

HEAD RICE YIELD OF SOME DOMESTIC AND FOREIGN RICE VARIETIES (*ORYZA SATIVA* L.) GROWN IN THE REPUBLIC OF MACEDONIA

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This paper presents the results of head rice yield research of rice varieties and genotypes grown in the Republic of Macedonia, conducted within the period 2009–2014. In the research, in total sixteen rice varieties and five genotypes were included, among which were the following: three Macedonian varieties (*Biser 2*, *Prima riska* and *Montesa*), three introduced Italian varieties, the most widely used in Macedonian rice production (*Monticelli*, *R-76/6* and *San Andrea*), five newly introduced Italian varieties (*Bianca*, *Galileo*, *Brio*, *Ellebi* and *Opale*), five newly introduced Turkish varieties (*Kiziltan*, *Gala*, *Halilbey*, *Gönen* and *Pasali*) and five newly bred Macedonian rice genotypes ($P1 \times M$, $P2 \times M$, $P \times MM$, $MBL \times M$ and $MBL \times MM$). Laboratory milling (peeling or bleaching or processing) was performed on a paddy processing machine to determine the head rice yield and by-products of milling: brokens, brans and husks. According to the results obtained, the highest head rice yield (percent of whole grains after milling rough rice kernels) of the domestic varieties was achieved with *Biser-2* (54.01%), while the lowest one was shown by *Prima riska* (49.38%). The highest head rice yield of the prevalent Italian varieties was 59.68% (*Monticelli*) and the lowest one was 43.35% (*San Andrea*). Regarding the newly introduced Italian varieties, the values of the head rice yield ranged from 35.4% (*Galileo*) to 64.46% (*Ellebi*). Among the Turkish varieties, *Kiziltan* showed the highest head rice yield (62.67%) and *Gönen* the lowest one (43.34%). In the newly bred Macedonian rice genotypes, the head rice yield ranged from 55.60% ($P1 \times M$) to 63.77% ($P \times MM$). The percentage of brokens, bran and husks (hulls) in all investigated varieties and genotypes varied in different years of production.

Key words: rice; varieties; genotypes; head rice yield; brokens; bran; husks

РАНДМАНОТ КАЈ НЕКОИ ДОМАШНИ И СТРАНСКИ СОРТИ ОРИЗ (*ORYZA SATIVA* L.) ОДГЛЕДУВАНИ ВО РЕПУБЛИКА МАКЕДОНИЈА

Во трудот се презентирани резултатите од испитувањето на рандманот во периодот од 2009 до 2014 година кај вкупно 16 сорти и 5 генотипови на ориз одгледувани во Република Македонија. Тоа се: три домашни (македонски) сорти (*бисер-2*, *прима риска* и *монџеса*), три интродуирани италијански сорти широко застапени во оризопроизводството (*монџичели*, *р-76/6* и *сан андреа*), пет новоинтродуирани италијански сорти ориз (*бианка*, *галileo*, *брио*, *елеби* и *ојале*), пет новоинтродуирани турски сорти (*кизилџан*, *гала*, *халилбеи*, *гонен* и *пашали*) и пет новосоздадени домашни генотипови ориз ($P1 \times M$, $P2 \times M$, $P \times MM$, $MBL \times M$ и $MBL \times MM$). Рандманот на белиот ориз е одреден на лабораториска лупилница. Според добиените резултати е утврдено дека највисок просечен рандман (процент на цели зрна) при белењето на суровиот ориз кај испитуваните домашни сорти ориз е добиен кај сортата *бисер-2* (54,01%), а најнизок кај сортата *прима риска* (49,38%). Највисок рандман кај интродуираните италијански сорти ориз застапени во поширокото оризопроизводство во Република Македонија е утврден кај сортата *монџичели* (59,68%), а најнизок кај сортата *сан андреа* (43,35%). Кај испитуваните пет новоинтродуирани италијански сорти ориз највисок просечен рандман при белењето на суровиот ориз е добиен кај сортата *елеби* (64,46%), а најнизок кај сортата *галileo* (35,40%). Највисок просечен рандман кај испитуваните пет новоинтродуирани турски сорти ориз е добиен кај сортата *кизилџан* (62,67%), а најнизок кај сортата *гонен* (43,34%). Кај новосоздадените генотипови ориз во Република Македонија највисок двегодишен просечен рандман е утврден кај генотипот $P \times MM$ (63,77%), а најнизок кај генотипот $P1 \times M$ (55,60%). Фракциите кршен ориз, трици и плеви кај испитуваните сорти и генотипови се различни по сорта и година на производство.

Клучни зборови: ориз; сорти; генотипови; рандман; кршен ориз; трици; плева

INTRODUCTION

Rice (*Oryza sativa* L.) is an important cereal in the agricultural production of the Republic of Macedonia. The rice production meets the demand for the product on the domestic market, and considerable amount remains for export [1].

The harvest of the rice plant results in obtaining the product (paddy rice or rough rice) that is not directly usable for human consumption. Therefore, the harvest is followed by the post-production during which the paddy rice is processed at factories (mills) equipped with special machines.

Unlike the other cereals, which grains are milled into flour or animal feed while processing, in rice the hulls, bran, and surface area of the endosperm and the embryo are separated from the grain, and the remaining kernel should remain whole.

Aside from the paddy rice yield obtained during harvest, the main interest of rice producers is the white rice yield, which is an important varietal characteristic determined by the head rice yield in % of the whole grains of white rice after the milling of the paddy rice. High paddy yield of rice varieties does not always imply high head rice yield, and consequently high white rice yield. [2–4]. The utilization of rice hulls obtained from hulling domestic rice varieties was investigated [5]. The investigation on the physical properties and cooking behavior of domestic rice varieties belonging to the short and middle long grain and comparison to the respective foreign rice varieties has pointed out that Macedonian rice varieties are similar to the Italian and Spanish rice varieties, while their identification with gliadin HPLC method has shown their common origin and intercrossing [6].

In case of delayed maturation (like it happened several years ago), there is a risk of early frosts that very often leads to deterioration of paddy rice yield and quality. Later maturation is also often caused when the irrigation after heading is prolonged, or the drainage of the rice fields prior to harvest is delayed [7]. Then, during the milling procedure of the late harvested rice, very low head rice yields have been obtaining.

The aim of the investigation of this paper is to determine the head rice yield (% of whole grains) of some local rice varieties and genotypes and foreign introduced rice varieties cultivated in the environmental conditions of the Republic of Macedonia from 2009 to 2014.

MATERIALS AND METHODS

The investigations on the head rice yield presented in this study are conducted in a period of 6 years (from 2009 to 2014). A total of 16 rice varieties and 5 genotypes were examined: 3 domestic (Macedonian) varieties (*Biser-2*, *Prima riska* and *Montessa*), 3 introduced and widely cultivated Italian varieties (*Monticelli*, *P-76/6* and *San Andrea*), 5 newly introduced Italian varieties (*Bianca*, *Galileo*, *Brio*, *Ellebi* and *Opale*), 5 newly introduced Turkish varieties (*Kiziltan*, *Gala*, *Halilbey*, *Gönen* and *Pasali*), and 5 newly bred domestic (Macedonian) rice genotypes ($P1 \times M$, $P2 \times M$, $P \times MM$, $MBL \times M$ and $MBL \times MM$). The investigated rice varieties and genotypes were grown in the Republic of Macedonia (in the rice production region of Kochani) with standard rice production technology. The head rice yield, the whole grains and by-products of the paddy rice processing (broken rice, rice bran and husks) were determined by laboratory milling samples of each variety and genotype on a paddy processing machine. The duration of milling (peeling or bleaching) was 1.40 min. The results obtained are shown in Tables.

RESULTS AND DISCUSSION

The results obtained for the head rice yield of the examined domestic varieties are shown in Table 1. According to them, the highest head rice yield (percent of whole grains after milling of the rough rice kernels) was achieved by the variety *Biser-2* in 2009 (61.00%). The highest average of head rice yield for the examined period (2009–2012) was also achieved by the same variety (54.01 %). The lowest head rice yield by years (42.90 % in 2012) and the lowest average (49.38 %) was determined with the variety *Prima riska*, while the average head rice yield with the variety *Montessa* is 50.31 %.

The results presented in Table 2 show the head rice yield of the introduced Italian varieties prevalent in the rice production in Macedonia. The highest head rice yield (68.68%) was achieved by the variety *Monticelli* in 2010. The highest average was achieved by the same variety (59.68 %). The lowest head rice yield by years (26.60 % in 2012) and the lowest average of all years (43.35 %) was determined with the variety *San Andrea*. The average head rice yield of the variety *R-76/6* was 51.98 %.

Table 1

Head rice yield of Macedonian (domestic) rice varieties (in %)

Varieties	Year	Whole grains	Brokens			Total whole grains + brokens	Chalky grains	Rice bran	Husks
			1/3	2/3	Total				
<i>Biser-2</i>	2009	61.00	2.85	4.87	7.72	68.72	0.59	14.04	16.65
	2010	52.89	2.23	9.60	11.83	64.72	2.00	15.05	18.23
	2011	55.33	3.31	6.74	10.05	65.38	0.77	15.90	17.95
	2012	46.80	2.90	9.80	12.70	59.50	4.60	16.70	19.20
	2009/12	54.01	2.82	7.75	10.58	64.58	1.99	15.42	18.01
<i>Prima riska</i>	2009	44.51	1.98	18.02	20.00	64.51	1.09	14.80	19.60
	2010	53.12	2.04	10.98	13.02	66.14	0.72	12.90	20.24
	2011	44.42	1.70	19.17	20.87	65.29	0.27	14.89	19.55
	2012	42.90	2.50	15.90	18.40	61.30	1.00	16.80	20.90
	2013	51.23	2.20	9.23	11.43	62.66	0.50	17.33	19.51
	2014	60.10	2.50	5.10	7.60	67.70	1.87	10.96	19.47
	2009/14	49.38	2.15	13.07	15.22	64.60	0.91	14.61	19.88
<i>Montesa</i>	2009	52.85	1.84	3.64	5.48	58.33	6.4	14.03	21.24
	2010	51.00	2.84	7.30	10.14	61.14	5.12	14.50	19.24
	2011	50.20	2.90	8.30	11.20	61.40	5.20	15.50	17.90
	2012	47.20	3.50	9.70	13.20	60.4	6.20	14.90	18.50
	2009/12	50.31	2.77	7.24	10.01	60.32	5.73	14.73	19.22

Table 2

Head rice yield of introduced Italian varieties widely used in Macedonian rice production (in %)

Varieties	Year	Whole grains	Brokens			Total whole grains + brokens	Chalky grains	Rice bran	Husks
			1/3	2/3	Total				
<i>Monticelli</i>	2009	64.04	1.00	2.19	3.19	67.23	0.90	11.34	20.53
	2010	68.68	0.89	1.00	1.89	70.57	0.00	12.10	17.33
	2011	62.30	2.00	3.11	5.11	67.41	0.86	11.03	20.70
	2012	43.70	3.10	10.80	13.90	57.60	6.50	15.40	20.50
	2009/12	59.68	1.75	4.28	6.02	65.70	2.07	12.47	19.77
<i>R-76/6</i>	2009	53.23	1.99	11.26	13.25	66.48	0.90	11.58	21.04
	2010	57.05	1.65	10.40	12.05	69.10	0.32	11.45	19.13
	2011	52.53	1.39	13.56	14.95	67.48	0.00	12.48	20.04
	2012	40.90	2.95	15.55	18.50	59.40	7.06	14.04	19.50
	2013	59.12	1.85	2.10	3.95	63.07	2.63	14.80	19.50
	2014	49.04	2.13	14.13	16.26	65.30	2.20	15.72	16.78
	2009/14	51.98	1.99	11.17	13.16	65.14	2.19	13.35	19.33
<i>San Andrea</i>	2010	57.68	3.18	4.53	7.71	65.39	0.66	14.00	19.95
	2011	45.30	3.20	15.90	19.10	64.40	1.92	15.64	18.04
	2012	26.60	3.80	28.80	32.60	59.20	6.45	14.51	19.84
	2013	36.90	3.30	25.10	28.40	65.30	0.90	14.00	19.80
	2014	50.27	2.40	14.00	16.40	66.67	1.19	13.01	19.13
	2010/2014	43.35	3.18	17.67	20.84	64.19	2.22	14.23	19.35

The head rice yield is genetically determined characteristic of each variety, however at the same time it might be influenced of the applied production technology and environmental conditions (climate and soil) of particular rice producing region [3–4, 8].

The results obtained for the head rice yield of the 5 newly introduced Italian varieties in 2009 and 2012 are shown in Table 3. According to them, the highest head rice yield (percent of whole grains after milling of the rough rice kernels) was achieved by the variety *Ellebi* in 2010 (64.96 %). The highest average of head rice yield for the examined period (2010–2011) was also achieved by the same variety (64.46 %). The lowest head rice yield by years (33.66 % in 2010) and the lowest average one (35.40 %) was determined with the variety *Galileo*. The average head rice yield of the other 3 varieties was as follows: 50.31% of *Bianca*, 59.73 of *Brio* % and 41.47 % of *Opale*.

The results obtained for the head rice yield of the 5 newly introduced Turkish varieties examined in 2013 and 2014 are shown in Table 4. According to these results, the highest head rice yield (percent of whole grains after milling of the rough rice kernels) was achieved with the variety *Kiziltan* in 2013 (64.00%). The highest average of head rice

yield for the examined period (2013–2014) was also achieved with the same variety (62.67 %). The lowest head rice yield by years was determined with the variety *Halibey* (42.10 % in 2013), while the lowest average one in the two-year period (43.34 %) was determined with the variety *Gönen*. The average head rice yield of the other 3 varieties was the following: 55.09% of *Gala*, 52.00 % of *Pasali* and 45.65 % of *Halilbey*.

The results obtained from the investigations of Andov *et al.* [9] on the head rice yield of some Turkish rice varieties grown in the environmental conditions of Macedonia and Turkey, have pointed out that on the head rice yield (which is a variety characteristic) strong influence have also the climate-soil growing conditions. The average head rice yield of the Turkish rice varieties grown in Republic Turkey was 57.97% being 9.45% higher in comparison to the head rice yield of the same varieties which were grown in Republic of Macedonia (48.52%).

A previous investigation showed that under the climatic conditions of Edirne region in Turkey, the highest head rice yield was achieved when the harvesting has been conducted 49 days after the flowering at 25% of grain moisture content [10].

Table 3

Head rice yield of newly introduced Italian rice varieties grown in R. of Macedonia (in %)

Varieties	Year	Whole grains	Brokens			Total whole grains + brokens	Chalky grains	Rice bran	Husks
			1/3	2/3	Total				
<i>Bianka</i>	2009	52.92	1.45	13.00	14.45	67.37	0.31	12.85	19.47
	2010	47.70	2.88	16.41	19.29	66.99	1.40	11.97	19.64
	2009/10	50.31	2.17	14.71	16.87	67.18	0.86	12.41	19.56
<i>Galileo</i>	2009	37.14	4.70	22.92	27.62	64.76	1.20	14.13	19.91
	2010	33.66	7.94	24.60	32.54	66.20	1.20	10.44	22.16
	2009/10	35.40	6.32	23.76	30.08	65.48	1.20	12.29	21.04
<i>Brio</i>	2010	58.63	0.80	9.60	10.40	69.03	0.77	9.25	20.95
	2011	60.82	0.93	6.04	6.97	67.79	0.00	10.77	21.44
	2010/11	59.73	0.87	7.82	8.69	68.41	0.39	10.01	21.20
<i>Ellebi</i>	2010	64.96	1.07	2.92	3.99	68.95	0.86	13.00	17.19
	2011	63.95	1.77	2.66	4.43	68.38	0.62	14.00	17.00
	2010/11	64.46	1.42	2.79	4.21	68.67	0.74	13.50	17.10
<i>Opale</i>	2010	36.43	11.30	19.50	30.80	67.23	0.27	10.80	21.70
	2011	44.97	1.72	20.89	22.61	67.58	0.52	12.30	19.60
	2012	43.00	3.90	11.80	15.70	58.70	3.60	15.80	21.90
	2010/12	41.47	5.64	17.40	23.04	64.50	1.46	12.97	21.07

Table 4

Head rice yield in the newly introduced Turkish rice varieties grown in R. of Macedonia (in %)

Varieties	Year	Whole grains	Brokens			Total whole grains + brokens	Chalky grains	Rice bran	Husks
			1/3	2/3	Total				
<i>Kiziltan</i>	2013	64.00	1.30	3.90	5.20	69.20	1.00	9.80	20.00
	2014	61.33	2.60	5.70	8.30	69.63	0.77	9.30	20.30
	2013/2014	62.67	1.95	4.80	6.75	69.42	0.89	9.55	20.15
<i>Gala</i>	2013	58.20	3.80	10.80	14.60	72.80	0.00	8.20	19.00
	2014	51.97	3.90	16.10	20.00	71.97	0.13	8.30	19.60
	2013/2014	55.09	3.85	13.45	17.30	72.39	0.07	8.25	19.30
<i>Halilbey</i>	2013	42.10	3.90	24.30	28.20	70.30	0.40	9.50	19.80
	2014	49.20	3.80	16.76	20.56	69.76	2.10	9.41	18.73
	2013/2014	45.65	3.85	20.53	24.38	70.03	1.25	9.46	19.27
<i>Gönen</i>	2013	44.40	2.80	21.20	24.00	68.40	1.95	9.95	19.70
	2014	42.27	3.90	24.46	28.36	70.63	1.14	9.60	18.63
	2013/2014	43.34	3.35	22.83	26.18	69.52	1.55	9.78	19.17
<i>Pasali</i>	2013	53.90	2.90	17.50	20.40	74.30	0.00	8.70	17.00
	2014	50.10	3.60	17.70	21.30	71.40	0.00	9.90	18.70
	2013/2014	52.00	3.25	17.60	20.85	72.85	0.00	9.30	17.85

The results obtained for the head rice yield of the 5 newly bred domestic genotypes in Republic of Macedonia are shown in Table 5. According to them, the highest head rice yield (percent of the whole grains after milling of the rough rice kernels) was achieved by the genotype $P \times MM$ in 2013 (63.90%). The highest average value of the head rice yield for the examined period (2012–2013) was also achieved by the same genotype

(63.77 %). The lowest head rice yield obtained by years was determined with the genotype $P2 \times M$ (54.30% in 2013), while the lowest average value for the two-year period (55.60 %) was determined with the genotype $PI \times M$. The average head rice yield of the other 3 genotypes was as follows: 56.58% of $P2 \times M$, 58.45 % of $MBL \times M$ and 62.55% of $MBL \times MM$.

Table 5

Head rice yield of newly bred Macedonian rice genotypes grown in R. of Macedonia (in %)

Genotypes	Year	Whole grains	Brokens			Total whole grains+brokens	Chalky grains	Rice bran	Husks
			1/3	2/3	Total				
$PI \times M$	2012	55.00	6.30	10.20	16.50	71.50	0.51	10.59	17.40
	2013	56.20	2.40	4.80	7.20	63.40	1.10	16.40	19.10
	2012/13	55.60	4.35	7.50	11.85	67.45	0.81	13.50	18.25
$P2 \times M$	2012	58.86	3.67	7.97	11.64	70.50	0.28	10.14	19.08
	2013	54.30	2.50	7.40	9.90	64.20	1.90	16.00	17.90
	2012/13	56.58	3.09	7.69	10.77	67.35	1.09	13.07	18.49
$P \times MM$	2012	63.64	2.20	5.70	7.90	71.54	0.30	12.10	16.06
	2013	63.90	1.10	2.50	3.60	67.50	1.90	11.60	19.00
	2012/13	63.77	1.65	4.10	5.75	69.52	1.10	11.85	17.53
$MBL \times M$	2012	61.69	3.22	5.97	9.19	70.88	0.30	11.66	17.16
	2013	55.20	3.10	6.60	9.70	64.90	0.60	16.00	18.50
	2012/13	58.45	3.16	6.29	9.45	67.89	0.45	13.83	17.83
$MBL \times MM$	2012	61.59	3.40	6.30	9.70	71.29	0.50	11.83	16.38
	2013	63.50	1.00	2.90	3.90	67.40	1.20	13.10	18.30
	2012/13	62.55	2.20	4.60	6.80	69.35	0.85	12.47	17.34

CONCLUSIONS

On the basis of the investigations conducted and the results obtained regarding the head rice yield of the afore mentioned rice varieties and genotypes, the following conclusions can be done:

The highest head rice yield (percent of the whole grains after milling of the rough rice kernels) of domestic varieties was achieved by the variety *Biser-2* (54.01%), while the lowest one was obtained by *Prima riska* (49.38%).

The highest head rice yield of the prevalent Italian varieties was 59.68% (*Monticelli*) and the lowest was 43.35% (*San Andrea*).

The highest head rice yield of the newly introduced Italian varieties was achieved by the variety *Ellebi* 64.46%, while the lowest one was achieved by the variety *Galileo* of 35.40 %.

Among the Turkish varieties, the variety *Kiziltan* showed the highest head rice yield (62.67%) and the variety *Gönen* the lowest one (43.34%).

Among the newly bred Macedonian rice genotypes, the genotype *P×MM* showed the highest head rice yield (63.77%), while the genotype *PI×M* the the lowest one (55.60%).

The percentage of the brokens, bran and husks with the all investigated varieties and genotypes varied during different production years.

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