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MORPHOLOGICAL CHARACTERS AND YIELD ANALYSIS OF *BIANKA* AND *GALILEO*-TWO NEWLY INTRODUCED VARIETIES OF RICE (*Oryza sativa L.*) IN MACEDONIA

ABSTRACT

The new varieties' performances were compared to the standard rice varieties *prima riska* (Macedonian variety) and *R-76/6* (domesticated Italian variety), grown under agroecological conditions of the Kocani region. The research was carried out during 2009 and 2010 by setting-up field trials (randomized block system). The following traits were analyzed: paddy rice yield, biological yield, stem height, panicle length and number of productive tillers per m^2. The highest average yield of paddy rice was achieved in the variety *galileo* (8548 kg/ha), and the lowest was in the standard variety *R-76/6* (7735 kg/ha). The highest average biological yield was reached of the standard variety *R-76/6* (17166,50kg/ha), while the lowest was in variety *bianca* (16125,00kg/ha). The introduced rice varieties were characterized by lower average stem height (*bianca*-53,70 cm, *galileo*-58,24 cm) compared to standards (*prima riska*-86,20cm and *R-76/6*-92,40 cm). The average panicle length of the varieties: *bianca* (17,20 cm), *galileo* (16,43 cm) and the standard *R-76/6* (16,27 cm) was lower compared to the standard variety *prima riska* (19,15cm). The highest average number of productive tillers per m^2 was determined for the standard variety *R-76/6* (399,83) and the lowest for the variety *bianca* (334,67). In 2009, the significantly largest number of productive tillers per m^2 (for both levels of probability) was estimated for the standard variety *R-76/6* (493,33), since in 2010, for the same character, the significantly highest value was reached in the variety *galileo* (420,33).

Keywords: rice, varieties, paddy rice yield, stem, panicle, productive tillers

INTRODUCTION

Rice represents a traditional cereal crop for the Republic of Macedonia. From the total of 513 000 ha cultivated land area in the country in 2009, 3125 ha were sown by rice, reaching the average yield of 6 368 kg per hectare (Statistical Yearbook of the Republic of Macedonia, 2011).

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The rice production is mainly concentrated in the eastern part of Macedonia, along the valley of Bregalnica river (the regions around Kocani, Stip, Vinica and Blatec), where the soil and climatic conditions are favorable. Rice is also grown on smaller surfaces around the cities Veles and Probistip (Statistical Yearbooks of the Republic of Macedonia 2000-2010, State Statistical Office of the Republic of Macedonia, www.stat.gov.mk).

The constant efforts of rice growers to increase the yields and improve the quality, beside the applied technology, comprehend an important question of choosing varieties with high yielding potential and good quality. Only those varieties that are well adapted to a complex of environmental (soil and climatic) conditions might ensure full expression of productive and quality traits. Nowadays consumers become choosier regarding the quality of rice for human consumption, expressing affinity to certain specific rice varieties on the market. The main constraints of rice farming, such as low temperatures at sowing and flowering time, blast disease and red rice could be solved within rice breeding programs but also by introducing new, improved varieties (Russo and Callegarin, 1997).

The prevalent rice varieties in Macedonia are characterized with long stem, not being very suitable for intensive production systems, especially not responding to high doses of inorganic fertilizers (Andreevska et al, 2007, 2009).

Parallel to breeding process, in order to enrich the assortment of rice varieties in the rice production in Macedonia, there is also need of introduction of high-yielding and good quality varieties (Andov et al 2003/2004, 2008/2009, 2010, Ilieva et al 2005/2006), that require further investigations regarding their adaptability to local environmental factors (Ilieva et al 2000, 2007, 2008, 2010).

The aim of this research was to determine the paddy rice yield, biological yield and certain morphological traits of two newly introduced Italian rice varieties within the agro-ecological conditions of Kocani region.

MATERIALS AND METHODS

The research was conducted during 2009 and 2010 at the locality "Bosevica", Department for Rice in Kocani (part of the Experimental Field of the Institute of Agriculture in Skopje). Field experiments were set up upon the randomized complete block design, in three repetitions. Standard technology for rice growing was applied. The land preparation (deep ploughing, disc ploughing, land leveling and harowing) was done during the spring time. The mineral fertilizers were applied prior to seeding (basic application with 100 kg/ha N and 75 kg/ha P and K) while split application was done during the tillering stage (30 kg/ha N). Seeding was carried out during the first decade of May. Previously soaked seeds were manually broadcasted into standing water in the field, with the seed rate of 500 germinating seeds per m^2. Since crop establishment to close to harvest, rice was grown under continuously flooded field; water was drained only for herbicide application. During the vegetation, the necessary pest management was practiced to ensure crop health.

Two introduced Italian rice varieties (*Bianca and Gallileo*) were investigated in parallel with standards *prima riska* (modern Macedonian variety, released in 2004) and *R-76/6* (domesticated Italian variety, widely spread in production in Macedonia), in order to compare their results. The focus of the research was put on the yielding potential of the investigated varieties (paddy rice yield, biological yield), the morphological characteristics (stem height and panicle length) and the number of productive tillers per m^2. The results were statistically analyzed by ANOVA and means were tested by least significant differences (LSD) test.

Soil and climatic conditions

The soils of the locality "Bosevica", where the field trials were set up on are of alluvium soil type, carbonate-free at the examined depths (Table 1). The soil texture was fine sandy loam. The pH of the soil solution was acid; the content of humus was low, the content of total nitrogen was strongly correlated to the content of humus. The soil was medium supplied with easily available potassium and phosphorus (Andreevska et al 2005/2006).

Tab.1. Some chemical properties of the soil from the locality "Bosevica"

Depth (cm)	$CaCO_3$ (%)	Humus (%)	Total Nitrogen (%)	pH		Easy available (mg/100 g soil)	
				H_2O	nKCl	P_2O_5	K_2O
0-20	-	2.16	0.09	5.79	4.92	17.85	14.02
20-40	-	1.50	0.06	5.88	5.07	11.57	12.04

Tab. 2. Data on average monthly temperatures and monthly sums of rainfalls during the rice vegetation period in Kocani in 2009 and 2010

Year	Months							Average	
	IV	V	VI	VII	VIII	IX	X	Per year	Per vegetation
Average monthly temperature (Cº)									
2009	14,0	18,7	22,4	24,9	24,9	21,2	14,0	14,1	20,0
2010	13,7	18,5	22,1	24,9	26,9	19,3	12,2	14,3	19,7
Aver.	13,9	18,6	22,3	24,9	25,9	20,3	13,1	14,2	19,9
Average monthly maximum temperature (Cº)									
2009	19,6	25,0	28,5	31,7	30,8	26,6	19,8	19,4	26,0
2010	19,0	23,9	26,9	29,9	32,7	25,6	16,8	19,3	25,0
Aver.	19,3	24,5	27,7	30,8	31,8	26,1	18,3	19,4	25,5
Average monthly minimum temperature (Cº)									
2009	6,4	9,0	13,0	15,8	15,4	12,1	6,4	6,8	11,2
2010	8,3	11,8	15,2	17,0	18,7	12,4	8,2	8,9	13,1
Aver.	7,4	10,4	14,1	16,4	17,1	12,3	7,3	7,9	12,2
Monthly sum of rainfalls (mm)									
2009	36,0	59,7	96,7	11,0	33,0	34,5	44,0	576,3	314,9
2010	63,3	20,5	86,0	19,5	6,5	33,0	119,5	623,3	348,3
Aver.	49,7	40,1	91,4	15,3	19,8	33,8	81,8	599,8	331,6

Regarding the climatic conditions during the rice vegetation period (since April to October), the average monthly air temperature in 2009 (20 ^{0}C) was slightly higher compared to 2010 (19,7 ^{0}C). The total average sum of rainfalls during the investigation (2009/2010) was 331,6 mm. In the first year (2009), the maximum of rainfalls was recorded in June (96,7mm), and the minimum in July (11,0 mm). In the second year of investigation, the biggest sum of rainfalls was in October (119,5 mm), and the lowest in August (6,5 mm).

In general, the climatic conditions during both years of investigation were favourable for rice cultivation.

RESULTS AND DISCUSSION

Analysis of variance (Tab. 3) showed significant differences between varieties for all the traits. Also, significant variation was found between two years of investigation for all the examined traits, except for panicle length). Interactions of cultivars with year were significant for paddy rice yield, biological yield, plant height and number of productive tillers.

Tab. 3. Analysis of variance for the examined traits

Analysis of variance						
		Mean Squares				
Source	df	**Paddy rice yield**	**Biological yield**	**Plant height**	**Panicle length**	**Number of productive tillers**
R	2	2287.50	14029.17	2.89	0.85	524.67
V	3	755292.71 **	1131944.44 **	2285.06 **	10.49 **	4335.00 **
Y	1	30049626.04 **	80666666.67 **	464.64 **	0.77	2816.67 **
V * Y	3	830781.60 **	6631944.44 **	95.88 **	0.51	21521.67 **
Error	14	22324.40	15267.26	1.81	0.32	215.67
Total	24					

Paddy rice yield

The results for paddy rice (rough rice) yield are presented in Table 4. The highest average yield in both years of investigation was obtained by the variety *galileo* (8548 kg/ha) that was 10,52% higher than the yield of the standard *R-76/6* (7735 kg/ha) and 1,99 % higher than other standard variety *prima riska* (8381 kg/ha). The two-years average paddy rice yield of the variety *bianca* (8113 kg/ha) was 4,89% higher than the yield of the standard *R-76/6*, but 3,20% lower than the yield of the other standard *prima riska.*

In 2009, the rough rice yield of *bianca* and *galileo* was significantly higher (for both levels of probability) compared to the standards *P-76/6* and *prima riska*.

In 2010, the paddy rice yield of *galileo* was significantly higher (for both levels of probability) compared to the standard variety *R-76/6.* The rough rice yield of *bianca* in 2010 did not significaly differ from the rough rice yield of the variety *P-76/6*. The best yielding variety in 2010 was the standard *prima riska* (9960 kg/ha), significantly better among all the varieties in the investigation.

Tab. 4. Paddy rice yield of the investigated varieties (kg/ha)

Varieties	Yield per year (kg/ha)		Average yield (kg/ha)	Index from	
	2009	2010		*Prima riska*	*R-76/6*
Prima riska(st.)	6802	9960	**8381,00**	0	+8,35
R-76/6 (st.)	6520	8950	**7735,00**	-7,71	0
Bianka	7413	8813	**8113,00**	-3,20	+4,89
Galileo	7567	9530	**8548,50**	+1,99	+10,52
Average	**7075,50**	**9313,25**	**8194,38**	-	-
LSD $_{0,05}$	*306,53*	*202,99*			
LSD $_{0,01}$	*446,46*	*295,66*			

Biological yield

The results for biological yield (straw + grain) are presented in Table 5. In both years of investigation the highest biological yield was reached by one of the standard varieties (*R-76/6*, 17166,50 kg/ha) that was 4,89% higher than the biological yield of variety bianca (16125,00 kg/ha), 10,52% higher than *galileo* (16791,50 kg/ha) and 8,35% higher than the other standard *prima riska* (16583,50 kg/ha).

The biological yield of the introduced Italian varieties *bianca* and *galileo* in 2009 was significantly lower (for both levels of probability) compared to the standards *R-76/6* and *prima riska.*

In the second year of investigation, the highest biological yield was measured in the variety *galileo* (19500 kg/ha), significantly higher than all other varieties - *bianca* (18500 kg/ha), *prima riska* (18500 kg/ha) and *R-76/6* (17500kg/ha).

Table 5. Biological yield (straw+grain) kg/ha

Varieties	Yield per year (kg/ha)		Average yield (kg/ha)	Index from	
	2009	2010		*Prima riska*	*R-76/6*
Prima riska(st.)	14667	18500	**16583,50**	0	-3,40
R-76/6 (st.)	16833	17500	**17166,50**	+3,52	0
Bianka	13750	18500	**16125,00**	-2,76	-6,07
Galileo	14083	19500	**16791,50**	+1,25	-2,18
Average	**14833,25**	**18500,00**	**16666,63**	0	-3,40
LSD $_{0,05}$	*126,16*	*275,36*			
LSD $_{0,01}$	*183,76*	*401,07*			

Table. 6. Stem height (cm)

Varieties	Year	X	S	Sx	CV %	min	max
Prima riska(st.)	2009	81,87	3,15	0,57	3,85	76,00	88,00
	2010	90,53	4,42	0,81	4,88	84,00	103,00
	Average	**86,20**	**3,79**	**0,69**	**4,37**	**80,00**	**95,50**
R-76/6 (st.)	2009	82,33	5,00	0,91	6,07	75,00	91,00
	2010	102,47	4,42	0,81	4,32	93,00	111,00
	Average	**92,40**	**4,71**	**0,86**	**5,20**	**84,00**	**101,00**
Bianka	2009	51,83	2,95	0,54	5,69	48,00	60,00
	2010	55,57	2,82	0,52	5,08	51,00	65,00
	Average	**53,70**	**2,89**	**0,53**	**5,39**	**49,50**	**62,50**
Galileo	2009	56,97	2,79	0,51	4,89	53,00	63,00
	2010	59,50	3,91	0,71	6,57	53,00	72,00
	Average	**58,24**	**3,35**	**0,61**	**5,73**	**53,00**	**67,50**
Year	*2009*	*2010*					
LSD $_{0,05}$	*2,16*	*2,14*					
LSD $_{0,01}$	*3,27*	*3,24*					

Stem height

The results in Table 6 show that the introduced Italian varieties, in general, are characterized with shorter stem in comparison with the standard varieties.

In both years of investigation, the stem height mean values of the introduced varieties (*bianca* 53,70cm and *galileo* 58,24cm) are significantly lower than the mean values of the standards (*prima riska* 86,20cm and *R-76/6 92*,40cm) for both levels of probability. The coefficient of variation was low (below 6,57 %) for all examined varieties.

Panicle length

During the investigation (2009 and 2010), the average panicle length values of the varieties *bianca* (17,20 cm), *galileo* (16,43 cm) and *R-76/6 (*16,27 cm) were significantly lower than the average panicle length value of the variety *prima riska* (19,15cm), for both levels of probability. The results are presented in Table 7.

Table 7. Panicle length (cm)

Varieties	Year	X	S	Sx	CV (%)	min	max
Prima riska(st.)	2009	19,07	1,82	0,33	9,54	15,00	22,00
	2010	19,23	1,99	0,36	10,37	15,00	23,00
	Average	**19,15**	**1,91**	**0,35**	**9,96**	**15,00**	**22,50**
R-76/6 (st.)	2009	16,40	2,28	0,42	13,92	10,00	20,00
	2010	16,13	1,53	0,28	9,45	14,00	19,00
	Average	**16,27**	**1,91**	**0,35**	**11,69**	**12,00**	**19,50**
Bianka	2009	16,63	1,92	0,35	11,55	14,00	22,00
	2010	17,77	1,83	0,33	10,31	14,00	22,00
	Average	**17,20**	**1,88**	**0,34**	**10,93**	**14,00**	**22,00**
Galileo	2009	16,23	1,50	0,27	9,25	14,00	20,00
	2010	16,63	1,59	0,29	9,54	14,00	21,00
	Average	**16,43**	**1,55**	**0,28**	**9,40**	**14,00**	**20,50**
Year	*2009*	*2010*					
LSD $_{0,05}$	*1,40*	*0,89*					
LSD $_{0.01}$	*2,12*	*1,34*					

The coefficients of variation in all the varieties were between 9 and 13,9 %, higher than in case of stem height.

Number of productive tillers per m^2

According to the results presented in Table 8, the highest average number of productive tillers per m^2 was found in the variety *R-76/6* (399,83), while the lowest was in the variety *bianca* (334,67).

In 2009, the standard variety *R-76/6* reached the value of 493,33 productive tillers per m^2 which was significantly higher (for both levels of probability) compared to all the other varieties.

In 2010, the introduced variety *galileo* showed the highest number of productive tillers per m^2 (420,33) among all the varieties, significantly higher for both levels of probability.

Tab 8. Number of productive tillers per m^2

Varieties	Year		Average	Index from	
	2009	2010		*Prima riska*	*R-76/6*
Prima riska(st.)	379,33	371,33	**375,33**	0	-6,13
R-76/6 (st.)	493,33	306,33	**399,83**	+6,53	0
Bianka	330,00	339,33	**334,67**	-10,83	-16,30
Galileo	321,33	420,33	**370,83**	-1,20	-7,25
Average	**381,00**	**359,33**	**370,16**	0	-6,13
LSD 0,05	*25,29*	*26,54*			
LSD 0,01	*36,83*	*38,66*			

CONCLUSION

The two-years research of the newly introduced Italian rice varieties *galileo* and *bianca* determined some of their productive performances within the agro-ecological conditions of Kocani region.

Significant variety-by-year interaction indicated that growing season affected paddy rice yield, biological yield, plant height and number of productive tillers in all the varieties included. The assessed variability of these traits between the two years of investigation shoved high dependence on the genotypes' responses to the varying environmental conditions. Unlike, the panicle length was stable under different growing environment.

Regarding the yielding ability of the investigated varieties, the variety *galileo* reached the highest average paddy rice yield (8548,50 kg/ha) among all the varieties during the investigation. The variety *bianca* achieved the paddy rice yield that was above or between the values of the standards, depending on the growing conditions.

According to determined yielding performances, the newly introduced Italian rice varieties *galileo* and *bianca* could be recommended for entire production in the Kocani region. Because of their short stem they are suitable for growing within intensive farming systems but also they are interesting to be included in the rice breeding program for breeding short stem varieties.

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MORFOLOŠKE KARAKTERISTIKE I ANALIZA PRINOSA DVIJE NOVOINTRODUKOVANE SORTE PIRINČA (*Oryza sativa L.*) *BIANKA* I *GALILEO* U MAKEDONIJI

SAŽETAK

U ovom radu su prikazani rezultati ispitivanja dvije novointrodukovane italijanske sorte pirinča *Bianca* i *Galileo*. Osobine novih sorti su upoređene sa standardiim sortama riže *prima riska* (Makedonska sorta) i *R-76/6* (odomaćena Italijanska sorta) u agroekološkim uslovima regiona Kočani.

Istraživanje je sprovedeno tokom 2009. i 2010. godine metodom poljskih ogleda (slučajni blok sistem).

Analizirane su sljedeće osobine: prinos sirovog (neoljuštenog pirinča), biološki prinos, visina stabljike, dužina metlica i broj produktivnih bokora po m^2. Najveći prosječni prinos sirovog pirinča imala je sorta *Galileo* (8548 kg/ha), a najmanji standardna sorta *R-76/6* (7735 kg/ha). Najveći prosječni biološki prinos imala je standardna sorta *R-76/6* (17166,50 kg/ha), a najmanji sorta *Bianca* (16125,00 kg/ha).

Introdukovane sorte sui imale nižu prosječnu visinu stabala (*Bianca* - 53,70 cm, *Galileo* - 58,24 cm) u poređenju sa standardima (*Prima riska* - 86,20cm i *R-76/6*-92,40 cm). Prosječna dužina metlice sorti *Bianca* (17,20 cm), *Galileo* (16,43 cm) i standarda *R-76/6* (16,27 cm) bila je niža u poređenju sa standardnom sortom *Prima riska* (19,15cm). Najveća prosječna vrijednost broja produktivnih bokora po m^2 je izmjerena kod standardne sorte *R-76/6* (399,83) a najniža kod sorte *Bianca* (334,67). Najveći broj produktivnih bokora po m^2 (za oba nivoa vjerovatnoće) je zabilježen kod standardne sorte *R-76/6* (493,33) u 2009. godini, dok je u 2010. godini za istu osobinu značajno veća vrijednost izmjerena kod sorte *Galileo* (420,33).

Ključne riječi: pirinač, sorte, prinos sirovog (neoljuštenog pirinča), stablo, metlica, produktivni bokori