Varietal Structure of Rice Crops in the Krasnoarmeisky District of Krasnodar Region: Analysis and Recommendations

Maksim A. Ladatko[1]; Sergey V. Garkusha[2]; Lyubov V. Esaulova[3]; Alexey P. Naumenko[4]

[1]Candidate of Agricultural Sciences, Federal State Budgetary Scientific Institution, Federal Scientific Rice Centre (FSBSI FSC of Rice), Russia.

[1]edit@academicpapers.org

[2]Doctor of Agricultural Sciences, Professor, Federal State Budgetary Scientific Institution, Federal Scientific Rice Centre (FSBSI FSC of Rice), Russia.

[3]Candidate of Biological Sciences, Federal State Budgetary Scientific Institution, Federal Scientific Rice Centre (FSBSI FSC of Rice), Russia.

[4]Candidate of Agricultural Sciences, Federal State Budgetary Scientific Institution, Federal Scientific Rice Centre (FSBSI FSC of Rice), Russia.

Abstract

This paper presents the varietal structure of rice crops and the results of ecological variety tests in the Krasnoarmeisky district of Krasnodar region for 2016-2019. It also identifies the promising varieties taking into account the acreage of sowing and crop productivity. A rice varietal complex has been developed for the conditions of the Krasnoarmeisky district.

Despite certain external similarities and the same productive potential of the varieties offered for production, they differed in biological and technological indicators, i.e. in relation to environmental factors and responsibility to technologies. In this regard, the formation of the varietal structure of rice crops, the main thing is to identify the most productive varieties for each district and farm, taking into account the agro-ecological quality of the land, the cultivation technology and the predecessor by making environmental and production tests.

Key-words: Rice, Variety, Varietal Structure, Varietal Complex, Agricultural Machinery, Crop Productivity.

1. Introduction

Every year, according to the results of the state variety testing (SVT): two or three varieties enter the State register of breeding achievements approved for use on the territory of the Russian Federation (Kovalev VS 2011). However, in many farms of the Krasnoarmeisky district, a significant

share in the varietal structure belongs to Rapan variety. It was zoned more than twenty years ago. Thus, for the dynamic development of the industry through science-based variety substitution (that is, replacing the existing varieties with more productive and resistant to biotic and abiotic stressors ones), agroecological variety tests are conducted. They are aimed at demonstrating new varieties, developing varietal agricultural equipment and making recommendations for varietal complexes (Ladatko MA 2016, Ladatko MA 2016, Ladatko MA 2019, Wang Zhu et al 2016, Nascente AS, Stone LA 2018, Khanam Shakhina et al 2016, Fageria NK 2015, Tari DB et al 2017, Deac et al 2015).

Improving rice productivity and its economic efficiency is a top priority that is addressed mainly in three ways. The first one is breeding: developing new highly productive and adaptive varieties. The second one is the improvement and intensification of cultivation technologies. The third is the correct placement of varieties. This paper deals with the development of effective varietal complexes that contribute to improving the adaptability and productivity of rice. The development and implementation of varietal structures that use the maximum of the positive effects of genotype-environment interactions is of great importance for increasing grain productivity in production. Its implementation makes it possible to increase and stabilize the crop productivity and gross output, significantly increase the economic efficiency of the produced grain, and increase the competitiveness of the crop without additional expenditures of irreplaceable resources (Kudryashov IN 2006, Wu Wei et al 2015, Jing Liquan et al 2016, Prakash Shyam et al 2015, Mhammadi Rezaet al 2011, Xiang CH et al 2007, Yi Q et al 2015).

2. Materials and Methods

Environmental tests of rice varieties were carried out in FSBI ESOS 'Krasnaya' and FSBI RPZ 'Krasnoarmeisky' of the Krasnoarmeisky district for 2016-2019. The objects of study were rice varieties selected by the FSBSI "Federal Scientific Rice Centre". They were zoned, transferred or ready for transfer to the SVT, and were named as follows: Rapan, Favorit, Polevik, Partner, Apollon, Patriot, Azovsky, Nautilus, Yubileyny-85, Yakhont, Alyans, Veles, Kauris, Lenaris, and Signal. The research was carried out in the premises of microplot experiments. The location of the experiment was randomized, and the experiment repeatability was four-fold. The plot area was 10 m2. The sowing was carried out by a selection seeder SSNC-8; the seeding rate is 7 million germinated grains per 1 ha. Irrigation mode was shortened flooding. Each year the experiment evaluated the varieties for three predecessors: rice, winter wheat and soy. Harvesting was carried out by the method of solid

threshing with a small-sized DKC-515 combine, followed by conversion to 14% humidity and 100% purity. Tillage, irrigation regime and care for rice crops were performed in accordance with recommendations for rice cultivation in the Krasnodar region (Agarkov VD et al 2006).

The data on the varietal structure of crops in Krasnoarmeisky district for the period of 2016-2018, i.e. acreage and crop productivity, was collected and analyzed.

3. Results and Discussion

Krasnoarmeisky district occupies one of the leading places in terms of the acreage of sowing and rice yield. Analysis of the varietal structure of rice crops for 2016-2018 showed that 20 to 24 varieties are sown annually in this district. The main share of the area is occupied by Rapan variety. However, recently there has been a positive trend to reduce the saturation of rice fields with this variety, which was largely facilitated by measures of state support for rice seed production at the federal and regional levels (Malysheva NN, Pishchenko DA 2016). If in 2016 the Rapan variety occupied 38.7% of rice crops, in 2017 it decreased by 1.8%, and in 2018 - by another 10.1%, amounting to 14.5 thousand hectares, i.e. 26.8% (Fig. 1-3).

Replacing old varieties with new ones is associated with a higher crop productivity potential for the latter, due to the better efficiency of the used mineral fertilizers (mainly nitrogen). In the conditions of a flooded rice field in the first minimum they limit the yield (Pan Junfeng 2017, Stone EC Hornberger GM 2016, Yi Q et al 2015, Tari DB 2017). Weather conditions also have a significant impact on the realization of the productive potential of cultivated rice varieties (Wu Wenxiang et al 2014, Li Z et al 2015, Li Z et al 2015, Mhammadi Reza et al 2011, Chhotaray Debasmita et al 2014). Analysis of changes in agro-climatic conditions of the Krasnodar region showed that the sum of effective temperatures above 15°C of the growing season of rice (from May to September) has increased by 330-530°C over the past 40 years if compared to the average annual values (Chebotarov MI 2017). Increased insolation and air temperature affect the work of the photosynthetic apparatus of plants. Together with the improvement of rice cultivation technology, it also contributes to changes in crop productivity (Mesfin L, Zemedu AH 2018, Mhammadi Reza et al 2011, Chen Xinping et al 2014). Thus, the variety exchange and the correct placement of varieties in the crop rotation fields can increase the gross rice output. For example, for the Rapan variety, its crop productivity in 2016 was 65.1 dt/ha, and the average for the district was 67.0 dt/ha; in 2017 these indicators were 62.7 and 65.4 dt/ha, and in 2018 – 66.4 and 69.2 dt/ha, respectively. Consequently, producers received 52.7

million rubles less in 2016 (in terms of prices for paddy rice at the time of harvesting), in 2017 – 74.2 million rubles, and in 2018 – 67.9 million rubles.
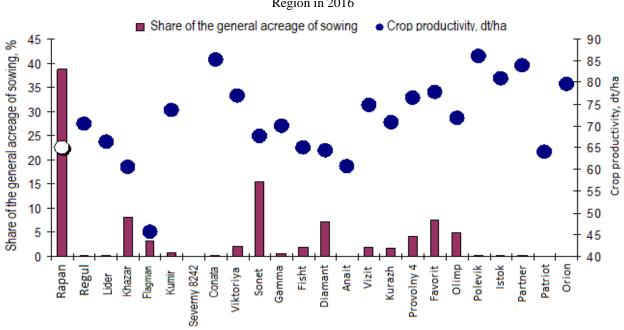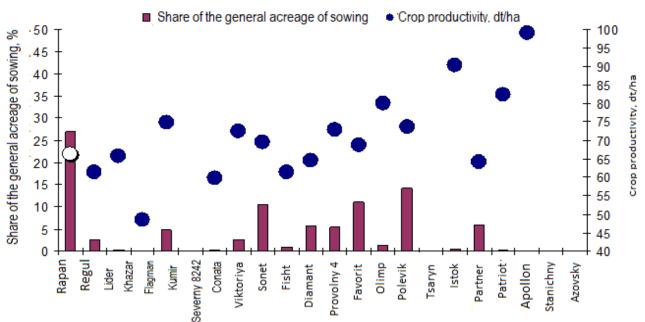
Figure 1 - Acreage of Sowing and Crop Productivity of Rice Varieties in the Krasnoarmeisky District of Krasnodar Region in 2016

Figure 2 - Acreage of Sowing and Crop Productivity of Rice Varieties in the Krasnoarmeisky District of Krasnodar Region in 2017
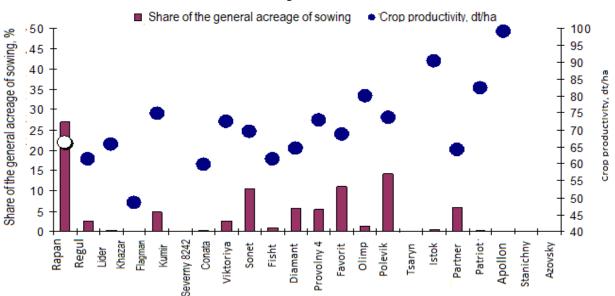
Figure 3 - Acreage of Sowing and Crop Productivity of Rice Varieties in the Krasnoarmeisky District of Krasnodar Region in 2018
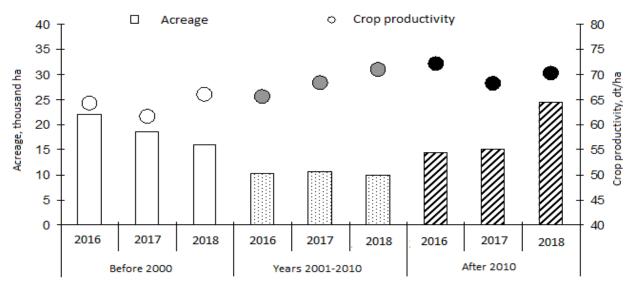

As can be seen from figures 1-3, the number of varieties sown and their acreage vary from year to year. It indicates a rapid response of agricultural producers to changing conditions, where the main criterion for making a decision is the crop productivity of the previous year. On the one hand, this indicates the ability of the industry to change varieties quickly, and on the other - the lack of evidence-based recommendations for rice growers for systematic variety change and varietal agrotechnics. As a result, there are surpluses (not sold seeds) and a shortage (demand exceeds supply) of seed material in seed farms, which are subsequently cautious about increasing the volume of both varieties already grown in production and new ones that are allowed to be used. This negatively affects both the speed of variety change and the duration of the 'life' of the variety in production. That is, the longer it is introduced into production, the faster its resistance to adverse environmental factors decreases.

The variation in sown areas is clearly seen in the example of Khazar, Flagman and Fisht varieties: their yield is lower than most varieties including Rapan from year to year. As a result, the acreage sown with them decreased. Crops of Regul, Sonata, Privolny-4 and Olymp varieties in 2017 first increased due to good crop productivity in 2016, and in 2018 decreased again due to a decrease in crop productivity in 2017. The reverse trend was observed for the Diamant and Victoria varieties, the acreage of which first decreased and then increased in 2018. Growing of the varieties Anait, Visit and Kurazh has completely stopped after a number of unsuccessful years. Crops of Kumir, Polevik and Partner increased annually due to their high crop productivity in 2016-2017.

Analysis of the crop productivity showed that it was the highest in 2018, and the lowest in 2017. At the same time, the yield variability for varieties in 2017 and 2018 was set as significant (21% and 28%, respectively), and in 2016 – average (19%).

Varieties grown in the Krasnoarmeisky district can be divided into three groups according to the time of inclusion in the State register of breeding achievements allowed for use: 1) before 2000, 2) from 2000 to 2010, 3) after 2010. The acreage of sowing and crop productivity of varieties in these groups for the analyzed period is shown in Figure 4.
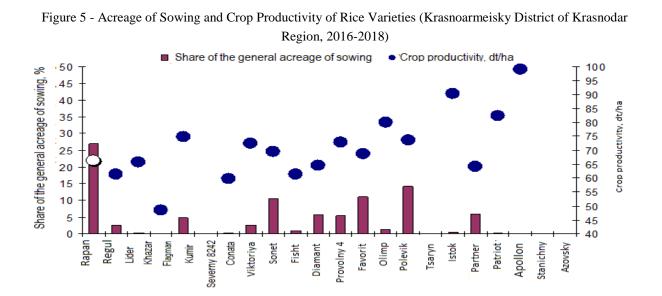
Figure 4 - Acreage of Sowing and Crop Productivity of Rice Varieties (Krasnoarmeisky District of Krasnodar Region, 2016-2018)

The diagram shows that the largest area in 2016-2017 was occupied by varieties included in the State register before 2000. However, their crop productivity was lower than that of varieties zoned in the period 2001-2010 and after 2010 by 6.9 and 9.6%, respectively. The variability of crop productivity in the groups over the years of the research was found to be insignificant: it ranged from 2.7-4.0%. The smallest area was occupied by the varieties zoned in the period from 2001 to 2010. The highest crop productivity in this group was formed by the varieties Sonet, Kumir, Victoria and Sonata. The most numerous (more than half of the cultivated varieties in the district), with positive dynamics of growth in acreage of sowing, was the third group, which consisted of the varieties zoned after 2010.
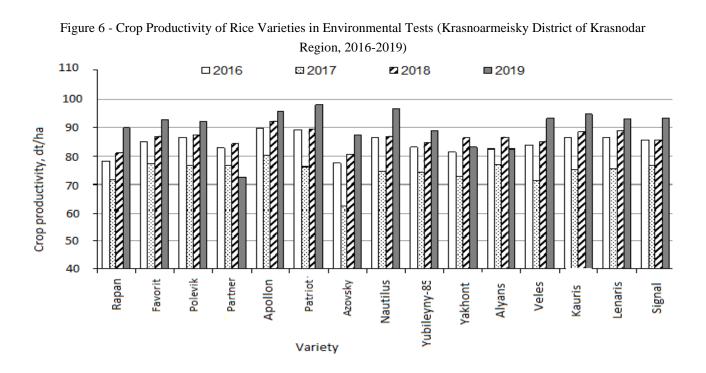
Taking into account the fact that the crop productivity of varieties included in the State register of breeding achievements in the period of 2001-2010 and later does not differ significantly, they would be combined into one group for more information. The analysis of crop productivity and demand in the production of varieties zoned before and after 2000 shows a steady decline in the acreage sowed with 'old' varieties: the area in 2017 and 2018 decreased by 15.8 and 14.0%, respectively (Fig. 5). At the same time, there was an increase in acreage sowed with 'new' varieties: 4.1% in 2017 and 34.4% in 2018. The increased demand from the production for seeds of new varieties is due to their increased crop productivity and resistance to abiotic and biotic stressors. The increase in crop productivity of new varieties in relation to the varieties included in the State register of breeding achievements before 2000 was 4.5-6.6 dt/ha for 2016-2018, with a 1.1-2.1 times larger acreage. The greatest difference between the studied groups of varieties was recorded in 2017, when the average crop productivity for the district due to agro-climatic and phytosanitary conditions was lower than in 2016 and 2018. Once again, all this indicates a higher stability of new varieties.

Figure 5 - Acreage of Sowing and Crop Productivity of Rice Varieties (Krasnoarmeisky District of Krasnodar Region, 2016-2018)

It should be emphasized that the economic and ecological efficiency of any variety depends on varietal agrotechnics, i.e. the use of all factors of exogenous regulation of adaptive reactions of cultivated plants including their potential productivity and environmental sustainability due to natural and agrotechnical factors of the environment. If adaptive, i.e. agroecological macro-, meso - and microdistricting of the crop and variety in time and space plays the greatest role, then the optimal timing and seeding rates for the characteristics of each variety, soil and weather conditions, the use of macro - and micro - fertilizers, pesticides, biologically active substances, etc. are the most significant

factors from the second group (Variety, varietal agricultural technology and economics). The lack of varietal technologies is the main reason that the genetic potential of plants is used by only 25-30%. At the same time, the subnormal productivity of rice varieties is due to inaccurate compliance with their cultivation technology (Korzun OS, Bruylo AS 2011).

Comparative analysis of rice varieties required performing some environmental and production tests that evaluated the crop productivity by observing the principle of the only difference, i.e. growing under the same conditions. The regularity of the results obtained in ecological variety tests is confirmed by the similar dynamics of crop productivity over the years and a high correlation between varieties - 0.84 (p-value = 0.0029). It should be borne in mind that the closeness of the connection for years may weaken due to the fact that in a production environment, the majority of varieties are sown without complying with variety rotation (placement grades depending on the field crop rotation) and agrotechnics (taking into account the reaction of the varieties in the elements of cultivation technology).

This research conducted in rice farms of the Krasnoarmeisky district found that in the period 2016-2019, the highest crop productivity was formed by crops of Apollon, Patriot, Kauris, Nautilus, and Lenaris (Fig. 6). The lowest crop productivity was observed in the Azovsky variety (- 4 dt/ha compared to the Rapan variety), but this is due to its precocity. In many situations (poor conditions during sowing or harvesting, the use of provocative irrigation before sowing to combat barnyard grasses and weed-field forms of rice, etc.) justifies this small difference in crop productivity.

Figure 6 - Crop Productivity of Rice Varieties in Environmental Tests (Krasnoarmeisky District of Krasnodar Region, 2016-2019)

During the four-year period of ecological variety tests, the dynamics of crop productivity reduction in relation to the average for the region in the varieties Partner, Alyans and Polevik was revealed. The greatest decrease, especially in 2019, was observed in the Partner variety. This is mainly due to its loss of resistance to blast (the variety has a Pi b resistance gene, the effectiveness of which in relation to the local population has decreased recently), as a result of which it has become severely affected by this disease. In the coming years, a sharp reduction in the area under this variety should be expected.

Having analyzed the yield data of industrial and scientific rice crops for a four-year period, it is possible to propose a varietal complex for sowing in 2020 in the Krasnoarmeisky district of the Krasnodar region as shown in Figure 7. The diagram shows that it is recommended to sow more than a third of the acreage with Rapan, Polevik and Favorit varieties. Another 37% is planned for the varieties Patriot, Apollon, Sonet, Victoria and Privolny 4. At the same time, the share of Rapan should be reduced to 14% and partially replaced by Rapan 2. After 2017, the decrease in the acreage sowed with the Sonet and Privolny 4 varieties in 2020 should be stabilized at the level of 7-8%, and the share under the promising Apollon variety is planned to increase to 8%. About 20 % of the sown area of the district should be allocated to the varieties Kumir, Azovsky, Istok, Olymp and Diamant for 2-6% each. To increase the rate of variety exchange, it is necessary to introduce new varieties, such as Nautilus, Yubileyny-85, Yakhont, Alyans, Veles, Kauris, Lenaris, and Signal. Their share should be anout 5%, and the special purpose varieties (coarse-grained, with colored pericarp, glutinous, etc.) should make under 5%.
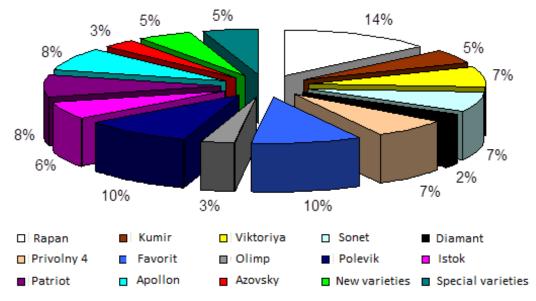
Figure 7 - Recommended Varietal Complex for the Krasnoarmeisky District in 2020

The producers of Krasnoarmeisky district engaged in cultivation of rice are 37 producers according to information of 2019, and those cultivating rice annually make 29 farms. They differ not only in ownership, but also in the acreage of sowing. To increase the stability of rice production, they should stick to the recommendations on varietal diversity. Most farms in the district annually sow rice on an acreage of less than 1 thousand hectares. Of these, 2/3 are located on an area under 500 hectares. For them, a varietal complex of 3-4 and 1-3 varieties is recommended respectively. Producers with a sown acreage of rice of 1-3 thousand ha are recommended to grow 4-6 varieties, and with a larger area – up to 8.

4. Conclusion

Fast variety exchange, science-based variety rotation and varietal agrotechnics are the basis for increasing the competitiveness and efficiency of the rice industry.

One of the main criteria of the variety exchange is crop productivity. However, it is necessary to correctly interpret the results obtained, following on from the prevailing agro-climatic and soil conditions, and data on the whole agro-landscape zone.

Varieties bred before 2000 should be replaced in the shortest possible period with new varieties with crop productivity of average 5.6 dt/ha (8.7%) higher.

The main varieties in the sowing structure of the district for 2020 should be Polevik, Patriot, Favorit and Apollon. At the same time, the acreage sown with new varieties such as Nautilus, Yubileyny-85, Yakhont, Alyans, Veles, Kauris, Lenaris and Signal should make up to 8%.

5. Authors Contributions

Maksim A. Ladatko - 70%

Sergey V. Garkusha – 15%

Lyubov V. Esaulova - 10%

Alexey P. Naumenko - 5%.

Competing Interests

The authors declare that they have no competing interests.

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