UDC 575:633.11
DOI: 10.2298/GENSR1202251D
Original scientific paper

GENOTYPIC SPECIFICITY OF SOME WINTER WHEAT TRAITS AND THEIR EFFECT ON GRAIN YIELD

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Deletić N., S. Stojković, S. Gudžić, V. Djurić, and M. Aksić (2012): *Genotypic specificity of some winter wheat traits and their effect on grain yield.* - Genetika, Vol. 44, No. 2, 249 - 258.

This paper presents the two year results of a study dealing with genotypic specificity of some nitrogen accumulation parameters and yield components, as well as their individual and joint influence on grain yield per plant, in twenty Serbian winter wheat cultivars. There were significant differences among the investigated cultivars regarding the all studied traits. Coefficient of variation ranged from 6.81% for 1000 grain mass to 12.91% for total nitrogen accumulation. Cluster analysis showed the studied genotypes divided into two clusters, where larger one was further divided into several smaller clusters. Good definition of clusters is a sign that these

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traits' pattern is a distinctive property of a genotype. Multiple regression analysis showed that the all four studied traits, as well as intercept value, had significant effect on grain yield. The greatest effect was expressed by number of grain per spike, where standardized regression coefficient (β) was 0.535. Adjusted R^2 value (0.984) showed that 98.4% of the observed variation in grain yield was explained by the studied four traits. When biological yield is regarded, only total nitrogen accumulation and intercept value were significant. β value for total NA was 0.713, and adjusted R^2 was 0.787.

Key words: cluster analysis, grain yield, nitrogen, regression, wheat

INTRODUCTION

Nitrogen fertilizers are widely used for increasing grain yield and protein content of wheat and other cereals. 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 capability of their root system to uptake higher quantities of nitrogen from soil (DELETIĆ *et al*., 2010). 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, 2001).

Contribution of various plant traits to grain yield is a permanent subject of studies in plant breeding, because grain yield is dependent on many traits and largely affected by environmental factors. After water, nitrogen is generally the most limiting factor in cereal crop production (SZUMIGALSKI and VAN ACKER, 2006). A 20% increase in nitrogen use efficiency for cereal production around the world would be worth $10 billion annually (GIRMA *et al*., 2010). Nitrogen accumulation from soil and its translocation from root and leaves to grains are primarily under genetic control (KNEŽEVIĆ *et al.,* 2007). Therefore, a great scientific effort is directed to establish genetic specificity of nitrogen metabolism parameters, as well as to explain inheritance mode of those parameters (LE GOUIS *et al*., 2008; HABASH *et al*., 2007).

This study has been aimed to investigate genetic specificity of some nitrogen accumulation parameters and yield components, as well as their individual and joint influence on grain yield per plant, in twenty Serbian winter wheat cultivars.

MATERIALS AND METHODS

The trials were set 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 (listed in tab. 1). The following traits were studied: total nitrogen accumulation (mg/plant), physiological efficiency index of absorbed nitrogen (PEN) (g of grain / g of N), number of grains per spike, 1000 grain mass, grain yield (g/plant), as well as the total biological yield (g/plant). Grain and biological yield were expressed per plant, in order to exclude effect of nitrogen through number of plants per square unit, so that to point out to direct effect of nitrogen on grain and dry matter production. The trials were set in random complete block design (RCBD), with four replications in each year. The obtained data were processed by analysis of variance, cluster analysis based on the all studied traits, as well as by simple and multiple regression analysis (grain yield and biological yield as dependent variables).

RESULTS AND DISCUSSION

The studied parameters varied widely between years of investigation and among the observed cultivars (tab. 1). The greatest variation was shown by total nitrogen accumulation per plant which ranged from 15.9-50.3 mg, and coefficient of variation for that parameter was 12.91%. Among the investigated traits, 1000 grain mass was the most uniform one, with CV value of only 6.81%. However, the picture based only on individual traits variation is not sufficiently informative, so we tried to find pattern of those traits variability among the studied genotypes, and their effect on grain and biological yield. For those reasons, we performed cluster analysis, as well as simple and multiple regression analysis.

Cluster analysis of the studied cultivars based on the all observed parameters (graph 1) shows the genotypes divided into two clusters, where larger one was further divided into several smaller clusters. The observed clusters are well defined. Good definition of clusters is a sign that these traits' pattern is a distinctive property of a genotype.

In order to get better insight in the effect of studied traits on grain and biological yield, simple and multiple regression analyses were performed. Simple regression analysis (graph 2) shows that the all independent variables had a positive effect on grain yield, and that effect was clearly visible for total nitrogen accumulation per plant and number of grains per spike.

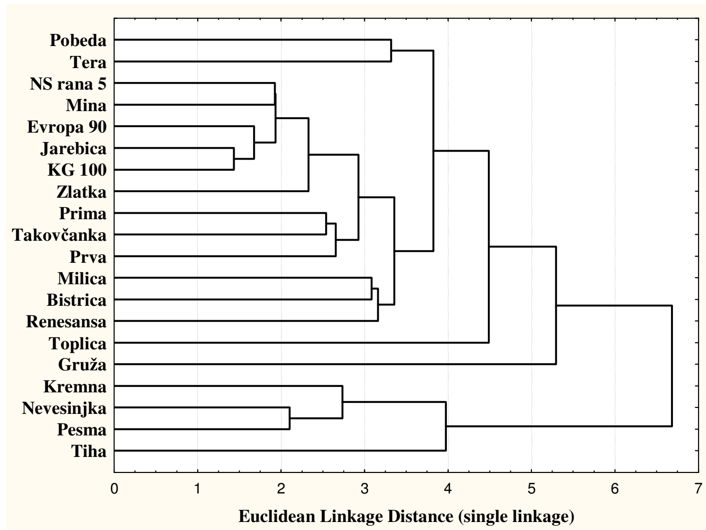
Multiple regression analysis of individual and joint effect of the studied parameters on grain yield showed that the all four studied traits, as well as intercept value, had significant effect on grain yield. The greatest effect was expressed by number of grain per spike, where standardized regression coefficient (β) was 0.535. Adjusted R^2 value (0.984) showed that 98.4% of the observed variation in grain yield was explained by the studied four traits. It means those four parameters were clearly responsible for variation in grain yield among the investigated cultivars. Having in mind that the trials were set on an acid soil, one could say that plant nutrition by nitrogen was particularly important in such conditions, which also was reported previously (DELETIĆ *et al.*, 2010).

Table 1. Some parameters of nitrogen accumulation and yield components, grain yield and biological yield of various winter wheat cultivars (two-year average)*

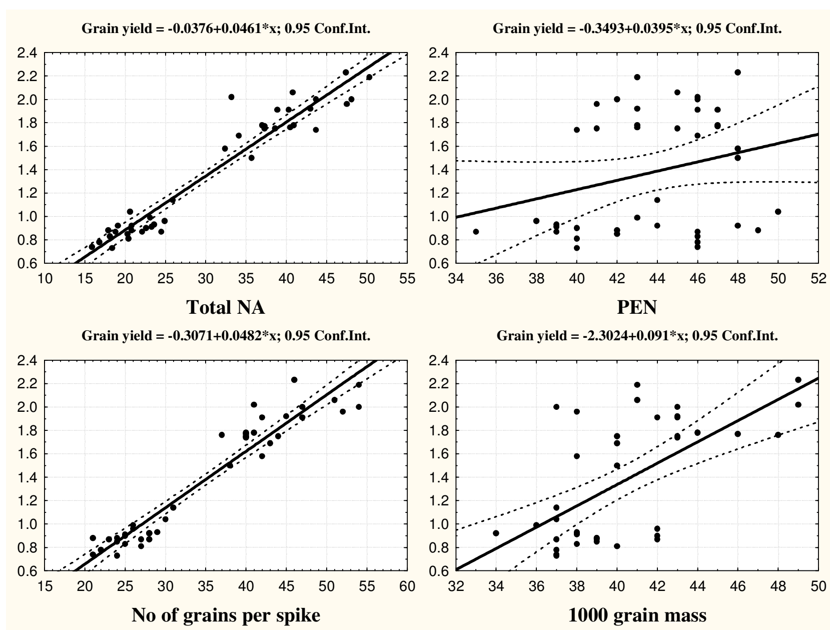
Cultivars	total NA (mg/plant)	PEN (g/g)	grains per spike	1000 gr. mass (g)	grain yield (g/plant)	biol. yield (g/plant)
1. Pobeda	29.20	46.00	30.50	43.50	1.32	3.25
2. NS Rana 5	29.60	44.00	33.00	41.00	1.38	3.16
3. Evropa 90	30.55	44.50	35.00	40.50	1.37	3.33
4. Milica	31.05	40.00	32.00	40.00	1.23	3.13
5. Jarebica	30.30	43.00	34.50	41.00	1.35	3.21
6. Kremna	32.25	45.00	41.00	35.50	1.46	3.22
7. Prima	26.45	46.00	35.50	38.50	1.28	2.94
8. Renesansa	32.70	39.00	34.00	41.50	1.32	3.23
9. Tera	26.60	46.50	30.50	41.50	1.25	2.85
10. Nevesinjka	34.70	45.50	41.00	39.50	1.55	3.46
11. Takovčanka	27.75	45.50	34.00	37.00	1.28	3.29
12. Gruža	35.00	44.00	35.50	45.50	1.56	3.37
13. Toplica	29.05	42.00	33.50	45.50	1.49	3.70
14. Bistrica	29.05	41.50	30.50	41.00	1.31	3.32
15. KG 100	31.20	43.00	35.00	42.00	1.39	3.29
16. Pesma	34.05	45.50	41.00	37.50	1.50	3.49
17. Zlatka	30.95	42.00	34.50	39.00	1.33	3.20
18. Prva	28.80	45.50	36.50	39.00	1.42	3.18
19. Mina	28.05	44.00	32.50	40.00	1.15	3.20
20. Tiha	37.00	43.00	39.00	40.00	1.57	3.83
Average	30.72	43.78	34.95	40.45	1.38	3.28
St. deviation	3.97	3.31	4.01	2.75	0.14	0.28
CV(%)	12.91	7.55	11.47	6.81	10.34	8.49
min-max	15.9-50.3	35.0-50.0	21.0-54.0	34.0-49.0	0.73-2.23	2.42-4.10
LSD 0.05	9.55	2.59	6.40	3.71	0.27	0.61
LSD 0.01	13.07	3.54	9.30	5.40	0.40	0.89

*Only cultivar means. Statistical parameters include both years of the study.

Influence of the studied parameters on biological yield (grain plus straw) was not so obvious. Multiple regression analysis showed that only total nitrogen accumulation and intercept value were significant. β value for total NA was 0.713, and adjusted R^2 was 0.787, i.e. 78.7% of variation in biological yield was explained by these four studied parameters.



Graph 1. Cluster analysis of the studied cultivars based on the all six observed traits



Graph 2. Effects of the observed traits on wheat genotypes' grain yield (simple regression)

Table 2. Effects of the observed traits on wheat genotypes' grain yield calculated by multiple regression analysis

	β	SE (β)	B	SE (B)	t (d.f.35)	P value
Intercept	--	--	-1.88	0.181	-10.4***	0.0000
Total NA	0.331	0.085	0.02	0.004	3.9***	0.0004
PEN	0.099	0.024	0.01	0.004	4.1***	0.0002
Grains per spike	0.535	0.079	0.03	0.004	6.8***	0.0000
1000 grain mass	0.204	0.028	0.03	0.004	7.2***	0.0000

R=0.993; R^2=0.986; adjusted R^2=0.984; goodness of fit: F(4, 35)=625.62 p<0.0000

Table 3. Effects of the observed traits on wheat genotypes' biological yield calculated by multiple regression analysis

	β	SE (β)	B	SE (B)	t (d.f.35)	P value
Intercept	--	--	1.468	0.635	2.312*	0.0268
Total NA	0.713	0.316	0.032	0.014	2.256*	0.0304
PEN	0.010	0.089	0.001	0.012	0.109	0.9140
Grains per spike	0.133	0.293	0.006	0.014	0.454	0.6526
1000 grain mass	0.099	0.105	0.014	0.014	0.943	0.3522

R=0.900; R^2=0.809; adjusted R^2=0.787; goodness of fit: F(4, 35)=31.10 p<0.0000

On the basis of the study, dealing with genotypic specificity of some nitrogen accumulation parameters and yield components, as well as their individual and joint influence on grain yield per plant, in twenty Serbian winter wheat cultivars, we can point out to several observations. There were significant differences among the investigated cultivars regarding the all studied traits. Coefficient of variation ranged from 6.81% for 1000 grain mass to 12.91% for total nitrogen accumulation. Cluster analysis showed the studied genotypes divided into two clusters, where larger one was further divided into several smaller clusters. Good definition of clusters is a sign that these traits' pattern is a distinctive property of a genotype. Multiple regression analysis showed that the all four studied traits, as well as intercept value, had significant effect on grain yield. The greatest effect was expressed by number of grain per spike, where standardized regression coefficient (β) was 0.535. Adjusted R^2 value (0.984) showed that 98.4% of the observed variation in grain yield was explained by the studied four traits. When biological yield is regarded, only total nitrogen accumulation and intercept value were significant. β value for total NA was 0.713, and adjusted R^2 was 0.787.

ACKNOWLEDGEMENTS

The investigation published in this paper is a part of the project “The development of new technologies of small grains cultivation on acid soils using contemporary biotechnology” financed by the Ministry of Science and Technological Development of the Republic of Serbia, grant No TR-31054.

Received October 04th, 2011
Accepted May 05th, 2012

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GENOTIPSKA SPECIFIČNOST NEKIH SVOJSTAVA OZIME PŠENICE I NJIHOV UTICAJ NA PRINOS

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U radu su prikazani rezultati dvogodišnjih ispitivanja genotipske specifičnosti nekih parametara akumulacije azota i komponenti prinosa, kao i njihov pojedinačni i združeni uticaj na prinos po biljci, kod dvadeset domaćih sorata ozime pšenice. Uočene su značajne razlike između ispitivanih genotipova u svim proučavanim svojstvima. Koeficijent varijacije se kretao od 6,81% za masu 1000 zrna do 12,91% za ukupnu akumulaciju azota. Klaster analiza je pokazala podelu ispitivanih genotipova u dve grupe, od kojih se veća grupa dalje deli na više podgrupa. Dobra definisanost grupa znači da obrazac variranja ovih svojstava predstavlja karakteristično svojstvo genotipa. Višestruka regresiona analiza je pokazala da sva četiri ispitivana svojstva, kao i vrednost preseka, pokazuju značajan efekat na prinos zrna. Najjači efekat na prinos zrna je imao broj zrna u klasu, sa standardizovanim regresionim koeficijentom (β) od 0,535. Korigovana vrednost R^2 (0,984) pokazuje da je 98,4% od ukupnih varijacija u prinosu zrna objašnjeno dejstvom četiri ispitivana svojstva. Kada se posmatra biološki prinos, samo ukupna akumulacija azota i vrednost preseka su bile značajne. β vrednost za ukupnu AN je bila 0,713, a korigovana R^2 vrednost 0,787.

Primljeno 04. X. 2011.
Odobreno 05. V. 2012.