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The Effect of Nitrogen Fertilizers on Nitrogen Metabolism in Three tip Leaves of Wheat in its Flowering

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Abstract: Under experimental field conditions of wheat in its flowering stage, the effects of N fertilization (250 kg/ha) in the form of KAN, carmabide and formaldehyde urea on nitrogen matter of three tip leaves, were studied individually. The results suggest a reduced activity of lower foliage during translocation of nitrogen supplied from root, and a higher re-utilization of N required for spike formation.

Key words: N forms, accumulation, utilization, re-utilization, fertilizers

Introduction

In the stage of spiking-flowering, the growth of the third tip leaf is completed (Pavlov, 1984; Đokic, 1988). Lower leaves are completing their growth earlier so that, in this stage, their activity weakens. A reduced activity takes place due to N transfer, firstly to spikes during their formation, and later to grain. The contents of chlorophyll, ribulose-de-phosphate carboxylase and nitrate reductase (Frith and Dalling, 1980; Christensen et al., 1981; Swank et al., 1982; Evans and Selman, 1984; Clark, 1989) are thus reduced. The overall leaf metabolic activity weakens, nitrate reductase is slowed down as well as the next stages of N assimilation into proteins, and that of CO_2, too.

The question, which is simultaneously the goal of these studies, is raised on whether N, taken up in this period from the environment, reaches the older leaves of a much weakened or ceased function that are unable to fully assimilate N. This may be concluded on the base of nitrogen matter content from earlier stages of N assimilation (NO_3, NH_4, NH_2).

Material and method

Wheat variety Srbijanka subjected to experimentation under field conditions, was fertilized with KAN, carmabide and formaldehyde urea (FAU). The treatment without fertilization (control) was also used.

The flag, second and third leaf downwards, were analysed during wheat flowering. The sample averaged 100 leaves in each treatment. The leaves were dried at 75°C to obtain solid mass, then ground and analysed on the content of individual nitrogen fractions (total, ammonium+amide and nitrate). N contained in proteins and amino-acids was calculated on the basis of the difference between total N and the sum of its fractions. The content of total N was determined according to the method of Kjeldahl, that of ammonium and amide nitrogen according to the method of Anofrine (1990), and that of nitrate N according to the nitroxylene method, with plant material extracted in the solution of trichloroacetic acid.

Results and discussion

Compared with obtained values of the control treatment, the total N, contained in the flag leaf of wheat, increased by 57% using KAN, by 58% using carmabide, and only by 20%, using formaldehyde urea (Tab.1.). The highest amount of N appeared in the form of proteins and free amino-acids, followed by its rather small amount of 3,9%, fertilizing with KAN, even lower of 2,3%, fertilizing with carmabide, as well as by a slightly higher one of 2,7%, using FAU in the form of NO_3, NH_4 and NH_2. The next leaf below the flag one, had higher increases of total nitrogen, compared to the control i.e. by 75%, 83% and 27% using KAN, carmabide and FAU, respectively. The share of amide and nitrate N in its total content was 15,3%, 9% and 3,5%, fertilizing with KAN, carmabide and FAU, respectively. The highset increases in total N occurred in the third leaf, ie. by 128%, 142% and 54% using KAN, carmabide and FAU, respectively. Compared with the total of N, the share of ammonium, amide and nitrate N amounted to 19,7%, 11,4% and 5,7% fertilizing with KAN, carmabide and FAU, respectively.

The total of N, that containd in proteins and free amino-acids, tended to decrease from the flag leaf downwards, whereas the contents of ammonium, amide and nitrate N tended to decrease. Compared with flag leaf, a relatively highest decrease in total N occurred in the third leaf of the control plants (45%) just as it did in those fertilized with FAU, but as it didn't in those ferilized with carmabide (15%) and KAN (20%) to indicate a lowest decrease in the total of N.

After completing its growth in the stage of spiking-flowering, flag leasf showed optimal photosynthetic activity. The second, particularly third leaf downwards, showed much weaker photosynthetic as well as the other activities in the same period. Their activity was partly reduced due to N translocation from the foliage to spikes and grains. Re-utilizing N, grain provided its two-thirds to three-fourths, which were accumulated by plant, and further transformed in organic compounds of the vegetative organs until flowering (Austin et al., 1977; Gregory et al., 1981; Pavlov, 1984; Van Stanford and McKown, 1987; Đokic, 1988; Đokic and Lomovic, 1990). Lower N content in the second, and especially third leaf, is accounted for by earlier time of their N re-utilization.

Tab.1. The content of N fractions in three tip leaves in the stage of wheat flowering (% of dry matter)

Leaf	Total nitrogen	$(NH_2 + NH_4)$ nitrogen	NO_3 nitrogen	AC+proteins nitrogen	%N		
					$NH_2 + NH_4$	NO_3	AC+proteins
				KAN			
I	4.83	0.07	0.12	4.64	1.4	2.5	96.1
II	4.64	0.31	0.40	3.93	6.7	8.6	84.7
III	3.87	0.32	0.44	3.11	8.3	11.4	80.4
				Carbamide			
I	4.86	0.08	0.03	4.75	1.6	0.6	97.7
II	4.85	0.13	0.29	4.43	2.7	6.0	91.3
III	4.12	0.11	0.36	3.65	2.7	8.7	88.6
				Formaldehyde urea			
I	3.69	0.06	0.04	3.59	8.6	1.1	97.3
II	3.36	0.07	0.05	3.24	2.0	1.5	96.4
III	2.62	0.11	0.04	2.47	4.2	1.5	94.3
				Without fertilization			
I	3.08	0.03	0.00	0.00	0.0	0.0	0.0
II	2.65	0.05	0.00	0.00	0.0	0.0	0.0
III	1.70	0.06	0.00	0.00	0.0	0.0	0.0

The higher N availability to plant was, the slowlier N re-utilization, was. This also holds true for the decreases in N content in the older leaves. Re-utilized N from the foliage could be partly supplemented by root absorption from the environment. On the other hand, a rather limited root potential for N transformation (Ashley et al., 1975; Cooper et al., 1986; Clark, 1989), particularly with abundant nutrition, was the reason that N, which had been partly transported through transpiration paths to leaf, appeared in the form of nitrates, ammonium and amides. A strong photosynthetic activity of the flag leaf facilitated conversion of nearly all its N amounts into amino-acids and proteins. In contrast to flag, the second and third leaf contained appreciable N amounts, which were neither used nor transformed in proteins.

High contents of nitrate, ammonium and amide nitrogen in the second and third leaf, suggested an intensive release of N from the root to these leaves. In fact, such a higjh content of N was likely to depend on the leaf activity rather than on the water supplied and used for transpiration whose water-soluble matter mainly containing N, remained in the leaf.

Lacking energy, reducing agents ($NADPH_2$) and acceptors (NH_3) slowed down the reduction of inorganic nitrogen, and therefore the synthesis of amino-acids and proteins in the second and especially third leaf. However, in the youngest leaves, the presence of a high physiological activity provided the conditions for conversion of inorganic into organic nitrogen, thus, the content of inorganic N was low, compared with the total of N, being rather high (Zaharov, Dozorceva, 1986).

High content of the total N in the leaves subjected to urea, was incited by the intensity of urea conversion into N ammonium form, which was taken up by plant more rapidly and built up in nitrate organic compounds of nitrogen (Đokic, 1973). The high content of nitrate nitrogen in these plants was partly supplied from the available to soil N, mainly existing in the form of nitrates, and partly from the fertilizers whose amide form had been converted into the ammonium as well as the nitrate form.

Low content of nitrogen in tip leaves of wheat, with N fertilized with formaldehyde, was due to too slow release of N from the complex to become available to plants. This led not only to N deficiency, but also to its excessive utilization in the leaves. The same holds true for the absence of inorganic N forms in the control plants leaves.

Conclusion

On the basis everything done, several conclusions may be drawn:

- wheat fertilization resulted in a highly increased N content in the three tip leaves in the stage of flowering. The total N decreased, and that of the ammonium+amide and nitrate N increased from the flag leaf downwards. This suggests a remarkably declined transformation of the foliage nitrogen matter from the flag leaf downwards.
- the higher N level in the flag leaf and plants was, the slowlier N decrease in the second and third leaf, was. This largely alleviated N decrease in these leaves, otherwise caused by its re-utilization.
- In conclusion, the highest increases in N in the three tip leaves were achieved using carmabide, and the lowest ones, using formaldehyde fertilization.

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METABOLIZAM AZOTA U TRI VRŠNA LISTA U FAZI CVETANJA PŠENICE ZAVISNO OD VRSTE AZOTNIH ĐUBRIVA

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Rezime

U poljskom ogledu sa pšenicom izučavan je uticaj đubrenja azotom (250 kg/ha) u obliku KAN-a, karmabida i formaldehid uree na sadržaj azotnih materija u svakom od tri vršnih lista posebno. Rezultati ukazuju na smanjenu aktivnost nižih listova u transformaciji azotnih materija koje dolaze iz korena i povecanu reutilizaciju azota iz ovih listova za potrebe formiranja klasa. Posledica toga je da se sadržaj ukupnog i proteinskog + aminokiselinskog azota smanjivao, a sadržaj NH_4 + NH_2 i NH_3 povećavao u drugom i trećem u odnosu na prvi list. Povećanje ovih oblika azota je bilo veće a smanjenje ukupnog azota manje pri boljoj obezbeđenosti azotom, đubrenju karmabidom i KAN-om. Kao posledica povećanog dotoka azota iz korena, ublaženo je smanjenje ukupnog azota koje izaziva njegova translokacija iz drugog i trećeg lista u klas, a povećan sadržaj NH_4+NH_2 i NH_3 azota zbog njihove smanjene aktivnosti u transformaciji azota.