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GENETIC VARIABILITY FOR YIELD AND SOME YIELD-RELATED TRAITS IN RICE (*Oryza sativa* L.)

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Abstract

Fourteen rice varieties originating from Italy (arsenal, nembo, ronaldo, galileo, sprint, ulisse, krystalino, mirko, sfera, gloria, pato, creso, vasco and san andrea) were grown in agro-ecological conditions in the Republic of Macedonia in 2014 and 2015, in order to evaluate the genetic variability for yield and some important yield-related traits, like number of panicles per m^2, plant height, panicle length, number of grains per panicle, weight of grains per panicle and 1000 grains weight. Statistical analysis showed that phenotypic coefficient of variability was higher than the genotypic coefficient of variability for all evaluated traits. The highest values for genotypic and phenotypic coefficients were obtained for the number of grains per panicle (GCV = 48.51%; PCV = 55.02%) and plant height (GCV = 46.23%; PCV = 48.85%). High level of broad sense heritability for the plant height (89.57%), the number of grains per panicle (77.74%), panicle length (77.64%) and a number of panicles per m^2 (59.44%) was observed. High level of heritability coupled with genetic advance was noticed for the number of panicles per m^2, a number of grains per panicle and panicle length, which underscores the importance of these traits for the process of selection and improvement of rice genetics.

Key words: *variety, genotypic and phenotypic variability, broad sense heritability*

INTRODUCTION

In the Republic of Macedonia, there are favourable ecological conditions for high yield and quality rice production which can meet European and world quality standards. Among the factors of production, variety selection plays an important role in the productivity of rice in any location (Alam et al., 2009). A long period of time, the main rice varieties included in the process of production in the Republic of Macedonia were the Italian varieties san andrea and R-76/6, which account for over 90% of the entire production in the country. The rest are represented with selected domestic varieties (prima riska, montessa and biser-2). In the range of the selected domestic rice varieties, the main varieties are the Italian ones, also. The process of the production improvement depends on the continued providing of new germplasm possessing different genes with significant production properties. The introduction of new populations can be made easily from one region to another and may be used for further manipulation to develop new breeding lines (Ifftikhar et al., 2009). When new populations are introduced, especially from geographically distant regions, the evaluation is mostly focused on determination of their productivity and variability.

The understanding of genetic variability present in a given crop species for the traits under improvement is an imperative for the success of any plant breeding programme (Sankar et al., 2006). Parameters such as genotypic and phenotypic coefficients of variation (GCV and PCV) are a useful tool in detecting the amount of variability present in a given trait. Heritability (h^2) of a trait is important in determining its response to the selection. Genetic improvement of plants for quantitative traits requires reliable estimates of heritability in order to plan an efficient breeding program (Akinwale et al., 2011). Heritability coupled with high genetic advance (GA) would be more useful in predicting the resulted effect in the selection of the best genotypes for yield and its attributing traits (Singh et al., 2011).

The purpose of this research was to evaluate the genetic variability for yield and some important yield components in fourteen Italian rice varieties grown in Macedonia, identification of superior varieties that can be used as sources of genetic variability in future process of rice selection.

MATERIAL AND METHODS

Plant material and experimental design

During the period 2014 – 2015, fourteen rice varieties were evaluated in agro-ecological and production conditions of Macedonia. Thirteen of them were newly introduced varieties from Italy (arsenal, nembo, ronaldo, galileo, sprint, ulisse, krystalino, mirko, sfera, gloria, pato, creso and vasco), and the cultivar san andrea, also an Italian variety used for a long period as a main variety in commercial rice production in Macedonia. The experiment was performed on alluvial soil type in the region of Kocani. Each test area was 5 m^2 set in three repetitions in randomized block method. Standard agronomic practices were used.

Data collection

Ten randomly selected plants from each repetition have been analyzed for the plant height (cm), panicle length (cm), number of grains per panicle and weight of grains per panicle (g). The number of plants per m^2 was determined by counting the plants from m^2 of each repetition. 1000 grains weight has been determined to measure 1000 grains of each repetition. Grain yield obtained from the 5 m^2 was calculated in tha^{-1}. When calculating the 1000 grains weight and grain yield, the moisture content was reduced in 14%.

Statistical analysis

For the analysis of variance (ANOVA) the statistical package SPSS (2010) was used. The least significant difference (LSD) was calculated using Statistical analysis system software JMP (2002). The correlation between yield and yield components was calculated according to Singh and Chaudhary (1985) and the broad sense heritability was calculated according to Falconer (1989). Genotypic (σ^2g) and phenotypic (σ^2ph) variance were obtained from the analysis of variance table according to Comstock and Robinson (1952). The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were determined according to Singh and Chaudhury (1985). Genetic advance (GA) was calculated with the method suggested by Allard (1960)_and Singh and Chaudhury (1985).

RESULTS AND DISCUSSION

The results obtained from the analysis of variance for traits examined during the two years are given in Table 1. The effect of the variety shows significant values for all examined properties. Interaction of variety with the year also showed a significant effect for all examined traits except for 1000 grains weight, while the effect of the year was significant for all properties except for panicle length and weight of grains per panicle. The results showed that the selection of these traits can be effective for further improvement of rice genetics.

Table 1. Mean square for yield and some yield related traits examined in 14 rice varieties (2014-2015)

Traits	Source of variation			
	Variety (V)	Year (Y)	Interaction (V x Y)	Error
GY	3.13**	767.01**	2.75**	0.76
NP	16683.82**	939588.76**	6766.35**	5903.43
PH	5036.07**	673.22**	525.21**	31.42
PL	140.66**	0.48ns	31.45**	5.26
NGP	7050.77**	11677.89**	1569.44**	393.23
WG	4.03**	1.04ns	2.67**	0.44
1000GW	261.04**	219.93**	1.53ns	0.57

V: variety; Y: year; V x Y: Interaction between variety and year; GY: grain yield (tha^{-1}); NP: number of panicles per m^2; PH: plant height (cm); PL: panicle length (cm); NGP: number of grains per panicle; WG: weight of grains per panicle (g); 1000GW: 1000 grains weight (g); ns: no significant; **: significant at 1% level probability

Mean values for the examined traits are shown in Table 2. Among the examined varieties significant differences were identified for all evaluated traits. Superiority regarding grain yield of the variety was noticed at variety ronaldo (7.08 tha^{-1}), while the lowest grain yield was obtained from the variety gloria (4.77 tha^{-1}). The number of panicles per m^2 range from 360.17 for galileo variety to 537.50 for san andrea variety. The highest was variety san andrea (88.35 cm) and the shortest variety sfera (48.98 cm). A variety mirko was characterized with the longest panicle (16.63 cm), while krystalino has the shortest one (11.50 cm). Maximum number of grains per panicle showed variety krystalino (80.03), while the minimum number of grains per panicle was observed in variety gloria (44.88). The highest weight of grains per panicle was obtained from the variety galileo (2.58 g) and the lowest from sprint (1.59 g). The 1000 grains weight varies from 23.34 g to 42.79 g at variety mirko and gloria, respectively.

Significant differences obtained between varieties show the presence of genetic variability between them and provide a great opportunity for yield improvement.

Table 2. Means for yield and some yield related traits examined in 14 rice varieties (2014-2015)

Variety	GY	NP	PH	PL	NGP	WG	1000GW
Arsenal	5.23def	452.83a_e	54.45e	15.33abc	63.38bcd	1.79cd	28.12fg
Nembo	4. 92ef	377.00 de	61.82bc	12.68ef	73.28ab	2.30ab	31.35de
Ronaldo	7.08a	445.83a_e	54.37e	15.72ab	70.50abc	2.23abc	32.21d
Galileo	6.84abc	360.17e	54.57e	16.53a	62.27bcd	2.58a	42.34a
Sprint	5.73c_f	474.67a_d	61.28bcd	15.82ab	59.73b_e	1.59d	26.92g
Ulisse	6.21a_d	444.33a_e	61.27bcd	16.08ab	48.10ef	2.02bcd	41.90ab
Krystalino	5.98a_e	445.00a_e	56.72de	11.50f	80.03a	2.31ab	29.88def
Mirko	5.96b_e	514.20abc	57.31cde	16.63a	79.93a	1.84bcd	23.34h
Sfera	6.97ab	543.00a	48.98f	13.53de	61.33b_e	1.80cd	29.16efg
Gloria	4.77f	442.50b_e	57.38cde	15.17bcd	44.88f	1.96bcd	42.79a
Pato	5.23def	437.80cde	62.87b	13.87cde	51.02def	2.10bc	42.40a
Creso	5.99a_e	427.50cde	56.02e	15.05bcd	64.48bcd	2.09bc	31.66de
Vasko	6.17a_d	489.00abc	54.98e	15.13bcd	58.38c_f	2.04bcd	35.53c
San Andrea	5.82c_f	537.50ab	88.35a	16.38ab	55.00def	2.21abc	39.50b
Means	5.92	456.52	59.31	14.96	62.31	2.06	34.08
Minimum	1.97	281.29	46.79	9.14	26.93	0.81	30.94
Maximum	9.33	623.14	75.07	21.00	120.36	3.97	38.76
$LSD_{0.05}$	1. 12	99.40	4.85	1.41	14.15	0.48	2.68
CV (%)	11.27	13.01	4.89	5.65	13.58	13.84	4.70

Means followed by a common letter(s) within a column do not differ at 5% level; GY: grain yield (tha^{-1}); NP: number of panicles per m^2; PH: plant height (cm); PL: panicle length (cm); NGP: number of grains per panicle; WG: weight of grains per panicle (g); 1000GW: 1000 grains weight (g); CV: coefficient of variation

Genotypic variance, phenotypic variance, the genotypic coefficient of variability, phenotypic coefficient of variability, broad sense heritability, genetic advance and genetic advance, expressed as a percentage of the mean for evaluated traits, are presented in Table 3. High genotypic and phenotypic variance was obtained for the number of panicles per m^2 (1652.91 and 2780.64, respectively), number of grains per panicles (913.55 and 1175.13), plant height (751.81 and 839.34), 1000 grains weight (43.25 and 43.51) and panicle length (18.20 and 23.44, successively). Low values for a genotypic and phenotypic variance were observed only for weight of grains per panicle (0.23 and 0.67) and grain yield (0.06 and 0.52 respectively). Generally, the phenotypic variance is higher than genotypic for all examined traits.

Table 3. Genetic parameters for yield and some yield related traits examined in 14 rice varieties (2014-2015)

Traits	σ^2g	σ^2ph	GCV,%	PCV,%	h^2,%	GA,%	GAM,%
GY	0.06	0.52	4.24	12.20	12.07	0.18	3.04
NP	1652.91	2780.64	8.91	11.55	59.44	64.57	14.14
PH	751.81	839.35	46.23	48.85	89.57	53.46	90.14
PL	18.20	23.44	28.52	32.37	77.64	7.74	51.74
NGP	913.55	1175.13	48.51	55.02	77.74	54.90	88.11
WG	0.23	0.67	23.13	39.79	33.78	0.57	27.67
1000GW	43.25	43.51	19.30	19.35	99.41	13.51	39.64

σ^2g: genotypic variance; σ^2ph: phenotypic variance; GCV: genotypic coefficient of variation; PCV: phenotypic coefficient of variation; h^2: broad sense heritability; GA: genetic advance; GAM: GA as % of mean; GY: grain yield (tha^{-1}); NP: number of panicles per m^2; PH: plant height (cm); PL: panicle length (cm); NGP: number of grains per panicle; WG: weight of grains per panicle (g); 1000GW: 1000 grains weight (g)

The phenotypic coefficient of variability was higher than the genotypic coefficient of variability for all examined traits. However, these differences are low, except when it comes to the grain yield, number of grains per panicle and weight of grains per panicle. Genotypic coefficient of variability and phenotypic coefficient of variability have high values for the number of grains per panicle (GCV = 48.51%; PCV = 55.02%), plant height (GCV = 46.23%; PCV = 48.85%), panicle length (GCV = 28.52%; PCV = 32.37%) and weight grains per panicle (GCV = 23.13%; PCV = 39.79%). Moderate variability was observed at 1000 grains weight with a genotypic coefficient of variability 19.30% and phenotypic coefficient of variability 19.35%. Grain yield and number of panicles per 1m^2 showed low variability (GCV = 4.24%; PCV = 12.20%; GCV = 8.91%; PCV = 11.55%, respectively). Variation present among the rice genotypes is very important for the improvement and developing of new cultivars (Rashid et al., 2014).

High values were observed for broad sense heritability in all examined traits (> 70%) except for the grain yield and weight of grains per panicle (12.07% and 33.78%, respectively). Heritability for the number of panicles per m^2 was 59.44%. High heritability indicates that the impact of environment had less influence on the traits and that such traits can easily be improved by the process of selection.

Genetic improvement (GA) ranged from 0.18% for grain yield to 64.57% for of the number of panicles per m^2. The highest values for GAM were obtained for plant height (90.14%), the number of grains per panicle (88.11%) and for panicle length (51.74%). Other examined traits showed moderate GAM, except the grain yield which has the lowest value. High heritability coupled with high GA shows additive gene effects, while high heritability coupled with low GA shows non-additive gene effects in the control of a trait.

The obtained results showed that plant height, panicle length, a number of grains per panicle and 1000 grains weight are important properties that need to be considered in the process of selection and improvement of rice.

High heritability with the high genetic advance for different traits in rice was also reported by Abdus et al., (2009), Akinwale et al., (2011), Pallabi et al., (2013), Pratap et al., (2012), Sadeghi (2011).

CONCLUDING REMARKS

The study has shown significant differences between tested varieties for all evaluated traits. The results indicate significant phenotypic and genotypic variance between varieties for the analyzed traits. The genotypic and phenotypic coefficient of variability was highest for the number of grains per panicle. Estimated broader sense heritability was in the range from 12.07% for the grain yield to 99.41% for 1000 grains weight. High level of heritability was obtained also for the plant height (89.57%), a number of grains per panicle (77.74%), panicle length (77.64%) and the number of panicles per m^2 (59.44%). High level of heritability for the panicle number per m^2, number of grains per panicle and panicle length is associated with high genetic improvement, which means that these traits can be successfully used in the process of

selection and rice genotype improvement.

Among the evaluated varieties, the highest potential to adapt to the production conditions of Macedonia and varieties with the highest yield are ronaldo, sfera and galileo. Based on the obtained results, these varieties can be used as parents in the selection programs to create new rice genotypes with better combinations of genes for the evaluated traits.

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ГЕНЕТСКА ВАРИЈАБИЛНОСТ НА ПРИНОС И НЕКОИ КОМПОНЕНТИ НА ПРИНОСОТ КАЈ ОРИЗ (*Oryza sativa* L.)

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Резиме

Четиринаесет сорти ориз со потекло од Италија (*arsenal, nembo, ronaldo, galileo, sprint, ulisse, krystalino, mirko, sfera, gloria, pato, creso, vasco* и *san andrea*) беа одгледувани во 2014 и 2015 година во агроеколошки услови на Македонија, со цел да се евалуира генетската варијабилност за приносот и некои позначајни компоненти на приносот (број на метлички на m^2, висина на стебло, должина на метличка, број на зрна во метличка, маса на зрна по метличка и маса на 1000 зрна). Фенотипскиот коефициент на варијабилност беше повисок од генотипскиот коефициент на варијабилност за сите анализирани својства. Највисоки вредности за истите се добиени за број на зрна по метличка (GCV=48.51%; PCV=55.02%) и висина на растение (GCV=46.23%; PCV=48.85%). Висока херитабилност во поширока смисла е пресметана за висина на растение (89.57%), број на зрна по метличка (77.74%), должина на метличка (77.64%) и број на метлички на 1 m^2 (59.44%). Висока херитабилност во комбинација со високо генетско подобрување е регистрирана за број на метлички на 1 m^2, број на зрна по метличка и должина на метличка, што го потенцира значењето на овие својства за селекцијата и подбрувањето на гентската основа на оризот.

Клучни зборови: *сорта, генотипска и фенотипска варијабилност, херитабилност*