INFLUENCE OF HARVESTING METHODS ON YIELD AND QUALITY OF RICE IN THE REPUBLIC OF MACEDONIA

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Abstract
In this study, the influence of two different paddy harvesting methods (manual harvesting and combine harvesting) on paddy yield, head rice yield and white rice yield was investigated. Field trials were set up in three different locations in the rice producing regions Kocani, Cesinovo-Oblesevo and Stip under the standard production technology, adopted in the entire Macedonian rice production. Two Italian introduced varieties (San Andrea and Onice) were included in the trials. Samples were taken from the treatments with different methods of harvesting (manual and combine harvesting) from which the paddy rice yield data were collected directly. In order to determine the head rice yield, laboratory milling of paddy grains was performed on a paddy quality testing machine (three average samples of 100 g per treatment, duration of milling 1,40 min.). On the base of the data for paddy rice yield and head rice yield, the white rice yield was estimated. According to the results obtained, the highest paddy rice yield (11,925.67 kg ha^{-1}) as well as the highest white rice yield (6,710.57 kg ha^{-1}) were achieved in the treatment with manual harvesting in Kocani region (San Andrea variety). The highest head rice yield (65.80 %) was determined in the treatment with manual harvesting in Stip region (Onice variety), while the lowest head rice yield (43.90 %) was in the treatment with combine harvesting of the variety Onice in Kocani region. In general, the method of manual harvesting resulted in higher values of paddy yield, head rice yield and white rice yield compared to the method of mechanized, combine harvesting in all the examined treatments (two varieties, three locations).

Keywords: varieties, paddy rice, white rice, head rice yield.

Introduction

The implemented methods and time of harvesting are some of the conditions influencing the crop yield and grain quality. During the rice harvesting, inappropriate procedures might cause the loss of the paddy rice yield, followed by the grain quality deterioration. Unlike the other cereals (where the milling process transforms the grains into flour), milling paddy rice results in obtaining whole white grains. Therefore, any mechanical damages of the paddy grain, potentially caused by the different parts of the combine harvester are unwanted. But, the use of inadequate harvesting machinery certainly results in mechanical damages of the paddy grain, such as breakages, cracks, excessive peeling etc. The damaged paddy grains are problematic for storage, since they are highly prone to quality deterioration. The outcome of the post-harvest procedures (milling) on damaged paddy grains is always lower head rice yield and consequently lower yield of white, milled rice per unit of harvested area. Moreover, as the result of milling low quality paddy rice, the grain discoloration often appear – non-typical color for the variety, such as black to brown grains, reddish, brown, yellowish, amber etc. Also, the grain spoilage from fungal growth or molds might happen. The rice harvesting in the Republic of Macedonia is mostly performed by using combine harvesters that are also used for harvesting other small cereals (wheat, barley). Actually, very few of the used combine harvesters in our country are designed for rice only. The most of the harvesters that are in use in the

Republic of Macedonia are very old and produced by the "Zmaj "company. The adjustment of the combines' working parts of the specialized rice harvesters and especially adaptation of the universal harvesters from one to another mode of operation (depending of the crop – rice or other cereal) are very often irregularly done and followed by mistakes. All this can cause grain damage and quality deterioration of the paddy rice. The milling fractions including the head rice yield and white rice yield of different rice varieties grown in the environmental conditions of Republic of Macedonia were previously studied by Andreevska et al., 2015; 2014; Andov et al., 2014 and Ilieva et al., 2009. The aim of this study was to determine the influence of the harvesting methods on yield and quality of rice in three rice producing regions in the Republic of Macedonia.

Material and methods

The study was carried out by setting up field macro-trials in three rice producing regions (Sredorek-Kocani, Ularci-Cesinovo-Oblesevo and Tarinci-Stip). The standard production technology was applied. Two varieties were included in the investigation – San Andrea, the predominant rice variety in the Macedonian rice production and Onice, Italian introduced variety. The paddy yield was assessed on two types of samples – the first was taken out from manually harvested rice and the second – sampled from combine harvested rice bulk. The head rice yield was determined by laboratory milling of paddy grains on a paddy quality testing machine (three average samples of 100 g per treatment, duration of milling 1,40 min.). The white rice yield was estimated on the base of the paddy yield and head rice yield. The obtained data were statistically performed (ANOVA) and differences tested with LSD test (probability levels 0.05 and 0.01). In Table 1, the chemical characteristics of the soils from the studied localities are presented. According to some previous investigations (Petkovski et al., 1997), the soil type in Sredorek-Kocani locality is alluvial. The pH of the soil is slight acid in water solution (Filipovski, 1984) while in N KCl solution is acid (Ubavić et al. 2001). According to the used Al method, the easily available Phosphorus was at high level, while the easily available Potassium is at medium level (Džamić et al.1996). Regarding the soil of the locality Ularci-Cesinovo-Oblesevo, the pH in water solution is slightly alkaline while pH in nKCl is neutral and the soil is slightly carbonated (according to American classification). The content of the easily available Phosphorus is at very high level and the content of the easily available Potassium is at high level. In the locality Tarinci-Stip, the soil pH in water solution is slightly alkaline, while in nKCl it is alkaline. The content of the easily available Phosphorus is at low level. The content of the easily available Potassium is at optimal level.

Table 1. Chemical characteristics of the soils from the investigated localities

Depth (cm)	$CaCO_3$ %	pH		Easily available Phosphorus and Potassium (mg/100 g soil)	
		H_2O	N KCl	P_2O_5	K_2O
Locality Sredorek-Kocani					
0 – 30	-	5.6	4.7	18.87	19.80
Locality Ularci-Cesinovo-Oblesevo					
0 – 30	1.07	7.6	6.6	25.58	34.97
Locality Tarinci-Stip					
0 – 30	5.78	8.0	7.30	6.62	25.75

Results and discussion

The results for the paddy rice yield obtained by manual harvesting as well as by combine harvesting are presented in Table 2. The highest average paddy rice yield was achieved in the locality Sredorek-Kocani through manual harvesting for both varieties (*San Andrea*- 11,925.67 kg ha^{-1}, *Onice*-11,223.33 kg ha^{-1}), while the lowest in the locality Tarinci-Stip through combine harvesting (*San Andrea*-3,100.00 kg ha^{-1}, *Onice*-4,900.00 kg ha^{-1}). For the variety San Andrea, the differences between the

mean values of paddy rice yield in two treatments (manual and combine harvesting) were significant. In the variety Onice, there was significant difference between the means of paddy rice yield in two treatments (manual and combine harvesting) in the localities Sredorek-Kocani and Tarinci –Stip for both levels of probability, while in the locality Ularci-Cesinovo-Oblesevo the significance was at 0.05 level of probability.

Table 2. Paddy rice yield [kg ha^{-1}]

San Andrea			
	Harvesting method		
Locality:	Manual harvesting	Combine harvesting	Average
Sredorek-Kocani	11,925.67	7,916.52	9,921.10
Tarinci-Stip	5,373.33	3,100.00	4,236.67
Ularci-Cesinovo-Oblesevo	9,416.67	6,834.00	8,125.33
Tarinci-Stip	8,905.22	5,950.17	
Onice			
	Harvesting method		
Locality:	Manual harvesting	Combine harvesting	Average
Sredorek-Kocani	11,223.33	5,230.70	8,227.02
Tarinci-Stip	7,256.67	4,900.00	6,078.33
Ularci-Cesinovo-Oblesevo	10,806.67	9,484.80	10,145.73
Average	9,762.22	6,538.50	
LSD 0,05	1,098.94		
LSD 0,01	1,493.29		

Table 3. Head rice yield [%]

San Andrea			
	Harvesting method		
Locality:	Manual harvesting	Combine harvesting	Average
Sredorek-Kocani	56.27	51.69	53.98
Tarinci-Stip	64.57	56.00	60.28
Ularci-Cesinovo-Oblesevo	59.67	52.90	56.28
Average	60.17	53.53	
Onice			
	Harvesting method		
Locality:	Manual harvesting	Combine harvesting	Manual harvesting
Sredorek-Kocani	57.60	43.90	50.75
Tarinci-Stip	65.80	57.00	61.40
Ularci-Cesinovo-Oblesevo	61.57	46.80	54.18
Average	61.66	49.23	
LSD 0,05	3.25		
LSD 0,01	4.42		

The results presented in Table 3. show the highest average head rice yield that was achieved through manual harvesting in the locality Tarinci-Stip in both varieties (*San Andrea*- 64.57% and *Onice*- 65.80%), while the lowest head rice yield was obtained through combine harvesting in the

locality Sredorek-Kocani (*San Andrea*- 51.69% and *Onice*- 43.90%). Significant differences (for both levels of probability) were found between head rice yield's mean values of the two treatments (manual harvesting and combine harvesting), for both varieties, in all three localities in this study.
In Table 3, the results for the white rice yield, obtained through different methods of harvesting are presented, for the two varieties in three localities. There it is stated that the highest white rice yield was estimated for the treatment with manual harvesting, in the localities Sredorek-Kocani (San Andrea variety, 6,704.13 kg ha^{-1}) and Ularci-Cesinovo-Oblesevo (Onice variety, 6,634.23 kg ha^{-1}). The lowest white rice yield was gained for the treatment with combine harvesting in the locality Tarinci-Stip (*San Andrea*- 1,734.60 kg ha^{-1}) and in the locality Sredorek-Kocani (*Onice*- 2,296.85 kg ha^{-1}). For both the investigated varieties San Andrea and Onice, significant differences between the means of the white rice yield were found, for both levels of probability, in all three localities.

Table 4. White rice yield [kg ha^{-1}]

San Andrea			
	Harvesting method		
Locality:	Manual harvesting	Manual harvesting	Average
Sredorek-Kocani	6,704.13	4,092.61	5,398.37
Tarinci-Stip	3,471.81	1,734.60	2,603.21
Ularci-Cesinovo-Oblesevo	5,606.17	3,615.98	4,611.07
Average	5,260.70	3,147.73	
Onice			
	Harvesting method		
Locality:	Manual harvesting	Manual harvesting	Average
Sredorek-Kocani	6,477.66	2,296.85	4,387.26
Tarinci-Stip	4,771.12	2,793.77	3,782.44
Ularci-Cesinovo-Oblesevo	6,634.23	4,438.10	5,536.16
Average	5,961.00	3,176.24	
LSD 0,05	583.59		
LSD 0,01	793.21		

Conclusions

On the base of the results of the study on different methods of harvesting (manual and combine), conducted in three regions on two rice varieties (San Andrea and Onice), the following conclusions on their influence to rice yield and quality could be done:
The highest paddy rice yield (11,925.67 kg ha^{-1}) as well as white rice yield (6,710.57 kg ha^{-1}) were achieved in Sredorek-Kocani region in the variety San Andrea, by using manual harvesting.
The highest head rice yield (percent of whole grains of white rice) of 65.80% was gained in the variety Onice, locality Tarinci-Stip by using manual harvesting. The same variety had the lowest head rice yield of 43.90% in the locality Sredorek-Kocani, when combine harvesting was applied.
In both examined varieties and in three regions, significantly better results for paddy yield, head rice yield and white rice yield were achieved when manual harvesting was applied, compared to combine harvesting.
Mechanized harvesting might have negative effects on yield and quality of harvested rice in case of inappropriate use of the equipment. Therefore, serious attention has to be paid to the right choice of proper combine harvesters and especially to careful adjustments of their working parts for different modes of operation.

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References

1. Danica Andreevska**,** Dobre Andov, Emilija Simeonovska (2014). Dressing percentage and yield of white rice in *Bianca* and *Galileo* – two newly introduced rice varieties (*Oryza sativa* L.), grown under agro-ecological conditions of Macedonia. 4th Congress of Ecologists of the Republic of Macedonia with international participation.Ohrid, 12-15 October 2012. Book of Proceedings p.212-217.
2. Dobre Andov, Danica Andreevska, Emilija Simeonovska (2014). Yield of white rice and byproducts of rice milling in some newly introduced Italian rice varieties grown under agro-ecological conditions of Macedonia 4th Congress of Ecologists of the Republic of Macedonia with international participation.Ohrid, 12-15 October 2012. Book of Proceedings p.218-223.
3. Danica Andreevska**,** Dobre Andov, Mirjana Menkovska, Emilija Simeonovska, Trajče Dimitrovski (2015): Head rice yield of some domestic and foreign rice varieties (*Oryza sativa* L.) in the Republic of Macedonia. Macedonian Journal of Animal Science, Vol. 5, No. 2, pp. 89–94. On line ISSN 1857 – 7709.
4. Džamić Ružica, Stevanović D., Jakovljević M. (1996). Praktikum iz agrohemije. 1-162. Beograd.
5. Filipovski, Ǧ. (1984). Pedologija. Treto izdanie. 599 pp. Univerzitet „Sv. Kiril i Metodij". Skopje.
6. Ilieva Verica, Andreevska Danica, Andov D., Markova Natalija, Jankulovska Mirjana (2009). Dressing percentage of white rice in corelation with the harvest time of the rice. Yearbook of the Faculty of Agricultural sciences and food, Skopje, vol. 54, 19-27.
7. Petkovski D., Mukaetov D., Andreevski M. (1997). Sodrzina na nekoi lesnorastvorlivi teski metali vo aluvijalnite pocvi od Kocansko Pole. Makedonska zemjodelska revija, 44 (1-2), 1- 5.
8. Ubavić M., Kastori R., Oljača R., Marković M. (2001). Ishrana voćaka. 1-150. Banjaluka.