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Ecological Testing of Rice Varieties of Kuban and Foreign Breeding Inconditions of Republic of Adygea

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***Abstract*— In solving the issues of modern rice growing, the central place is occupied by development of new varieties and their timely introduction into production. The assortment of rice varieties of Kuban breeding is annually replenished with more productive ones with increased resistance to adverse biotic, abiotic and anthropogenic factors, with different culinary qualities. The yield of the variety is one of the main indicators of value and the main requirement of production. This article presents the results of ecological variety testing of 20 rice varieties over three years (2016-2018) on the territory of private company "Rice" in Republic of Adygea. The variability of yield and the number of productive stems per unit area are determined for every variety. The average and weak intervarietal variability of productive crop density (13.9%; 10.3% and 13.5%) and yield (12.4%; 9.2% and 9.9%) during the study period is associated with the level of agricultural technology of the farm. Varieties of Krasnodar breeding: Polevik, Patriot, Favorit, Apollon, Veles, as well as foreign ones - Galla (Italy) and Yatkyn (Turkey), which formed a significantly high yield with its insignificant variability, are recommended for cultivation in "Rice" company (Republic of Adygea).**

Keywords—rice, new variety, ecological variety testing, variability and correlation of traits, yield, growing period, productive crop density.

I. INTRODUCTION

The role of the variety in obtaining the yield is extremely large. Varietal change is the most important process, the success of plant growing, including rice growing, in many respects depends on the timely and scientifically sound conduct of it. To obtain consistently high results in the industry, it is necessary to update the structure of rice sowing areas with the most effective varieties corresponding to this agroclimatic zone.

The trend of recent years - a steady increase in demand for cereal grains of large-grain varieties, could not but affect the direction of work of breeders. Of the five varieties transferred to the State Variety Testing in 2017, three are large-grained, in 2018 - two out of five, in 2019 - two out of four [1, 2].

In a scientifically based technological system for the cultivation of agricultural plants, breeding and seed production occupy a leading position as the most powerful, environmentally friendly levers in increasing the yield and quality of crop products [3]. According to available estimates, the contribution of breeding to increasing crop yields over the past decades is estimated at 30-70%, and taking into account possible climate changes, the role of breeding will increase [4, 5]. Selection and introduction of new, more productive varieties into production is one of the factors contributing to the growth of rice production efficiency [1]. Much of the increase in yield and gross collection, as well as the increase in technological indicators of grain and milled rice, is provided by the introduction of new rice varieties, mainly of an intensive type, which in turn determines the efficiency of the industry.

For the progressive development of rice growing, a scientifically based varietal policy is needed, including increasing the assortment of cultivated varieties of different technological energy intensity (varieties of intensive, extensive and intermediate types), taking into account their characteristic features, as well as agroclimatic conditions of cultivation [2, 6].

Therefore, as part of the research, FSBSI ARRRI conducts large-scale environmental and production tests in Russia and the near abroad with the purpose of optimal selection and placement of new-generation rice varieties. [7].

The best results in recent years have been achieved by Krasnodar region in the field of rice growing, thanks to efficient breeding, quick timely variety-changing and the introduction of adaptive varietal complexes taking into account agrolandscape zoning [8].

The increase in yield and gross rice harvest in the Republic is associated with close cooperation with scientists. In 2018, the seeds of ARRRI breeding occupied about 41.4% of the sown area in the Republic of Adygea, which is 30% more than in 2017 [9].

In the Republic of Adygea in 2019, the rice sown area was increased to 8.2 thousand ha. There is a positive trend. In 2017, the sown area of rice amounted to 5.1 thousand ha, in 2018 - almost 6.7 thousand ha. In 2018, the gross harvest of rice amounted to about 35 thousand tons. In 2019, an increase in yield is expected [10].

II. Materials and methods of research

The objects of research were 20 rice varieties (Rapan, Flagman, Polevik, Yakhont, Yatkyn, Sharm, Vodopad, Yubileiny-85, Istok, Natasha, Azov, Patriot, Favorit, Apollon, Nautilus, Veles, Stanichny, Kurazh, Galla and Elbrus) of which 18 were developed at ARRRI (including using biotechnological methods - incorporation of blast resistance genes) and 2 of foreign breeding - Galla (Italy) and Yatkyn (Turkey). The predecessor is rice.

According to the growing season, varieties are divided into 4 groups: 1) early ripening - up to 110 days; 2) medium ripening - 111-119 days; 3) medium-late ripening - 120-125 days; 4) late ripening - more than 125 days [11,12].

For sowing plots of ecological variety testing (EVT), a selective batch seeder of central seeding was used. The plot area is 20 m^2, in triplicate with a randomized placement and sowing rate of 7 million germinating seeds per 1 ha [13]. The number of rows in the plot is eight, the distance between the rows is 15 cm, the distance between the plots is 0.5 m. Medium-ripening variety Rapan served as the standard in the EVT. Unified mineral nutrition background $N_{120}P_{60}K_{40}$. Sowing terms – first decade of May. The experiment was carried out for three years (2016-2018) on the territory of ANTC Rice LLC. Takhtamukaysky District of the Republic of Adygea.

During the growing season, the dates of preventive treatments and the onset of phenological phases were noted: heading and full ripeness. Productive crop density was determined in the phase of full ripeness before harvesting. Biological productivity was calculated from model sheaves, manually harvested on plots of 0.5 m^2 (0,25 $м^2$+0,25 $м^2$) with each repetition of the experiment (6 sheaves per variety).

In general, the climatic conditions of the delta of the Kuban river favor rice cultivation and provide the required amount of heat to this crop.

Between the different agrolandscape districts of rice growing zone of Krasnodar region there are no significant differences in climatic parameters in accordance with the requirements of rice plants. Therefore, when agroecological evaluation of the territory is suitable for rice cultivation, the agroclimatic coefficient is taken as 1.0 (complete satisfaction of the need for determining climatic factors) for the entire Kuban rice-growing zone [14]. The heat supply during the rice growing season for years of research turned out to be significantly higher than long-term average values. But the course of air temperatures and the amount of precipitation in 2016 were characterized by unevenness. There were periods of vegetation of rice plants with a shortage of effective air temperatures, which could not but affect the yield and extend the growing period.

The dynamics of average daily air temperatures and the amount of precipitation in 2017 were characterized by unevenness. There were periods with a shortage of effective air temperatures and with air temperatures high for the normal development of rice plants, as well as with an increase in wind speed (up to 15 m / s) and the duration of this phenomenon (up to 7 days). This was reflected in the increased panicle sterility and the lengthening of the growing season and harvesting time.

Despite the sufficient amount of heat and mineral nutrition in 2018, the share of empty and shrinked grain in the yield exceeded the indicators of previous years (15-30%). Periods with extremely low air humidity were observed (flowering and fertilization of the grain), (milky-wax - wax ripeness of grain). At the same time, a very high maximum air temperature (38-45 ° C) was observed for a long period, which negatively affected milled rice quality.

The results obtained were processed by the methods of variance and correlation analyzes [13, 15], and the coefficient of variation (CV) was used to compare the degree of variability of traits. Knowledge of the nature of the variability of traits was used to evaluate varieties [16]. According to Dospekhov B.A. (1979) and Dzyuba V.A. (2007) variability is considered insignificant if the coefficient of variation does not exceed 10%; medium if V is above 10% but less than 20%, and significant if the coefficient of variation is more than 20% [13, 15].

III. Results and discussion

An important characteristic of crops in the formation of high yields is the crop density in the cenosis. The number of productive plants per unit area is regulated by agrotechnical methods and depends on the type of variety (plant) and environmental factors [11, 17]. This trait has high modification variability and low heritability, which leads to its high variability (Table 1).

TABLE I. VARIABILITY OF CROP DENSITY OF RICE VARIETIES, 2016-2018

№	Variety	Crop density, pcs./m^2				
		2016	*2017*	*2018*	*Mean value*	*CV, %*
1	Rapan (st)	292	436	378	368.7	19.7
2	Flagman	380	414	405	399.7	4.4
3	Polevik	496	352	480	442.7	17.8
4	Yakhont	428	329	416	391.0	13.8
5	Yatkyn	488	364	553	468.3	20.5
6	Sharm	400	502	480	460.7	11.7
7	Vodopad	408	355	470	411.0	14.0
8	Yubileyniy 85	416	356	392	388.0	7.8
9	Istok	420	302	663	461.7	39.9
10	Natasha	380	484	568	477.3	19.7
11	Azovskiy	496	258	511	421.7	33.7
12	Patriot	384	468	449	433.7	10.2
13	Favorit	420	428	473	440.3	6.5
14	Apollon	444	310	467	407.0	20.8
15	Nautilus	428	370	369	389.0	8.7
16	Veles	372	432	316	373.3	15.5
17	Stanichniy	328	350	385	354.3	8.1
18	Kurazh	408	374	356	379.3	7.0
19	Galla	536	453	576	521.7	12.0
20	Elbrus	384	395	363	380.7	4.3
Mean value		415.4	386.6	453.5		
CV, %		13.9	10.3	13.5		
LSD_{05}		71.20	83.50	77.50	77.40	

Variability of crop density during research was 4,4-39,9%. High variability of this trait was noted in the varieties Yatkyn, Apollon, Azov and Istok - 20.5; 20.9; 33.7 and 39.9%, respectively. The minimum variability is noted in Flagman, Yubileiny 85, Favorit, Nautilus, Stanichny, Kurazh and Elbrus - from 4.3% to 8.7%. The remaining varieties were characterized by an average degree of variability in the crop density – 10.2-19.7%. It should be assumed that varieties with high variability of this trait, with other conditions of

cultivation being equal, require a more specific approach to cultivation technology.

The inter-varietal variability of the trait over the years was 13.9; 10.3 and 13.5%. More equal values of crop density for the studied varieties were in 2017. Significant differences in this indicator were noted in the varieties Yatkyn, Sharm, Istok, Natasha and Galla, which exceeded the standard variety Rapan. In general, from experiement it can be stated that during the research period 2016-2018 in the studied varieties, the optimal crop density was formed to obtain high yields.

Productivity of varieties – is the main complex characteristic that evaluates their promise and demand in agricultural industry.

The yield of half of the rice varieties presented in the environmental test was within the range of the least significant difference (LSD_{05}). The varieties Polevik, Veles, Yatkyn, Favorit, Natasha, Patriot, Apollon, Stanichny, Galla significantly exceeded the standard (Table 2). The average annual yield variability of the studied rice varieties was 2.0-25.7%.

Varieties Natasha, Azov and Stanichny were characterized by a high degree of yield variability - 22.5; 25.7 and 21.7%, respectively, and may require a special approach when growing in this farm.

TABLE II. YIELD VARIABILITY OF RICE VARIETIES, 2016-2018

№	Variety	Yield, c/ha				
		2016	*2017*	*2018*	*Mean value*	*CV, %*
1	Rapan (st)	97.3	113.7	79.9	97.0	17.4
2	Flagman	102.5	108.5	96.0	102.3	6.1
3	Polevik	108.2	102.3	114.1	108.2	5.5
4	Yakhont	102.7	101.9	111.4	105.3	5.0
5	Yatkyn	119.3	108.8	127.7	118.6	8.0
6	Sharm	73.4	71.9	74.8	73.4	2.0
7	Vodopad	96.3	94.5	107.6	99.5	7.1
8	Yubileyniy 85	97.7	116.8	96.6	103.7	11.0
9	Istok	80.3	91.0	85.8	85.7	6.2
10	Natasha	119.8	92.9	116.7	109.8	22.5
11	Azovskiy	87.9	66.7	112.5	89.0	25.7
12	Patriot	105.3	113.3	103.6	107.4	4.8
13	Favorit	105.5	115.3	101.6	107.5	6.6
14	Apollon	112.8	107.8	120.3	113.6	5.5
15	Nautilus	88.3	106.3	78.2	90.9	15.7
16	Veles	108.5	116.2	97.2	107.3	8.9
17	Stanichniy	121.6	136.3	87.6	115.2	21.7
18	Kurazh	97.3	110.1	100.5	102.6	6.5
19	Galla	102.7	126.1	109.3	112.7	10.7
20	Elbrus	104.7	100.5	99.0	101.4	2.9
Mean value		101.6	105.1	102.5		
CV, %		12.4	9.2	9.9		
LSD_{05}		8.25	12.45	7.62	9.44	

The varieties Rapan, Yubileiny 85, Nautilus and Galla have average yield variability of 17.4; 11.0; 15.7 and 10.7%, respectively. The productivity of the majority of the studied rice varieties turned out to be unstable for three years, which suggests the possibility of their successful cultivation in the conditions of this FARM.

The inter-varietal yield variability was 12.4; 9.2 and 9.9% by year. These differences over the years can be explained by the individual reaction of the varieties to the growing conditions, since each growing season had its own characteristics. In 2016, the highest degree of yield variability in the experiment was caused by adverse conditions during the period of filling and ripening of grain [18]. The values of the trait in the years of research ranged from 71.9 kg / ha (Sharm in 2017) to 127.7 kg / ha (Yatkyn in 2018).

The duration of the growing season of rice varieties is a hereditary characteristic, but depends on agro-climatic conditions and cultivation technology. Even with the same cultivation technology, the duration of the growing season can vary within 3-5 days, and in some years up to 10 days [19]. A close correlation of this trait with yield (r = 0.753) was revealed (Table 3).

TABLE III. CORRELATION ANALYSIS OF RICE VARIETIES IN ECOLOGICAL TESTING, 2016-2018

Trait	mean value of the trait	Trait*				
		1	2	3	4	5
Duration, days	116.9					
Crop density, pcs./m^2	418,5	-0.083				
Yield, c/ha	103.1	0.753	0.063			
Productivity of vegetation day, kg/day/ha	88.0	0.316	0.128	0.869		
Grain content of agrophytocenosis, thous. pcs./m^2	34.654	0.251	-0.286	0.635	0.716	
Mass of 1000 grains at 14 % moisture, g	29.9	0.588	0.393	0.447	0.199	-0.406

**Trait:*
1 – Duration, days;
2 – Crop density, pcs./m^2;
3 – Yield, c/ha;
4 – Productivity of vegetation day, kg/day/ha;
5 – Grain content of agrophytocenosis, thous. pcs./m^2

On average, over three years, the varieties presented formed a high yield (Fig 1.).

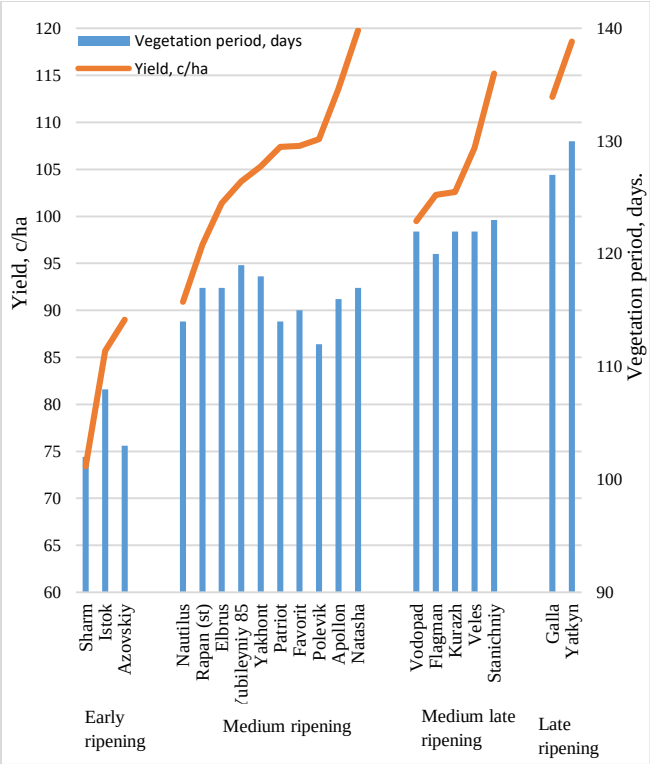

Fig. 1. Yield of rice varieties from different ripening groups, 2016-2018

Early ripening varieties in the experiment were less productive, compared with late ripening: 1) early ripening - 82.7 c / ha; 2) medium-ripening - 105.5 c / ha; 3) medium-late - 105.4 c / ha; 4) late ripening - 115.7 c / ha.

In our experiment, there was no significant effect of productive plant standing on the studied traits — only a weak connection with the mass of 1000 grains at technological humidity (W = 14%) (r = 0.393). Since this indicator is not genetically determined, as evidenced by its high variability (table 1), it should be considered in the light of a set of traits.

Increasing the yield of new rice varieties plays a key role in their further demand and prospects. Productivity in the experiment had a positive correlation with other traits. A close relationship between the yield was noted with the duration of growing period (r = 0.753) and the productivity of one day of vegetation of the cenosis (r = 0.869), the average - with grain content of agrophytocenosis and a mass of 1000 grains (r = 0.635 and 0.447).

The productivity of one day of cenosis vegetation characterizes the potential ability of variety to form a specific grain mass during the day and is determined by the ratio of yield to duration. The value of the trait above 75-77 kg / day / ha characterizes a high yield potential. In the studied varieties, it was an average of 88.0 kg / day / ha. A close positive association of the trait was noted with the grain content of agrophytocenosis (0.716).

The number of grains per unit area (grain content of agrophytocenosis) is a complex trait, determined by the number of productive shoots in this area and grain content of their panicles. Of the disadvantages of this trait, it should be noted that it does not take into account the mass of 1000 grains. Nevertheless, it deserves much attention when evaluating breeding samples for productivity [11]. A close positive correlation of the trait was revealed with the productivity of vegetation day (r = 0.716). Grain content of agrophytocenosis can be increased, for example, by reducing grain sterility from 15-17% (possibly by agrotechnical measures and the introduction of new varieties) to 5-7%, which will allow for the formation of a larger number of grains per unit area. Grain content of agrophytocenosis in the experiment was 34.654 thousand grains / m2 on average for varieties.

The mass of 1000 grains is one of the most important traits characterizing the variety, and it is also a reliable criterion for the variety to belong to a certain group by grain size (small-grain, medium-grain and large-grain) [20]. Our studies confirmed the findings of other rice breeders that the mass of 1000 grains refers to a slightly varying trait [21, 22]. For the mass of 1000 grains, an average positive relationship was revealed with the duration of growing period (r = 0.588), crop density (r = 0.393) and productivity (r = 0.447); and with grain content of agrophytocenosis, the average is negative (r = -0.406).

IV. Conclusions.

The high yield and its insignificant variability in new rice varieties allows the industry to be profitable, and timely introduction of varieties into production – to be competitive in the seed market and self-sufficient in processing, i.e. milled rice production, which partly corresponds to the import substitution program.

According to the results of environmental testing, all the presented varieties formed the optimal crop density – 354.3-521.7 pcs/m^2. Flagman, Yubileiny 85, Favorit, Nautilus, Stanichny, Kurazh and Elbrus differ in minimal variability of the trait - from 4.3% to 8.7%. The remaining varieties were characterized by an average degree of variability in the crop density – 10.2-19.7%.

It was revealed that new rice varieties have a high potential for accumulation of dry matter (88.0 kg / day / ha), which makes them possible to form a large number of grains (34.654 thousand units / m^2) per unit area and, as a result – to form yields of more than 100.0 c / ha.

Correlation analysis showed that the yield of the studied varieties in the experiment is closely related to the duration of the growing period (r = 0.753) and such calculated indicators as the productivity of one day of vegetation (r = 0.869) and grain content of agrophytocenosis (r = 0.716).

Yield potential with insignificant variability (CV <10%) allows us to recommend varieties of Krasnodar breeding: Polevik, Patriot, Favorit, Apollon, Veles, as well as foreign ones - Galla (Italy) and Yatkyn (Turkey) for cultivation in ANTC Rice LLC (Republic of Adygea).

References

[1] R. R. Dzhamirze, N. V. Ostapenko, N. N. Chinchenko, and M. E. Filimonova, “Breeding of large grain rice varieties,” Moscow: RUDN, pp. 180-182, 2017. (in russ.) [Proceedings of the XII International Symposium: New and unconventional plants and prospects for their use, June 2017]

[2] R. R.Dzhamirze, N. V. Ostapenko, and N. N. Chinchenko, “Variability of economically valuable features of new rice varieties in the competitive test,” Journal of proceedings of the Gorsky SAU, No. 56 (1), pp. 19-25, 2019. (in russ.)

[3] R. R. Dzhamirze and N. V. Ostapenko, "Correlation of traits and their variability in rice breeding, Trudy Kubanskogo Gosudarstvennogo Agrarnogo Universiteta (Works of KubSAU), No. 5 (74), pp. 25-32, 2018. (in russ.)

[4] A. A. Zhuchenko, Resource potential of grain production in Russia (theory and practice). Moscow: Publishing office «Agrorus», 2004.

[5] V. V. Moiseev, "On the issue of increasing the economic efficiency of growing grain crops in Krasnodar region through the development of breeding and seed production," Regional'naya ehkonomika: teoriya i praktika (Regional economy: theory and practice), No. 7 (46), pp. 139-144, 2007. (in russ.)

[6] N. N. Malysheva and S. A. Garkusha, "Aspects of development of rice growing industry," Rostov-on-Don, pp. 18-21, 2017. (in russ.) [IV international scientific-practical conference: New trends in the development of agricultural sciences, 2017]

[7] L. V. Esaulova, S. V. Garkush, and S. V. Kizinek, "Scientific priorities of adaptive intensification of rice production in Russian Federation," Krasnodar: FSBSI ARRRI, pp. 34-36, 2019. (in russ.) [International scientific-practical conference with elements of young scientists school: Scientific priorities of adaptive intensification of agricultural production, 2019]

[8] S. V. Garkusha, "Ways of plan breeding adaptation towards climate change," Krasnodar: FSBSI ARRRI, pp. 3-7, 2019. [Materials of the international scientific-practical conference with elements of young scientists school: Scientific priorities of adaptive intensification of agricultural production, 2019]

[9] Yu. A. Lysenko, I. N. Chuev, and V. A. Khrisonidi, "Problems and prospects of drawers on the example of Krasnodar territory AND THE Republic of Adygea, Fundamental Research, No. 4, pp. 66-70, 2019. (in russ.)

[10] In Adygea, the rice sowing area will increase by 22%. https://www.yuga.ru/news/441575

[11] N. V. Vorobyev, M. A. Skazhennik, V. S. Kovalev, T. S. Pshenitsina, and O. Yu. Motornaya, "Features productional process of rice varieties, determing their yield," Risovodstvo (Rice growing), No. 3-4 (28-29), pp. 6-12, 2015. (in russ.)

[12] V. A. Maslivets, V. N. Gerasimenko, and S. A. Makarenko, Rice growing: methodology. Krasnodar: KubSAU, 2014. (in russ.)

[13] B. A. Dospekhov, Methodic of field experiment. Moscow: Kolos, 1979. (in russ.)

[14] The agricultural system of Krasnodar region on an agrolandscape basis. Krasnodar, 2015. (in russ.)

[15] V. A. Dzyuba, Multifactorial experiments and methods of biometric analysis of experimental data: methodological recommendations. Krasnodar, 2007. (in russ.)

[16] A. Kh. Sheudzhen and T. N. Bondareva, Methods of agrochemical research and statistical evaluation of their results: study guide 2nd ed. revised and enlarged. Maykop: Polygraph-Yug, 2015. (in russ.)

[17] A. G. Lyakhovkin, Rice. Global production and genotype, 2nd ed. revised and enlarged. Saint Petersburg: Prophy-Inform, 2005. (in russ.)

[18] N. V. Ostapenko, Report on the research work on the topic "To develop a large-grain rice variety with improved grain and milled rice quality": executive. Krasnodar: Kuban State Agrarian University, 2016. (in russ.)

[19] R. R. Dzhamirze, N. V. Ostapenko, and N. N. Chinchenko, "Variability of economically valuable traits of rice varieties in a competitive test," Risovodstvo (Rice growing), No. 2 (39), pp. 11-15, 2018. (in russ.)

[20] R. R. Dzhamirze, N.. V Ostapenko, and N. N. Chinchenko, "Correlation of technological indicators of grain and milled rice quality of new varieties depending on climate condition," IOP Conference Series: Earth and Environmental Science, Vol. 315, 042011, 2019. [International Scientific Conference «AGRITECH-2019: Agribusiness, Environmental Engineering and Biotechnologies», June 2019] https://doi.org/10.1088/1755-1315/315/4/042011

[21] G. L. Zelenskiy, Intra-Varietal Variability and Primary Seed Production Methods of Intensive Type Rice Varieties: Candidate of Science (PhD) Dissertation (Agricultural Sciences). Krasnodar, 1985. (in russ.)

[22] N. V. Ostapenko, Selection of the best rice variety in a competitive test based on an analysis of quantitative traits: Candidate of Science (PhD) Dissertation (Agricultural Sciences). Krasnodar, 2002. (in russ.)