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NITROGEN UTILIZATION OF WINTER WHEAT ON AN ACID SOIL

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Abstract

This paper presents the two year results of a study dealing with nitrogen utilization of twenty recently developed Serbian winter wheat cultivars, on the acid soil typed as eutric vertisol. Soil pH value of the cultivated layer in water was between 5.41 and 5.85, and in KCl it was between 4.15 and 4.37. There were significant differences between genotypes regarding nitrogen reutilization. As the average for both years, this parameter ranged from 12.79 mg/plant in the cultivar Jarebica to 18.75 mg/plant in the cultivar Gruža. Percent of nitrogen supply for grain obtained by reutilization was significantly higher in the first year. As the average for both years the lowest percent of nitrogen supply for grain obtained by reutilization amounted 38% in cultivars Renesansa, Jarebica and Tiha, and the highest one 66% in the cultivar Milica. Mean values of physiological efficiency of nitrogen, considering both years, were within limits from 39 (Renesansa) to 46 kg/kg (Prima, Tera and Pobeda). The lowest crude protein content was observed in the cultivar Nevesinjka (8.29%), and the highest one in the cultivar Milica (10.14%)

Key words: *Wheat, Nitrogen, Soil, Acidity.*

Introduction

Nitrogen fertilizers are widely used for increasing grain yield and protein content of bread wheat. However, farmers must optimize their use in order to decrease environmental risks and production costs (Le Gouis et al., 2008). For that reason, efficiency of plant nitrogen use becomes a trait of the greatest importance in studying and breeding of all plants, so of wheat too (Hirel et al., 2007). The core of the problem is to increase nitrogen accumulation in plants not by increased amounts of nitrogen fertilizers added, but by creating genotypes with a better ability of their root system to uptake higher quantities of nitrogen from soil. On the other hand, in order to get higher values of grain yield, that process necessarily have to be followed by an increased photosynthetic intensity. If not, only higher concentration of nitrogen in grain and straw could be reached, and nitrogen utilization efficiency of plants would be significantly lowered (Stojković et al., 2006; Deletić et al., 2010). One can often hear a statement that over 60% of soils in Serbia are acid. According to the Report on Soils' Status published by the Ministry of Environment and Spatial Planning of the Republic of Serbia (2009), during last ten years that percent is characteristic for central Serbia, while in Vojvodina province soil acidity status is incomparably better. It is stated in this report that the percent of acid soils (on the basis of 25,118 samples from 2008) in central Serbia was 52.1%, with additional 29.2% of mildly acid soils. Percent of acid soils is also high throughout the world, so there is plenty of references dealing with parameters of nitrogen metabolism on acid soils (Bednarek and Reszka, 2009), and a great effort is directed to establishment of genetic specificity of nitrogen metabolism parameters, as well as to those parameters' inheritance mode (Le Gouis et al., 2008; Habash et al., 2007). This study has been aimed to investigate genetic specificity of nitrogen accumulation in twenty recently developed Serbian winter wheat cultivars on an acid soil.

Material and methods

The trials were set in Kraljevo, Serbia, during 2009/10 and 2010/11, on the soil typed as eutric vertisol, which was acid. Soil acidity of cultivated layer, measured as pH value in water, ranged between 5.41 and 5.85, while this value in KCl was between 4.15 and 4.37. Titration acidity of the soil amounted 17.89 ccm, and humus percent was from 2.13 to 2.54%. The investigation lasted two years, and twenty recently developed Serbian winter wheat cultivars were included. The following traits were studied: nitrogen reutilization, percent of nitrogen supply for grain obtained by reutilization, physiological efficiency of nitrogen (PEN), as well as crude protein content. The trials were set in random complete block design (RCBD), with four replications in each year. The obtained data were processed by analysis of variances, and statistical significance of differences among genotypes was estimated in general by F test. Statistical significance of differences between particular genotypes each other was established by comparing with the least significant differences (lsd test).

Results and discussion

Results of F test revealed statistically significant differences among the investigated genotypes regarding nitrogen reutilization (tab. 1). It is obvious that this parameter had much higher values in the first year of investigation. In the first year it was within range from 19.00 mg/plant in the cultivar Evropa 90 to 28.10 mg/plant in the cultivar Kremna, with the average value of 22.86 mg/plant. In the second year, the lowest nitrogen reutilization was observed in the cultivar Renesansa (3.76 mg/plant), and the highest one in the cultivar Milica (15.76 mg/plant), while the mean value was 9.37 mg/plant. As the average for both years variation interval was from 12.79 mg/plant in the cultivar Jarebica to 18.75 mg/plant in the cultivar Gruža.

Percent of nitrogen supply for grain obtained by reutilization (tab. 1) also was significantly higher in the first year than in the second one. Differences among genotypes were significant according to F test, and among particular genotypes each other in many cases they were greater than lsd values for both probabilities of error ($P<0.05$ or $P<0.01$). Variation interval in the first year of investigation was between 40% (Nevesinjka) and 70% (Takovčanka), and in the second one between 15% (Renesansa) and 85% (Milica). As the average for both years the lowest percent of nitrogen supply for grain obtained by reutilization amounted 38% in cultivars Renesansa, Jarebica and Tiha, and the highest one 66% in the cultivar Milica.

Physiological efficiency of nitrogen (PEN) means activity of nitrogen of a plant in producing assimilates needed to form its grain yield. It is also called efficiency of nitrogen utilization in plant, and represents a parameter of nitrogen utilization in forming grain yield. Physiological efficiency of nitrogen is measured as production of assimilates for grain filling per unit of plant nitrogen, so it is expressed as kg of produced grains per kg of nitrogen accumulated by crop. Differences among genotypes regarding physiological efficiency of nitrogen were significant according to F test, and comparisons between each other followed the same tendency (tab. 2). Values of the first year were between 40 (Milica) and 48 kg/kg (Takovčanka, Gruža and Mina), and of the second one between 35 (Renesansa) and 50 kg/kg (Pesma). As the average for both years, values of physiological efficiency of nitrogen were within limits from 39 (Renesansa) to 46 kg/kg (Prima, Tera and Pobeda). PEN can show significant variation depending on genotype and environmental conditions (Đokić and Kostić, 1992). The same researchers also stated that this parameter is greater when nitrogen nutrition is poor and weather conditions are favorable for grain yield, as well as in genotypes with lower protein content, lower nitrogen accumulation in plant and higher grain yield. Available data show that physiological efficiency of nitrogen is better indicator of cultivars productivity than nitrogen harvest index. Physiological efficiency of nitrogen is the parameter of nitrogen

utilization only for forming grain yield, while nitrogen harvest index regards nitrogen utilization for increasing both grain yield and protein content.

Table 1.Nitrogen reutilization (mg/plant) andpercent of nitrogen supply for grain obtained by reutilization

Cultivar	Nitrogen reutilization			% of nitrogen supplies for grain obtained by reutilization		
	1st year	2nd year	average	1st year	2nd year	average
1. Prima	19.10	7.60	13.35	56	40	48
2. Renesansa	25.30	3.76	14.53	62	15	38
3. Tera	23.60	10.90	17.25	63	68	65
4. Pobeda	24.40	11.80	18.10	60	66	63
5. NS Rana 5	26.70	6.08	16.39	69	30	49
6. Evropa 90	19.00	9.18	14.09	44	51	47
7. Milica	20.80	15.76	18.28	47	85	66
8. Jarebica	19.80	5.79	12.79	53	24	38
9. Kremna	28.10	10.22	14.16	64	49	56
10. KG 100	20.50	10.09	15.29	51	46	48
11. Pesma	23.20	10.26	16.73	49	50	49
12. Zlatka	24.90	9.32	17.11	64	40	52
13. Nevesinjka	20.40	13.88	17.14	40	72	56
14. Takovčanka	22.80	10.04	16.42	70	43	56
15. Gruža	27.20	10.31	18.75	57	45	51
16. Mina	22.70	10.67	16.68	63	52	57
17. Tiha	23.20	7.40	15.30	48	28	38
18. Toplica	21.90	5.91	13.90	66	24	45
19. Bistrica	21.60	10.52	16.06	58	50	54
20. Prva	22.10	7.94	15.02	54	47	50
Average	22.86	9.37	16.11	57	46	51
LSD 0,05		6.57			4.27	
0,01		8.99			5.84	

Crude protein content (tab. 2) of the all cultivars was significantly higher in the first year than in the second one. Differences between genotypes were not significant. Values of this parameter in the first year were between 9.52% (Prva) and 11.29% (Pesma), and in the second one between 6.50% (Pesma) and 9.23% (Zlatka). As the average for both years, values of crude protein content were within limits from 8.29% (Nevesinjka) to 10.14% (Milica).

Table 2. Physiological efficiency of nitrogen (kg/kg) and crude protein content (%).

Cultivar	PEN			Crude protein content		
	1st year	2nd year	average	1st year	2nd year	average
1. Prima	46	46	46	10.03	7.18	8.60
2. Renesansa	43	35	39	11.11	8.21	9.66
3. Tera	47	46	46	10.26	7.58	8.92
4. Pobeda	43	49	46	10.43	6.78	8.60
5. NS Rana 5	46	42	44	10.32	7.92	9.12
6. Evropa 90	43	46	44	10.77	7.64	9.20
7. Milica	40	40	40	11.11	9.18	10.14
8. Jarebica	47	39	43	9.92	7.41	8.66

9. Kremna	46	44	45	10.71	8.09	9.40
10. KG 100	47	39	43	9.75	8.61	9.18
11. Pesma	41	50	45	11.29	6.50	8.89
12. Zlatka	45	39	42	10.03	9.23	9.63
13. Nevesinjka	43	48	45	9.75	6.84	8.29
14. Takovčanka	48	43	45	9.69	8.72	9.20
15. Gruža	48	40	44	10.60	8.61	9.60
16. Mina	48	40	44	9.69	8.95	9.32
17. Tiha	42	44	43	10.89	7.98	9.43
18. Toplica	46	38	42	9.75	7.75	8.75
19. Bistrica	41	42	41	10.94	8.15	9.54
20. Prva	45	46	45	9.52	7.35	8.43
Average	45	43	44	10.33	7.93	9.13
LSD 0,05	2.59			6.08		
0,01	3.54			8.32		

Conclusions and future work

On the basis of the study, dealing with genetic specificity of nitrogen utilization in twenty recently developed Serbian winter wheat cultivars on an acid soil, we can conclude the following:

There were significant differences between genotypes regarding nitrogen reutilization. As the average for both years, this parameter ranged from 12.79 mg/plant in the cultivar Jarebica to 18.75 mg/plant in the cultivar Gruža.

Percent of nitrogen supply for grain obtained by reutilization was significantly higher in the first year. As the average for both years the lowest percent of nitrogen supply for grain obtained by reutilization amounted 38% in cultivars Renesansa, Jarebica and Tiha, and the highest one 66% in the cultivar Milica.

Mean values of physiological efficiency of nitrogen, considering both years, were within limits from 39 (Renesansa) to 46 kg/kg (Prima, Tera and Pobeda).

The lowest crude protein content was observed in the cultivar Nevesinjka (8.29%), and the highest one in the cultivar (10.14%).

Regarding nitrogen nutrition, grain yield mainly depends on amount of accumulated nitrogen and degree of its utilization in plant. That means these parameters could be a base for selection of wheat genotypes efficient in nitrogen nutrition. This selection strategy would try to improve simultaneously traits for high accumulation and efficient utilization of nitrogen in plant.

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