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THE EFFECT OF DIFFERENTIATED NITROGEN AND POTASSIUM FERTILIZATION ON THE HORTICULTURAL SUBSTRATE REACTION IN THE GLASSHOUSE VEGETABLES GROWING

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A b s t r a c t. The effect of differentiated nitrogen-potassium fertilization on the substrate reaction and the yields of some vegetables grown under covers has been examined. A pot experiment was carried out in the glasshouse where high moor peat of pH 3.6 was used as the substrate. In the experiment with lettuce the substrate reaction was maintained on the level of pH 6.3 and the following N fertilization was applied, in mg $N\text{-}NO_3/dm^3$: 150 and 300 as $(NH_4)_2SO_4$, $NaNO_3$, NH_4NO_3. In the experiment with red pepper the pH was 6.5 and the fertilization was as follows: nitrogen in mg $N\text{-}NO_3/dm^3$ - 150, 200, and 250 as $(NH_4)_2SO_4$, $Ca(NO_3)_2$ and potassium in KCl and K_2SO_4. The results obtained clearly indicate the acidifying effect of $(NH_4)_2SO_4$. It caused the decrease in substrate reaction on the average from pH 6.4 to 5.1. The $NaNO_3$ has alkalizing effect while $Ca(NO_3)_2$ and NH_4NO_3 very slightly affected the substrate reaction.

In the experiment with red pepper unfavourable effect of the increasing nitrogen doses (200 and 250 mg $N\text{-}NO_3/dm^3$) on the substrate reaction as well as on the pepper fruits yields and quality was found. Moreover, a high contribution of fruits attacked by dry rot was noted. The applied KCl and K_2SO_4 fertilization slightly decreased the substrate reaction.

K e y w o r d s: nitrogen fertilization, potassium fertilization, horticultural substrate reaction, red pepper, lettuce

INTRODUCTION

For growing plants under covers the use of high doses of mineral fertilizers is indispensable and justified. The amount and assortment of the applied mineral fertilizers is dependent both on the grown plant species and the cultivation method.

In practice, high moor peat is often utilized as the substrate. It satisfies almost all requirements of a good substrate, i.e., it has high sorptive capacity, favourable physical properties and low density [8].

High doses of mineral fertilizers cause a high concentration of nutrients in the nutritive environment of plants. Thus, through controlled fertilizing and proper selection of fertilizers it is possible to influence, in a positive way, upon the chemical composition and biological value of the crops and of the growth medium.

The aim of the present work was to determine the effect of differentiated nitrogen and potassium fertilization on the substrate reaction and the yield of some vegetable crops cultivated under covers.

MATERIALS AND METHODS

The experiments were carried out in the glasshouse of the Agriculture Experimental Station at Felin near Lublin.

The greenhouse lettuce of Alka variety was grown in pots of 0.5 dm^3 capacity in the spring cycle 1990-1991. Because the results gathered during two experiments were similar, this paper presents only the results of the second year.

The substrate chosen for the experiment, i.e., high moor peat of pH 3.6 was treated with calcium carbonate to obtain pH 6.3. The following fertilization was applied: nitrogen in mg/dm^3 N-NO_3-150 and 300 as $(NH_4)_2SO_4$, $NaNO_3$, and NH_4NO_3; phosphorus P-200 as $Ca(H_2PO_4)_2$; potassium K-300 as K_2SO_4; and magnesium Mg-150 as $MgSO_4$ $7H_2O$.

The substrate was analysed 5 times every 10 days during the vegetation period: I - April 5, II - April 15, III - April 25, IV - May 5, and V - May 15, 1991. The seedlings were planted into pots on March 27, 1991 and after 10 days the first analysis of the substrate was performed. At the time of lettuce harvest (May 15, 1991), the fresh mass of loafs was estimated and then the contents of nitrates and dry matter were determined.

The experiment with red pepper of Monsum variety was carried out in pots of 10 dm^3 capacity in 1991. The substrate was also high moor peat which pH was raised to the value of 6.5 as above. The following fertilization in mg/dm^3 was applied: nitrogen N-NO3-150, 200, and 250 as $(NH_4)_2SO_4$ and $Ca(NO_3)_2$; phosphorus P-200 as $Ca(H_2PO_4)_2$; potassium K-400 as KCl and K_2SO_4; and magnesium Mg-150 as $MgSO_4$ 7 H_2O.

The substrate was analysed 3 times during the vegetation period: I -June 25, II - July 15, and III - August 23, 1991. The yields of red pepper were recorded in kg/pot as well as the dry matter content in them.

The experiments were run in a complete randomized design in 8 replications. The results of fresh mass yields of lettuce loafs and red pepper fruits have been statistically evaluated using analysis of variance and the Tukey's significance tests [9].

The pH values were determined potentiometrically in H_2O at the rate of the substrate-to-solution 1:2. The content of nitrates in the lettuce were determined in a 2 % CH_3COOH extract with Bremner method in Starck's modification.

RESULTS

Lettuce experiment

The differentiated nitrogen fertilizing in the lettuce experiment had distinct influence on the substrate reaction (Table 1). During the preparation of high moor peat for the lettuce tests the peat reaction was raised to pH value 6.3 and simultaneously several mineral fertilizers were applied. After 10 days the analysis of the substrate was made. In objects where $(NH_4)_2SO_4$ was added the decrease in substrate reaction was noted from pH 6.3 to 5.7. This process intensified along with the course of the vegetation and after 50 days the pH value recorded was 5.2 (Fig. 1).

Table 1. Substrate pH_{H_2O} in the glasshouse lettuce growth, 1991

N fertilizer	Dose*	Date of analysis**				
		I	II	III	IV	V
$(NH_4)_2SO_4$	N_1	5.70	5.69	5.19	5.42	5.38
	N_2	5.60	5.60	5.40	5.20	5.00
$NaNO_3$	N_1	5.80	6.00	6.30	6.35	6.40
	N_2	6.00	6.01	6.00	6.20	6.60
NH_4NO_3	N_1	6.00	5.80	5.90	6.00	6.30
	N_2	5.80	5.60	5.90	6.20	6.20

Explanations: *N_1-150 mg N/dm^3; N_2-300 mg N/dm^3. **I - April 5, II - April 15, III - April 25, IV - May 5, V - May 15.

The applied saltpetre alkalized the substrate, although at the beginning of the vegetation period it lowered the pH from 6.3 to 5.9 but along with the vegetation the reaction tended to increase and in the analysis term V it reached the value 6.5 (Fig. 1). On the other hand, ammonium nitrate caused the decrease in substrate reaction from pH 6.3 to 5.7 (in term II), however with the elapse of time the increase in the pH value was noted.

The yield of lettuce loafs fresh green mass and the content of nitrates in them were strictly dependent on the nitrogen fertilizing dose

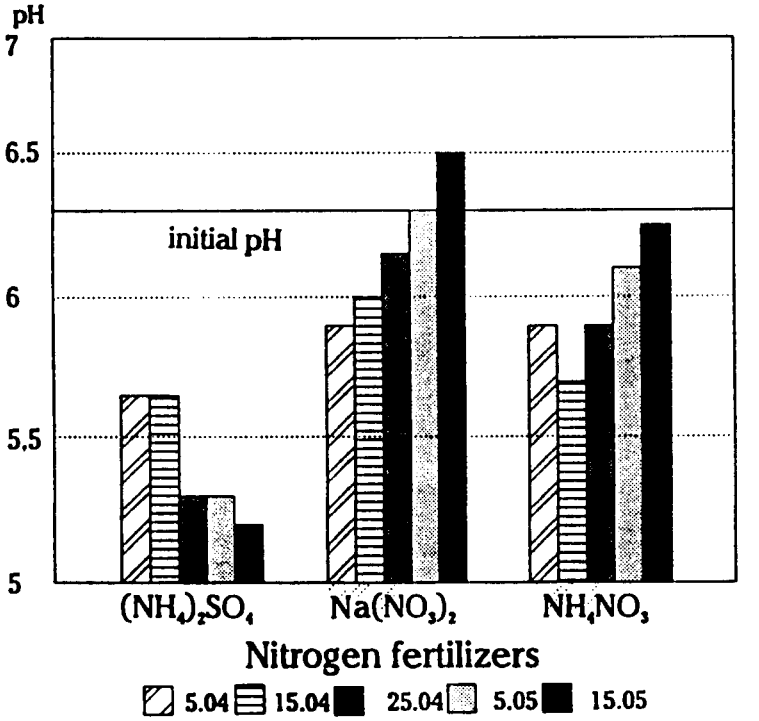

Fig. 1. The reaction $pH_{(H_2O)}$ of substratum in the culture of lettuce.

(Table 2). The highest lettuce yields (122.4 g) were obtained at applying 300 mg $N\text{-}NO_3$ as $NaNO_3$ and at the same N dose applied as $(NH_4)_2SO_4$ - 116.2 g/pot. These results prove that the decrease in the substrate reaction from pH 6.3 to 5.2 did not cause any significant differences in the lettuce yields.

Table 2. Yields of lettuce loafs green mass and content of dry matter and nitrates in lettuce leaves (date: May 15, 1991)

N fertilier	Dose (mg/dm^3)	Loaf weight (g/pot)	D. m. (%)	$N\text{-}NO_3$ (%)
$(NH_4)_2SO_4$	150	81.2	29.90	0.04
	300	116.2	17.60	0.09
$NaNO_3$	150	58.0	18.90	0.04
	300	122.4	14.60	0.31
NH_4NO_3	150	86.4	17.00	0.06
	300	102.0	14.80	0.10
LSD		15.7	4.32	

The content of nitrate is also very interesting. Over three times lower nitrates concentration (0.09 % $N\text{-}NO_3$) was noted in pots treated with 300 g $N\text{-}NO_3$ of $(NH_4)_2SO_4$ in comparison with the same dose of $NaNO_3$ (0.31 % $N\text{-}NO_3$).

Differentiated nitrogen fertilization also influenced the dry matter content in lettuce leaves. Its higher content was noted in all the objects fertilized with the dose 150 g $N\text{-}NO_3/dm^3$. However, higher dry matter content in pots fertilized with $(NH_4)_2SO_4$ in comparison to the other two can be noticed.

Red pepper experiment

In the experiment with red pepper the substrate reaction hase been raised to pH 6.5. The applied fertilizers, first of all the nitrogen ones, influenced the changes occurring in the substrate during the pepper's vegetation. The increasing doses of nitrogen within the range

Table 3. Substrate pH_{H_2O} in the red pepper glasshouse growth, 1991

Nitrogen fertilizer	Dose*	Potassium fertilization					
		KCl			K_2SO_4		
		Date of analysis**					
		I	II	III	I	II	III
$(NH_4)_2SO_4$	N_1	6.30	6.30	5.50	6.20	6.30	5.40
	N_2	6.30	6.00	5.40	6.00	5.80	5.40
	N_3	6.30	5.80	5.10	6.00	5.60	5.00
$Ca(NO_3)_2$	N_1	6.00	6.50	6.00	6.50	6.60	6.10
	N_2	6.10	6.40	6.10	6.20	6.60	6.10
	N_3	6.00	6.50	5.90	6.00	6.40	5.90

Explanations: *N_1-150 mg N/dm^3; N_2-200 mg N/dm^3; N_3-250 mg N/dm^3. **I-June 25, II-July 15, III-August 23, 1991.

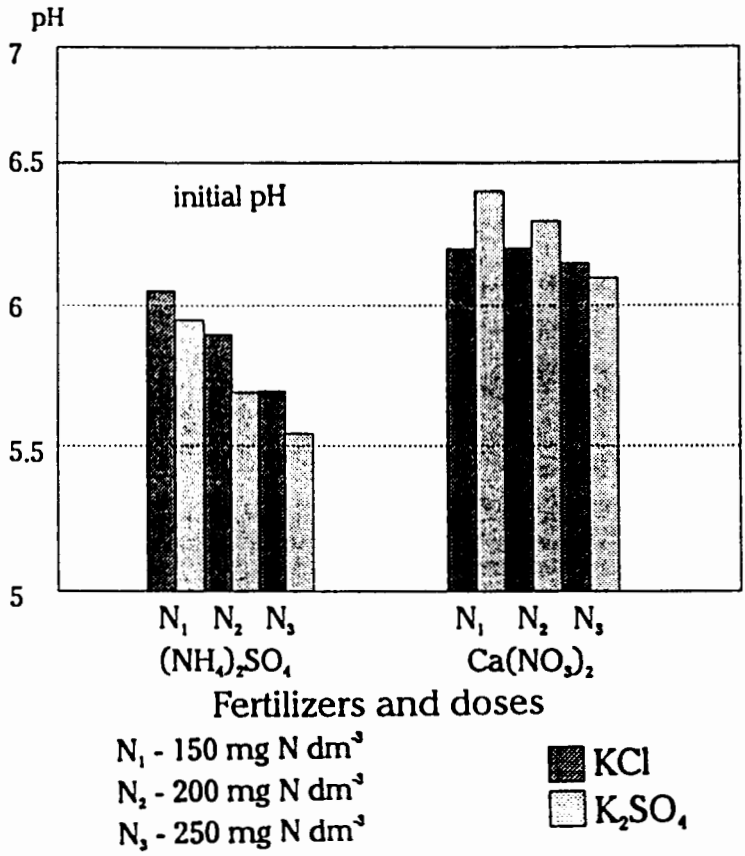

Fig. 2. The reaction $pH_{(H_2O)}$ of substratum in the culture of red pepper.

Table 4. Yield of fruits and dry matter content in fruits of red pepper, 1991

Potassium fertilizer	Nitrogen fertilizer	N dose (mg/dm^3)	Fruit weight (kg/pot)	D. m. (%)
KCl	$Ca(NO_3)_2$	150	0.73	11.5
		200	0.54	13.3
		250	0.33	14.0
	$(NH_4)_2SO_4$	150	0.55	10.1
		200	0.57	10.5
		250	0.44	11.0
K_2SO_4	$Ca(NO_3)_2$	150	0.83	10.9
		200	0.73	11.1
		250	0.63	11.1
	$(NH_4)_2SO_4$	150	0.71	10.7
		200	0.58	10.7
		250	0.51	11.0

150-250 mg N-NO_3/dm^3 caused the decrease in pH to a great degree when $(NH_4)_2SO_4$ was applied and to a bit smaller degree when $Ca(NO_3)_2$ was applied (Table 3). The lowering of reaction was also noted as the vegetation passed. These differences were especially visible in the 3rd term of the analysis at the dose 250 mg N-NO_3/dm^3 of $(NH_4)_2SO_4$. The pH decrease to 5.1 was recorded in pots treated with $(NH_4)_2SO_4$ and KCl and to pH 5.0 in pots fertilized with $(NH_4)_2SO_4$ and K_2SO_4.

No significant influence of potassium fertilization in the form of KCl and K_2SO_4 on the substrate reaction was observed (Fig. 2). The yields of red pepper fruits obtained were primarily affected by differentiated nitrogen doses. Higher crop yields were obtained from pots fertilized with 150 mg N-NO_3/dm^3 in comparison with the remaining two doses (Table 4). Different potassium fertilization influenced the amount of fruit yields much less. However, a tendency of increasing the pepper yields in objects fertilized with K_2SO_4 should be noted.

Dry matter content in the red pepper fruits ranged from 10.5 to 14.0 %. The applied potassium fertilizers slightly modified its content. It was found that the increasing nitrogen doses caused the decrease in the fruits' yield with a simultaneous increase of the dry matter content in them (Table 4).

The observations carried out during the vegetation of pepper plants let us note a large amount of fruits attacked by the dry rot in objects fertilized with 200 and 250 mg N-NO_3/dm^3.

DISCUSSION

The carried out research showed that the differentiated fertilization, and especially nitrogen one, had a distinct influence on the substrate reaction in the glasshouse production of vegetables grown on a high moor peat.

The studies of many authors [5,6,11] noted the influence of mineral fertilization on the soil and substrate reaction. They showed the acidifying effect of $(NH_4)_2SO_4$. It makes soil acid because it dissociates to NH_4^+ and SO^{-2}. Ion NH_4^+ is uptaken by the plants which give off the equivalent amounts of H^+ and with the rest H_2SO_4 is being formed. If the NH_4^+ ion is not uptaken by plants, it is subjected to nitrification and HNO_3 is formed as a consequence. Both the first and the second compound make soil acid. The results obtained entirely confirm the acidifying effect of $(NH_4)_2SO_4$, because during 50 days of lettuce vegetation in pots where this fertilizer has been used the substrate reaction lowered from pH 6.3 to 5.1, and that in the red pepper experiment from pH 6.5 to 5.1.

According to Fotyma and Mercik [5], $NaNO_3$ and $Ca(NO_3)_2$ have deacidifying effect. This result has been fully confirmed in case of $NaNO_3$ where after slight decrease of the reaction at the beginning of vegetation the

increase proceeded (from pH 6.3 to 6.6). However, lime saltpetre slightly lowered the substrate reaction. While growing vegetable crops under covers, the substrate reaction and calcium content are very significant because, according to some authors [3,4], they are the cause of occurrence of some physiological diseases, such as, e.g., dry rot of tomato and red pepper fruits. In the experiment with red pepper the decrease in fruits yield and its quality under the influence of increasing doses, and it was strictly related to proceeding decrease in the substrate reaction: the beginning of vegetation - pH 6.5, the end - pH 5.1.

The ammonium nitrate applied only slightly changed the substrate reaction in our experiment and that is not in accordance with the data of Kazanecka *et al.* [6], which indicated the acidifying effect of NH_4NO_3 in horticultural crops.

The substrate reaction also modifies chemical composition of plants. The studies of many authors [1,7,10] proved that soil acidification causes the weakening of nitrogen transport from vegetative to generative parts of the plant. Consequently, the plants responded with the decreased yield.

It was found that the content of nitrates was strictly dependent on the nitrogen doses and the form of the nitrogen fertilizer used. It appeared that the concentration of nitrates was three times lower in pots fertilized with $(NH_4)_2SO_4$ than in those with $NaNO_3$. However, no significant differences were noted in the lettuce yield.

The studies carried out by Borisova and Dineva [2] indicated that the dry matter content of protein and phosphorus in plants increases due to removing the toxic acidity. The results obtained in the lettuce experiment proved this statement, since higher dry matter yield was achieved at higher substrate reaction. While in the experiment with red pepper the opposite response was found, i.e., together with the decrease of reaction the increase in dry matter content was noted. This dependence should be explained by the fact that the red pepper fruits were attacked by the dry root and it was this disease that was responsible for the increase in the dry matter content.

CONCLUSIONS

1. Differentiated nitrogen fertilization had a decisive influence on the substrate reaction in the glasshouse production of vegetables, while potassium fertilization only slightly modifies its reaction.

2. The applied $(NH_4)_2SO_4$ caused the decrease in the substrate reaction in the experiment with the lettuce from pH 6.3 to 5.2, and in the experiment with the red pepper from pH 6.5 to 5.1. The applied $NaNO_3$ alkalizes the substrate while $Ca(NO_3)_2$ and NH_4NO_3 slightly differentiated the substrate reaction.

3. Unfavourable influence of the increasing nitrogen doses both on the crops yield and quality and on the substrate reaction was noted in the range of 200 and 250 mg $N\text{-}NO_3/dm^3$.

4. Because of the high yield of lettuce loafs and three times lower concentration of nitrates as well as high dry matter content the use of $(NH_4)_2SO_4$ for fertilizing the lettuce plants grown under covers should be considered.

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WPŁYW ZRÓŻNICOWANEGO NAWOŻENIA AZOTEM I POTASEM NA ODCZYN PODŁOŻA W UPRAWIE WARZYW SZKLARNIOWYCH

Badano wpływ zróżnicowanego nawożenia azotowo-potasowego na odczyn podłoża i plon niektórych warzyw uprawianych pod osłonami.

Doświadczenie przeprowadzono w szklarni, w wazonach. Jako podłoże wykorzystano torf wysoki o pH 3.6. W doświadczeniach z sałatą pH ustalono na 6.3 i zastosowano w mg $N\text{-}NO_3/dm^3$: 150, 300 jako $(NH_4)_2SO_4$, $NaNO_3$, NH_4NO_3. W doświadczeniu z papryką pH ustalono na 6.5 i zastosowano mg $N\text{-}NO_3/dm^3$: 150, 200, 250 jako $(NH_4)_2SO_4$, $Ca(NO_3)_2$ oraz potas w postaci KCl i K_2SO_4.

Uzyskane wyniki wskazują na zakwaszający wpływ $(NH_4)_2SO_4$. Powodował on obniżenie odczynu średnio z pH 6.4 do 5.1. $NaNO_3$ działała alkalizująco, zaś $Ca(NO_3)_2$ oraz NH_4NO_3 w niewielkim stopniu oddziaływał na odczyn podłoża.

W doświadczeniu z papryką odnotowano niekorzystny wpływ wzrastających dawek azotu w zakresie 200 i 250 mg $N\text{-}NO_3/dm^3$ na odczyn podłoża, plon owoców papryki i jego jakość. Stwierdzono w plonie duży udział owoców porażonych przez suchą zgniliznę owoców papryki.

Zastosowane nawożenie KCl i K_2SO_4 w niewielkim stopniu obniżało odczyn podłoża.

S ł o w a k l u c z o w e: nawożenie azotem, nawożenie potasem, odczyn podłoża ogrodniczego, papryka, sałata.