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PHYSIOLOGICAL REACTION OF THE SPECIES *BRASSICA JUNCEA* (L.) CZERN. ON SALINIZED SOILS AMELIORATED WITH ZEOLITIC TUFF, PEAT AND PERLITE

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Abstract: The physiological reaction of saline stress which *Brassica juncea* (L.) Czern. plants undergo shows a greater growth and fresh substance gain process on previously cultivated soils that were fined with 20% zeolitic tuff and 5.09 g of neutral peat than the ones that had a substrate which hasn't been cultivated on before that was fined with 5% zeolitic tuff and 1.39 g of perlite. The dry substance values obtained present a positive correlation with the values of fresh substance. Analysis of stomatal conductance enhances the hydric stress of plants which respond to saline stress with osmotic adjustment, accumulating high quantities of water comparing to the witness plant, which induces lower values of stomatal conductance and implicitly values are decreasing for photosynthesis, determining a low productivity. Higher values of stomatal conductance are reached at plants grown on previously cultivated soils fined with 20% zeolitic tuff and peat, and also at the ones grown on uncultivated soils fined with peat (29.45, respectively 30.05 mmol/m^2/s).

Key words: amended soil affected by salinity, oriental mustard, peat, perlite, zeolitic tuff.

Introduction

Soil salinity creates a great environmental issue with economic and social consequences worldwide [SCHUBERT, 2011; SIDIKE & al. 2014]. Globally, estimations show that approximately one third of irrigated fields are affected by salinity issues. Moreover, a half of the field in semi-arid and coastal regions are being affected [MUNNS, 2011; FARHANA & al. 2014].

This issue is one of the processes leading to desertification [KASSAS, 1987], as well as one of the most important land degradation processes [THOMAS & MIDDLETON, 1993]. Salt accumulation in soli has a negative effect on the growth of most crops, these soils being associated with poor fertility [TANJI, 2002]. This also is one of the main causes of low productivity in agriculture throughout the world.

The reduction of productivity contradicts with the rising need of food for the population. The situation becomes even more alarming due to the expectation of population rising to 8-10 billion people by 2050 [LUTZ & SAMIR, 2010]. This problem represents a matter of concern for many teams of researchers for it to be found best solutions for improvement. Current methods of irrigation and cultivation practices contribute little to the rehabilitation of these soils [QADIR & OSTER, 2002], which requires the testing and

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implementing other techniques. Population growth rate and global economic development inevitably lead to an increase in the consumption of materials and minerals.

Therefore the present research has focused on finding technical solutions that will show a smaller energy and fuel consumption. That led to research methods and technologies that can promote the principles of sustainable development. Thus it has been chosen the amelioration with zeolitic tuff, peat and perlite on soils affected by salinity. After COCHEME & al. (2003), volcanic tuffs in Romania originate in the explosive activities of volcanic materials that have accumulated in inclusions and benches in the Miocene and Pliocene ages. Previous analysis have shown that the effect of providing the radish crops, *Raphanus sativus*, with zeolitic tuff had a positive outcome with rising efficiency, improving the quality of the crop, by retaining salt in the soil, thus preventing root absorption [NOORI, 2006]. Analysis on *Raphanus sativus*, cultivated in salinity conditions, where it has been added zeolitic tuff and sand to the soil have proven that the tuff acts like a buffer system and although halophilic vegetation was used, it wasn't immune to the stress produced by the salinity that appeared during the fifth and the sixth months of growth [QIAH & al. 2001].

Materials and method

For testing, it was used the oriental mustard, *Brassica juncea* (L.) Czern., from *Brassicaceae* Family, *Brassica* genus, closely related to *Brassica oleracea* subsp. *oleracea* (cultivated cabbage). The leaves, the seeds and the stalk of this genus are edible. Encountered in Africa, Bangladesh, China, Japan, Korea, Italy and India, the varieties of *B. juncea* are grown both for the green plant and for the production of oilseeds. In Russia, it is the main cultivated variety for the production of mustard oil. *B. juncea* is used a lot, in the preservation, baking and margarine production in Russia, and most of the table mustard is made from the same species of mustard plant. Because of the content of erucic acid with toxic potential, mustard seed oil is restricted as vegetable oil. *Brassica juncea* is a plant whose tolerance to salinity had been researched and demonstrated in studies made by WRIGH & al. (1997); NORTON & al. (2004); ASHRAF & al. (2001); KUMAR & ABROL (1984), KUMAR & al. (2009). The soil samples used for the research were taken from the common meadow of Prut and Jijia in Prisacani, Iasi County, on a cultivated land. The soil of both sites is a clay soil characteristic of former marine basins formed by deposition and sedimentation [PASTIA & al. 2017; STĂTESCU & PAVEl, 2011].

The determinations were made in the Analytical Chemistry Laboratory of the Chemical Engineering and Environmental Protection Faculty of "Gheorghe Asachi" University of Iasi. The main features of the two soil categories are presented in Tab. 1 [LUCHIAN, 2016].

Tab. 1. Characteristics of soils used for amelioration

	Uncultivated Land (M)	Cultivated Land (S)
Sand (%)	4.25	8.17
Dust (%)	3.92	3.21
Clay (%)	56.55	48.62
pH	6.83	8.07
Cl^- (mg/100 g soil)	317.22	35.36
SO^{4-} (mg/100 g soil)	21.89	-
Ca^{2+} (mg/100 g soil)	2.54	18.08
Mg^{2+} (mg/100 g soil)	45.63	8.66
K^+ (mg/100 g soil)	230.75	465.65
Na^+ (mg/100 g soil)	589.0	40.68

Soil samples from the cultivated area (S) and those from the uncultivated area (M) were given 5%, 10%, 15%, 20% and 30% zeolitic tuff. In order to improve the porosity and hydraulic conductivity of the soil, it went in parallel with a 1:1 (v / v) soil / peat mixture and another 1:1 (v / v) perlite. The material used for the research was purchased from S.C. BIOSOLARIS S.R.L., data for chemical characterization of the material from the supplier are presented in Tab. 2.

Tab. 2. The chemical and mineralogical composition of zeolite tuff used in the research

Chemical composition	Mineralogic composition
SiO_2 - 68.75 % Al_2O_3 - 11.35 % Fe_2O_3 - 2.10 % CaO - 2.86 % MgO - 1.18 % $Na_2O + K_2O$ - 3.99 % P.C - 9.77 %	Clinoptilolite 71% - 83.3% Vocanic glass: 4.1% - 9.7% Plagioclase: 6.6% - 6.67% SiO_2: 2.25% - 2.6% Other minerals: 3% - 4%

Other features provided by the supplier are: apparent dry weight specific gravity of 1.65 - 1.75 gf/cm³, cation exchange capacity (CEC) of 1.51 me/100g, natural moisture (BET) of 23.4 m²/g, micronized product, pore diameter of 3.82 Å, total porosity of 33.08%, water absorption of 16.21%, specific mass of 2.15-2.25 g/cm³, bulk density 0.88 kg/dm3.

The peat used for research is TS3 Standard, produced by Klassmann, partially decomposed, pearly peat grains of 0-25 mm with the addition of microelements: Phosphorus, Nitrogen and Potassium of 1 g / l and pH 6.

The pearlite is a natural, inorganic, granular material containing silicon dioxide, in percent of approx. 75% and aluminum oxide, ca. 15%, is perfectly dry, sterile, environmental friendly, extremely light, very chemically stable, non-degradable over time.

The plants were grown under green conditions in the Botanical Garden of Iasi, in vegetation vessels. The samples were watered with distilled water in order not to modify the salinity of the substrate.

Harvesting: plants reached biological maturity, meaning flowering phenophase, technical maturity (stage of harvesting plants), which may occur earlier or later depending on use.

The plants were harvested and weighed individually. Then it was arithmetically calculated the average of the weight of the vegetal mass, expressed in grams (fresh substance)/subject, plant.

The water and dry matter content of the leaves was determined by the gravimetric method.

Chloride was extracted in hot water and measured coulometric by titrating with AgCl, using a Sherwood Chloride analyzer, model 926.

The plant material was dried until constant weight after inactivation of the enzymes for one hour in the oven at 105 °C in the laboratory of Plant Physiology of the Agricultural Faculty of the Agronomic University and Veterinary Medicine “Ion Ionescu de la Brad” of Iasi.

Results and discussions

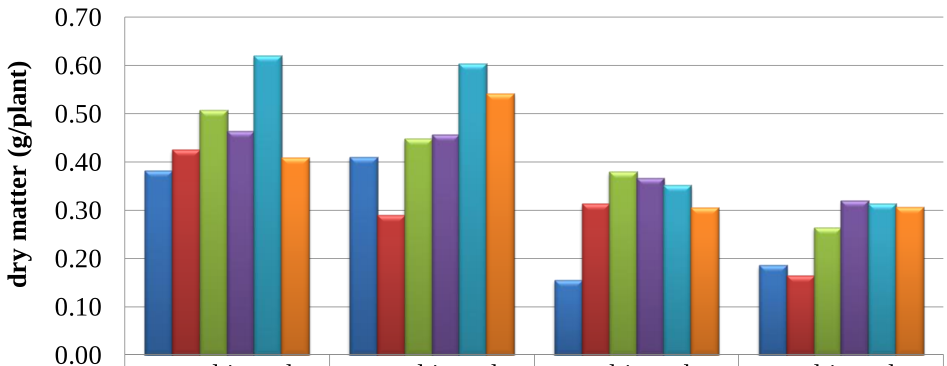
Effect of amendments on the plant growth process

The data presented in Tab. 3 shows the variations between the peat cultivated plants compared to the crops grown on perlite. Thus the average values of the vegetal mass per individual are higher for the plants cultivated on the peat and tufted soil, compared to the peat and tufted soil. The average value of the vegetal mass for the samples from the cultivated soil and fined with peat and pearlite ranges between 3.42 g / subject and 5.09 g, the maximum value being met with the 20% zeolitic pitch. The values for perlite and tuff fined cultivated soil are much smaller, varying between 1.77 g and 2.88 g / subject, the maximum value is reached at the 15% zeolitic tuff fine. The average value of the vegetal mass for the samples from the peat fined uncultivated soil, one series, and with another pearlite series, ranges between 3.8 g /subject and 5.44 g, the maximum value is reached at 20% zeolitic tuff. Values for perlite and tuff fined uncultivated soil are much lower, varying between 2.85 g and 3.9 g, the maximum value is reached at 30% zeolitic tuff.

Tab. 3. The average of the vegetal mass harvested at the end of the growing season, expressed in grams of fresh substance

	Witness (doesn’t contain zeolitic tuff)	**Zeolitic tuff**				
		5%	**10%**	**15%**	**20%**	**30%**
Cultivated soil - S (peat + tuff)	3.98	3.42	3.94	3.96	5.09	4.65
Cultivated soil - S (perlite + tuff)	1.83	1.77	2.69	2.88	2.41	2.66
Uncultivated soil - M (peat + tuff)	3.20	3.8	4.06	3.90	5.44	4.13
Uncultivated soil - M (perlite + tuff)	1.39	2.85	3.35	3.13	3.11	3.9

After analyzing the dry matter content, the plants grown on the arable soil and peat or tuff present a slightly higher dry substance values than the dry substance values of plants originated on perlite and tuff fined cultivated soil (Fig. 2).



	necultivated soil+peat	necultivated soil+perlite	cultivated soil+peat	cultivated soil+perlite
control	0.38	0.41	0.15	0.19
tuff 5%	0.42	0.29	0.31	0.16
tuff 10%	0.51	0.45	0.38	0.26
tuff 15%	0.46	0.46	0.37	0.32
tuff 20%	0.62	0.60	0.35	0.31
tuff 30%	0.41	0.54	0.30	0.31

Fig. 1. Effect of changes in the dry matter

Regarding the dry matter content percentage, the data shown in Tab. 4 stands that the values of the witness samples of both samples that were amended with peat and perlite aren’t showing really big differences. So for peat fined cultivated soil the dry substance value is 10.31%, and for perlite fined cultivated soil is 10.15%.

For samples from uncultivated soil fined with peat and zeolitic tuff, the minimum value is reached at sample ST 5% = 8.46% (cultivated soil + 5% zeolitic tuff), and the maximum value of the dry substance is reached at sample ST 20% = 11.86 (cultivated soil + peat + 20% zeolitic tuff).

For samples from cultivated soil fined with perlite and zeolitic tuff, the minimum value is reached at sample SP 5% = 9.29% (cultivated soil + perlite + 5% zeolitic tuff), and the maximum value is reached at sample SP 20% = 12.96 (cultivated soil + perlite + 20% zeolitic tuff).

Analyzing the data in Tab. 4, 5 it can be discovered that the plants grown on uncultivated soils that were fined with peat and tuff show values of the dry substance that are slightly higher that the values of dry substance from the plants grown on uncultivated soils that were fined with perlite and zeolitic tuff.

The values of witness samples that were fined with peat and perlite aren’t showing major differences. The dry substance value for uncultivated soil fined with peat is 11.93%, while for the uncultivated soil fined with perlite it is 10.11%.

For samples from uncultivated soil fined with peat and zeolitic tuff, the minimum value is reached at sample MT 30% = 9.88% (uncultivated soil + peat + 30% zeolitic tuff) and the maximum value is reached at sample MT 10% = 12.5 (uncultivated soil + peat + 10% zeolitic tuff).

For samples from uncultivated soil fined with perlite and zeolitic tuff the minimum value is reached at sample MP 30% = 7.8% (uncultivated soil + perlite + 30%

zeolitic tuff) and the maximum dry substance value is reached at sample MP 15% = 11.7 (uncultivated soil + perlite + 15% zeolitic tuff).

Analyzing the results obtained on the two soil types (cultivated and uncultivated), we can see that for 4 out of 6 samples (blank, 5% tuff, 10% tuff, 15% tuff) the dry matter values are higher for the uncultivated soil, although for samples fined with 20 and 30% tuff, dry matter values are lower.

After further analysis of the plants regarding the vegetal, dry substance and water mass it can be concluded that although uncultivated soil was initially presenting less favorable physical or chemical conditions for the growth, with values of higher apparent density compared to cultivated soil, values of total porosity and aeration less than arable soil, values of approx. 100 times higher in Sodium. Following experiments have shown that crops similar to those from arable soil samples were obtained on uncultivated soil. The results confirm that by taking suitable hydro- and soil ameliorative measures, the soil can be cultivated to give positive results.

The effect of soil fining on stomatal conductance and photosynthetic index of cultivated plants

An analysis that helps in understanding the stress to which plants grown on these saline soils are submitted to is the stomatal conductance of plants. This procedure highlights the hydric stress that communicates indirectly data on the impairment of the photosynthesis process, as can be seen from the analysis of the data presented in Tab. 5.

Adjustment of stomatal conductance by plants is done to improve the ratio between carbon capture and water loss. If plants suffer from water deficiency, the plants will survive by completely closing the stomata.

A high level of conductance means open stomata, leading to a high level of photosynthesis and, of course, good plant productivity. Smaller conduction, although reducing the risk of dehydration of the plant will have an effect on productivity by reducing it.

Stomatal conductance depends not only on the species but also on the cultivar. The cultivars that under salt stress condition exhibiting higher chlorophyll concentrations and higher stomatal conductance have a good Photosynthetic capacity [BOLOGA & al. 2016].

Tab. 4. Data on dry substance, stomatal conductivity and the photosynthesis index for the investigated samples

Sample	Dry substance (%)	Stomatal conductance (mmol/m^2/s)	Photosyntesis index
STm	10.31	17.76	13.05
ST 5%	8.46	12.6	5.04
ST 10%	11.38	12.35	3.6
ST 15%	11.55	17.2	9.85
ST 20%	11.86	29.45	7.6
ST 30%	11.71	12.8	2.75
SPm	10.15	5.8	2.05
SP 5%	9.29	6.05	9
SP 10%	9.79	14.5	2.05
SP 15%	11.13	18.7	2.25
SP 20%	12.96	28.1	2.5
SP 30%	11.49	21.8	2.15
MTm	11.93	12.9	6.55

MT 5%	11.18	14.8	3.46
MT 10%	12.5	30.05	3.25
MT 15%	11.98	12.8	1.4
MT 20%	11.41	14.5	2
MT 30%	9.88	13.15	7.55
MPm	11.14	21.65	1.65
MP 5%	10.98	12.95	2.05
MP 10%	11.33	26.05	5.75
MP 15%	11.7	9.5	2.35
MP 20%	11.29	20.45	2
MP 30%	7.8	11.8	1.43

It can be noticed that the values of stomatal conductance are lower for the plants from the cultures obtained on the samples investigated before fertilization. After fertilization (1g/L Nitrogen, Phosphorus, Potassium) it can be observed a double increase of the stomatal conductance values for the plants on STm (cultivated soil + peat with no addition of zeolitic tuff), ST 10% (cultivated soil + peat + 10% zeolitic tuff), ST 15% (cultivated soil + peat + 15% zeolitic tuff), ST 15% (cultivated soil + perlite+ 15% zeolitic tuff), ST 30% (cultivated soil + perlite + 30% zeoltic tuff). A triple increase of stomatal conductance values can be observed for ST 5% (cultivated soil + peat + 5% zeolitic tuff), ST 30% (cultivated soil + peat + 30% zeolitic tuff) and for the SPm (cultivated soil + perlite, with no addition of tuff) and SP 5% (cultivated soil + peat + 5% zeolitic tuff) we obtained an increase of five or six times.

In Tab. 5 there are shown average values of stomatal conductance of plants grown on soils investigated in two moments: a reading of stomatal conductance on unfertilized plants was done and a second one after the fertilization with 1g/L of Nitrogen, Phosphorus and Potassium.

Tab. 5. Stomatal conductance plant before and after fertilization with 1 g / L of Nitrogen, Phosphorus and Potassium

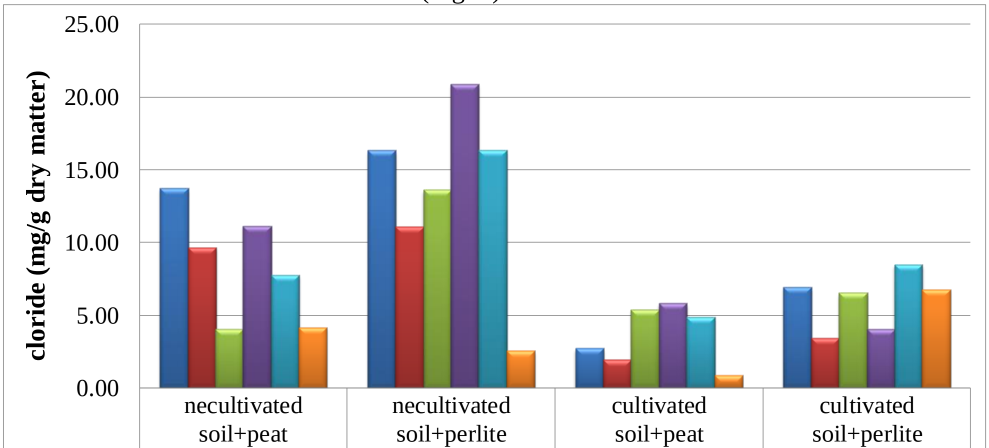
Sample	Stomatal conductance before fertilization (mmol/m^2/s)	Stomatal conductance after fertilization (mmol/m^2/s)	Sample	Stomatal conductance before fertilization (0mmol/m^2/s)	Stomatal conductance before fertilization (mmol/m^2/s)
STm	17.76	36	**MTm**	12.9	32.25
ST 5%	12.6	41.4	**MT 5%**	14.8	6
ST 10%	12.35	28.7	**MT 10%**	30.05	40.25
ST 15%	17.2	37.9	**MT 15%**	12.8	24.45
ST 20%	29.45	33.2	**MT 20%**	14.5	46.25
ST 30%	12.8	39.9	**MT 30%**	13.15	48.45
SPm	5.8	39.15	**MPm**	21.65	13.85
SP 5%	6.05	30.75	**MP 5%**	12.95	43.43
SP 10%	14.5	27.45	**MP 10%**	26.05	55.85
SP 15%	18.7	44.25	**MP 15%**	9.5	39.55
SP 20%	28.1	41.75	**MP 20%**	20.45	48.05
SP 30%	21.8	43.65	**MP 30%**	11.8	45.3

For samples coming from uncultivated soil fined with peat and perlite we obtained a double increase of stomatal conductance values for MTm (uncultivated soil + peat, with no addition of zeolitic tuff), MT 15% (uncultivated soil + peat + 15% zeolitic tuff), MP 10% (uncultivated soil + perlite + 10% zeolitic tuff) and MP 20% (uncultivated soil + perlite + 20% zeolitic tuff). Triple increase was noticed at MT 20% (uncultivated soil + peat + 20% zeolitic tuff), MT 30% (uncultivated soil + peat + 30% zeolitic tuff), MP 5% (uncultivated soil + perlite + 5% zeolitic tuff), MP 30% (uncultivated soil + perlite + 30% zeolitic tuff), cultivated soil + peat, and for the other plants that came from sample MP 15% (uncultivated soil + perlite + 15% zeolitic tuff) we have a 4 time-increase. For MT 5% (uncultivated soil + peat + 5% zeolitic tuff) and MPm (uncultivated soil + perlite, with no addition of zeolitic tuff) we registered a decrease in stomatal conductance values.

Analyzing the results obtained, it can be concluded that lower stomatal conductance values before fertilization show the degree of water stress of the plants, which, in order to protect themselves against dehydration, close their stomata, which has a negative effect on plant photosynthesis and productivity. The nutrient intake brought by fertilization helps plants increase the stomatal conductance, photosynthesis process and crop productivity.

Effect of soil fining on the accumulation of chlorine ions in plant tissues

Because the soils studied contain significant amounts of chlorine (Tab. 1), the research has also been aimed at the effect of soil improvement methods on the accumulation of chlorine ions in tissues. The determination of the chlorine content, expressed in mg/g of dry matter make able to observe the different effect of treatments on the accumulation of chlorine in tissues (Fig. 2).



	necultivated soil+peat	necultivated soil+perlite	cultivated soil+peat	cultivated soil+perlite
control	13.71	16.33	2.70	6.94
tuff 5%	9.65	11.05	1.95	3.45
tuff 10%	4.05	13.61	5.38	6.52
tuff 15%	11.14	20.88	5.79	4.04
tuff 20%	7.76	16.32	4.88	8.46
tuff 30%	4.17	2.53	0.88	6.76

Fig. 2. Effect of changes in chlorine concentration in plant tissues

In plants that were grown on soil from an uncultivated land was observed a significant decrease of chlorine concentration than from the witness, even after treatments with peat on all samples. On cultivated soil, the decrease only took place on the 5% and 30% samples. The perlite added on uncultivated soil determines reduction of chlorine accumulation in tissues only in MT 30% and on the uncultivated soil combined with 5% and 25% zeolitic tuff.

Conclusions

The investigation of amendment effect with zeolitic tuff on salinized soils, followed by a peat and respectively a perlite addition, have generated the following conclusions:

Plant growth, represented by biomass accumulation was positively influenced by the amendments application, the most efficient amendment variant was the 20% zeolitic tuff in a peat combination.

Stomatal conductivity and photosynthetic activity are not directly influenced by the applied amendments, in all cases the values of these parameters being reduced. Only after the phased plant fertilization with 1 g/l of nitrogen, phosphorus and potassium, an improvement in stomatal conductivity was observed in all research variants.

The concentration of chloride ions at the foliar level was influenced by the all soil treatments, the lowest values was recorded in the variants: 30% zeolitic tuff, in perlite and respectively peat combination, applied on the uncultivated soil, and at the cultivated soil, at the 30% zeolite tuff plus peat combination and 5% zeolite tuft and perlite combination.

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