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EFFECT OF PHOSPHORUS AND POTASSIUM FERTILIZATION ON NITRATES(V) CONTENT IN MAIZE AND BUCKWHEAT

WPŁYW NAWOŻENIA FOSFOREM I POTASEM NA ZAWARTOŚĆ AZOTANÓW W KUKURYDZY I GRYCE

Abstract: Investigation was carried out in the conditions of cold greenhouse in a two-year-cycle and even doses of nitrogen introduced into soil in different chemical forms provided a background for application of increasing doses of phosphorus and potassium amounting 0.5; 1.0 and 1.5 g P and K · pot^{-1}. The effect of these components was assessed by determination of yield mass of experimental plants (maize and buckwheat) as well as accumulation of nitrate(V) nitrogen in aboveground plant parts. Regarding the conditions of our investigation, increasing doses of phosphorus decided neither about maize nor buckwheat yielding, while potassium added to soil, which was at the same time provided with even doses of nitrogen, on treatments fertilized with urea did significantly decrease maize yield mass. Application of different nitrogen fertilizers, at simultaneous increase in phosphorus amount in soil, resulted in diversified nitrate(V) contents in maize and buckwheat. Phosphorus diminished $N\text{-}NO_3$ content in maize fertilized with ammonium saltpetre and urea. In the case of buckwheat this effect was observed only when this plant was fertilized with urea. On the remaining objects increasing doses of phosphorus did not modify the content of this nitrogen form in experimental plants. The use of potassium did evidently decrease nitrate(V) content in buckwheat fertilized with all kinds of nitrogen fertilizers except for ammonium sulfate. As far as maize was concerned, experiments proved that the decrease in nitrate(V) concentration as a result of higher doses of potassium fertilization occurred only when nitrogen was applied in the form of ammonium saltpetre. In plants cultivated on the remaining experimental treatments $N\text{-}NO_3$ concentration reached similar values. A dominant form of mineral nitrogen was nitrate(V) nitrogen.

Keywords: nitrogen, nitrogen fertilizers, phosphorus fertilization, potassium fertilization, $N\text{-}NO_3$ maize, buckwheat

In a number of scientific elaborations their authors stress that soil richness in nutrients can be a decisive factor regarding nitrogen absorption by plants, as well as accumulation of nitrate(V) form of this chemical element. Potassium and phosphorus play an important role in this process. Czuba [1] reported that plants cultivated in the

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conditions of poor supply with phosphorus accumulate nitrate(V) in older tissues, while those abundantly provided with nitrogen, at simultaneous potassium deficiency, feature the ability to accumulate in their tissues amines and ammonium ions. Similar results obtained Cieslik [2] who related that in different plant species fertilization with high doses of nitrogen, at phosphorus deficiency in soil, resulted in increased amount of nitrate(V) in plants. In experiments by Nowacki [3] as well as by Munzert and Lepschy [4] there was observed decreased nitrate(V) content under the influence of higher phosphorus doses, although in potatoes this relation was not observed. Also numerous authors reported that increased potassium fertilization, at continuous supply of nitrogen, did decrease nitrate(V) content in the examined plants [5, 6]. Yet different conclusions were drawn by Ciecko et al [7] who proved that increasing doses of potassium, at continuous nitrogen fertilization, were of no importance for nitrate(V) content in potato tubers. The aim of this investigation was the assessment of the effect application of increasing doses of phosphorus and potassium, at even doses of nitrogen fertilization but with different nitrogen compounds, exerted on nitrate(V) accumulation in maize and buckwheat.

Material and methods

Research was conducted on the basis of exact cultivation – pot experiments involving application of increasing doses of phosphorus and potassium ranging 0.5; 1.0 and 1.5 g · pot^{-1}, at even level of nitrogen fertilization using different chemical forms of nitrogen (ammonium salptetre, calcium saltpetre, urea and ammonium sulfate). The choice of nitrogen dose was based on the results of previous experiments so that plants were provided with the conditions for optimum yielding and, at the same time, for increased accumulation of nitrate(V) in their aboveground parts. As far as maize cultivation was concerned, this dose amounted 1.5 g N · pot^{-1}, while in the case of buckwheat it equaled 1.0 g N · pot^{-1}. Investigation was carried out on light soil of acid reaction, medium – rich in plant – accessible phosphorus. The content of absorbable phosphorus was low, while magnesium content was of a high value. The experiment was conducted within two-year period in Wagner pots of 5 kg volume, in four replications.

In the course of plant growing period there took place detailed observations regarding plants growth and development and, if needed, there was applied chemical control of diseases and pests. After the harvest of experimental plants there were determined their yields, as well as harvested plants were subjected to analysis involving the contents of total nitrogen and nitrate(V) nitrogen. The results obtained were expressed as mean values for the whole examination period. The data were processed according to statistical analysis using analysis of variance due to Tukey's test at level of significance 0.05.

Results and discussion

The results shown in Table 1 point to the fact that average maize yields were of similar size, regardless the kind of nitrogen fertilizer applied. The only exceptions were

experimental treatments fertilized with calcium saltpetre, where maize yields were considerably lower. In the case of buckwheat cultivation significantly lower yield was obtained for plants fertilized with ammonium sulfate, while the highest one when ammonium saltpetre was used. For the remaining fertilizers, although they did not modify yield size to a high degree, the differences between particular treatments occurred to be statistically proved.

Table 1

Experimental plants yields

Form of nitrogen	Phosphors dose g P · pot^{-1}	Maize	Buckwheat	Potassium dose g K · pot^{-1}	Maize	Buckwheat
		g dm · pot^{-1}			g dm · pot^{-1}	
$(NH_4)_2SO_4$	0.0	70.4	21.9	0.0	78.2	20.6
	0.5	71.6	22.3	0.5	79.6	21.3
	1.0	74.5	21.4	1.0	76.8	19.6
	1.5	74.7	19.0	1.5	78.3	19.8
Mean value		73.6	20.9	Mean value	78.2	20.3
$Ca(NO_3)_2$	0.0	66.2	24.4	0.0	72.2	27.6
	0.5	66.8	25.1	0.5	73.6	28.1
	1.0	67.3	24.8	1.0	70.4	27.7
	1.5	67.1	26.6	1.5	74.0	27.3
Mean value		67.0	25.5	Mean value	72.6	27.7
NH_4NO_3	0.0	72.9	26.0	0.0	76.5	26.3
	0.5	73.1	26.7	0.5	77.4	26.8
	1.0	71.5	25.8	1.0	75.5	28.9
	1.5	68.1	27.3	1.5	77.6	27.8
Mean value		70.9	26.6	Mean value	76.8	27.5
$CO(NH_2)_2$	0.0	70.4	23.6	0.0	78.0	25.4
	0.5	72.0	23.9	0.5	79.3	26.2
	1.0	73.3	24.3	1.0	71.6	25.3
	1.5	71.5	24.2	1.5	71.3	25.1
Mean value		72.2	24.1	Mean value	75.1	25.5
LSD						
I for nitrogen form		1.04	0.73		1.08	1.62
II for phosphorus/potassium dose		0.96	0.65		0.90	2.29
III for interaction I/II		2.14	1.48		2.01	5.13

* dm = dry matter.

The introduction of increasing doses of phosphorus, at even nitrogen fertilization, did not effect on maize yielding, yet on the treatments fertilized with ammonium sulfate, especially at higher P doses, there was observed a tendency to obtain increased yield size values (Table 1). The mentioned relation was not recorded on treatments where buckwheat was cultivated using high P dose.

In the experiment involving increasing doses of potassium, at even level of nitrogen fertilization both maize and buckwheat yields were diversified and they did significantly depend on the kind of nitrogen fertilizer used (Table 1). The highest maize yields were obtained when plants were fertilized with ammonium sulfate and ammonium saltpetre, while the lowest ones when calcium saltpetre was applied. Buckwheat occurred to react differently to diverse nitrogen forms. The lowest amounts of buckwheat dry matter were harvested from treatments fertilized with ammonium sulfate, while the remaining fertilizers, especially both saltpetres, resulted in significantly higher yields.

Introduction of increasing potassium doses into soil fertilized with even doses of different nitrogen forms did not undoubtedly influence the yielding of experimental plants, except for the treatment with urea-fertilized maize. Results obtained in our investigation can be confirmed by the literature data. Gasior and Kaniuczak [8] reported that the increase in mineral fertilizer dose brought about increased yields and the mentioned increase was higher on treatments fertilized with NPK in comparison with those fertilized only with PK.

Nitrate(V) content, both in maize and in buckwheat depended on the form of nitrogen applied. The highest amounts of $N\text{-}NO_3$ were determined in plants fertilized with calcium and ammonium saltpetre, while the lowest quantities – when ammonium sulfate was used. Maize and buckwheat fertilized with urea contained average amounts of this nitrogen form.

Application of increasing dose of phosphorus, at simultaneous fertilization with different nitrogen fertilizers, did diversify the amount of nitrate(V) nitrogen in maize and in buckwheat (Figs. 1, 2). The highest contents of $N\text{-}NO_3$ in both plants was found after the use of calcium and ammonium saltpetre, while the lowest amounts of nitrate(V) nitrogen were recorded after fertilization with ammonium sulfate. Average

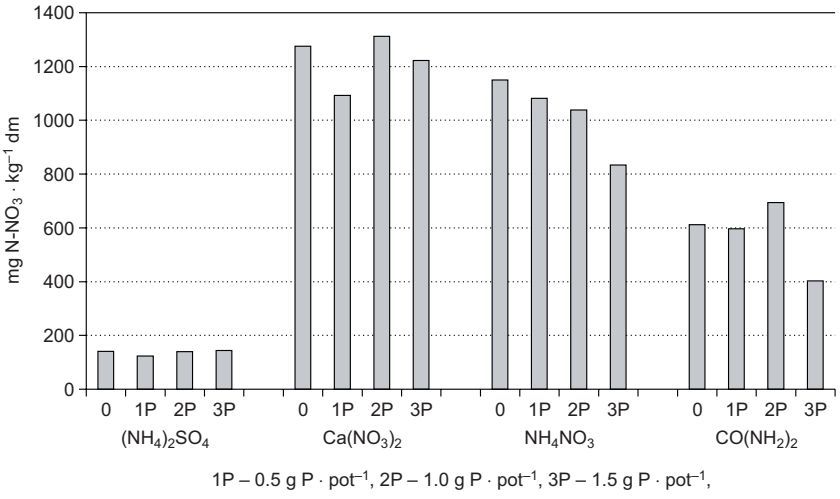

Fig. 1. Nitrate(V) content in maize fertilized with phosphorus at fertilization with different nitrogen forms

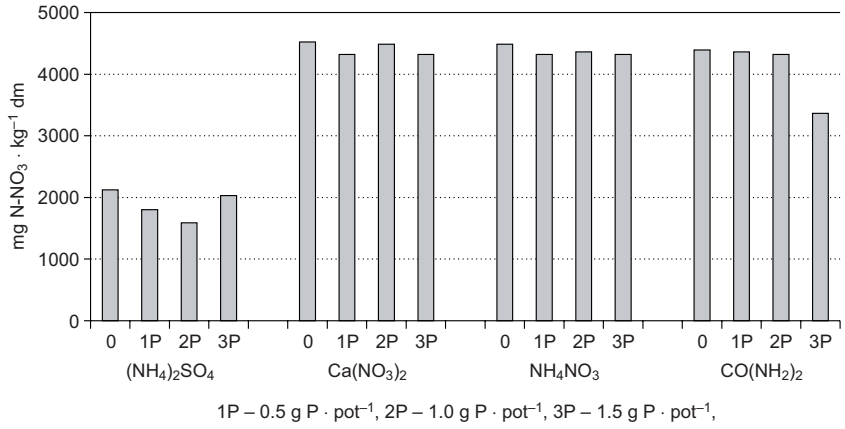

Fig. 2. Nitrate(V) content in buckwheat fertilized with phosphorus at fertilization with different nitrogen forms

amounts of nitrate(V) were determined in plants treated with urea. In maize, differences in this component content, depending on the form of nitrogen applied, were considerable (in some cases 10 times higher values) while in buckwheat they were not so profound.

Better supply in phosphorus decreased $N\text{-}NO_3$ concentration in maize fertilized with ammonium saltpetre and urea. In buckwheat, this phenomenon was observed only when the plant was fertilized with urea (Figs. 1, 2). Increasing dose of phosphorus on the remaining treatments was of no effect regarding the content of this form of nitrogen in experimental plants. Nowacki [3] reported after Sharer and Siebel, that phosphorus resulted in the decrease of nitrate(V) content, but only at low and medium nitrogen doses, while in the conditions of high-dose-nitrogen fertilization protective activity of phosphorus disappeared. Czuba [1] stated that even older plants cultivated in the conditions of deficient phosphorus supply plants could accumulate excessive amounts of nitrate(V) in their tissues. Gasior and Kaniuczak [8] recorded that nitrate(V) content in hay was much higher after the use of full fertilization with NPK than with P and K solely.

Application of increased potassium doses did explicitly decreases nitrate(V) content in buckwheat fertilized the examined nitrogen fertilizers, except for ammonium sulfate. According to the literature data [9] in the conditions of nitrogen fertilization the response of grass species to increased amounts of potassium was expressed by the possibility of nitrate(V) reduction. In the case of maize it was possible to prove that the decrease in nitrate(V) concentration as a result of increased potassium fertilization took place only when nitrogen was introduced in the form of ammonium saltpetre (Fig. 3). In plants cultivated on the remaining treatments $N\text{-}NO_3$ contents reached similar level. Ciecko et al [7] proved that in their experiments potassium deficiency caused nitrate(V) accumulation, as well as accumulation of organic nitrogen in plants in the form of amino acids and amides.

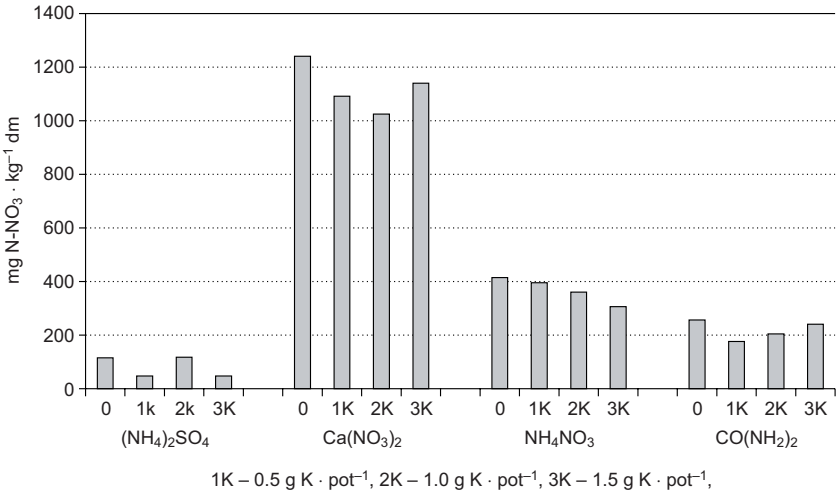

Fig. 3. Nitrate(V) content in maize fertilized with potassium at fertilization with different nitrogen forms

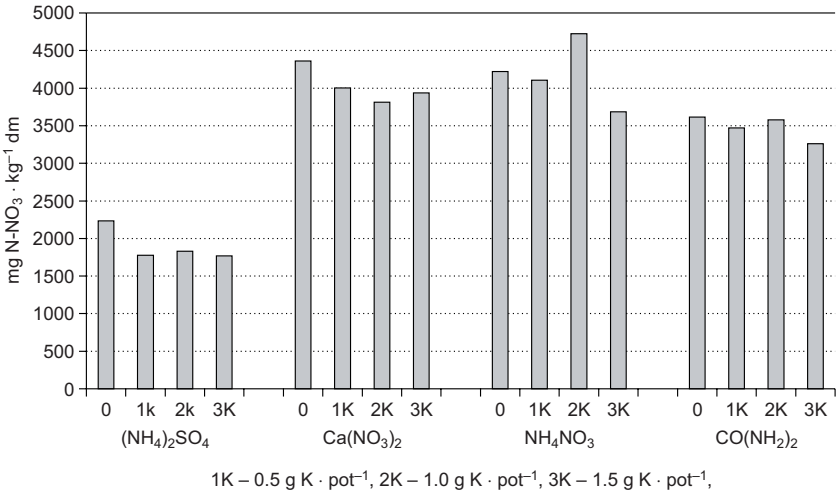

Fig. 4. Nitrate(V) content in buckwheat fertilized with potassium at fertilization with different nitrogen forms

After investigation had been finished, there was also estimated mineral nitrogen concentration in soil. In Figures 5 and 6 there was shown nitrate(V) nitrogen contribution to total amount of mineral nitrogen. The highest quantities of $N\text{-}NO_3$ were determined in soils collected from treatments fertilized with ammonium and calcium saltpetre and its contribution to mineral nitrogen on these treatments ranged 80 %. The contribution of this nitrogen form did apparently decrease according to the increase in phosphorus dose on each of the examined treatments (Fig. 5).

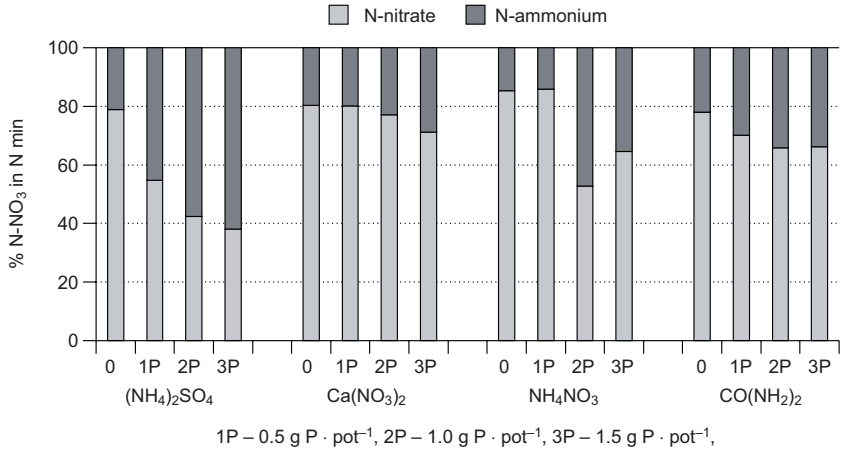

Fig. 5. $N\text{-}NO_3$ contribution to mineral nitrogen in soil fertilized with phosphorus at fertilization with different nitrogen forms

Application of increasing potassium doses at even – dose nitrogen fertilization was decisive as far as percentage contribution of nitrate(V) nitrogen in mineral nitrogen was concerned (Fig. 6).

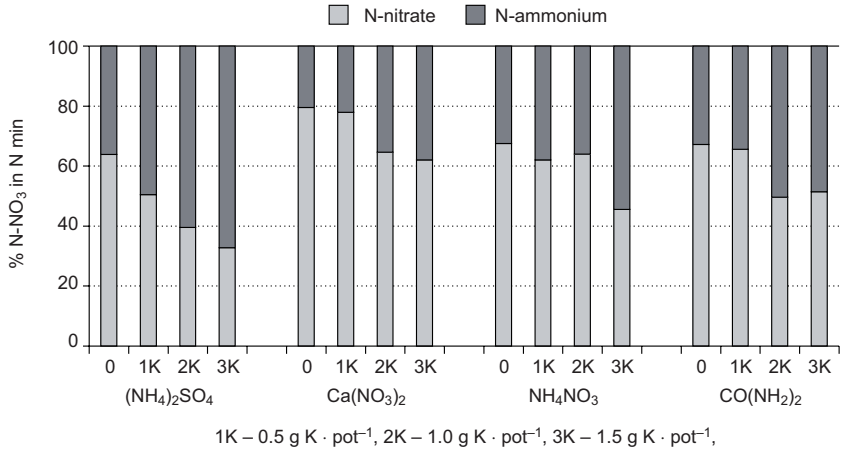

Fig. 6. $N\text{-}NO_3$ contribution in mineral nitrogen in soil fertilized with potassium at fertilization with different nitrogen forms

The highest amount of $N\text{-}NO_3$ was determined in soils fertilized with calcium saltpetre where contribution of this nitrogen form in mineral nitrogen ranged average 70 %, while the lowest quantities were assayed on treatments fertilized with ammonium sulfate. On these treatments there were determined average 40 % contributions of $N\text{-}NO_3$ to mineral nitrogen. On all experimental treatments there was recorded decreased contribution of nitrate(V) nitrogen to total scope of mineral nitrogen as potassium dose increased.

Conclusions

1. Introduction of phosphorus and potassium to soil fertilized with even dose of different nitrogen forms did not significantly influence on maize and buckwheat yield.

2. Increasing doses of phosphorus at nitrogen fertilization diversified nitrate(V) content in maize on treatments fertilized with ammonium saltpetre and urea while in the case of buckwheat only on treatments when urea fertilizer was used. On these treatments, according to the increase in phosphorus dose concentration of the $N\text{-}NO_3$ form decreased.

3. Potassium fertilization decreased nitrate(V) nitrogen content only on treatments fertilized with ammonium salpeter. On the remaining combinations no effect of this component was recorded regarding nitrate(V).

4. After experiment had been finished, a dominant form of mineral nitrogen was nitrate(V) nitrogen in soils of all treatments.

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WPŁYW NAWOŻENIA FOSFOREM I POTASEM NA ZAWARTOŚĆ AZOTANÓW(V) W KUKURYDZY I GRYCE

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Abstrakt: Badania prowadzono w warunkach hali wegetacyjnej w cyklu dwuletnim, na tle jednakowych dawek azotu wprowadzanego do gleby w różnych formach chemicznych stosowano wzrastające dawki fosforu i potasu w ilościach 0.5; 1.0 i 1.5 g P i K · wazon^{-1}. Działanie tych składników oceniano, określając masę plonów roślin doświadczalnych (kukurydzy i gryki) oraz nagromadzenie azotu azotanowego(V) w ich częściach nadziemnych. W warunkach prowadzonych badań wzrastające ilości fosforu nie decydowały o plonowaniu kukurydzy i gryki, natomiast potas dodawany do gleby na tle jednakowego nawożenia azotem na obiektach nawożonych mocznikiem znacznie zmniejszał masę plonów kukurydzy. Stosowanie nawozów azotowych w różnych formach, przy jednocześnie wzrastającej ilości fosforu w podłożu, różnicowało zawartość azotanów(V) w kukurydzy i gryce. Fosfor obniżał zawartość $N\text{-}NO_3$ w kukurydzy nawożonej saletrą amonową i mocznikiem, natomiast w gryce tylko wówczas, gdy nawożona była mocznikiem. Na pozostałych obiektach wzrastające dawki fosforu nie modyfikowały zawartości tej formy azotu w roślinach doświadczalnych. Stosowanie potasu wyraźnie zmniejszało zawartość azotanów(V) w gryce nawożonej wszystkimi nawozami azotowymi z wyjątkiem siarczanu amonu. W przypadku kukurydzy wykazano, że obniżenie koncentracji azotanów(V) w wyniku zwiększenia nawożenia potasem miało miejsce jedynie wówczas, gdy azot stosowano w postaci saletry amonowej. W roślinach uprawianych na pozostałych obiektach badawczych koncentracja $N\text{-}NO_3$ kształtowała się na zbliżonym poziomie. W glebach po zakończeniu doświadczenia dominującą formą azotu mineralnego był azot azotanowy(V).

Słowa kluczowe: azot, nawozy azotowe, nawożenie fosforem, nawożenie potasem, zawartość $N\text{-}NO_3$, kukurydza, gryka