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БОРЬБА С ПИРИКУЛЯРИОЗОМ РИСА ПУТЕМ СОЗДАНИЯ УСТОЙЧИВЫХ СОРТОВ

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Среди грибных заболеваний, поражающих рис, пирикуляриоз является наиболее вредоносным. Болезнь вызывается несовершенным грибом *Pyricularia oryzae* Cav. Рис восприимчив к пирикуляриозу во все фазы вегетации. Целенаправленная работа по селекции риса на иммунитет к этой болезни в России начата в 1982 году. За прошедший период созданы сорта риса, генетически защищенные от пирикуляриоза и не требующие химической защиты от этого заболевания

Ключевые слова: РИС, ПИРИКУЛЯРИОЗ, СЕЛЕКЦИЯ, СОРТ, БЕСПЕСТИЦИДНАЯ ТЕХНОЛОГИЯ

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RICE BLAST CONTROL WITH RELEASE OF RESISTANT VARIETIES

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Among fungus diseases of rice, blast is the most harmful. The disease is caused by *Pyricularia oryzae* Cav. Rice is sensitive to blast at all fazes of vegetation. In Russia, the purposeful breeding of rice varieties resistant to this disease began in 1982. Over the past period, the rice varieties which are genetically protected from blast and not requiring crop protection have been created

Keywords: RICE, BLAST, BREEDING, VARIETY, PESTICIDE-FREE TECHNOLOGY

Introduction

For the population of Russia rice grain is a valuable food, dietary and wholesome product [9]. The main rice-growing area in the country is the Krasnodar Territory. It produces more than 80% of Russian rice. In the last 5-7 years, rice growing dynamically develops every year increasing the yield capacity and rice paddy. In 2012 the rice farms of Krasnodar Territory got the record yield of 7.11 t/ha from 133,300 ha of the rice sown area. This is made possible through the introduction of new high-yielding rice varieties and improvement of rice cultivation including harvesting with modern rotary combines.

A further increase in rice production is constrained by several factors, one of them being rice diseases and, above all, rice blast frequent in the majority of the rice-growing countries. The most effective way to combat the disease is to create and release to farmers rice varieties resistant to blast [10].

In the then USSR rice breeding aimed at immunity to rice blast began in 1982, when on the basis of the Georgian branch of the Research Institute of Plant Pathology a special nursery to study rice resistance to blast was established

[25]. For 10 years (until the demise of the USSR) breeders and plant pathologists actively worked at the issue. The joint research produced unique breeding material, creating a series of rice varieties resistant to blast. And in the ensuing 20 years this material was widely used in breeding of the new generation of rice varieties [11].

1. Blast as a Harmful Rice Disease

Blast is the most noxious and common in the world among rice diseases [7]. It is caused by imperfect fungus *Pyricularia oryzae* Cav. Rice is susceptible to blast at all vegetation stages and all above ground plant organs (leaves, stem nodes and panicles) are affected.

Practically in all rice growing countries the yield losses according to different estimates reach 3% to 25% during normal years; up to 60% and even 100% during years with blast epiphytoty. The damage caused by blast increases significantly due poor grain quality received from affected plants. Rice yields are damaged by blast practically in all countries.

Over the 80-year period of rice cultivation in the Krasnodar Territory a certain cycle of blast epiphytoties has been observed. The first major outbreak occurred here in 1937-1938. In 1948-1949 the epidemics recurred. In 1960, only in Slavyansky area more than three thousand hectares of rice crop were completely damaged. In 1972-1973 severe manifestations of the disease was noted in almost all rice-growing regions of the Krasnodar Territory.

Then another epiphytoty followed in 1984-1985. The losses of rice yield of some farms were very high. According to Ye. Granin and I. I. Begunov [2] the level of blast infestation reached 88% in 1984 and 40% in 1985 in the untreated rice fields sown with Krasnodarsky 424, the yield was 1.8 and 3.5 t/ha correspondingly. The variety Kuban 3 at the farm "Protochny" of Slavyansky area was affected to such an extent that in some fields no rice was harvested.

Blast forms: panicle, node and leaf

In Teuchezhsky region of Adygeya on rice fields of 500 ha practically all plants of Krasnodarsky 424 were affected by blast of panicle leaving no viable plants. Only 0.7 t/ha rice unsuitable for human consumption was collected from this field. Considerable yield losses caused by rice blast were registered on all rice varieties in the same areas (Table 1).

Table 1 - Yield of rice varieties in Teuchezhsky State Test Field in 1983-1984 (Preceding crop - perennial grasses)

Variety	Yield, t/ha		Blast development in 1984, %	
	1983	1984	node	panicle
Kuban 3	5.62	1.88	60	24
Dubovsky 129	4.94	0.82	71	36
Antonovsky	5.69	1.92	52	22
Liman	5.20	3.85	48	20
Mutant 210	6.12	1.49	70	49
Start	6.28	3.26	36	31
Spalchik	6.64	3.66	32	28
Salsky	5.50	0.87	60	42
Krasnodarsky 424	7.20	1.62	62	34
Zhemchuzhny	7.30	1.49	68	35
Kulon	7.66	1.02	64	38
Urozhayny	5.48	0.46	72	50

High susceptibility of rice varieties Krasnodarsky 424 and Kuban 3 to blast resulted in quick reduction of sown areas. They were substituted with the new short stem and less blast susceptible varieties: Spalchik, Start, Kulon, Liman. With timely fungicide treatments these varieties are not so seriously affected by blast.

Thus the 10-12 year cycle of *P. oryzae* recurrence was registered [4]. It allowed forecasting successive epiphytoties in the Krasnodar Territory. Though the rice varieties and cultivation techniques changed blast continued to affect rice plants. Moreover the new rice varieties became infested even if previously blast had not been registered in them.

For example, in 1991 early maturing Mutant 428 was seriously infected in the Crimea, and in 1992 in the experimental fields another early maturing variety VNIIR 18 practically gave no yield due to *P. oryzae* infestation. The disease was also registered in red grain rice forms and varieties with late sowing dates (Laguna and others). This gives evidence of accumulation of infection 2-3 years prior to epiphytoty.

In August 1996 optimal weather conditions were observed for blast disease when rice stands reached milky-waxy and waxy stages. The disease harmed late maturing varieties. The climatic conditions of 1997 were extremely favorable for accumulation of infection and in July blast epiphytoty was registered at a number of farms. Majority of farms had no chemicals for blast control and by the end of vegetation period about 30% of rice fields were affected with blast. Some fields were not even harvested.

Favorable conditions for blast epiphytoty were also observed in 1998. Rice plant residues provided conditions for fungus wintering. The amount of red rice forms most susceptible to blast increased significantly. The farms had no fungicides to control the disease. The weather was favorable for blast development up to tillering stage when the disease was registered in many farms. But dry and hot weather in the following months prevented spreading of the disease.

The similar picture was observed over the next three years (1999- 2001). Blast development was restrained on the one side by the weather conditions, and on the other by the lack of fertilizers (none of the farms had applied excess fertilizers). This was followed by several years of decline blast infection. The plants were affected by the disease in some areas only.

As is known, the key to high rice yield is the optimal plant nutrition. Since 2004 the amount of mineral fertilizers applied to rice has been steadily increasing in the majority of farms. But this increase was mainly due to nitrogen. In 2009 the amount of fertilizers used in the region was 178 kg/ha a.i. on the average. Over the last 16 years it is the highest rate, but the optimal ratio of major nutrients is the worst. In 2010 this negative trend stayed. As stated at the regional meeting of rice farmers (2011) the composition of the fertilizers applied to rice was as follows: $N_{70}P_{26}K_4$. While the recommended application rates of potassium is 50 kg/ ha a.i., in 2010 the average applied amount of this element was 6.5 kg/ha [17]. This led to excessive growth of rice plants and a massive blast infestation. (Besides the peak in the 11-year cycle of the pathogen occurrence approached). The weather conditions contributed to blast spreading. The warm wet weather in June - July caused further spreading of blast epiphytoty. The first signs of the disease appeared as never too early in late June. The first affected fields were those with high plant stand with the applied high nitrogen rates. The situation was aggravated by the lack of reliable fungicides available to rice farmers. For many years the fungicides "fundazol" and "benazol" were recommended for use, recently a new product "colosal" (0.75 - 1.0 l / ha) became available [16]. To save the crop some rice farms treated the crops with fungicides twice or even thrice. The fungicide treatments and the dry weather that settled stopped the disease. However, the negative impact of the disease brought a significant yield reduction in the affected areas and a drastic deterioration of the rice grain quality. Additionally weakened by blast the tall rice stand due nitrogen high rates lodged thus leading to additional costs at harvest.

In 2011 the rice growers faced a new problem. The timely rice sowing was prevented by incessant rains in April and May. Therefore the work dragged on for a month. Many farms used rotary spreaders SSC-500. As a result the plant density at the junction of the drill passes was high. Following the nitrogen fertilization blast was spotted at these places. That was the time of rice tillering and the following paniculation phase when rice plants are especially vulnerable to disease. Besides the weather conditions of the following two weeks were extremely favorable for the development of fungal diseases. Therefore the affected rice fields had to be immediately treated with fungicides.

Chemicals are widely used all over the world to control blast. Aerial application is a forced method since there is no specialized ground equipment for treatment of flooded rice fields. It brings along increased production costs and ecological harm due to treatment of all components of the rice engineering facilities (canals, ramparts, roads).

In the Krasnodar Territory over 40% of rice fields are situated close to built-up areas and water reservoirs where the aerial application is forbidden and the nomenclature of allowed pesticides is very limited. The allowed pesticides are to be surface applied and only in an emergency. Practice has shown that chemical crop protection is not always efficient (due to pesticides untimely application) or cost effective (because the prices for crop protection chemicals and aerial application have shot up) and there can also be ecological counter-indications. Permanent application of fungicides may result in mutant, fungicide resistant forms of *P. oryzae*. Thus introduction of high yielding and immune to pathogen rice varieties should be the main methods of blast control. Therefore the relevance of breeding for blast resistance is constantly increasing. And it is impossible without reliable infectious background and joint research of plant breeders and plant pathologists.

It is known that rice resistance to *P. oryzae* fungal infection is divided into vertical (race specific) and horizontal (field). According to the theory of *Van der Plank* [19, 24] the vertical resistance is general and horizontal resistance is quantitative. The vertical resistance is controlled by genes; the horizontal is more often controlled by minor or multiple genes. The nature of the vertical resistance has been thoroughly studied.

On the basis of numerous experiments *S. Kiyosawa* [21] discovered that the nature of resistance is controlled by specific genes and is as follows:

1. Resistant reaction is caused by the interaction of resistance gene to the virulence gene which strictly adheres to resistance gene.

2. In most cases resistance is dominant over susceptibility.

3. If any variety possesses two genes controlling different degrees of resistance, the gene controlling the highest resistance degree is epistatic to another gene which controls the lowest resistance degree.

These basic rules give answers to many questions that arise in the process of studying rice genetic resistance to blast.

Our observations in the infectious nursery confirm the findings of many researchers that rice blast resistance is a dominant trait. Resistance trait splitting in hybrid population F_2 varied (Table 2).

Table 2 – Response of rice hybrids F_2 to blast infection (*P. oryzae*)

Population	Crossing combination	Ratio of resistant to susceptible plants, R:S
303	Krasnodarsky 424 / *Maratelli 5A*	3:1
369	VNIIR 8444 / VNIIR 87	3:1
394	VNIIR 7630 / NF-DZ-84	9:7
441a	VNIIR 8444 / *Dular*	3:1
540	*Yerua P.A.* /L-5-80	3:1
543	*Ham Nam* /VNIIR1588	9:7
585	*Maratelli 5A* / L-5-80	3:1
586	Kr-3-84 / *Maratelli 5A*	3:1

Resistance to *P. oryzae* in *Miratelli 5A*, *Yerua P.A.*, VNIIR 87 and *Dular* is controlled by one dominant gene, it is confirmed by the ratio 3R : 1S. In hybrid populations received after crossing VNIIR 7630 and *Han Nam* splitting was 9R : 7S. This proves the presence of two dominant genes of resistance to blast in these varieties.

The obtained data allow reliable assessing of hybrid material and selecting required genotypes for selection nursery.

As for horizontal resistance, the study of its inheritance involves great difficulties because environmental conditions greatly affect its expression. This type of resistance does not include the gene to gene interdependence. It operates equally against all races of the pathogen. According to *S. Ou* [22], two types of rice painful reactions indicate the horizontal resistance: 1) the variety produces minor damage regardless of race or 2) appearance of few injuries, although qualitatively these injuries testify to susceptibility.

J. Bidaux [20] and several other researchers have concluded that the horizontal (field) resistance is not race specific and it is poly-genetically inherited.

Most researchers believe that the horizontal resistance to blast provides, if partial, but a long-term protection of rice. However, *M. Vales* [23] states that the resistance of rice to *P. oryzae* has sufficiently high probability of being durable, if it is polygenic, but neither polygeny nor the knowledge of variety resistance where it is borrowed does not guarantee its duration.

Thus the most reliable factor controlling rice blast is timely substitution of the old varieties with the new ones possessing effective genes of resistance to pathogen.

2. Initial Material for Rice Resistance Breeding to Blast

Search for rice varieties and samples resistance to blast disease started in VNIIR in the 60-ies of XX century. A.G. Lyakhovkin [14] thoroughly studied the rice varieties and samples of the world collection of the Research Institute of Crop Science (VIR). In 1972 practically all samples of the collection (2,130) were assessed for their resistance to blast in field trials and 1,008 samples were tested at the specialized plot under artificial inoculation.

Assessment of varieties and breeding samples was continued in the years to follow. These tests brought to the conclusion that the majority of varieties grown at that period in Krasnodar Territory and / or being under state trials had weak resistance to blast. In many of them even under natural inoculation up to 85-100% plants were infected by *P. oryzae*. This can be explained by the fact that practically all varieties were bred from blast susceptible initial material [18].

Many years of research of *P. oryzae* population structure showed that pathogen races differed in virulence genes (Gorbunova et al., 1987). Thus it was discovered that in the European part of Russia the most efficient resistance genes for these populations are ***Pi-z, Pi-zt, Pi-ta2, Pi-b*** [13]. Phytopathologists determined that rice varieties both commercially grown and under state trials, have inefficient resistance genes ***Pi-ks, Pi-a*** or ***Pi-i*** and consequently are easily susceptible to blast.

The lack of effective resistance genes in domestic rice varieties does not allow them to withstand blast especially in epiphytotic spreading of the disease.

This situation dictated the need to find effective donors of resistance and based on them breeding blast tolerant source material for further breeding of immune varieties to the pathogen. A particularly valuable source material for breeding for rice blast resistance are the varieties combining race specific and field resistance (Table 3).

Table 3 - The World Rice Collection samples with effective blast resistance genes [13]

in VIR catalogue	Sample	Origin	Plant height, cm	Days before flowering	Resistance genes
European group					
6979	*Insen/Tremisino*	Spain	113	85	Pi-z
6951	*Maratelli 5A*	France	110	80	Pi-z
Oriental group					
7265	*Shimokita*	Japan	97	85	Pi-ta
3805	*PN 170*	China	132	92	Pi-z^t
7233	*Ham Nam*	Korea	87	88	Pi-z^t
Iranian group					
3787	*Champa*	Iran	138	80	Pi-z^t
Central Asian group					
5065	*Bir-me-fen*	Afganistan	120	95	Pi-z^t

Testing of 2,544 sample of the world collection for varieties best suited for soil-climatic conditions of Russia showed that the majority of them are susceptible to *P. oryzae*. Only 69 samples were not infected with foliar form of disease, 20 samples were slightly susceptible to panicle form (grade 1-2) and 18 samples combined immunity to both forms of blast. Among the studied varieties such properties are found in the sample from Spain *Insen/Tremesino* (К-6979) and the French variety *Maratelli 5A* (К-6951) [13]. These two are the most valuable samples for rice breeding.

Along with the study of the world collection the search for sources of blast resistance was done among the samples of the working collections of the

All Russia Research Institute of Rice (VNIIR) due to their better adaptation to the soil and climatic conditions of Russia.

Collected samples resistant to or slightly affected by blast in infectious nursery were again studied under greenhouse conditions by the scientists of All Russia Research Institute of Phytopathology. The researchers determined blast resistance in samples showing high tolerance to the pathogen. As a result several samples were selected successfully resisting domestic races of *P. oryzae* thanks to the presence of effective resistance genes (Table 4).

Table 4 - VNIIR rice collection samples with effective blast resistance genes

in VNIIR catalogue	Sample origin	Plant height, cm	Days before flowering	Resistance genes
0590	*O. glaberima* / Souzny 244	106.9	87	Pi-z^{t}
01016	*Korbeta* / Souzny 244	55.5	89	Pi-z^{t}
01717	*Taichung Native*/DVROS 15	97.8	84	Pi-z
01793	C.6063 / *Rialto*	74.6	82	Pi-z
01907	VNIIR 3657 / *Rialto*	86.2	86	Pi-z
02268	VNIIR 7630	100.9	86	Pi-z
02360	*Panoza sel*. / VNIIR 5001	110.6	85	Pi-z
02890	Mutant 744-82	92.8	86	Pi-ta
02919	Breeding line 83-1-14-1	84.8	85	Pi-z^{t}
03186	B3-600-436-85	90.6	81	Pi-z

As can be seen from Table 4, the rice varieties and forms of the world collection were the sources of resistance to *P. oryzae* when breeding samples included afterwards into the working collection. Such varieties like Mountain rice from Brazil, *Catalao, Rialto* from Italy, *Nato, Saturn* from the U.S.A., *Taichung Native* from China, etc. used in the hybridization process at the Rice Research Institute turned out to be donors of not only short stem habitus, high productivity and outstanding quality of the grain but also revealed resistance to blast. The progeny derived from them have been the most valuable examples of source material to create varieties with race specific and field resistance to blast.

Selected sources of blast resistance formed the basis for production of hybrid material. It resulted in over 200 hybrid populations. Blast resistant rice plants were selected from many of them, thus forming the bank of donors.

3. Breeding Race Specific Blast Resistant Rice Varieties

Selecting the breeding trends in rice blast resistance depends on soil and climatic conditions of rice growing area and genetic structure of *P. oryzae* population. The approach should be differentiated and determine initial material, methods of its evaluation and selection. Durability of variety resistance depends on how these issues are solved.

Race specific breeding is advisable for those areas where climatic conditions limit the development of the pathogen. Many years of complex research have proved that these are European part of Russia, Ukraine and Karakalpakia. For the Far East it is recommended to work out breeding programs for race specific and field resistance due to favorable climatic conditions for blast and high variability of the pathogen.

Race specific, real or vertical resistance is connected with super sensitive reaction of host to pathogen and controlled by the unique main gene. Thus initial material should be genetically variable. Breeding based on one effective gene can result in appearance of races overcoming this resistance.

When planning a hybridization program for breeding rice varieties with blast race specific resistance it has been assumed that in the European part of Russia the effective resistance genes to *P. oryzae*, as noted above, are ***Pi-z, Pi-z***^{t}***, Pi-ta***^{2} and ***Pi-b***. This dictated the choice of donors for hybridization. The following varieties with genome ***Pi-z*** (*Zenith*, VNIIR 7630, *Yerua PA*, *Maratelli 5A* and samples 1-жн-Г-84, БЗ-600-436-85) and samples with gene **Pi-z**^{t} (1- жн-Г-84 and 4- жн-Г-84) were included into breeding programs. However, during the breeding study it was found that simple paired crossings were not effective enough. The resulting hybrid material, in spite of blast resistance did not meet the requirements to modern rice varieties. The need for backcrosses with most donors was evident. Only in hybrids created using French variety *Maratelli 5A*, there were some plants showing promising results. The habitus of *Maratelli 5A* is close to Krasnodarsky 424 of Russian origin, it ripens only a few days later. However, in the hybrid population of Krasnodarsky 424/*Maratelli 5A* the plants with negative transgression were segregated: they were earlier maturing and short stem plants compared to both parental forms. As a result a few dozens of such plants were selected. Their resistance to blast combined with a complex of agronomic traits. After their thorough study and discovery of the resistance genes several samples were produced which were brought to the competitive test. After a comprehensive assessment in 1992 the variety VNIIR 92-88 under the trade name Blastonik was released for the state variety tests. It was the first variety with race specific resistance to blast bred from local hybrid material. In the subsequent years rice varieties Vityaz (1994), Talisman (1995), Snezhinka (1996), and Vodoley (1998) having similar resistance were released for the state variety tests.

Rice variety Snezhinka

However only Snezhinka has been included into the State Register of the approved varieties due to its grain parameters (long and high quality meal).

The other varieties were not included into the State Register. The reason is simple. Testing of new varieties is carried out by the State Commission on the usual background, optimal for the standard, without infection load. Under these conditions during years of the absence of blast epiphytoty, the immune varieties do not show their advantage over the standard in terms of yield.

4. Breeding Field Blast Resistant Rice Varieties

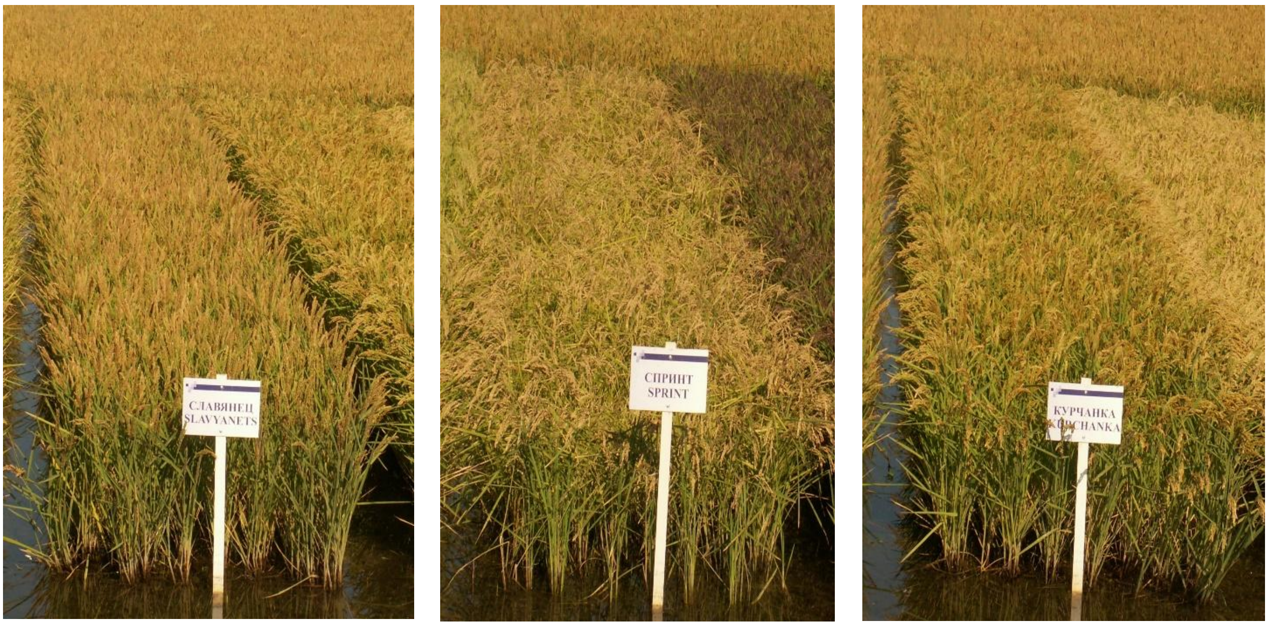
The assessment of the breeding material in infection nursery allows selecting not only immune samples, but also rice varieties and forms with high tolerance to diseases or possessing the so called “field resistance”. The main feature of this resistance is that it gives if not full, but at least steadfast protection and it is not ruined by the pathogen. The field or horizontal resistance is normally not race specific, it is more dependent on environmental factors and in majority of varieties it is polygene controlled.

To obtain varieties with field (horizontal) resistance *Van der Plank* [24] suggested selecting forms: a) that are more difficult to be infected, b) having the longer period from inoculation to sporulation, c) with less abundant sporulation. The varieties with horizontal resistance are characterized by a lesser area of spots and their count per 1 cm.

It is known that during rice growing season *P. oryzae* has many cycles of asexual reproduction, each cycle lasts about one week. Blast development is progressive by the law of compound interest. In this case the different varieties have small differences in the beginning of the epidemic, and very significant at its end.

The rice variety Slavyanetz is a good example. It was studied against the infectious background in 1984-1985 when it was called L-5-80 and was selected from other varieties due to its greater endurance to blast. *S. Ou* [22] reportes that the breeding lines of rice where the plants produce the smallest count of pustules during the infection with *P. oryzae* are more resistant to the pathogen than other lines. A different picture was observed in Slavyanetz. After artificial inoculation the disease developed slowly, spore formation was slow and the secondary inoculation was practically not registered. This valuable feature of the variety is of particular importance in the years of epiphytoty. Since 1991 Slavyanetz has been in commercial use in Krasnodar territory as the most blast resistance rice variety.

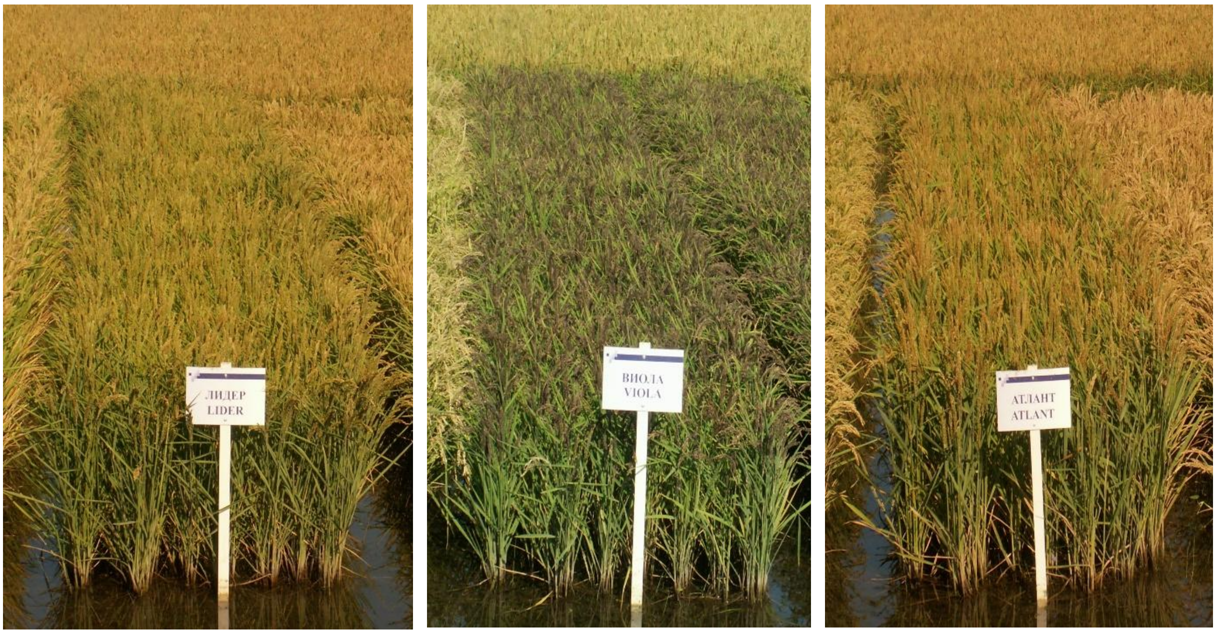
In addition to this variety it became possible to select in the infectious nursery a number of samples with minor injuries during blast epiphytotic development. These were used as parental forms for hybridization as having high field resistance. Among them are local samples VNIIR 87, VNIIR 1619-90, Mutant 533, VNIIR 7630, Kr-3-84, and the Japanese varieties *Shimokita* and *Reimei*.



Demo fields with varieties Slavyanetz, Sprint and Kurchanka

All the past 30 years the breeding of the blast resistant varieties is ongoing at the Institute of Rice. The best of varieties are listed in the State Register and are released for commercial use: Slavyanetz (1991), Pavlovsky (1995), Sprint (1996), Kurchanka (1997), Leader (1999), Viola (2001), Snezhinka (2003) Violetta (2007), Atlant (2007), Kumir (2009), Yuzhny (2009), Gamma (2010) [5, 6, 7, 8, 12]. These varieties are blast resistant and do not require chemical treatment against the disease. Of these varieties Leader stands out; it is registered in the State Register of Russia and Kazakhstan, where it shows excellent results in terms of yield and grain quality on the saline soils with rice plants growing shoots through a water layer [26].

It should be emphasized that breeding for resistance to diseases or other stress factors, requires additional expense. It is necessary to regularly evaluate breeding material against special infectious and provocative backgrounds. However, these costs are paid off, both economically and environmentally. Growing blast resistant varieties is more profitable compared to other varieties even if the same yield is received. It should be noted that the cost of each aerial fungicide treatment of rice crops including the pesticide cost are 1300 -1500 Rubles/ha.



Leader, Viola and Atlant, varieties for pesticide-free technology

Among the above-mentioned varieties of special interest for Russian production are the last three: **Kumir**, **Yuzhny** and **Gamma** which combine blast resistance with high yield. Here is a brief description of their agrobiological features.

Kumir and Yuzhny were created by breeding from Jupiter derived from a complex hybrid population: "*K-5287/8356 / / Azros 1713 / / / Bolshevik / Raduga / / / / L-5-80*". [6]

Despite their common origin these varieties (Kumir and Yuzhny) significantly differ in morphological and biological features. Therefore they are designed for different cultivation technologies: Kumir is meant for intensive technology, and Yuzhny is a versatile variety that can be used for energy-saving intensive technologies without herbicides.

Kumir belongs to the short-stemmed varieties of intensive type. The yield capacity is 11 t/ha was recorded in one of the agrotechnical trials.

The variety is awnless; it belongs to the species *Oryza sativa* L., subspecies *japonica*, botanical variety *italica* Alef. The plant is undersized, height 80 - 85 cm, the stem is of medium thickness (6 - 8 mm), durable, highly resistant to lodging. The leaves are green, no anthocyanin pigmentation, short, blade curve is insignificant. The panicle has the average length (14-15 cm), not pendulous with 150 - 200 spikelets. The panicle sterility is very low (6 -10%). The grain is of medium size, weight of 1000 grains 28 – 29 g. Grain shape is round, length to width ratio of 1.7. White grits, glassy. Meal yield is 71.0%.

In the field the rice plants are blast resistant. Therefore the variety can be grown without pesticide treatment. Given the short stem, the high productivity with adequate nutrition, the recommended predecessors for Kumir are perennial grasses, fallow with soybean or canola, fields clean of weed, using intensive technology. No shattering even in case of overmatured stand, but the panicles are easily trashed out. Therefore harvesting can be either direct or two-stage.

Yuzhny belongs to the varieties intermediate between medium maturing and medium-late maturing. The three year variety tests has shown an average vegetation duration of 120 days (with fluctuations from 116 to 122 days).

This variety is high yielding. In propagation nursery in 2005 the registered yield was 10.2 t/ha. The variety is awnless; it belongs to the species *Oryza sativa*

L., subspecies *japonica*, botanical variety *italica* Alef. The plant height is 90 - 95 cm. The leaves are short, wide slightly pubescent, set at 30 – 35º angle. The panicles are large (17 – 18 cm), with 150 - 170 spikelets. The panicle sterility is low (3 – 8 %). The panicles are erectoid, semi-compressed, by the end of vegetation slightly drooping. The grain is semi round, of average size, weight of 1000 grains 28 – 29 g. The length to width ratio of 1.9. White grits, glassy. Meal yield is 69,8 %, including 85,4 % kernel. Glassiness is up to 98%. The meal is of excellent quality with high culinary parameters.

The variety is resistant to lodging. No shattering even in case of overmatured stand, but the panicles are easily trashed out. Therefore direct late harvesting is admissible. Resistance tests under artificial inoculation showed the blast infestation did not exceed 5,6 %, while 33% standard plants were infected. Under field conditions no blast infestation of this variety was reported. Yuzhny stands out among other rice varieties by its high resistance to rice leaf nematode (resistance index 93,9%).

The plants of Yuzhny rice variety are characterized by the intensive growth during emergence that is why they easily overcome the water layer that grass weeds cannot grow through. Therefore the variety can be grown without herbicides and ecologically safe high quality rice grain is obtained at low cost. At the same time this variety shows good results when grown with herbicide treatment (with “nomini” and “segment” application). In this case the shoots appear through a minimum water layer, the plants are short and no susceptible to lodging. The plants tend to lodging in case high rates of nitrogen are applied. This is to be taken into account while planning agrotechnology for this variety.

In 2010-2011 production test of rice varieties Kumir and Yuzhny were held at "Azov-Kubanagro" Holding Company. In the epiphytotic year their crops did not require blast protection. While varieties Flagman and Rapan required one treatment, Khazar - two, Renard - three fungicide treatments.

The variety **Gamma** was bred by means of individual selection from a complex hybrid population of the second generation ***Kurchanka / VNIIR 554-90 // Leader / Talisman.*** The parent forms in their turn are the result of complex many years of crossing with Russian and foreign varieties from Argentina, Italy, Korea, France (fig.).

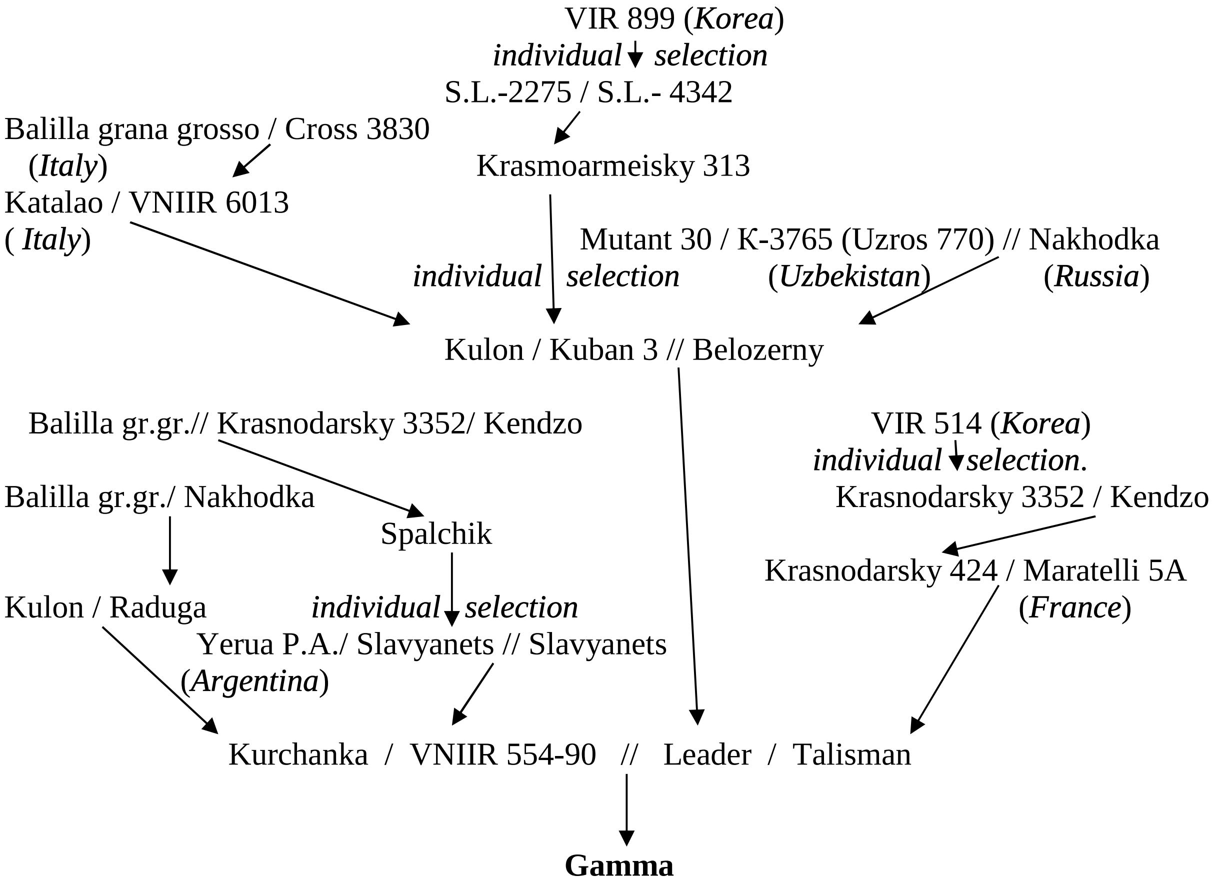


Figure. Pedigry of rice variety Gamma [8]

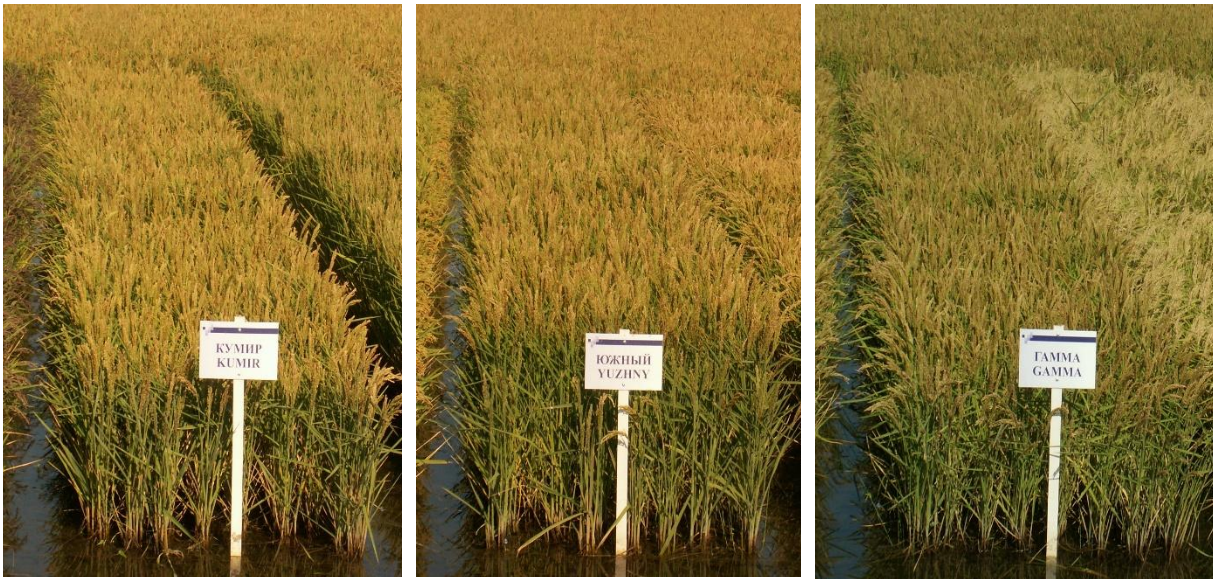
Gamma belongs to medium maturing varieties; the average vegetation duration registered during 4-year tests is 115 days varying from 110 to 118 days. This is a highly productive variety.

In propagation nursery in 2005 the registered yield was 9.8 t/ha, in 2007 - 10,4 t/ha. The agrotechnology tests of 2006 showed the yield of 12.0 t/ha in one of the trials.

The variety is awnless; it belongs to the species Oryza sativa L., subspecies japonica, botanical variety italica Alef. The plant height is 85 - 90 cm. The panicles are 16 – 17 cm, with 155 - 160 spikelets. The panicle sterility is low

(5–7 %). The grain is round type (l/b–1.9), the weight of 1000 grains 24–25 g. High glassiness. Meal yield 70 – 71.5 %, including 90 % kernel. The meal high quality is inherited from Kurchanka. The plants of Gamma rice variety are characterized by the intensive growth during emergence (the inherited feature from Leader) that is why they easily overcome the water layer that grass weeds cannot grow through. Gamma is blast resistant (the sources of blast resistance are BNIIR 554-90 and Talisman). Therefore the variety can be grown without pesticide treatment; ecologically safe high quality rice grain is obtained at low cost.

No shattering even in case of overmatured stand, but the panicles are easily trashed out. Therefore harvesting can be either direct or two-stage.



High yielding rice varieties resistant to blast Kumir, Yuzhny and Gamma

In 2010-2011 Gamma was tested in three rice growing areas of Krasnodar Territory: “Krasnoarmeisky” farm in Krasnoarmeisky region, “Aspect”LLC in Slavaynsky region and “Pravoberezhny”CJSC of Temryuk region. The yield of the new variety exceeded 8.0 t/ha, no fungicides were applied because it was not required. No blast was registered in Gamma. Meanwhile the fields sown with Liman and Rapan located nearby were fungicide treated twice.

Thus, the joint work of breeders and plant pathologists gives a real opportunity to provide rice farmers with the varieties that are genetically blast protected and do not require chemical protection against this disease of rice. This is an important result of 30 years of breeding for rice blast resistance.

G. Zelensky in the rice stand (Gamma)

The further joint research of the VNIIR specialists in biotechnology and rice breeders is aimed at pyramid escalation of blast resistance genes in local rice varieties [3.15].

Bibliography

1. Горбунова Ю.В. и др. Сводка по распространению рас и частоте встречаемости генов вирулентности пирикуляриоза риса на территории основных рисосеющих районов СССР в 1986 году. – Голицино, 1987. – 5 с.

2. Гранин Е.Ф., Бегунов И.И. Рицид – П против пирикуляриоза // Защита растений. – 1989. - № 1. – С. 21.

3. Дубина Е.В. Интрогрессия генов pi-ta, pi-b, pi-z в отечественный сорт риса “Снежинка» с применением методов маркерной селекции / Е.В. Дубина, Ж.М. Мухина // Политематический сетевой электронный научный журнал Кубанского государственного аграрного университета (Научный журнал КубГАУ) [Электронный ресурс].- Краснодар: КубГАУ, 2011.- № 02 (66). - Шифр Информрегистра: 0421100012\0068 - Режим доступа: http://ej.kubagro.ru/2011/02/pdf/08.pdf.

4. Зеленский Г.Л. Селекция сортов риса, устойчивых к пирикуляриозу, рисовой листовой нематоде и бактериальному ожогу в условиях Российской Федерации. // Автореф. дисс. доктора с.-х. наук. Краснодар, 1993, 48 с.

5. Зеленский Г.Л., Третьяков А.Р. Атлант – сорт риса, устойчивый к абиотическим стрессам // Рисоводство.- Краснодар, 2008.- Вып. 12.- С. 22 - 25.

6. Зеленский Г.Л. Новые сорта риса Кумир и Южный // Рисоводство.- Краснодар, 2009.- Вып. 15.- С. 80 - 33.

7. Зеленский Г.Л. Сорт – технология - пирикуляриоз // Агроснабфорум. – Краснодар, 2010.- №10 (80). – С. 28 – 29.

8. Зеленский Г.Л., Малышева Н.Н., Чухирь И.Н. Зеленский А.Г., Третьяков А.Р. Эффективность отдаленной и сложной гибридизации в селекции растений. Труды Куб. ГАУ. - №2 (23). – Краснодар, 2010 .- С. 89 – 95.

9. Зеленский Г.Л. Рис как продукт для диетического и лечебного питания / Г.Л. Зеленский // Политематический сетевой электронный научный журнал Кубанского государственного аграрного университета (Научный журнал КубГАУ) [Электронный ресурс].- Краснодар: КубГАУ, 2011.- № 08 (72). – С. 28 – 42. - Шифр Информрегистра: 0421100012\0346. - Режим доступа: http://ej.kubagro.ru/2011/08/pdf/02.pdf, 0,938 у.п.л.

10. Зеленский Г.Л. Морфо-биологическое обоснование агротехники риса/ Зеленский Г.Л. // Политематический сетевой электронный научный журнал Кубанского государственного аграрного университета (Научный журнал КубГАУ) [Электронный ресурс].- Краснодар: КубГАУ, 2012.- № 03 (77). – С. 1158 - 1193. - Шифр Информрегистра: 0421200012\0232. - Режим доступа: http://ej.kubagro.ru/2012/03/pdf/98.pdf , 2,25 у.п.л.

11. Зеленский Г.Л. Итоги 30-летней работы по селекции сортов риса, устойчивых к пирикуляриозу в России // Иммуногенетическая защита сельскохозяйственных культур от болезней: теория и практика: Материалы Международной научно-практической конференции, посвященной 125-летию со дня рождения Н.И. Вавилова, Большие Вяземы Московской области 17-21 июля 2012 г. – Большие Вяземы, 2012. – С. 427 – 440.

12. Каталог сортов риса селекции Всероссийского научно-исследовательского института риса / Авт. колл.: Н.П. Дьяченко, С.В. Жиленко, В.А. Кулик, Н.П. Иващенко, Е.М. Сорочинская и др.: Справочно-методическое издание. - Краснодар, 2007. – 48 с.

13. Коломиец Т.М. Отбор исходного материала для селекции на иммунитет к пирикуляриозу: Автореф. дисс. канд. биол. наук. – Голицино. -1991. – 21 с.

14. Ляховкин А.Г. Изучение устойчивости коллекционных сортов риса к пирикуляриозу. // Тр. по прикл. ботан., генет. и селекции. – Л., 1978. Т. 51, вып. 1. – С. 219 – 224.

15. Мухина Ж.М. Создание внутригенных молекулярных маркеров риса для повышения эффективности селекционного и семеноводческого процессов / Ж.М. Мухина, С.В. Токмаков, Ю.А. Мягких, Е.В. Дубина // Политематический сетевой электронный научный журнал Кубанского государственного аграрного университета (Научный журнал КубГАУ) [Электронный ресурс].- Краснодар: КубГАУ, 2011.- № 03 (67). - Шифр Информрегистра: . 0421100012\0115 - Режим доступа: http://ej.kubagro.ru/2011/03/pdf/19.pdf.

16. Система рисоводства Краснодарского края: Рекомендации. 2-е изд. перераб. и доп. / Под общ. ред. Е.М. Харитонова. – Краснодар: ВНИИ риса, 2011. - 316 с.

17. Совещание рисоводов Кубани «Об организации проведения сева риса и задачах, стоящих перед отраслью Краснодарского края в 2011 году» // Рисоводство.- Краснодар, 2011.- Вып. 18.- С. 3 - 13.

18. Фролова В.С. Поражаемость сортов риса пирикуляриозом в Краснодарском крае. // Бюлл. НТИ ВНИИ риса. – 1980. – Вып. 27. – С. 62 – 65.

19. Я. Ван Дер Планк Устойчивость растений к болезням. Пер. с англ. М.: Колос. – 1972. – 254 с.

20. Bidaux J.M. Screening for horizontal resistance to rice blast (Pyricularia oryzae) in Africa (Proceedings of a conference held at International Institute of Tropical Agriculture, 7-11 March, 1977). // Rice in Africa. – 1978. – P. 159 – 174.

21. Kiyasawa S. Studies on genetics and breeding of blast resistance in rice. // Mise. Rubl. Nat. Jast. Agrc. Sci. D. – 1974. – N1/ - P. 1 – 58.

22. Ou S.H. Disease resistance in rice // Mutation breeding for disease resistance. – IAEA. Vienna. 171. – P. 78 -85.

23. Vales M. La resistance durable: cas de la pyriculariose du riz. 1/ Les qualities assciees a la resistance durable. // Agron. Trop. – 1987. – 42. – N 2. – P. 103 – 111.

24. Van der Plank J.E. Horisontal resistanse six projects in relation to blast disease of rice. // Horisontal resistanse to blast disease of rice. – CIAT. Ser. CE 9.Call. Colombia. – 1975. – P. 21 – 26.

25. Zelensky G.L., Zelenskaya O.V. Anoshenkov V.V. Rice breeding for blast resistance in Russia // CIHEAM-IAMM, 2001.– 126 p. Available on-line only. Cahiers Options Mediterraneennes. – Vol. 58: Workshop on the New development in rice agronomy and its effects on yield and quality in Mediterranean areas, 13-15 September 2000, Edirne, Turkey. - Режим доступа: http://ressources.ciheam.org/om/pdf/c58/03400080.pdf.-7 p.

26. Zelensky G. L. Ecological and biological bases of the rice variety Leader growing on pesticide-free technology/ G. L. Zelensky, O.V. Zelenskaya // Политематический сетевой электронный научный журнал Кубанского государственного аграрного университета (Научный журнал КубГАУ) [Электронный ресурс].- Краснодар: КубГАУ, 2011.- № 07 (71). – С. 71 - 81. - Шифр Информрегистра: . 0421100012\0298 - Режим доступа: http://ej.kubagro.ru/2011/07/pdf/06.pdf, 0,688 у.п.л.