture)	71,5	Sandy land	51,04	Clayey rocky	53,9	Clayey rocky a	55,44	Clayey rocky
Organic substances	2,05	Middle	2,80	Middle	1,64	A little	1,24	A little
Total Nitrogenium(N) / %	0,10	Enough	0,14	Enough	0,08	A little	0,06	A little
ApsorbedPhosphorus(P) / P_2O_5 kg/da	16,03	Very high	40,36	Very high	24,7	Very high	14,77	Very high
ApsorbedPotasium (K) as K_2O / kg/da	17,1	Very little	49,7	Enough	23,6	A little	14,0	Very high
ApsorbedCalcium (Ca) / ppm	3745,0	High	1235,0	Enough	2170,0	Enough	1113,0	A little
Absorbed Magnesium (Mg) / ppm	74,58	A little	138,7	A little	220,9	Enough	184,7	Enough
Absorbed iron(Fe) / ppm	1,163	Middle	81,92	Enough	157,8	Enough	76,20	Enough

ApsorbedManganese (Mn) / ppm	1,283	A little	21,00	Enough	24,25	Enough	12,12	A little
ApsorbedZink (Zn) / ppm	1,031	Enough	5,473	High	2,570	High	1,848	Enough
ApsorbedCooper(Cu) / ppm	3,309	Enough	4,655	Enough	4,322	Enough	2,822	Enough

Source: JovicaMomirchevski, own research (2018).

After several (four) years, a subsequent inspection of the quality of the soil follows, so that in 2023 the same soil was examined.

3.2 Second experimental trials in Laboratory 2

Following the first examination and chemical analysis of the soil performed in four soil samples, the data of which are presented in Table 2, in 2023, in the period from March 13 to 20, soil testing was carried out in another laboratory (Laboratory for Soil and Fertilizer Analysis at the University "St. Cyril and Methodius"

Skopje, at the Faculty of Agricultural Sciences and Food). Within this test, 11 samples were taken for testing, 10 of which are soil at a depth of 15-25 cm, while the last number 11 corresponds to the refrigerator label, on which a physical and chemical test was performed in order to determine the suitability of the soil for raspberry planting. The data obtained from the trials are shown in Table 3.

Table 3.Second Soil analyses results in Laboratory 2

Parameters/ Sample	Humus / %	N (Total Nitrogenium) / %	$CaCO_3$ / %	pH во H_2O /	P_2O_5 /(mg/100g)	K_2O /(mg/100g)
1	1,98	0,104	0,00	5,76	26,08	37,45
2	2,01	0,112	0,11	5,55	24,25	45,76
3	1,90	0,118	0,00	6,04	38,56	48,30
4	1,76	0,106	0,00	6,09	21,05	37,69
5	1,74	0,096	0,00	5,55	21,23	31,16
6	1,68	0,108	0,00	6,31	19,10	36,13
7	1,68	0,091	0,00	5,58	10,15	29,52
8	1,59	0,084	0,00	5,83	11,86	27,31
9	1,42	0,085	0,00	6,10	9,21	30,28
10	1,67	0,092	0,00	5,97	10,66	29,44
11	2,05	0,117	0,00	6,26	25,64	26,27

Source: JovicaMomirchevski, own research (2023)

3.3 Results for comparison of soil tests in the Laboratory 3

In the period from the third month of 2023, tests were done on five samples of 1 kg of soil in laboratory 3 (PROANALİZ Laboratory, accredited by the TURKAK Accreditation Agency) which deviate significantly from the real situation on the ground, which was determined by the results obtained from the tests in 2018 year. The obtained results of the tests conducted in March 2023 are taken for comparison with the initial ones and are shown in the following table Table 4.

Table 4. Soil analyzes – comparative study from Laboratory 3

Parameters	Sample 1		Sample 2		Sample 3		Sample 4		Sample 5	
	Results	Conclusion	Results	Conclusion	Results	Conclusion	Results	Conclusion	Results	Conclusion
pH	7,48	Neutral	7.52	Neutral	7,95	Neutral	7.01	Neutral	6,86	Neutral
Calcium carbonate ($CaCO_3$) /%	6,8	Medium	6,92	Medium	2,9	Medium	3.15	Medium	3,10	Medium
EC / (ds/m)	0,323	Without salt	0,324	Without salt	0,815	Without salt	0.764	Without salt	0,774	Without salt
Saturation (Texture)	56,10	Sludge	54,55	Sludge	60,0	Sludge	55.48	Sludge	55,00	Sludge
Organic substances	1,6	Low	1,58	Low	1,2	Low	1.93	Low	1,84	Low
Total Nitrogenium(N) / %	0,08	Low	0,09	Low	0,1	Low	0,12	Low	0,09	Low
ApsorbedPhosphorus (P) / P_2O_5 kg/da	6,3	Enough	6,32	Enough	7,2	Enough	7,15	Enough	7,11	Enough
ApsorbedPotasium (K) as K_2O / kg/da	77,2	Enough	77,4	Enough	84,1	Enough	99,44	Enough	99,40	Enough
ApsorbedCalcium (Ca) / ppm	6544	High	7880	High	7438	High	5549	High	5547	High
Absorbed Magnesium (Mg) / ppm	720,9	High o	512,6	High	300,9	High	266,4	High	241,1	High

Absorbed iron(Fe) / ppm	7,19	Enough	7,25	Enough	4,15	Enough	5,12	Enough	5,11	Enough
ApsorbedManganese (Mn) / ppm	1,33	A little	1,34	A little	11	A little	7,44	A little	7,43	A little
ApsorbedZink (Zn) / ppm	1,65	Enough	1,77	Enough	1,0	Enough	1,22	Enough	1,23	Enough
ApsorbedCooper(Cu) / ppm	3.56	Enough	3,52	Enough	0,58	Enough	1,10	Enough	1,11	Enough

Source: JovicaMomirchevski, own research (2023)

IV. DISCUSSION

In the results from the First Laboratory we can see that **organic substances** in soil samples under serial number 3 and 4 have a low content of organic substances, while samples with serial number 1 and 2 have a medium content of organic substances. It is recommended to carry out composting with 20 - 30 t/ha of burnt barnyard manure or compost that contains about: 0.3% N, 0.1% P, 0.3% K and about 2 – 3% CaO. **In terms of soil acidification** it is necessary to perform it only for the surface from which sample number 1 was taken, where the pH value is 7.7 (slightly alkaline). From the results obtained **saturation – texture of soil** it can be seen that only in the first sample a higher value of 71.51% was obtained compared to other samples whose value ranges from 51.04% to 55.44% so the first sample is a surface with deposits of sand or sandy soil, while the other three samples are clayey rocky soil. For **Electrical conductivity of the soil** / (ds / m) of the ions of the elements of the sample present with a suitable temperature of 20.70 C - 21.70 C and without salt (NaCl) are in the normal range, which is the result of the absence or minimal presence of salt in the soil. The percentage of NaCl is from 0.009 to 0.07% and corresponds to the requirements for planting raspberries. About **calcification** which independent from contents of pH value, shows the content of calcium in the soil. A minimal addition of calcium to this surface is recommended, all in order to bring the calcium to the ideal content required by the raspberry plantation. Further calcification can be carried out every 3 years, to replenish the carbonate evaporated or removed from the soil by natural processes. Regarding the **presence of Elements,** it can be seen that **Nitrogen (N)**, with the application of a fertilizer, the soil from which sample number 1 was taken, the nitrogen content will increase, and in the sample number 2, the nitrogen content is sufficient, and in the samples number 3 and 4, ammonium nitrate will be added. to achieve the desired nitrogen content. **Phosphorus (P)** is important for the properties of fruits during their storage. The representation of phosphorus in all samples is high, and it is especially the highest in the sample under number 2. Due to such a high representation of phosphorus in the soil, it is recommended that further fertilization be performed with fertilizers where there is no representation of phosphorus in them or that the representation is minimal. **Potassium (K)** is the main element and plays a major role in obtaining a good yield. In sample number 2, the content of K is good, and the content in the remaining samples 1, 3, 4 is insufficient. Fertilizing with potassium chloride (60%) is recommended for these samples. When **Magnesium (Mg)** is mentioned, its role is not the most important. The main role for magnesium is played by the relationship with K (K/Mg), which should be in the ratio 2:1 to 3:1. This relationship in all the samples taken is not favorable. Therefore, in this case, individual fertilizers are used, and not multiple components. Due to the unfavorable ratio of K/Mg, fertilizing with Mg is not recommended.

From the Results of Second laboratory several conclusions can be drawn which are presented in the next few passages. In view of each of the examined parameters **pH** in water. The samples that have been examined vary from weakly acidic in samples 6, 9 and 11 to moderately acidic in samples 1, 3, 4, 8 and 10 to strongly acidic in samples 2, 5 and 7. According to the **Humus** content of the soils subject to this analysis, it can be concluded that the values of each sample range from 1.42% as the lowest to 2.05% as the highest limit, placing the samples in a soil with a low humus content. Regarding the **total Nitrogen (N)** level from the process of examining the amount of total nitrogen in the samples and taking into account the classification of soils according to the content of total nitrogen and according to the results of the analysis, it can be said that the samples numbered 5, 8, 8, 9 and 10 belong to soils soil which is moderately provided for growing plants, while the samples numbered 1, 2, 3, 4, 6 and 11 belong to soil that is well provided for growing plants. In terms of **Calcification - $CaCO_3$** the analysis of the soils from these samples according to the content of $CaCO_3$ shows that all the samples that were taken and examined are classified in soil without carbonates with the exception of sample number 2 which can be said to be classified in low carbonate soils although the values it has are minimal that is, only 0.11. About **Macronutrients in soil** during the analyzes performed in terms of P_2O_5, from the obtained results it can be said that five of the samples, i.e. 1,2, 4, 5 and 11, are in the group of soils with a very high level of phosphorus, which according to the classification includes soils where this level of provision is 20-30 mg/ 100 g of soil, while sample number 3 also exceeds these limits with 38.56 mg/ 100 g of soil, which can be said to have too high levels of phosphorus. Sample number 6 belongs to the group of high level of security, while the other samples 7, 8, 9 and 10 have a medium level of phosphorus security. Regarding **K2O**, according to the data obtained from the tests, it is concluded that samples 1, 4, 5 and 6 are soils with a very high level of potassium provided, which according to the classification includes soils where this level of provision is 35-45

mg/ 100 g of soil. while sample number 2 and 3 also come out of these limits with 45.76 and 48.30 mg/ 100 g of soil, which can be said to have too high levels of potassium. Sample number 9 belongs to soils with a high level of provision, so that samples under ordinal number 7, 8, 10 and 11 belong to soils with an intermediate level of potassium provision.

According to the obtained data from the **Third experimental trials in Laboratory 3**, although it deviates from the obtained data from the other tests performed in the first two laboratories, it can still be concluded that in terms of the samples, the obtained results match, that is, we conclude that the values for the five samples are the same.

V. CONCLUSION

Our country occupies a central place on the Balkan Peninsula in terms of raspberry production possibilities.

The test results showed that this soil is good for growing the desired raspberry plantations. With small interventions and the addition of certain fertilizers to the soil, optimal soil quality is achieved. Because the elements are most needed for quality production, raspberries are in good proportion and well contained in the soil, it is safe to say that this land is good for raising a new raspberry plantation. From the results you can also get the recommendations that are the conclusions of this research:

- The choice of land for raising long-term raspberry plantations is mostly used: deep soils with good permeability, humus content is 3-5%, pH value is in the range of 5.5 - 6.5 (slightly acidic) and medium heavy soil (about 50% clay).

- The method of irrigation case is important, because through that system the land can be restored by adding appropriate crystalline enzymes, to achieve a better quality of the soil composition and, if possible, to reach the requirements of raspberries for the soil composition to raise an appropriate plantation.

- Nitrogen (N) is the element with the highest mobility in the soil, which can be a significant problem from an environmental point of view. The uncontrolled application of fertilizers can lead to a series of unwanted consequences that are manifested through various forms of disadvantages, deposition of various foods, unevenness of the elements in the soil, but also in the plant itself.

- The most important elements that should be included in the soil to raise the raspberry plantation are: phosphorus (P2O5) in amounts of 10mg and potassium (K2O) in an amount of 40mg per 100g of soil.

Due to the fact that the elements most necessary for quality raspberry production are in good proportion and well contained in the soil, it is safe to say that this land is good for starting a new raspberry plantation.

Values that the soil should contain for raising a raspberry plantationare pH value should be 5.5 – 6.5, the value of K_2O(light soils) should be 20 – 25 mg / 100g and K_2O (heavy soils) should be 25 – 30 mg / 100g, P_2O_5 should be 12 – 15 mg and MgO should be grater that 10 mg (best K/Mg ratio 2:1 to 3:1).

The values obtained from the soil analysis represent a direction to aim for, but equally important are the climatic conditions, the type and structure of the soil where the respective plantation will be raised, in the case of raspberry, in order to fully understand the processes that take place in the soil itself.

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