Original scientific paper
10.7251/AGRENG1702092T
UDC: 633.18

IMPACT OF FOLIAR FERTILIZATION ON PRODUCTIVITY OF NEW INTRODUCED CULTIVARS OF PADDY RICE

Ivanka TOROMANOVA, Tonya GEORGIEVA*

Agricultural University, 4000 Plovdiv, Bulgaria
*Corresponding author: tonia@au-plovdiv.bg

ABSTRACT

The interest to the introduced rice cultivars (*Oryza sativa* L.) is explained by the search for more suitable varieties with good adaptability and high yield to be grown under the agro-climatic conditions in Bulgaria. The new foliar treatment products on the market - Folur, Amalgerol and Lithovit, have also provoked our interest. The survey was carried out in 2013 - 2015, applying the two-factor field experiment following the split plot method. Two Turkish - Osmanchik 97 and Gala, along with four Italian cultivars – Lince, Cameo, Puma and Brio were set as factor one. The foliar product Folur (2 l/da), Amalgerol (1.2 l/da) and Lithovit (0.300 kg/da) were set as factor two. The following factors were studied: phenological development of the cultivars, productive tillering capacity and yield. It has been specified that Osmanchik 97 and Gala had a shorter vegetative period. Lince stood out against the 6 tested cultivars by highest tillering results – 4.70 number of tillers/plant and was sharply outlined from the standard – Osmanchik 97, Puma and Brio. The tested products Folur and Lithovit had proven their effect on the formation of more productive tillering capacity – by 7.7% and 13.1% respectively. The highest yield was observed with Cameo (954.5 kg/da) and Brio (949.1 kg/da), which surpassed the Osmanchik 97 (control) by 8.6% and 8% respectively. The Amalgerol treatment proved to have the strongest positive impact on productivity and increased the average yield of the tested cultivars by 11.3%.

Keywords: *Rice (Oryza sativa L.), cultivars, foliar treatment products, development and productivity.*

INTRODUCTION

As a result of various objective (climate, limited suitable soils) and subjective reasons, (constant reorganizations, reconstructions, change of property, etc.), temporary reductions and subsequent recoveries of cultivated areas have been observed during the last two decades in Bulgaria. After the analysis of harvested areas, average yield and total production in this country, it has become clear that despite all fluctuations, harvested areas and average yields are steadily growing. By 2015, harvested areas amounted to 124 000 da and production for the same period increased almost 2.9 times – from 20 000 to 67 000 tons. Average yields were

comparatively steady - from 448.0 kg/da (2005) to 545.4 kg/da (2015), depending mainly on the biological characteristics of the cultivars and agro-meteorological conditions throughout the whole year. The immediate task for ensuring competitive power of Bulgarian rice production on the European market is yield increase and high quality production (Angelova, 1999). Additional options for raising productivity via foliar treatment products (Bari *et al.*, 2009; Dong *et al*, 2012) are being explored. The objective of the present study is to make a comparative characteristics of perspective Turkish and Italian rice cultivars, regarding phenological development, tillering capacity and productivity in the agro conditions of South Bulgaria, as well as the influence of Folur, Amalgerol and Lithovit foliar products on them.

MATERIAL AND METHODS

In the period 2013-2015 a two-factor field experiment using the split plot method was carried out in the town of Saedinenie, Plovdiv region, Bulgaria. The basic studied factor (big plots) in the experiment was the genotype. Six introduced cultivars were tested – two of Turkish origin (Osmanchik 97 and Gala) and four of Italian origin (Cameo, Lince, Puma and Brio), whereas Osmanchik 87 was used as the control. The tested foliar products (Folur, Amalgerol and Lithovit) were applied on the small plots. A non-treated control for each cultivar served for comparison. The experiment was set after rice as a fore-crop in four repetitions, with reported size of the harvested plot of 14.85 m^2. The statistical procession of the test data was made through SPSS V.9.0 for Microsoft Windows. Variation proofs were indicated at significance level P 5% (Fowler *at al.*, 1992). The experiment was carried out on alluvial-meadow soil with humus content below 2.5%, well-stored with phosphorus and potassium and insufficient total nitrogen. The reported pH defined the soil as acidic (pH 5.81 to 5.18). The meteorological conditions for the vegetation year 2013 were favourable for rice growing (Figs.1 and 2). The high temperatures which followed after sowing, preconditioned fast germination and intensive plant growth in terms of height. The average temperatures from May till October were by +0.2°C to +3.8°C higher, compared with those in the long-term period. The latter contributed to: growth and development acceleration, formation of maximum productivity and shortening the vegetation period. The agro-conditions in 2014 were completely different from those in 2013. The average daily temperature results for the first two months of the vegetation period (May – June) showed, that at this stage rice was in less favourable conditions than the previous year. In May temperatures were considerably lower (by 2.7°C), compared with the long-term period which had a negative effect on the duration of the germinating period and initial development. In the process of tillering and reaching full maturity, the registered temperatures were comparatively close to those in the long-term period. On the other hand, compared to 2013, they were lower by 0.5°C to 1.2°C. The average monthly rainfall for the whole vegetation period in 2014 was dramatically heavier compared to the long-term period and 2013 (Fig.2). The registered heavy rains proved to be unfavourable for rice development as they changed the regulated

water regime and microclimate in the rice enclosure. The amount of rainfall was lower only in August and the registered temperatures reached 35.6°C, which did not facilitate normal rice flowering.

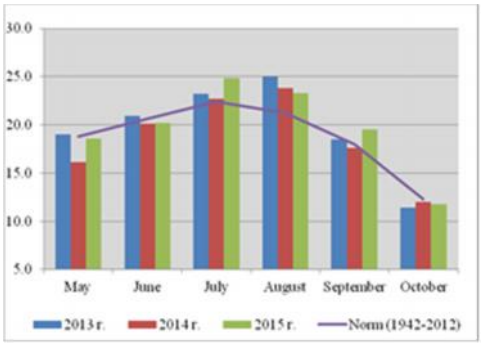

Figure 1. Average monthly temperatures (°C) for the research period, 2013-2015

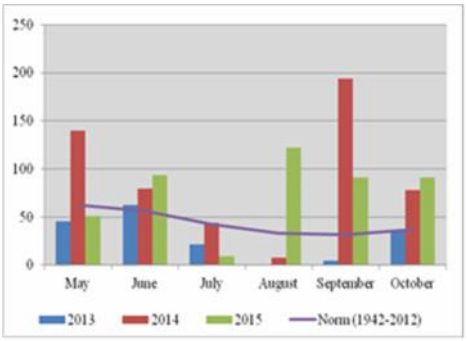

Figure 2. Total sum of rainfall (mm/m^2) for the for the research period, 2013-2015

RESULTS AND DISCUSSION

Phenological development. It is extremely important to realize and observe the biological characteristics of the crop and coordinate them with the environmental growing conditions towards achieving maximum manifestation of biological crop potential. Some factors, such as temperature, are limited under the agro-conditions in Bulgaria. The rice plant development strongly depends on the sowing date and environmental factors (Moldenhauer *et al*., 2003). Each cultivar, according to its origin, is significantly different in terms of time required for passing through the separate phenological phases and reaching fruiting, thus performing its full potential capacity.

Table 1 indicates the length of the interphase periods in days. The presented data show no difference among the cultivars from emergence until tillering. This period lasted for the longest (39 days) in 2013, followed by 2015 (32 days) and 2014 (24 days).

Depending on the agro-meteorological conditions, between 20 (average for all cultivars) (2013) and 35 (2014) days were needed from tillering until the panicle initiation. This stage lasted for the longest with the Italian cultivars (from 25 to 40 days for the different years), while the Turkish cultivars required from 9 (Osmanchik 97, 2013) to 33 days (Gala, 2014).

The average stage duration since panicle initiation till heading continued 20 - 25 days (average for all cultivars) for the three years of the study. For the time of the experiment, the interphase proceeded longer with the Turkish cultivars (21-32 days) compared with the Italian (18-25 days). The aforementioned stage is of great importance to plants, as this is the time for panicle formation and differentiation. It is considered to be the most critical stage for rice. Extreme temperatures at this

stage, both high and low, combined with other factors, may lead to a number of disturbances in plant development (Moldenhauer *et al.*, 2003).

Table 1. Duration of inter-phase periods of the tested rice cultivars, 2013-2015

Year	Rice cultivar	Inter-phase period (duration in days) of rice								
		S-E	E-TL	TL-T	T-PI	PI-H	H-MR	MR-DR	DR-M	VP
2013	Osmanchik 97	12	16	23	9	32	4	21	10	115
	Gala	12	16	23	14	31	7	14	12	118
	Linche	12	16	23	25	20	7	23	12	126
	Kameo	12	16	23	25	21	6	23	8	122
	Puma	12	16	23	25	18	9	23	8	122
	Brio	12	16	23	25	21	6	23	12	126
2014	Osmanchik 97	20	8	16	28	24	8	21	12	117
	Gala	20	8	16	33	21	8	23	13	122
	Linche	20	8	16	40	17	8	26	10	124
	Kameo	20	8	16	37	21	9	27	10	128
	Puma	20	8	16	37	19	9	26	10	125
	Brio	20	8	16	37	20	9	26	10	125
2015	Osmanchik 97	12	12	20	15	31	7	18	18	121
	Gala	12	12	20	20	29	8	17	17	123
	Linche	12	12	20	28	22	10	20	18	130
	Kameo	12	12	20	31	20	10	20	19	132
	Puma	12	12	20	26	24	9	21	15	127
	Brio	12	12	20	26	25	8	21	18	130

Legend: Sowing (S), Emergence (E), Third leaf (TL),Tillering (T), Panicle Initiation (PI), Heading (H), Milky Ripening (MR), Dough Ripening (DR), Maturity (M), Vegetation period (VP)

The duration of the vegetation period is a complex function, combining the interaction between genotype and growing conditions. It was hard to make the connection between deadline for sowing and deadline for the reported full maturity in the course of the experiment. Vegetation could have ended up as early as the second half of September (from 16.09. till 25.09 in 2015) under the created sowing conditions (on 04.05.2015), but it could have also continued until 05-08.10.2014, if sowing had taken place 9 days later. Sowing was done the latest in 2013 (16.05), nevertheless, at sufficiently high temperature sum, the seed entered full maturity until 01.10.

After tracing the growing processes of the variants treated with Folur, Amalgerol and Lithovit, it became clear that there was no difference in their phenological development compared with the non-treated control. The duration of each stage can rather be defined by the growing conditions. There is no connection between deadline for sowing, germination and duration of the subsequent inter-phase periods. According to these results and the classification used by Arraudeau *et al.* (1988), all the tested cultivars come under the category of cultivars with average vegetation duration of 120 – 140 days.

Table 2. Impact of main factors (variance analysis) on productive tillering capacity of rice

Tillering capacity (TC: number per plant), and Duncan's test (DT)											
	TC	DT	%		TC	DT	%		TC	DT	%
Year effect				Cultivar effect				Foliar treatment effect			
				Os. 97	4.13	a	100.0				
2013	4.41	a	100.0	Gala	4.44	ab	107.5	Contr.	4.13	b	100.0
2014	4.97	b	112.7	Linche	4.70	a	113.8	Folur	4.45	a	107.7
2015	3.63	c	82.3	Kameo	4.34	ab	105.1	Amal.	4.37	ab	105.8
				Puma	4.27	b	103.4	Litovit	4.67	a	113.1
				Brio	4.14	b	100.2				

Means followed by the same letter are not statistically different (P<0,05) by Duncan's multiple range test

Productive tillering capacity. Productive tillering capacity has always corresponded more directly with yield. In the conditions of strongly reduced number of plants in the paddy field for objective reasons (low field germination, stress), the number of the productive tillers is an incredibly significant component of yield. Table 2 represents the summarized results of the three-year period, as well as the statistically reported influence of the respective year. The data analysis shows proved differences throughout the years, regarding the studied indicator. Best tillering capacity of plants was observed in 2014, followed by 2013 and 2015.
Among all tested cultivars, Lince proved itself to have formed the highest number of tillers during the three years of the experiment. The other cultivars also outmatched the control – Osmanchik 07. Puma and Brio only kept closer values to the control.After reporting the effect of the foliar treatment products, it was found out that all of them improved productive tillering capacity by 5.8% to 13.1%, whereas Folur and especially Lithovit were statistically outlined. *Yield (paddy rice).* The agro-meteorological conditions in 2013, 2014 and 2015 were highly specific and created prerequisites for obtaining proven different yields. The tested cultivars most successfully realized their potential in 2013, reaching average values for harvested paddy rice of 1112.6 kg/da (Table 3). The climatic situation throughout the same year was extremely favourable for rice growing (Figs.1 and 2), emphasizing the effect of high yield values. The years 2014 and 2015 witnessed proven lower yields as a result of cooler weather and heavier rainfall, reaching values of 819 kg/da and 750 kg/da respectively. These values were lower by 27% in 2014 and by 33% in 2015, compared with the favourable 2013.

Table 3. Impact of main factors (variance analysis) on paddy rice yield

Grain yield (kg/da) of paddy rice and Duncan's test (DT)											
	kg/da	DT	%		kg/da	DT	%		kg/da	DT	%
Year effect				Cultivar effect				Foliar treatment effect			
				Os. 97	879.2	a	100				
2013	1112.6	a	100	Gala	878.9	a	99.9	Contr.	846.0	b	100.0
2014	819.0	b	73.6	Linche	862.1	a	98.1	Folur	887.0	ab	101.3
2015	750.0	c	67.4	Kameo	954.5	a	108.6	Amal.	942.0	a	111.3
				Puma	839.5	a	95.5	Litovit	898.9	ab	102.5
				Brio	949.1	a	108.0				

Means followed by the same letter are not statistically different (P<0,05) by Duncan's multiple range test.

The data analysis for the independent effect of the cultivar on productivity throughout the three consecutive years showed that highest seed yielding was performed by Cameo and Brio – average yield of 954.5 kg/da and 949.1 kg/da which was by 8.6% and 8.0% respectively higher than the control – Osmanchik 97. The cultivars performing lower yield than the control (by 2% to 5%) were Lince – 862.10 kg/da and Puma – 839.5 kg/da, while considering the huge differences throughout the years, the complex assessment of the factors showed that all tested cultivars came within the same range as the control.

Averagely for the period, the tested foliar treatment products had comparatively stronger effect on yield. A statistically proven effect on the variants treated with Amalgerol was definitely observed throughout the whole 3-year period. Increase of paddy rice yield was noted by 7.5% on the average. Bearing in mind that 2014 and 2015 were not very favourable years, the tested products proved to be most suitable for paddy rice crop under the conditions of changeable agro-meteorological parameters. On the average, the variants treated with Folur and Lithovit for the whole duration of the experiment, also outstanded the control, although by lower percent.

CONCLUSION

The cultivars of Turkish origin Osmanchik 97 and Gala developed faster in the agro conditions of Saedinenie compared with the tested Italian cultivars – Lince, Cameo, Puma and Brio. The duration of the vegetation period for the Turkish cultivars was 115-123 days, (making them more adaptive to the Bulgarian agro-conditions), while for the Italian cultivars it was from 122 to 130 days.

The complex conditions throughout the years had proved their effect on tillering productive capacity. Out of the six tested cultivars in the process of the research period, Lince had highest tillering capacity – 4.70 number of tillers/plant and was proved to stand out against the control – Osmanchik 97, Puma and Brio. The tested foliar treatment products Folur and Lithovit had a proven effect on the formation of higher number of productive tillers – by 8% and 13% respectively.

The most favourable conditions for the realization of rice productive potential were in 2013. The average harvested yields of paddy rice for all tested cultivars were 1112.6 kg/da, standing higher than 2014 - by 26.4% and higher than 2015 - by

32.6%. The cultivars with highest mean values of yields for the period were Cameo (954.5 kg/da) and Brio (949.1 kg/da), which surpassed the control Osmanchik 97 by 8.6% and 8.0% respectively.

The most positive effect on productivity was reported after treating with Amalgerol, which increased tested cultivar yield by 11.3% on the average. The average effect of Lithovit and Folur for the period was insignificant – 2.5 and 1.3% respectively.

REFERENCES

Angelova, S. (1999): Testing of introduced varieties of rice. Soil Science, Agrochemistry and Ecology, Vol. XXXIV, № 4-5, 158-162.

Arraudeau, M. A., & Vergara, B. S. (1988). *A farmer's primer on growing upland rice*. Int. Rice Res. Inst..

Bari, R., & Jones, J. D. (2009). Role of plant hormones in plant defence responses. *Plant molecular biology*, *69*(4), 473-488.

Dong, C. F., Gu, H. R., Ding, C. L., Xu, N. X., Liu, N., Qu, H., & Shen, Y. X. (2012). Effects of gibberellic acid application after anthesis on the feeding value of double-purpose rice (*Oryza sativa* L.) straw at harvest. *Field Crops Research*, *131*, 75-80.

Fowler, J., Cohen, L. 1992. Practical statistics for field biology. New York.

SAS Institute Inc.1999. SAS Procedures Guide, SPSS for Microsoft Windows, V.9, 4 edition.

Moldenhauer, K. A., & Gibbons, J. H. (2003). *Rice morphology and development* (pp.103-127). Rice: Origin, History, Technology, and Production. Hoboken, NJ. John Wiley and Sons.