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Development of wheat plants on soil reclaimed by mineral waste

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Abstract: This study presents the influence of soil amendment with two mineral waste on the wheat plants development. Both types of tested mineral waste have resulted from the magnesium products industry, namely as waste-product and as deposits on the industrial equipment. The composition of these waste shows significant contents of precipitated magnesium and calcium carbonates as well as low contents of iron, copper, manganese and zinc. The difference between the two tested mineral waste lies in the double magnesium content, established for the crusts composition. An acid low fertile soil was treated with four different doses of each waste, in absence or in presence of nitrogen addition. The waste influence on the development of wheat was established by analysing some physiological characteristics of green wheat plants, on one hand as well as their essential and trace elements content, on the other hand.

Keywords: magnesium products industry, mineral waste, soil amendment, wheat plant

1. Introduction

The industrial processes of manufacturing magnesium compounds - oxide and carbonates mainly, from dolomites, by carbon dioxide leaching, generate important amounts of waste [1,2]. The composition of these waste include precipitated calcium carbonate and magnesium carbonates (in ratio of 3:1 till 4:1) toghether with other impurities, present in the raw material such as iron, manganese, copper and zinc [3, 4].

The alkaline reaction and the important mineral content – essential and trace elements – of these waste can be valuated in agriculture as soil amendment and fertilizer for acid soils with low fertility [5-7].

The main objective of this study is to present the influence of waste types and doses on the fertility characteristics of an acid soil. The paper reports the effects of several waste doses and types on luvosoil with or without nitrogen contribution. Two types of waste were experimented, one from the industrial process (A) and the second resulted as crusts deposed on the equipment walls (B) [8].

2. Experimental

Luvosoil, having a pH_{H2O} of 6.94 and a rather low soil fertility was collected, air-dried, crushed, mixed and put into pots, each containing 1 kilogram soil. The soil was treated with two types of waste in different amounts, having each the composition presented in Table 1.

TABLE 1. Composition of the industrial mineral waste

Specification	Waste A	Waste B
Ca, %	28	19
Mg, %	7	14
Fe, mg/kg	1850	880
Cu, mg/kg	1.9	51
Mn, mg/kg	136	51
Zn, mg/kg	2.6	50

The experimental alternatives pursued by this research consist of four different doses for each waste (A, B) and also a control alternative (C_0) representing the untreated soil. The description of the experimental alternatives is shown in Table 2, in which R represent the replicates without nitrogen treatment and R_N the replicates treated with nitrogen as ammonium nitrate.

All the pots were sown with thirty wheat grains. The vegetation period was that of green plant, pursued for 6 weeks [9]. Along the vegetation period, some morphological parameters, like number of risen plants, plant size, fresh and dry weight were pursued. Some composition features like dry matter and mineral content were determined too. The metal element content in plant at harvest time was established by AAS - ICP method [10].

TABLE 2. Description of the experimental alternatives

Experimental alternative		Nitrogen contribution, mg/kg	Mineral supplement						
			Dose, mg/kg	Ca, mg/kg	Mg, mg/kg	Fe, mg/kg	Mn, µg/kg	Zn, µg/kg	Cu, µg/kg
A_1	R	-	179	50	13	0.33	24.3	0.47	0.34
	R_N	134	179	50	13	0.33	24.3	0.47	0.34
A_2	R	-	357	100	25	0.66	48.7	0.93	0.68
	R_N	134	357	100	25	0.66	48.7	0.93	0.68
A_3	R	-	714	200	50	1.32	97.4	1.86	1.36
	R_N	134	714	200	50	1.32	97.4	1.86	1.36
A_4	R	-	1429	400	100	2.64	194.7	3.72	2.72
	R_N	134	1429	400	100	2.64	194.7	3.72	2.72
B_1	R	-	263	50	37	0.23	13.4	13.2	13.4
	R_N	134	263	50	37	0.23	13.4	13.2	13.4
B_2	R	-	526	100	74	0.46	26.8	26.4	26.8
	R_N	134	526	100	74	0.46	26.8	26.4	26.8
B_3	R	-	1053	200	147	0.93	53.6	52.6	53.6
	R_N	134	1053	200	147	0.93	53.6	52.6	53.6
B_4	R	-	2105	400	295	1.85	107.3	105.2	107.3
	R_N	134	2105	400	295	1.85	107.3	105.2	107.3

3. Results and discussion

A previous paper have presented the results regarding the amendment role of the mineral waste on the mentioned soil from Banat. By treating with rising dose of both waste, the pH values have risen from low acid to low alkaline [10].

The waste type and dose influence on the wheat plant development was established by analysing some physiological characteristics of green wheat plants (Table 3), their essential elements content (Table 4) and trace element content (Table 5).

The influence of addings contribution on some vegetation characteristics of wheat plants results from Table 3. Nitrogen contribution improves the number of risen plants. Soil treatment with waste A and nitrogen supplement improves the size of green wheat plants more significant than treatment with waste B. The highest values for fresh wheight was determined in green wheat plants, treated with waste A and nitrogen apport. For the highest dose of waste A in presence of nitrogen, the improve of dry wheight is 31.4%. For the same conditions of soil treatment with waste B, the increase lies by 35.3%. The values for dry matter are higher for the alternatives with waste B in presence of nitrogen than that treated with waste A.

TABLE 3. Influence of addings contribution on some vegetation characteristics of wheat plants

Experimental alternative		Risen plants		Size of green plant		Fresh weight		Dry weight		Dry matter
		number	%	cm	%	mg/piece	%	mg/piece	%	%
C_0	R	28	93.3	31.2	100	212	100	30.7	100	14.5
	R_N	30	100	32.6	100	207	100	40.8	100	19.7
A_1	R	30	100	31.6	101.3	205	96.7	33.0	107.5	16.1
	R_N	30	100	33.2	101.8	171	82.6	42.8	104.9	25.0
A_2	R	30	100	30.6	98.1	182	85.9	31.1	101.3	17.1
	R_N	30	100	36.2	111.0	251	121.3	42.4	103.9	16.9
A_3	R	28	93.3	32.3	103.5	139	65.6	32.0	104.2	23.0
	R_N	28	93.3	38.8	119.0	241	116.4	53.3	103.6	22.1
A_4	R	29	96.6	33.6	107.7	233	109.9	35.6	116.0	15.3
	R_N	30	100	38.3	117.5	237	114.5	53.6	131.4	22.6
B_1	R	29	96.6	31.2	100	163	78.9	39.1	127.4	24.0
	R_N	29	96.6	36.6	112.3	156	75.4	51.8	127.0	33.2
B_2	R	27	90.0	31.0	99.4	143	67.5	35.3	115.0	24.7
	R_N	30	100	35.3	108.3	155	74.9	48.5	118.9	31.3
B_3	R	28	93.3	32.6	104.5	152	71.7	36.3	118.2	23.9
	R_N	30	100	34.6	106.1	169	81.6	48.5	118.9	28.7
B_4	R	29	96.6	31.3	100.3	241	113.7	37.8	123.1	15.7
	R_N	29	96.6	34.5	105.8	203	98.1	55.2	135.3	27.2

TABLE 4. Impact of addings on the macroelements content in plants

Experimental alternative		Ca		Mg		P		K	
		g/kg	%	g/kg	%	g/kg	%	g/kg	%
C_0	R	6.009	100	2.434	100	4.121	100	50.46	100
	R_N	6.828	100	2.715	100	2.900	100	48.17	100
A_1	R	5.553	92.4	2.426	99.7	4.368	106.0	48.169	95.5
	R_N	8.330	122.0	3.326	122.5	2.664	91.9	47.258	98.1
A_2	R	5.724	95.3	2.396	98.4	4.448	107.9	45.412	90.0
	R_N	8.650	126.7	3.432	126.4	2.454	84.6	43.657	90.6
A_3	R	5.977	99.5	2.541	104.4	4.220	102.4	45.571	90.3
	R_N	8.253	120.9	3.390	124.9	2.495	86.03	44.654	92.7
A_4	R	5.995	99.8	2.869	117.9	4.207	102.1	49.983	99.1
	R_N	7.705	112.8	3.656	134.7	2.656	91.6	43.638	90.6
B_1	R	4.753	79.1	2.161	88.8	4.375	106.2	40.833	80.9
	R_N	7.842	114.9	3.217	118.5	2.535	87.4	46.088	95.7
B_2	R	4.786	79.6	2.200	90.4	4.304	104.4	38.604	63.3
	R_N	6.105	89.4	2.843	104.7	2.433	83.9	31.438	65.26
B_3	R	6.566	109.3	3.017	127.6	4.749	115.2	54.845	108.7
	R_N	8.453	123.8	3.730	137.4	2.230	76.9	51.380	106.7
B_4	R	7.224	120.2	3.794	155.9	4.798	116.4	62.285	123.4
	R_N	8.502	124.5	4.057	149.4	2.508	84.5	56.080	116.4

TABLE 5. Impact of addings contribution on the microelements content in plants

Experimental alternative		Fe		Cu		Mn		Zn	
		μg/g	%	μg/g	%	μg/g	%	μg/g	%
C_0	R	148.7	100	11.78	100	36.10	100	95.86	100
	R_N	107.4	100	11.53	100	38.45	100	112.7	100
A_1	R	168.1	113.0	11.23	95.3	35.91	99.5	77.51	80.9
	R_N	101.2	94.2	11.53	100	36.58	95.1	91.34	81.0
A_2	R	132.0	88.8	10.48	89.0	35.62	98.7	87.52	91.3
	R_N	131.3	122.3	12.03	104.3	25.97	67.5	99.22	88.0
A_3	R	182.8	123.0	30.86	262.0	31.37	86.9	82.16	85.7
	R_N	135.7	126.4	28.27	245.2	19.96	51.9	83.12	73.7
A_4	R	178.4	120.0	28.23	239.6	26.57	73.6	64.65	67.4
	R_N	130.4	121.4	35.85	311.0	18.09	47.0	68.26	60.6
B_1	R	129.9	87.4	25.09	213.0	30.58	84.7	83.15	86.7
	R_N	110.2	102.6	23.69	205.5	28.37	73.8	102.1	90.6
B_2	R	105.8	71.1	40.93	347.5	30.75	85.2	73.22	76.4
	R_N	77.0	71.7	32.66	283.3	20.49	53.3	88.62	78.6
B_3	R	139.7	93.9	45.86	389.3	30.60	84.8	68.62	71.6
	R_N	126.0	117.3	63.64	551.9	24.91	64.8	94.52	83.9
B_4	R	166.8	112.2	54.34	461.3	29.22	80.9	72.78	75.9
	R_N	133.2	124.0	49.28	427.4	19.90	51.8	92.10	81.7

The impact of addings on plants macroelements content is shown in Table 4. Rising the waste dose in presence of nitrogen improves the calcium content in plant by 26.7% for waste A and 24.5% for waste B. Analysing the magnesium content of plant, an improvement was established for the alternatives with waste A in presence of nitrogen by 34.7% and 49.4% for waste B in presence of nitrogen too. Nitrogen supplement generates a decrease of the phosphorous content of plant for both waste types along with their dose increase. The potassium content of plant shows lower values than those of the control alternatives only for treatment with waste A. Waste B improves the potassium content of the plant by rising the waste dose.

The impact of addings contribution on plants microelements content is shown in Table 5. The iron content of plant improves by rising the waste doses and decreases in presence of nitrogen. The copper content of plant shows higher values once with increase of the waste dose and magnesium content. By rising the waste doses, manganese and zinc content of plant decreases. An increase of zinc content in plant was established in presence of nitrogen.

4. Conclusions

Soil amendment with two mineral waste (waste-product, crusts) from the magnesium products industry has a benefic effect on wheat plants development (number of risen plants, size) and their physiological features (fresh weight, dry weight). The effect increases in presence of nitrogen.

For both waste types, the increase of doses has an important influence on the content of essential elements (calcium, magnesium, potassium) in plant, excepting the phosphorous content which decreases once with the waste dose increase.

Treating soil with the two waste types and different doses, the increase of the trace elements content in plant was established, namely iron, copper, zinc. Only the manganese content of plant decreases once with the increase of both waste doses.

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