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Original scientific paper

VARIATION AND INHERITANCE OF NITROGEN CONTENT IN SEED OF WHEAT GENOTYPES (*Triticum aestivum* L.)

Desimir KNEŽEVIĆ[1], Violeta MAKLENOVIĆ[2], Ljubiša KOLARIĆ[2], Danica MIĆANOVIĆ[3] Andrej ŠEKULARAC[1], Jasmina KNEŽEVIĆ[1]

[1]University of Priština, Faculty of Agriculture, Kosovska Mitrovica, Lesak, Kosovo and Metohia, Serbia
[2]University of Belgrade, Faculty of Agriculture Belgrade, Zemun, Serbia
[3]Serbian Chamber of Comerce, BelgradeBelgrade, Serbia

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In diallel crosses (without reciprocals) of four genetically divergent wheat cultivars (Jugoslavija, Osiječanka, Žitnica, and NS Rana 2) produced seed of hybrids which planted on experimental field. F_2 hybrids plants used for harvest and source of F_3 seeds which used for nitrogen content analysis. The mode of inheritance, gene effect, heritability in parent cultivars and F_3 hybrids were studied for nitrogen content in seed. On the base of obtained results, different mode of inheritance: dominance, intermediate and overdominance for content of N in seed was established. Among parent cultivars, the highest nitrogen contents had Novosadska Rana 2 (3.50%). The combination Osiječanka/NS Rana 2 in F_3 grain generation was the best for nitrogen content (3.70%).

Key words: cultivars, hybrids, inheritance, nitrogen, wheat

INTRODUCTION

Among cereals, winter wheat (*Triticum aestivum* L.) is a species with high requirements for nitrogen nutrition. Thus, breeding wheat cultivars improved adaptation to less nutrition as well optimized nitrogen nutrition in different environment is very important (BRANCOURT-HULMEL *et al.*, 2005; BARRACLOUGH *et al.*, 2010). For achievement economic low-input genotypes except optimal input technology is very important task is identifying mode of inheritance and efficiency genes in various genotypes and incorporate them in new wheat cultivars at the breeding program (KNEŽEVIĆ *et al*., 2014a). Nitrogen nutrition play important role in synethesis and accumulation of protein in seed of wheat. The some investigation reported that efficiency of nitrogen utilization is

Corresponding author: Desimir Knežević-Faculty of Agriculture, University of Priština, Kosovska Mitrovica, Lesak 38219, Kopaonicka bb., Kosovo and Metohija, Serbia, Phone: +381 64 614 8882 e-mail deskoa@ptt.rs

negatively associated with both nitrogen uptake efficiency and seed nitrogen concentration indicate that is necessary screening of large wheat collection i.e. germplasm (SYLVESTER-BRADLEY and KINDRED, 2009; GÓRNY *et al.,* 2011). The improving of wheat genotypes for more efficient nitrogen uptake and translocation to seed without reducing grain yield under nitrogen shortage is the important task for wheat breeders (KNEZEVIC *et al*., 2007a; BARESEL *et al*., 2008). Considering the inheritance modes revealed among F_2 populations (YILDIRIM *et al*., 2007; KNEZEVIC *et al*., 2014a) and effects of environmental conditions to the expression of components of N efficiency (KNEZEVIC *et al*., 2007b, MALIK *et al*., 2012) protein content and their relationships with grain yield (ZEČEVIĆ *et al*., 2009) these objectives of breeding will be difficult to realize. Almost every year in some regions appeared extreme environmental condition like drought, cold, heat stress which causes damage of plant crops (wheat, rice, and soybean) NAKASHIMA *et al.* (2014). Decreasing of seed weight is influenced by environment stress at the key phase of seed development (filling seed) which cause reduction of protein and starch accumulation (BALLA *et al*., 2008; BRANKOVIC *et al*., 2015a; KNEZEVIC *et al*., 2015). The abiotic stress implicated to technological quality traits (ZEČEVIĆ *et al.,* 2010; DJUKIĆ *et al.,* 20011) nutritional quality (MENKOVSKA *et al.,* 2015) morphological traits (BRANKOVIC *et al*., 2015b) grain yield of crops (JOSHI *et al*. 2002; PETROVIĆ *et al*., 2006; DIMITRIJEVIĆ et al., 2011). This is a reason for creating improved cultivars adaptive to express genetic potential in different environment (SHIQING *et al.,* 2005; ZEČEVIĆ *et al.,* 2010). Therefore created semi-dwarf wheat cultivars characterized by efficient nitrogen utilization and translocation from vegetative organs to seed (DAKHIM *et al*., 2012; KNEZEVIC *et al*., 2014b). One of the main tasks of breeders is to develop model of plant growth for efficient assimilation and translocation of nitrogen (MUURINEN *et al*., 2007). For that it is necessary optimizing application of nitrogen fertilizers (KNEZEVIC *et al.,* 2015) pesticides, water etc (JOLANKAI and NEMETH, 2002) as well knowledge of assimilation, utilization and translocation of nitrogen in wheat plant (WILHELM *et al*., 2002). The very important for plant productivity is intensities of genotype reaction on nitrogen uptake on environment and its utilization in plants represents nitrogen efficiency utilization (GAMZIKOV and NOSOV, 2010; KHALILZADEH *et al*., 2011; KNEZEVIC *et al.,* 2014b). Although grain protein composition depends primarily on genotype, it is significantly affected by environmental factors and their interactions (ZEČEVIĆ *et al*., 2009; 2010). Within the large numbers of produced progeny in the breeding process we make ability for identifying phenotypes with favorable gene combinations for determining efficient nitrogen utilization (KNEZEVIC *et al*., 2014a; MADIĆ *et al.,* 2014). Also, nitrogen plays main role in wheat nutrition because of its importance in protein and nucleic acid synthesis as well plant productivity (KNEZEVIC&NOVOSELSKAYA-DRAGOVICH, 2007; DJUKIĆ and KNEŽEVIĆ, 2013).

The aim of this paper is to investigate mode of inheritance of nitrogen uptake in wheat genotypes and variability of seed nitrogen contents and identifying perspective genotypes of wheat breeding for improving this trait.

MATERIALS AND METHODS

The variability of nitrogen concentration in grain used four divergent wheat cultivars (Jugoslavija, Osiječanka, Žitnica and NS Rana 2) which created in different breeding centers. Those wheat cultivars used for cross after testing together with one hundred cultivars grown on experimental field. In laboratory analysis those cultivars showed the highest N concentration and protein content in seed under low nitrogen fertilizers. Diallel crosses without reciprocals were

performed and developed six hybrids combination. The experiment was carried out at the experimental field of the Center for Small Grains in Kragujevac. For this study, seed materials of parents and 6 crosses combination was sown in 1.0 m long rows, with row to row distance of 20cm and plant to plant distance of 5cm. Nitrogen concentration was analyzed at the full maturity stage by analysis of 120 plants per genotypes (40 plants per replication) for parents and F_3 hybrids of grain. Analysis of variance and test of significant differences for analyzed traits were computed by using MSTAT.

RESULTS AND DISCUSSION

For the nitrogen concentration in reproductive organs was found large variation among four wheat parent cultivars and their six hybrid progenies. Thus, seed nitrogen content ranged from 2.98% in Osiječanka to 3.50% as the highest value that was in NS Rane 2.

Table 1. Average value of nitrogen contents in F_2 grain of hybrids and parent wheat cultivars

Cultivar	*Jugoslavija*	*Osiječanka*	*Žitnica*	*NS Rana 2*	LSD $_{0.05}$	LSD $_{0.01}$
Jugoslavija	3.05	3.50^{sd}	2.75^{-sd}	3.54^{d}	3.72	5.02
Osiječanka		2.98	3.18^{i}	3.70^{sd}		
Žitnica			3.36	2.81^{-sd}		
NS Rana 2				3.50		

* d=bominance; sd=overdominance; i=intermediate

Among investigated combinations in the F_3 generation, the lowest average content ($\bar{x}$) of nitrogen in the grain had Jugoslavija/Žitnica (2.75%) and with the highest content was a combination of Osiječanka/NS rana 2 (3.70%) table 1. Similar values of the variation in grain nitrogen concentration, while different mode of inheritance of N concentration in wheat grain were found in investigation of F_2 progenies by using the same wheat cultivars as parents (KNEŽEVIĆ *et al*., 2014a). Similar variation in F_2 progenies, but produced from different wheat cultivars reported in investigation YILDIRIM *et al*. (2007).

Nitrogen content in grain of wheat is indicator of assimilate synthesis per unit of accessible nitrogen and in the same time represents measure of N utilization (GÓRNY *et al.*, 2012; KNEZEVIC *et al.*, 2015). For commercial production of wheat, the most interesting characters are grain yield and grain protein concentration (ZECEVIC *et al.*, 2014). If the reduction of yield with increased concentration of nitrogen in the grain, the genotypes have reduced efficiency and utilization of nitrogen fertilizer (KNEŽEVIĆ *et al.*, 2014a). However, choosing the reduced concentration of nitrogen in grain, in order to increase productivity, can lead to deterioration in the quality of grain as raw material for food industry (JOSHI *et al.*, 2002; DAKHIM *et al.*, 2012)

In analyzed wheat cultivars and hybrids progenies of F_3 population registered different mode of inheritance nitrogen content in seed. The most common type of inheritance of nitrogen in the tested hybrid combinations was over- dominance, registered at the four hybrid combinations (Jugoslavija/Osiječanka – 3.50%; Osiječanka/NS Rana 2 – 3.70%; Jugoslavija/Žitnica – 2.75% and Žitnica/ NS Rana 2 -2.81%) tab. 1. It means that over- dominance present in 66.6% of produced hybrids in crosses of four wheat cultivars. In comparison with results obtained in F_2 progenies produced from the crossing of the same parent wheat cultivars (KNEŽEVIĆ *et al.*, 2014a) we found increasing number of hybrid combination with over-dominance, what can be effect of selection of individual plants. Dominance was expressed at the one combination Jugoslavija/NS

Rana 2. The intermediate inheritance expressed at the one hybrid progenies (16.66%). The concentration of nitrogen can be used as an indicator after harvest about supply plant with nitrogen tab.1.

Assessed values of the variability of nitrogen content in parental cultivars included in investigations indicate that there were gaps among them. The highest heritability of N content found at hybrid combination Osiječanka/Žitnica (h^2 =52.2%) tab.2. The least heritability value was found in F_3 hybrid combination Žitnica/ NS Rana 2 (h^2 =26.59%).

Similar value of heritability of seed nitrogen content were found in investigation of F_2 progenies (KNEŽEVIĆ *et al.*, 2014a) and the highest and the least values of N content registered in the same cross combination of wheat.

Table 2. Values of parameters of nitrogen contents in grain wheat

Cultivar Hybrid combination	Hybrid's Generation	$\bar{x}$	$s_{\bar{x}}$ (%)	S^2	S	C_v(%)	h^2 (%)
Jugoslavija	P_1	3.05	0.06	0.10	0.32	10.10	
Osiječanka	P_2	2.98	0.03	0.11	0.33	10.80	
Žitnica	P_3	3.36	0.04	0.16	0.40	11.40	
NS Rana 2	P_4	3.50	0.16	0.23	0.48	12.22	
Jugoslavija/Osiječanka	F_3	3.50	0.06	0.12	0.35	9.68	30.39
Jugoslavija/Žitnica	F_3	2.75	0.05	0.13	0.36	9.40	35.81
Jugoslavija/NS Rana 2	F_3	3.54	0.04	0.14	0.37	9.50	32.58
Osiječanka/Žitnica	F_3	3.18	0.06	0.11	0.33	10.1	52.22
Osiječanka/NS Rana 2	F_3	3.70	0.09	0.20	0.45	13.2	42.34
Žitnica/NS Rana 2	F_3	2.81	0.05	0.19	0.44	12.1	26.59

Thus, with the highest coefficient of variation (CV) for this trait was NS Rana 2 (12.22%) and the lowest was Jugoslavia (10.10%). In the F_3 grain generation, the smallest variation in grain nitrogen content was found in hybrid combination Jugoslavija/Žitnica (9.40%) and highest Osiječanka/NS Rana 2 (13.2%). The majority of hybrid combination expressed high variability of nitrogen concentration than in F_3 grain generation.

Nitrogen concentration in seed of analyzed genotypes in F_3 progenies are different and indicate genetic potential of hybrid for absorption, accumulation, utilization and translocation to productive organs. Protein content and grain yield are in negative correlation, because is difficult create new cultivars with combined both high yield and protein content (KHALILZADEH *et al.*, 2011) and should be succeed by using broad genetic variation of parents cultivars (KNEŽEVIĆ *et al.*, 2014b). The concentration of nitrogen in the aboveground part may affect the differences in yield, through the influence on the intensity and length of the activity of vegetative organs and protein content in wheat cultivars in dependence of climatic changes. Differences in nitrogen concentration in plants usually are influenced by nitrogen content in vegetative organs, whose reutilization done much of the grain protein synthesis. However, some studies showed that the cultivars with high and low protein content in seed did not differ according to the concentration of nitrogen in the period to flowering (GÓRNY *et al.*, 2011) and that protein content is quantitatively inherited trait, strongly influenced by environmental factors and connected to grain yield and plant height (BRANKOVIĆ *et al.*, 2015b). The connection between high nitrogen content at maturity and high N uptake after anthesis, indicating that in wheat the proportion of the assimilated N used

immediately in the developing seed, but there was no strong N translocation from vegetative parts of the main shoots in wheat and reproductive organs. This could be advantage in wheat breeding for high yield and high efficiently use available N in different growing conditions (KNEZEVIC *et al*., 2007b; MUURINEN *et al.*, 2007*).*

Nitrogen concentration in seed is well known to be related to amounts of late available N during the plant development. In the most cultivars nitrogen concentrations were between 1.8 and 2.15%. Minimum value of the concentration of nitrogen in the seed that gives the maximum yield varies in dependence of genotype and growing conditions (GAMZIKOVA *et al*., 1992; ZEČEVIĆ *et al*., 2014). Also, the relationship between the development of seed and protein content, precisely, grain protein concentration was found to be more related to N availability during plant development than to dry weight or N concentration in various plant parts (MALIK *et al*., 2012). Specifically, under the influence of enhanced nitrogen nutrition are increasing the yield and protein content, and finally only up increasing the protein content.

CONCLUSION

Nitrogen contents in seed of four wheat parent cultivars and six hybrids of F_3 generation were different in the year of analysis. Among the parent cultivars the highest value of nitrogen concentration had NS Rana 2 (3.50%) and the least value of N concentration had Osiječanka (2.98%). For the increasing of N content is necessary creating new genotypes with high efficiency of nitrogen absorption as well with high capacity of utilization, translocation and accumulation. The development of new genotypes with high efficiency of N absorption and capacity of nitrogen utilization will contribute to decreasing rate of application of nitrogen fertilizers. In this investigation were developed genotypes, by crossing *Osiječanka/ NS Rana 2* in F_3, which expressed the highest nitrogen contents and represents promising genotypes for cultivar creation with high yield low requirements for fertilizer application. For successful breeding is a necessary use parent with low requirement of nitrogen and high efficiency of absorption, utilization and translocation of nitrogen to grain.

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VARIJABILNOST I NASLEDJIVANJE SADRŽAJA AZOTA U ZRNU GENOTIPOVA OZIME PŠENICE (*Triticum aestivum* L.)

Desimir KNEŽEVIĆ[1], Violeta MAKLENOVIĆ[2], Ljubiša KOLARIĆ[2], Danica MIĆANOVIĆ[3], Andrej ŠEKULARAC[1], Jasmina KNEŽEVIĆ[1]

[1]Univerzitet u Prištini, Poljoprivredni fakultet, Kosovska Mitrovica, Lešak, Kosovo i Metohija, Srebija
[2]Univerzitet u Beogradu, Poljoprivredni fakulet Beograd, Zemun, Srbija
[3]Pivredna Komora Srbije Beograd, Beograd,Republika Srbija

Izvod

U radu je izučavano variranje sadržaja azota u zrnu sorti i hibrida pšenice, u cilju odabiranja genotipa sa minimalnim zahtevima ishrane ayotom. U izučavanjima su obuhvaćene 4 genetički divergentne sorte pšenice: Jugoslavija, Osiječanka, Žitnica, i NS Rana 2, poreklom iy različitih selekcionih centara i 6 hibrida F_3 koji su proizvedeni u dialelnom ukrštanju (bez recipročnih). Izučavano je nasleđivanje sadržaja azota u zrnu kod F_3 hibrida i ustanovljno je da su se ispoljili različiti tipovi nasleđivanja sadržaja azota: dominacija, intermedijarno nasleđivanje i superdominacija. Najveću vrednost sadržaja azota kod sorti imala je Novosadska rana 2 (3,50%) a najmanju Osiječanka (2,98%). Kod hibrida F_2 generacije najveći saržaj aota je nadjen u kombinaciji Osiječanka/NS Rana 2 (3,70%), Jugoslavija/NS Rana 2 (354%) koji predstavljaju najperspektivnije genotipove u daljem programu oplemenjivanja za ovo svojstvo.

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