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Original article

Paddy Rice Yield, Milling Fractions and white Rice Yield of Efe, Hamzadere, Çakmak and Tunca Rice Varieties in the Rice producing Conditions of North Macedonia

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Abstract

The paddy rice yield, milling fractions (head rice yield, brokens, bran and hulls) and white rice yield were examined in the newly introduced Turkish varieties: Efe, Hamzadere, Çakmak and Tunca grown under typical rice producing conditions of North Macedonia during 2013 and 2014, compared to standard variety San Andrea. The field trials were set up in randomized complete block design. The results were analyzed by ANOVA and LSD test. The new varieties showed higher paddy rice yield in both years, with average values ranging from 9365.39 kg/ha in Efe to 10704.02 kg/ha in Tunca compared to San Andrea (8784.40 kg/ha). San Andrea was characterized with the highest fluctuation in head rice yield and the lowest average (38.30 %). All Turkish varieties showed more stable and higher average head rice yield. Efe had the highest value by year and the highest average (56.15 %). The white rice yield in the new varieties was higher in both years, with average values of 4420.66 kg/ha in Hamzadere to 5351.65 kg/ha in Tunca, compared to San Andrea, where the lowest average of 3276.12 kg/ha and the highest fluctuation was obtained. Significant differences for the paddy and white rice yield and the head rice yield were obtained in both years. The new varieties showed promising results regarding the head rice yield and white rice yield, which is problematic and unstable in the prevalent rice varieties in the rice production of North Macedonia.

Keywords: Rice, Milling fractions, Yield, Paddy, White rice, Turkish varieties.

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INTRODUCTION

In North Macedonia, a centuries old tradition of rice cultivation persists. The first written sources dating back to the middle of the XV century (Atanasova, 2015). The rice producing region is located mainly in the eastern part of the country, with an average production area of 4,926.36 ha, 4,692.67 kg/ha average paddy yield and 23,145.12 t average yearly production of paddy for the 1939- 2014 period (Andreevska and Andov, 2015). The rice production meets the domestic market demand, and considerable amount of the product remains for export (Andreevska et al., 2009). In recent years, since most of the area under rice is sown with the Italian variety San Andrea the rice production in North Macedonia is facing negative effect due to unstable head rice yield. This situation culminated in 2012, when low values of head rice yield (even down to 26.60%, according to Andreevska et al., 2015) were recorded. The main reason for the unstable head rice yield of San Andrea and other Italian varieties is their long vegetation and the late ripening during period when adverse effects in the environment may occur (sudden fluctuations and drop of temperature, precipitation and high relative humidity) leading to grain fragility. This ultimately results in low head rice yield, high brokens percentage and low white rice yield.

As an attempt to improve the quality of rice, several number of Turkish rice varieties were introduced for the first time in the North Macedonian rice production. In previous research paper (Dimitrovski et al., 2017) the results for the yield properties of Kiziltan, Gala, Halilbey, Gönen and Paşali varieties are given. In this paper are presented the results for the varieties Efe, Hamzadere, Çakmak and Tunca.

Materials and Methods

Plant material

In this study, plant material from 5 newly introduced Turkish rice varieties (Kiziltan, Gala, Halilbey, Gönen and Paşali) was used. These varieties are developed at the Trakya Agricultural Research Institute, Edirne in Turkey. The most common variety in cultivation- Italian variety San Andrea, registered in 2000, was used as a standard. Some characteristics of the examined varieties are shown in Table 1 (Ente Nazionale Risi, 2003, 2010; Trakya Agricultural Research Institute, n.d.).

Table 1. Some characteristics of the examined rice varieties in the trial

Variety	**Origin**	**Vegetation length (days)**	**Plant height (cm)**	**Head rice yield (%)**	**1000 grains weight of paddy (g)**	**Potential paddy yield (kg/ha)**
Efe*	Baldo x Demir	125-130	100-105	64	37	8000- 9000
Hamzadere	Demir x 83013-TR631-4-1-2	130	95	62	37-38	8000-9000
Çakmak*	Trakya x N1-41T-1T-0T	130	90 - 100	60	33	8000-10000
Tunca *	Rocca x Tthainato	136-140	90 - 95	65	32-33	8000- 9000
San Andrea **	Rizzoto (line)	150-160	107 -116	61-66.5	35-37	6480-8710

*Trakya Agricultural Research Institute. n.d. "Cultivars". retrieved from http://arastirma.tarim.gov.tr/ttae/Links/16/Cultivars.

** Ente Nazionale Risi, 2003 ; Ente Nazionale Risi, 2010.

Experimental design

The field trials (complete randomized block design, 3 replications) were set up during 2013 and 2014, in the Rice experimental station of the Institute of Agriculture Skopje, in Sredorek area of Kochani, typical rice producing conditions. The standard rice production technology was applied. Prior to harvesting, the plant samples (bundles of whole plants – above ground biomass from 1 m^2) were taken to assess the number of tillers per plant and the biological yield (this results are given in separate publication). The paddy rice in each replication was harvested and measured. Yield of paddy rice was calculated on a 14 % grain moisture. In order to determine the milling fractions (head rice yield - whole grains, broken grains, bran and hull), paddy rice sample (100 g) from each replication were milled on laboratory milling machine during 1.40 min. The white rice yield was estimated on the basis of obtained paddy rice yield and head rice results. Results were analyzed by ANOVA and LSD test at 0.05 and 0.01 levels of probability.

Climate and soil conditions

The field trial site is located within the main rice producing region that belongs to the temperate continental- sub-Mediterranean region of the country (Filipovski et al. 1996). The temperatures and precipitation sums during the trial, along with long-term average data for the 1998- 2012 period are presented in Table 2.

Table 2. Temperatures and precipitation sums for 2013 and 2014, along with 1998- 2012 averages

Year	Months							Average	
	IV	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**Yearly average**	**During vegetation**
	Mean monthly temperatures (ºC)								
2013	15.3	20.1	21.8	23.9	26.1	19.8	15.7	14.7	20.4
2014	12.4	16.8	20.8	23.2	23.8	18.3	13.8	13.8	18.4
AVG 1998-2012	13.8	18.6	22.9	25.6	25.1	20.0	14.7	14.1	20.1
	Mean monthly maximum temperature (ºC)								
2013	21.7	26.5	28.2	30.8	33.3	27.2	23.1	20.6	27.3
2014	18.0	23.0	28.1	30.9	31.8	25.0	20.7	20.1	25.4
AVG 1998-2012	19.2	23.9	28.7	31.6	31.5	26.2	20.2	19.4	25.9
	Mean monthly minimum temperature (ºC)								
2013	7.9	13.0	15.4	16.2	17.5	11.2	7.3	8.4	12.6
2014	7.4	10.8	14.0	16.5	16.6	13.4	8.7	8.5	12.5
AVG 1998-2012	5.7	10.1	13.3	15.1	15.0	10.8	6.8	6.3	11.1
	Monthly precipitation (mm)							**Precipitation sum**	
2013	39.0	45.0	130.5	32.0	11.0	29.0	30.0	559.5	316.5
2014	121.0	92.0	116.0	65.0	31.0	89.0	37.0	794.0	551.0
AVG 1998-2012	39.7	49.4	54.5	27.6	34.5	42.7	60.4	489.5	308.9

Data obtained from the meteorological station at the Institute of Agriculture Skopje - Rice research station in Kochani.

From previous surveys (Petkovski et al., 1997) the soil in Sredorek area where the field trial was set up is classified as alluvial. The carbonate content of soil was measured with Scheibler calcimeter (Mitrikeski and Mitkova, 2001). The soil pH in distilled water and 1M KCl solution was determined electrometrically using a glass electrode (Mitrikeski and Mitkova, 2001). The soil available P_2O_5 and K_2O were determined using the AL (ammonium lactate) method (Džamić et al.1996). The following major soil characteristics were determined: the sample at 0 – 20 cm depth had a pH reaction of 5.6 (in H_2O) i.e. 4.7 (in KCl), 23.61 mg/100 g soil available P_2O_5 and 13.30 mg/100 g soil available K_2O. The soil sample at 20- 40 cm depth had a pH reaction of 6.0 (in H_2O) i.e. 5.3 (in KCl), 7.48 mg/100 g soil available P_2O_5 and 12.95 mg/100 g soil available K_2O. Carbonates were not detected.

Results and Discussion

Paddy rice yield

In the environmental conditions of North Macedonia, the new Turkish varieties reached the paddy rice yield potential. In both years the Turkish varieties produced a higher paddy rice yield in comparison

to the standard variety San Andrea, where the lowest yield per year and the lowest two year average was recorded (8784.40 kg). Significant differences were found in Hamzadere and Çakmak in 2013 and Tunca in 2014. The highest yield in 2013 was determined in Hamzadere (11266.32 kg/ha), while in 2014 in Tunca (10744.55 kg/ha). Tunca also had the highest two year average (10704.02 kg/ha), and the lowest paddy yield fluctuation in between years.

Table 3. Paddy rice yield (kg/ha)

Year	Efe	Hamzadere	Çakmak	Tunca	San Andrea	$LSD_{0.05}$	$LSD_{0.01}$
2013	9867.88	11266.32 *	11045.18 *	10663.48	9500.00	1351.07	1965.67
2014	8862.90	9688.11	9890.98	10744.55 *	8068.79	2016.24	2933.43
Average	9365.39	10477.22	10468.08	10704.02	8784.40		

* significant difference at $\alpha_{0.05}$ level of probability; ** significant difference at $\alpha_{0.01}$ level of probability - compared to standard.

Milling fractions

The results of the examination of the milling fractions in 2013 and 2014 are shown in Table 4. Significant component of the white rice yield is the head rice yield (the whole grains fraction). In the past years, the white rice yield drastically varied in certain years because of periodical occurrence of low head rice yield of the prevalent Italian varieties in cultivation. This was also evident in the trial, as the standard San Andrea gave very low head rice yield in 2013 (26.33%). In 2014, the head rice yield of this variety was 50.27%, with the biggest difference of 23.94% among the examined varieties. All Turkish varieties had a significantly higher head rice yield in 2013 compared to San Andrea. Hamzedere also had a somewhat unstable head rice yield, with low value of 35.70% in 2013. The head rice yield was generally higher in 2014 compared to 2013. The highest value in both years and the highest two year average was determined in Efe (56.15%). Compared to the standard, in 2014, Efe and Tunca had significantly higher head rice, while the head rice yield of Çakmak, where the lowest value was obtained (46.57%) was significantly lower.

The highest broken grains average was found in the standard San Andrea (23.80%), where the lowest head rice yield was determined, followed by Hamzadere (22.35%). The lowest broken grains average (14.12 %) was determined in Efe, which had the highest head rice yield.

The highest average content of hulls (22.00%) and bran (15.90%) were determined in San Andrea. The lowest hull content was determined in Efe (17.80%), while the lowest bran in Çakmak (11.42%).

In comparison to the country of origin, both the standard and the new varieties had a lower head rice yield.

Table 4. Milling fractions: Head rice yield (whole grains), broken grains, hulls and bran (%)

Year	Efe	Hamzadere	Çakmak	Tunca	San Andrea	$LSD_{0.05}$	$LSD_{0.01}$
Head rice yield (Whole grains)							
2013	50.27 **	35.70 **	46.03 **	46.93 **	26.33	2.60	3.78
2014	62.03 **	49.83	46.57 **	53.03 **	50.27	1.61	2.34
Average	56.15	42.77	46.3	49.98	38.30		
Broken grains							
2013	17.37 **	27.87 **	20.67 **	15.37 **	31.20	1.27	1.84
2014	10.87**	16.83	21.57 **	15.73	16.40	2.04	2.97
Average	14.12	22.35	21.12	15.55	23.80		
Hulls							
2013	18.23 **	19.33 **	22.23 **	21.17 **	24.63	0.87	1.27
2014	17.37 **	20.27	20.10	20.30	19.37	1.14	1.67
Average	17.80	19.80	21.17	20.74	22.00		
Bran							
2013	14.13**	17.10	11.07 **	16.53	17.83	1.49	2.16
2014	9.73**	13.07*	11.77**	10.93**	13.97	0.87	1.26
Average	11.93	15.09	11.42	13.73	15.90		

* significant difference at $\alpha_{0.05}$ level of probability; ** significant difference at $\alpha_{0.01}$ level of probability - compared to standard.

White rice yield

The Turkish varieties produced higher and more stable white rice yield compared to the standard in both years. In 2013, the results were significant for all Turkish varieties, while in 2014 for Efe and Tunca. The highest yield in 2013 was reached in Çakmak (5084.25 kg/ha), followed by Tunca with 5004.46 kg/ha. Tunca yielded the highest white rice in 2014 (5698.83 kg/ha) and the highest average yield in the trial (5351.65 kg/ha). San Andrea produced the lowest yield per year and the lowest average (3276.12 kg/ha).

Table 5. White rice yield (kg/ha)

Year	Efe	Hamzadere	Çakmak	Tunca	San Andrea	$LSD_{0.05}$	$LSD_{0.01}$
2013	4955.55 **	4012.74 **	5084.25 **	5004.46 **	2496.90	571.07	830.86
2014	5494.28 *	4828.57	4599.53	5698.83 **	4055.34	1040.44	1513.74
Average	5224.92	4420.66	4841.89	5351.65	3276.12		

Significant difference at $\alpha_{0.05}$ (*) and $\alpha_{0.01}$ (**) compared to standard; α - level of probability;

Conclusion

In the rice production of North Macedonia, variety San Andrea gives similar paddy rice yield to the one in the country of origin. Still, the low white rice yield and high brokens percentage caused by the fluctuating and low head rice yield in certain years generate financial losses to farmers. In this study, the examined Turkish varieties gave higher and more stable values for the analyzed yield components

(paddy yield, head rice yield and white rice yield) in the same rice producing conditions, and as such are potentially suitable for growing in the Kochani production region.

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