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EFFECT OF THE NITROGEN AND MICROELEMENTS APPLICATION METHOD ON THE CHANGES IN THE CONTENT OF TOTAL NITROGEN AND ITS MINERAL FORMS IN LIGHT SOIL

ODDZIAŁYWANIE SPOSOBU APLIKACJI AZOTU I MIKROELEMENTÓW NA ZMIANY ZAWARTOŚCI AZOTU OGÓŁEM I JEGO MINERALNYCH FORM W GLEBIE LEKKIEJ

Abstract: The present research, carried out over 2004–2007, aimed at evaluating the effect of the nitrogen application method and foliar application of microelements on the quantitative changes in nitrogen compounds in soil under monoculture of two corn cultivars. Nitrogen fertilisation was applied at a single dose (soil application) and at a split dose (soil and foliar application). Fertilisation with microelements was applied at the 5-leaf phase. After three research years it was observed that the corn cultivars researched as well as the nitrogen application method significantly determined the content of total N in soil. Significantly higher contents of this parameter were recorded in soil under 'L.G 22.44' corn and after the use of a single nitrogen dose, as compared with the split dose. The nitrogen application method showed a significant effect on the contents of available nitrogen forms. Significantly higher contents of both ammonium nitrogen and nitrate nitrogen(V) were recorded after the application of a single nitrogen dose, as compared with the split dose and irrespective of the cultivar and nitrogen application method, after the use of the microelements investigated.

Keywords: nitrogen application method, microelement fertilisation, total nitrogen, mineral nitrogen

The basic agrotechnical treatment which aims at maintaining the soil fertility and ensuring the plants with an adequate amount of nutrients, including available nitrogen forms, is fertilisation. On average in Poland about 88 kg N per 1 ha of agricultural acreage is introduced to soil with fertilisers, and crops use from 50 to 70 % of this nutrient [1, 2]. In contemporary agriculture there is a principle of balanced fertilisation to ensure maximum crop yields of good quality and maintaining soil in the state of

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adequate fertility. The optimization of fertilisation is of special importance when nitrogen is applied as it can pose a potential threat for ecosystems [3].

With that in mind, over 2004–2007 research was launched which aimed at determining the effect of the nitrogen application method and foliar microelement application on the quantitative changes in nitrogen compounds in soil under corn in monoculture.

Material and methods

The research was carried out (2004–2007) as the field experiment set up on the soil of IVa quality class, representing the good rye complex, located on the farm at Wieldzadz (the Kujawy-Pomerania province). The soil reaction was slightly acidic. The soil showed an average content of available forms of phosphorus and potassium and an average content of total nitrogen.

The field experiment was set up as a randomized split-plot design as a three-factor experiment in four replications. The experimental plot size was 20 m^2. The experimental factors were as follows:

– factor I – corn cultivar of FAO 240 (n = 2, 'LG 22.44', 'Nysa');
– factor II – nitrogen application (n=2, into soil, into soil + foliar application):
  – 150 kg N · ha^{-1} pre-sowing in a form of $CO(NH_2)_2$,
  – 150 kg N · ha^{-1} (2/3 +1/3), 2/3 of the dose into soil (100 kg N · ha^{-1}), + 1/3 of the dose (50 kg N · ha^{-1} was applied as follows: 20 kg N · ha^{-1} into soil + 30 kg N · ha^{-1} foliar application: every 10 days in three sprayings (1/3 + 1/3 + 1/3), at the 5-leaf phase in a form of 10 % urea solution);
– factor III – microelement fertilisers were applied together with nitrogen at the 5-leaf phase, (n = 4, B_0 – control, B_1 – ADOB Zn, B_2 – ADOB Cu, B_3 – Basfoliar 36 Extra).

The corn seed dressing applied was VITAVAX 200 FS and seed-sowing took place on 25.04.2007. All the cultivation treatments, sowing and the harvest performed at full grain ripeness were compliant with the adequate agrotechnical guidelines for that crop. Phosphorus and potassium fertilisers were applied at the following doses: 43 kg P · ha^{-1} – in a form of triple superphosphate, 124 kg K · ha^{-1} – in a form of high-percentage potassium salt. Throughout the vegetation period in 2007 the average temperature and total rainfall were higher than the multiyear means (1996–2007).

In 2007 of corn from the arable layer representative soil samples were taken for which the following were determined:

– total nitrogen content (N_t) – with the Kjeldahl method, after mineralization process in H_2SO_4,
– content of nitrate(V) nitrogen (N-NO_3^-) extracted with potassium sulphate(VI) – using the colorimetric method with diphenylsulphonic acid,
– the content of ammonium nitrogen (N-NH_4^+) – extracted with 1 % aluminium--potassium sulphate(VI) and determined with the Kjeldahl method.

The present research results were statistically verified with the analysis of variance following the model compliant with the experimental design. The significance of differences was verified with the Tukey test.

Results and discussion

In soil the nitrogen forms in soil most available to plants are nitrate(V) and ammonium ions. The content of these nitrogen forms is inconsiderable and it can range from a few dozen or so milligram per 1 kg of soil, which undergo considerable changes throughout the year depending on the weather conditions, intensity of plant uptake and the fertilisation dose and fertiliser application date.

The contents of total nitrogen and nitrate(V) nitrogen in soil under corn in monoculture were significantly determined by the genotype of the cultivars researched (Table 1). The average contents ranged, respectively, from 0.61 to 0.87 g · kg^{-1} and from 3.06 to 5.70 mg · kg^{-1}. Following the application of nitrogen, both at the single dose and split dose (2/3 + 1/3), there was noted on average significantly higher contents of total nitrogen in soil under 'LG 22.44' corn, as compared with 'NYSA'. It is common knowledge that the yield-forming nature of nitrogen increases the amount of plant post-harvest residue [4, 5], and the relationship is closely connected with crop species and even their cultivars [6–8].

Table 1

Content of different nitrogen forms in soil

Nitrogen fertilization	Cultivar							
	'LG 22.44'				'NYSA'			
	Microelements fertilization							
	B_0	B_1	B_2	B_3	B_0	B_1	B_2	B_3
Total Nitrogen [g · kg^{-1} soil]								
150	0.87*	0.96*	0.87*	0.86*	0.73	0.75	0.71	0.61
100 + 50	0.76*	0.76*	0.88*	0.82*	0.67	0.63	0.57	0.61
Average	0.81^x	0.86^x	0.87	0.84^x	0.70^x	0.69^x	0.64^x	0.61
Ammonium N-NH_4^+ [mg · kg^{-1} soil]								
150	18.95b	27.38a	11.50d	16.18c	15.88b	21.75a	16.50b	22.10a
100 + 50	14.93b	16.45a	11.80c	13.38c	15.88b	19.30a	11.50c	16.45b
Average	16.94^x	21.91^x	11.65	14.78^x	15.88	20.53^x	14.00^x	19.28^x
Nitrate V N-NO_3^- [mg · kg^{-1} soil]								
150	4.46*c	6.37* a	5.54*b	2.93d	3.31b	3.25b	3.56b	4.63*a
100 + 50	2.87c	4.19b	5.86a	3.18c	3.97a	4.05a	3.31c	3.23c
Average	3.66^x	5.28^x	5.70	3.06	3.64^x	3.65^x	3.43	3.93^x

a, b… – average value marked with different letters in the row differ significantly depending on the microelements applied ($p < 0.05$); * – higher average values which differ significantly depending on the corn cultivars researched ($p < 0.05$); x – average values which differ significantly depending on the nitrogen application method ($p < 0.05$).

The contents of nitrate(V) nitrogen were, in general, also significantly higher in soil under 'LG 22.44' corn only after the application of single dose nitrogen (150 kg $N \cdot ha^{-1}$). The average contents ranged, from 2.93 to 6.37 $mg \cdot kg^{-1}$. Fertilisation shows a high impact on the fertility of soils, affecting the content of nitrogen forms [9–11]. The research showed that both the content of total nitrogen and its mineral forms ($N\text{-}NH_4^+$, $N\text{-}NO_3^-$) were significantly modified by the nitrogen application method, while the contents of $N\text{-}NH_4^+$ and $N\text{-}NO_3^-$ also depended on the microelements applied. It was observed that the contents were, in general, significantly higher following the nitrogen application at the single dose against microelements, especially the content of ammonium nitrogen (Table 1).

The significantly highest contents of the available nitrogen forms researched, in general, were noted after the application of zinc (B_2), which enhances the corn yield size, and thus the amount of plant post-harvest residue. Zinc plays an essential role in metabolism as well as participates in different enzymatic processes (synthesis of protein and auxins) [12].

Optimization of fertilisation, namely adjusting the fertiliser doses to real fertilisation needs, as well as fertiliser applications at optimal dates can have a significant effect on a more effective use of nitrogen from the fertilisers applied and thus – on the corn yielding [13].

Nutrients uptake by corn in the initial period of development accounts for only 3 % [14]. The mineral nitrogen forms, introduced together with nitrogen fertilisers, unused by the plant, undergo processes of retrogradation and immobilization and can make their effective use by crops difficult.

The present results showed that the percentage of $N\text{-}NH_4^+$ in total nitrogen was higher than $N\text{-}NO_3^-$, both after the application of the single dose and the split dose (Fig. 1).

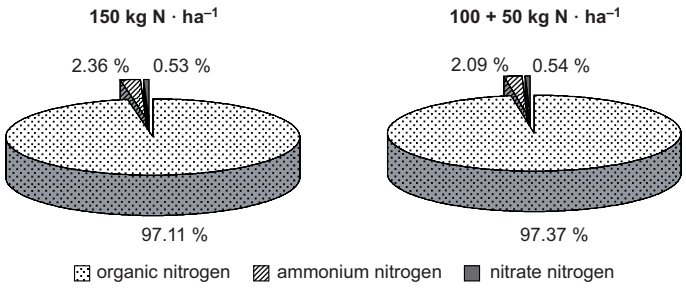

Fig. 1. Percentage of the mineral nitrogen forms researched in the total nitrogen

One can therefore assume that the soil conditions were favourable to the hydrolysis of urea and to mineralization processes of eg post-harvest residue.

There were also noted higher contents of ammonium nitrate following the application of a single dose (Table 1, Fig. 1), which could have been due to the fact that splitting the nitrogen dose increases the effectiveness of the use of this element by corn and thus prevents its retrogradation by incorporating this element into the plant biomass [15, 16].

Conclusions

1. After three research years, it was observed that the corn cultivars researched as well as the nitrogen application method significantly determined by the content of total nitrogen in soil. Significantly higher contents of this parameter were found in soil under 'L.G 22.44' corn and after the application of a single nitrogen dose, as compared with the split dose.

2. The nitrogen application method demonstrated a significant effect on the contents of available nitrogen forms in soil. Significantly higher contents of both ammonium nitrogen and nitrate(V) nitrogen were recorded following the application of a single nitrogen dose, as compared with the split dose.

3. On average higher contents of ammonium nitrogen and nitrate(V) nitrogen were found following the application of the microelements researched, irrespective of the cultivar and the nitrogen application method.

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Abstrakt: Badania prowadzono w latach 2004–2007, których celem było określenie wpływu sposobu aplikacji azotu oraz nalistnego stosowania mikroelementów na zmiany ilościowe związków azotu w glebie pod uprawą w monokulturze dwóch odmian kukurydzy. Nawożenie azotem stosowano w dawce jednorazowej (doglebowo) oraz w dawce dzielonej (doglebowo i nalistnie) Nawożenie mikroelementami natomiast zastosowano w fazie 5 liścia. Po trzech latach badań stwierdzono, że badane odmiany kukurydzy, jak również sposób aplikacji azotu istotnie decydowały o zawartości N ogółem w glebie. Istotnie wyższe zawartości tego

parametru stwierdzono w glebie spod uprawy kukurydzy odmiany “L.G 22.44” oraz po zastosowaniu jednorazowej dawki azotu w stosunku do dawki dzielonej. Sposób aplikacji azotu istotnie wpływał na zawartości przyswajalnych form azotu. Istotnie wyższe zawartości zarówno azotu amonowego, jak i azotu azotanowego(V) stwierdzono po zastosowaniu jednorazowej dawki azotu w porównaniu do dawki dzielonej oraz niezależnie od odmiany i sposobu aplikacji azotu, po zastosowaniu badanych mikroelementów.

Słowa kluczowe: sposób aplikacji azotu, nawożenie mikroelementami, azot ogółem, azot mineralny