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THE INFLUENCE OF SOIL TYPES ON SEEDS GERMINATION AND PLANTS HEALTH TO DIFFERENT SPECIES OF VEGETABLES

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Abstract

Vegetable yield is significantly influenced by the pedoclimatic conditions in the growing areas, by the applied technology and by the level of soil infection with different pathogens. We worked with 7 soil samples from Cluj County and 7 samples from Arad County. The soil samples were analyzed in terms of infection levels with various soil pathogens that cause seed rot and `damping-off`. The presence of pathogens was determined by the `trap plants` method. The experiment was performed in laboratory conditions, at an average temperature of 20.6-26.0°C and average relative humidity of 34.5-46.4%. In the soil samples it was determined the presence of soilborne pathogens Pythium debaryanum, Phytophthora parasitica and Rhizoctonia solani which cause seed rot and `damping-off`. Soil samples from Cluj County presented the largest number of `fallen` cabbage plants. Arad County showed the highest number of `fallen` tomato plants, 38 `fallen` cucumber plants.

Key words*: pathogens, nutrients, damping-off, Pythium debaryanum, Phytophthora parasitica, Rhizoctonia solani.*

INTRODUCTION

Vegetable yield is significantly influenced by the pedoclimatic conditions in the growing areas, by the applied technology, and by the level of soil infection with different pathogens. Soilborne pathogens *Pythium debaryanum, Phytophthora parasitica* and *Rhizoctonia solani* can cause seed rot and damping-off in most vegetable species where crops are established by directly sowing. The attack of the fungus *Pythium debaryanum* on vegetable seedlings has an acute character, a tomato plant can be destroyed, depending on temperature and humidity, in 12-24 hours, and in the greenhouses for seedlings production, in a few days, they can perish most plants (Baicu et al., 1996). *Phytophthora parasitica* manifests itself in temperature conditions between 20 and 25°C and in the presence of a film of water (Costache et al., 2018; Șovărel et al., 2020). *Rhizoctonia solani* is a polyphagous pathogen (over 25 known hosts), able to survive on plant debris from various plant species. Contamination is possible also through horticultural substrates (Blancard, 1997). The present researches aimed to establish the infectious potential of 14 soil samples from Cluj and Arad counties collected from the field and protected areas. Knowing the role of nutrients in plant life and their influence on harvest quality is of particular importance, because it underpins the measures that are required to ensure optimal plant growth and development and the production of superior quality plant products (Budoi, 2000). Tomato plants require at least twelve nutrients, also called “essential elements”, for normal growth and reproduction. These are nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), boron (B), iron (Fe), manganese (Mn), copper (Cu), zinc (Zn) and molybdenum (Mo) (Sainju et al., 2003).

MATERIALS AND METHODS

To detect the presence of soil pathogens, in the soil samples from Cluj and Arad counties, the "trap plants" method was used. At the samples from Cluj county we worked with cauliflower (49S, 50S), cabbage (66S, 67S, 68S, 70S), and celery (69S) and at the samples from Arad county with pepper (90S, 92S), tomatoes (91S, 93S, 94S, 96S) and cucumbers (95S). Plastic trays measuring 25 cm long, 20 cm wide and 5

cm high in which the soil samples were placed were used. On the same day, in the trays thus prepared, 100 seeds (10 rows of 10 seeds) of cauliflower (Herfstreusen variety), cabbage (Buzău variety), celery (Dolvi variety), peppers (Asteroid 204 variety), tomatoes (Pontica 102 variety) and cucumbers (Cornichon de Paris variety) were sown. After sowing the seeds were covered with 0.5 cm of soil (from the same soil sample) and watered with the same amount of water. Next, every 2 days, the dynamics of the emergence of these 6 species of vegetables (cauliflower, cabbage, celery, peppers, tomatoes, cucumbers) and the appearance and evolution of the attack of the mentioned soil pathogens were followed (frequency of rotten seeds, frequency [%] "damping-off". During the experiment, the temperature and atmospheric humidity in the room in which it was placed were permanently recorded using a thermohygrometer type EMC DT - 172. In the experimental period (08.02.2021-02.03.2021) the minimum temperature was 19.8-24.1°C, the average temperature was 20.6-26.0°C, and the maximum temperature was 21.5-33.3°C. The minimum relative humidity varied between 23.5 and 42.5%, the average relative humidity between 34.5 and 46.4%, and the maximum relative humidity between 38.2 and 49.0%.

RESULTS AND DISCUSSIONS

Table 1 shows the samples code, the county and the location where the samples were taken, the origin of the sample, and the previous culture.

Table 1. The provenance of the analyzed soil samples

Nr. Crt.	Samples code/ county	Location	Provenance of sample	Previous crops
0	1	2	3	4
1.	49 S/Cluj	Apahida	Field	cauliflower
2.	50 S/Cluj	Sânnicoară	Field	cauliflower
3.	66 S/Cluj	Câmpia Turzii	Field	cauliflower
4.	67 S/Cluj	Câmpia Turzii	Field	cabbage
5.	68 S/Cluj	Viișoara	Field	cabbage
6.	69 S/Cluj	Viișoara	Field	celery
7.	70 S/Cluj	Viișoara	Field	cabbage
8.	90 S/Arad	Macea	Field	bell pepper
9.	91 S/Arad	Apateu	high plastic tunnels	tomato, cucumbers
10.	92 S/Arad	Nădlag	Field	hot pepper
11.	93 S/Arad	Apateu	high plastic tunnels	tomato, bell pepper
12.	94 S/Arad	Apateu	high plastic tunnels	tomato
13.	95 S/Arad	Olari	high plastic tunnels	cucumbers
14.	96 S/Arad	Apateu	high plastic tunnels	Tomato

Samples from Cluj County (Table 2)

In general, the soil is weakly alkaline, well supplied with organic matter, but which in some cases has relatively high concentrations of sodium; it's about solonchak soils. It recommended that the soil will be amended with gypsum - CaSO4.2H2O, phosphogypsum (residual material of phosphate fertilizer plants), calcium chloride - CaCl2.6H2O, Al sulphate, Fe sulphate, native sulfur, or lignite powder.

- pH: soil reaction varies between neutral (7.06) and weakly alkaline. Under these conditions, the more alkaline the pH, the lower the mobility and availability of nutrients for plants: phosphorus, manganese, boron, zinc, and relatively magnesium, iron, and copper. The most affected is phosphorus, which influences the growth of the root system, and together with boron the development of plants. Foliar fertilization with fertilizers rich in assimilable phosphorus and boron is recommended.
- ammoniacal nitrogen: it is relatively good; at the seedling stage, when the energetic state of the plants is precarious and in conditions of deficient solar radiation, however, higher values are recommended, but not more than 1/10 of the nitric nitrogen level.
- potassium: varies from low (sample 2-50S) to very low. Where the values are very low-low, root fertilizers with potassium sulfate are needed, which will also correct the pH.
- calcium: normally should be at least equal to water-soluble potassium, if not even higher by 50%. Samples 1 (49S) and 5 (68S) can lead to calcium deficiency, in which case the resistance to pathogens (fungi and bacteria) decrease.
- magnesium: the optimal values, depending on the cultivated species, vary between 1/2 and 1/4 of the potassium values. Where the balance is in favor of magnesium, potassium deficiency may occur (and vice versa). This is the case for samples 3 (66S), 4 (67S), 5 (68S) and 7 (70S). Due to its role in energy metabolism, protein, and especially nucleic acids, it increases the resistance of plants to pathogens (fungi and

bacteria). Its lack reduces the seed germination faculty.
- nitrites + nitrates: except for sample 3 (66S), the values are very low. Additional fertilization (practically every watering) with ammonium nitrate and alternating (one in three) with urea is required. The importance of nitrogen, especially nitric, on plant growth is known. Its lack increases their sensitivity to the attack of harmful organisms.
- chlorides: they present acceptable values.
- sulphates: except for the values corresponding to samples 2 (50S) and 4 (67S), the other samples are acceptable.
- phosphorus: all samples, except sample 2 (50S), reflect phosphorus-poor soils for field-grown vegetables.
Phosphorus deficiency increases the sensitivity of plants to: *Alternaria, Botrytis, Phytophthora, Fusarium* and *Erwinia*.
High phosphorus values facilitate the absorption of nitric nitrogen (sample 2-50S, whose concentration of nitric nitrogen is very low).
Basic fertilization with superphosphate or complex 22.22.0 or 16.48.0 or in vegetation with MAP (monoammoniacal phosphate) is required.

Table 2. The content in the main nutrients of soil samples from Cluj county

County	Samples no. and code	Determinations performed*										
		pH	N-NH_4	K mg/kg	Na mg/kg	Ca mg/kg	Mg mg/kg	N mg/kg	Cl^- mg/kg	SO_4^{2} mg/kg	P mg/kg	Humus
Cluj	1 (49S)	8.19	<1.25	<1.25	<1.25	41.1	<1.25	3.9	3.5	52.1	30.3	2.34
	2 (50S)	8.05	1.9	87.2	<1.25	114.0	35.2	9.3	8.0	239.6	262.8	4.47
	3 (66S)	7.06	<1.25	7.0	6.7	59.6	13.3	23.4	17.4	55.5	43.8	4.95
	4 (67S)	8.11	<1.25	4.0	36.3	146.2	9.3	7.7	26.7	173.6	11.0	2.14
	5 (68S)	7.86	<1.25	7.6	21.7	51.6	8.6	14.1	17.1	57.3	40.0	3.38
	6 (69S)	7.94	<1.25	12.9	25.4	82.4	9.4	14.9	26.8	83.8	16.9	4.28
	7 (70S)	8.22	<1.25	4.4	8.8	69.1	5.2	12.0	30.3	52.8	13.5	1.24
Normal limits		6.2 - 6.8	20.1 - 40.0	66.1 - 132.0	5.0 - 10.0	48.0 - 85.0	25.0 - 70.0	20.1 - 40.0	10.0 - 60.0	35.0 - 65.0	18.1 - 36.0	2.5 - 4

*physicochemical analysis results (HAGRO laboratory)

Samples from Arad County (Table 3)
In general, the soil is weakly alkaline (except for sample 12-94S which represents the reaction of a weakly acidic soil), well supplied with organic matter, but which in most cases has high-very high concentrations of sodium; it's about solonchak soils. If possible, amend the soil with gypsum - CaSO4.2H2O, phosphogypsum (residual material of phosphate fertilizer plants), calcium chloride - CaCl2.6H2O, Al sulphate, Fe sulphate, native sulfur or lignite powder.
- pH: soil reaction varies between weakly acidic (6.56) and weakly alkaline. Under these conditions, the more alkaline the pH, the lower the mobility and availability for plants of some nutrients: P, Mn, B, Zn and relatively Mg, Fe and Cu. The most affected is phosphorus, which will influence the growth of the root system, and together with boron the development of plants. Foliar fertilization with fertilizers rich in assimilable phosphorus and boron is recommended.
- ammoniacal nitrogen: it is relatively good; at the seedling stage, when the energetic state of the plants is precarious and in conditions of deficient solar radiation, however, higher values are recommended, but not more than 1/10 of the nitric nitrogen level.
- potassium: varies from very low (samples 8-90S, 10-92S and 12-94S) to very good (samples 9-91S and 14-95S; Figure 1). Where the values are very low-low, root fertilizers with potassium sulfate are needed, which will also correct the pH.
- calcium: normally should be at least equal to water-soluble potassium, if not even higher by 50%. Except for sample 10 (92S), the remainder reflects high concentrations of calcium. Analyzing these values compared to those of potassium, we can expect deficiencies in this last element.

Figure 1. Sample 12 (94 S – Arad) – normally developed tomato plants and Sample 14 (96 S – Arad) – tomato plants inhibited due to the high soil content of nitrites and nitrates

- magnesium: the optimal values, depending on the cultivated species, vary between 1/2 and 1/4 of the potassium values. Where the balance is in favor of magnesium, potassium deficiency may occur and vice versa. This is the case for samples 8 (90S) and 12 (94S). Due to its role in energy metabolism, protein, and especially nucleic acids, it increases the resistance of plants to pathogens (including fungi and bacteria). Its lack reduces the seed germination faculty.
- nitrites + nitrates: except for samples 10 (92S) and 12 (94S) which have low concentrations, the values are either normal or very high (sample 13-95S) or excessively high (sample 9-91S and especially 14 -96S).
- chlorides: varies from very low to excessively high (sample 10-92S and 9-91S and 14-96S respectively). Otherwise, the values are acceptable.
- sulfates: these are high values due to Ca, Mg and Na sulfates. There is, however, a beneficial effect. If there were lower values, we would probably have higher pH values.
- phosphorus: except for samples 8 (90S), 10 (92S) and 12 (94S), the other values are very high. Phosphorus deficiency increases the sensitivity of plants to: *Alternaria, Botrytis, Phytophthora, Fusarium* and *Erwinia* (case of samples 10-92S and 12-94S). High phosphorus levels facilitate the absorption of nitric nitrogen, which is high anyway. Excess of nitrogen may occur.

Table 3. The content in the main nutrients of soil samples from Arad county

Samples no. and code	Determinations performed*										
	pH	$N\text{-}NH_4$	K mg/kg	Na mg/kg	Ca mg/kg	Mg mg/kg	N mg/kg	Cl^- mg/kg	SO_4^{2} mg/kg	P mg/kg	Humus
8 (90S)	7.94	<2.5	48.4	367.6	580.0	103.8	247.5	68.8	3165.5	87.9	2.91
9 (91S)	7.56	<2.5	452.7	370.3	295.5	158.7	373.9	406.5	154.2	245.0	9.03
10 (92S)	8.31	<1.25	3.5	2.3	88.2	10.3	8.4	3.6	124.8	12.0	2.81
11 (93S)	7.64	<2.5	93.0	214.1	196.6	80.7	184.0	171.4	171.0	218.4	5.74
12 (94S)	6.56	<2.5	29.1	80.6	113.4	52.4	66.0	55.2	180.9	34.1	2.72
13 (95S)	7.62	<2.5	230.3	166.2	446.8	135.6	297.0	88.9	441.2	176.2	6.31
14 (96S)	7.46	<2.5	518.6	372.6	925.3	450.3	1007.3	440.1	275.5	239.9	6.31
Normal limits	6.2 - 6.8	20.1 - 40.0	66.1 - 132.0	5.0 - 10.0	48.0 - 85.0	25.0 - 70.0	20.1 - 40.0	10.0 - 60.0	35.0 - 65.0	18.1 - 36.0	2.5 - 4

*physicochemical analysis results (HAGRO laboratory)

Number of rising plants and frequency of attack of soilborne pathogens depending on the sample.
In the 14 soil samples (7 samples from Cluj county, 7 samples from Arad county) received for phytopathological analyzes, the presence of soil fungi *Pythium debaryanum, Phytophthora parasitica* and *Rhizoctonia solani* was detected, which cause "damping-off".

a. **Soil samples from Cluj County** (Table 4)
Depending on the soil sample, the number of cauliflower seedlings ranged from 62%

(sample 49S) to 100% (sample 50S; Table 4). The number of rotten seeds due to the attack of soil pathogens (*Pythium debaryanum, Phytophthora parasitica, Rhizoctonia solani*) varied between 0 (50S sample) and 38% (49S sample). In sample 49S the number of "fallen" plants was 2 (1 of *Pythium debaryanum* and 1 of *Rhizoctonia solani*) and in sample 50S the number of "fallen" plants was 3 (2 of *Pythium debaryanum* and 1 of *Rhizoctonia solani*). Depending on the soil sample, the number of plants grown on cabbage varied between 92% (sample 66S) and 100% (samples 67S and 70S). In sample 66S the number of rotten seeds, due to the attack of soil pathogens, was 8%, and in sample 66S 14%. In sample 66S the number of "fallen" plants was 13, of which 10 were due to the attack of *Pythium debaryanum* and 3 of *Rhizoctonia solani*. In sample 67S the number of "fallen" plants was 6, of which 5 were due to the attack of *Pythium debaryanum* and 1 of *Rhizoctonia solani*. In the 68S sample, the number of "fallen" plants was 6, of which 4 were due to the attack of *Pythium debaryanum* and 2 of *Rhizoctonia solani*. In the 70S sample, the number of "fallen" plants was 51, of which 44 due to the attack of *Pythium debaryanum* and 7 of *Rhizoctonia solani*. In the 69S soil sample, the number of sprouted celery plants was 70 and the number of rotten seeds was 30. In this sample, no “fallen” plants were registered. In the case of soil samples the 50S (seedlings 100, “fallen” plants 3) and 67S (seedlings 100, plants “fallen” 6) it can be estimated that they are slightly contaminated with soilborne pathogens.

Table 4. Number of plants raised and frequency [%] of attack of soilborne pathogens depending on the sample, Cluj County

Nr. crt.	Sample cod	Species tested	No. sprouted plants	Rotten seeds *)	"Damping-off" plants			
					Pythium debaryanum	*Phytophthora parasitica*	*Rhizoctonia solani*	Total
1	49S	Cauliflower	62	38	1	0	1	2
2	50S	Cauliflower	100	0	2	0	1	3
3	66S	Cabbage	92	8	10	0	3	13
4	67S	Cabbage	100	0	5	0	1	6
5	68S	Cabbage	86	14	4	0	2	6
6	69S	Celery	70	30	0	0	0	0
7	70S	Cabbage	100	0	44	0	7	51

*) Soilborne pathogen complex (*Pythium debaryanum, Phytophthora parasitica, Rhizoctonia solani*)

b. **Soil samples from Arad County**

Depending on the soil sample, the number of plants grown on peppers was between 84% (sample 92S) and 85% (sample 90S; Table 5). The number of rotten seeds due to the attack of soil pathogens varied between 15% (sample 90S) and 16% (sample 92S). In the 90S sample, the number of "fallen" plants was 5, of which 3 due to the attack of *Pythium debaryanum* and 2 of *Rhizoctonia solani*. In the 92S sample, the number of "fallen" plants was 2, 1 of which was due to the attack of *Pythium debaryanum* and *Rhizoctonia solani*. Depending on the soil sample, the number of plants grown on tomatoes was between 72% (sample 91S) and 95% (samples 94S and 96S). The number of rotten seeds, due to the attack of soil pathogens, was 28% (sample 91S), 21% (sample 93S), 5% (sample 94S) and respecitv 5% (sample 96S). In sample 91S the number of "fallen" plants was 60, of which 24 were due to the attack of *Pythium debaryanum* (Figure 2), 29 of *Phytophthora parasitica* (Figure 3) and 7 of *Rhizoctonia solani* (Figure 4).

Figure 2. *Pythium debaryanum* attack on tomatoes

Figure 3. Phytophthora parasitica attack on tomatoes

In sample 93S, the number of "fallen" plants was 19, of which 8 due to the attack of *Pythium debaryanum*, 9 of *Phytophthora parasitica* and 2 of *Rhizoctonia solani*.
No "fallen" plants were recorded in samples 94S and 96S.
In the 95S sample, the number of sprouted cucumber plants was 84% and the number of rotten seeds was 16%.

The number of "fallen" plants was 38, of which 32 were due to the attack of *Pythium debaryanum* and 6 of *Rhizoctonia solani*.
In the case of soil samples, 94S (rotten seeds 5, "fallen" plants 0) and 96S (rotten seeds 5, "fallen" plants 0) can be considered to be slightly contaminated with soilborne pathogens.

Figure 4. *Rhizoctonia solani* attack on tomatoes

Table 5 Number of plants raised and frequency [%] of attack of soilborne pathogens Depending on the sample, Arad County

Nr. crt.	Sample cod	Species tested	No. sprouted plants	Rotten seeds *)	"Damping-off"-plants			
					Pythium debaryanum	*Phytophthora parasitica*	*Rhizoctonia solani*	Total
8	90S	Bell pepper	85	15	3	0	2	5
9	91S	Tomatoes	72	28	24	29	7	60
10	92S	Hot pepper	84	16	1	0	1	2
11	93S	Tomatoes	79	21	8	9	2	19
12	94S	Tomatoes	95	5	0	0	0	0
13	95S	Cucumbers	84	16	32	0	6	38
14	96S	Tomatoes	95	5	0	0	0	0

*) Soilborne pathogen complex (*Pythium debaryanum, Phytophthora parasitica, Rhizoctonia solani*)

CONCLUSIONS

It is recommended to control of soilborne pathogen complex (*Pythium debaryanum, Phytophthora parasitica, Rhizoctonia solani*) with the following products:
1. Chemical products:
- Merpan 80 WDG (captan 800 g/kg) 0.15% (4-5 L solution/sqm) A maximum of 2 treatments are applied after sowing, at 14-day intervals (tomato seedlings).
- Previcur energy (propamocarb 530 g/L + fosetil 310 g/L) for tomatoes and cucumbers in protected spaces 3 L/ha applied by drip after transplanting (3-day break).
- Proplant 72,2 SL (propamocarb 722 g/L) 0.2% - 2 treatments are applied to the seedlings: the first at sowing - emergence 3-5 L solution/sqm and the second treatment one week before transplanting 3-5 L solution/sqm.
2. Biological products:
- Cavaler 600 SL (*Bacillus licheniformis* 1 x 10^7 ufc/ml + *Bacillus polymyxa* 1 x 10^6 ufc/ml + *Bacillus pumilus* 1 x 10^8 ufc/ml + Bacillus subtilis 1 x 10^8 ufc/ml) applied to vegetables by drip: solution of 1% (1L product in 100 L water) and foliar: 3L/hectar, 2 treatments, respectively 30 ml solution, in 10 liters of water/100 sqm.
- Garex B (garlic extract 80.73% + Bor 2%) 0.1-0.2% foliar application.

-Copfort (water-soluble copper 6% + copper complexed with gluconic acid 6%) 0.2% + Mimox Zn (Mimosa extract 80% + Zn 0.6% + Mn 1%) 0.3%.
-Algiforte (seaweed Ascophyllum nodosum + water-soluble magnesium oxide 1% + magnesium oxide complexed with gluconic acid 0.6%) 0.3% + Altosan (chitosan 4%) 0.3%
It is recommended to fertilize crops based on an integrated soil analysis service, from all points of view: physico-chemical (soil nutrient potential), phytopathological and microbiological (diseases and pests), from the point of view of pesticide residues remaining in the soil, pedological (sandy, loamy, clay soil, etc.).

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