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РОСТ И РАЗВИТИЕ РАННЕСПЕЛЫХ И ПОЗДНЕСПЕЛЫХ СОРТОВ РИСА В РАЗНЫХ РЕЖИМАХ ЗАТОПЛЕНИЯ

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В этой статье обсуждается рост и развитие сортов риса при различных режимах затопления. Затопление используется для предотвращения появления сорняков на рисовом поле. Не все сорта устойчивы к условиям затопления, поэтому существует необходимость в выведении устойчивых сортов, которые могут расти в условиях гидравлического стресса. В условиях лизиметра изучали три сорт риса: Рапан (ст), Титан, раннеспелый и Арбалет, позднеспелый. Наши результаты показывают, что эти сорта могут расти в условиях затопления, но Титан показывает хорошие результаты при затоплении 15 см, поэтому его можно рекомендовать для посева в санитарной зоне

Ключевые слова: РОСТ, РАЗВИТИЕ, ЗАТОПЛЕНИЕ, РАННЕСПЕЛЫЕ И ПОЗДНЕСПЕЛЫЕ СОРТА РИСА, ТИТАН, РАПАН, АРБАЛЕТ

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GROWTH AND DEVELOPMENT OF EARLY AND LATE MATURING RICE VARIETIES UNDER VARIOUS FLOODING REGIMES

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The article discusses the growth and development of rice varieties under various flooding regimes. Flooding is used to prevent weeds from growing in crops. Not all of the varieties are tolerant to flooding conditions, so there is a need to develop resistant varieties that can grow under water stress. Three varieties of rice: Rapan (standard), Titan (early maturing) and Arbalet (late maturing) were included into our experiment carried out under lysimeter conditions. The results show that all these varieties can be grown under flooding, but Titan shows good results with 15 cm water layer, thus it can be recommended for planting sanitarian zones

Keywords: GROWTH, DEVELOPMENT, FLOODING, EARLY AND LATE MATURING RICE VARIETIES, TITAN, RAPAN, ARBALET

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Breeding for creating more productive and resilient varieties adapted to several ecosystems is among main strategies for feeding the world [15].

Rice is one of the important cereal crops in the daily life of man. Indeed, wheat, rice and maize are the most used cereals in the world and provide more than 50 % human food calories directly and more indirectly via feed grains [15, 18, 21]. Considering the extend of its plantation, rice is the second most widespread cereal in the world, with crops planted in 115 countries on around 150 million hectares. In terms of yield, rice ranks first in the world among all cereals [3, 13, 18, 21]. For 2017 season, FAO has raised its forecast of world paddy production by 2.9 million tons to 759.6 million tons (503.9 million tons, milled basis) [13].

Rice is unique among the world's major food crops by virtue of the extent and variety of its uses and its adaptability to a broad range of climatic, edaphic, and cultural conditions [3, 15, 19]. Rice has a unique ability to grow and produce high caloric food values per unit area on all types of land and water regimes. Combined with its adaptation to a wide variety of climates and agricultural conditions, rice becomes the world's most important cereal crop [3, 9, 21]. The semiaquatic character of rice was the key to the development of wet lowlands in Asia at an early stage in the history of agriculture [11]. It is recognized that rice is usually grown under shallow flood or "wet paddy" conditions and can also be cultured where floodwaters may be several meters deep and, at the opposite extreme, as an upland cereal [4].

If rice plants are growing in moistened conditions without a layer of water, then their roots are covered with root hairs like seed grasses [9]. Otherwise, if the rice grows in a layer of water, its roots develop without rootless hairs and, unlike the roots of upright grasses, form an air-carrying tissue - an aerenchyma, which is an oxygen conductor of aerial organs to the ground [11, 19, 21, 23].

Resilient species for each type of ecosystem are regularly created by the institutions involved in the development of rice culture.

In Russia, direct seeding rice is the main used system in rice production. Several authors claim that, in the absence of chemical weed control, this method is not flawless compared with transplanting method [2, 4, 6, 7, 8, 10, 12, 17, 20] that's the reason why ecological methods are encouraged.

There are many methods used for combating weeds in rice plantation. Manual weeding and/or herbicides application are commonly used to control weeds [2]. Although flooding is an effective method, it is not widely practiced due to the lack of water in certain regions and the lack of resilient varieties. Manual weeding is becoming less common in many countries because of the non-availability of labor at critical times and increased labor costs [2, 4, 6, 7, 8, 10, 12, 17, 20]. Herbicides and cultural methods help in suppressing weed growth and in enhancing rice seedling establishment and growth.

The biology of the rice culture, the technology and resources available are the main decisive elements for the selection of a method to be used for weed management program. The selected for using method in sanitarian areas would be environment sustainable method with low cost. Thus, the use of chemical herbicides is not only expensive, but is in certain conditions limited, reason why flooding rice fields can be one of preferred methods [20].

The competition between rice and weeds is most severe during early growth of the rice when yield components (tillers, panicles, kernels, etc.) are being formed [2, 20].

Considering the hydrophilic nature of rice, flooding at that growth stage favors the rapid development of rice and inhibits most weeds. Thereby, when water is not a limiting condition, the permanent flooding of the rice fields reveals that this practice can contribute, in addition to favoring the flourishing of the rice plants, to fight against the weeds. It is likely a rational response by rice farmers to a cost-price squeeze in rice production [2, 6, 7, 10, 12, 17, 20].

Water, a precious resource for the well-being of humanity, is unevenly distributed around the world [17]. It is subject to various pressures and threats, the reason why it must be protected and rationally used. Thus, in some sanitarian areas, in which the excessive use of chemical fertilizers and herbicides is restricted, special precautions deserve to be taken with a view to contributing to increasing profitability while preserving the environment [2, 20]. This is the case of a large part of the Krasnodar region.

Since the 1960s, varieties with various adaptations have been created by All Russian Research Rice Institute (ARRRI) [20, 21, 22, 23].

In order to test varieties to be used in sanitarian areas where the excessive use of herbicides is prohibited, a comparative study of the growth of rapid-maturing and late-maturing varieties was carried out applying different flooding layers.

Methods

With the aim of creating adapted varieties for the conditions of permanent flooding, experiments of culture of 3 rice varieties were carried out in lysimeters located in the Botanical Garden of the Kuban State Agrarian University.

A comparison of the growth of two varieties, Titan, early maturing, and Arbalet, late maturing, was carried out with two different flooding levels. The rice variety Rapan, belonging to middle maturing group, was used as a standard for the region.

The rice variety Titan with growing season of 114-116 days was bred at the ARRRI. The variety is characterized by high rates of initial growth. The plants of Titan overcome the water layer at emergence well enough; they also possess average tolerance to soil salinity [21].

The growing season of the rice variety Arbalet is 120-136 days, it is recommended for cultivation in the West Delta zone of the Krasnodar Territory. Arbalet is a highly resistant to lodging and shedding.

The growing season of Rapan, standard variety, is 115-117 days. It is characterized by a low seed germination and growth rate in the initial phases of development. Therefore, the main method of its sowing is scattering, with post-sowing rolling with smooth rollers. With this method, seedlings can be obtained without discharging water, lowering its layer to 10-12 cm some 10 - 14 days after the initial flooding [21].

Under the lysimeter conditions the rice plants were spaced at 1 - 2 cm and the inter-row space was 15 cm. After the emergence of the coleoptile, when rice plants were 4 – 6 cm high, lysimeters were flooded respectively to 5 cm and 15cm. That water layer was maintained until the maturity of plants. Minimal nitrogen quantity, in the form of urea, was applied at different growth stages.

Different growth parameters were compared throughout the vegetative period of the different varieties. Data analysis was done with the use of Excel and SPSS software.

Results and Discussion

Growth Dynamic in Different Flooding Conditions

At the early stage of the vegetative period, in the beginning of the tillering phase, the growth of all varieties is very rapid in the case of flooding at 15cm. That growth is much more marked in Arbalet then Titan, while Rapan is the shortest. In the middle of the tillering period, an opposite trend is observed with marked growth in the case of varieties planted in plots with low layer water (5cm). In this case, the results obtained are similar to those with 15 cm water layer, with Titan followed by Arbalet and then Rapan. At the maturity, under the two flooding conditions, Arbalet is the tallest plant followed by Titan (Fig.1).

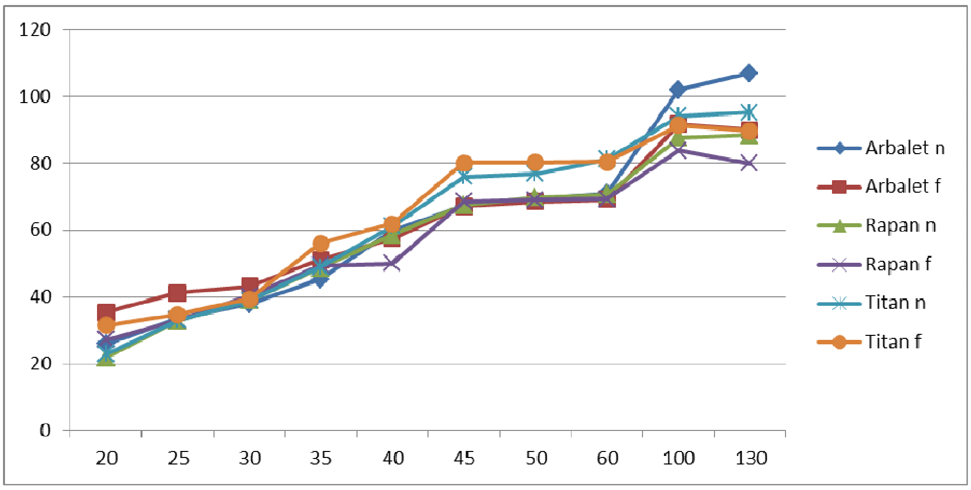

Fig.1 : Growing of 3 rice varieties under different flooding conditions (n: low water layer at 5cm ; f : flooding at 15cm).

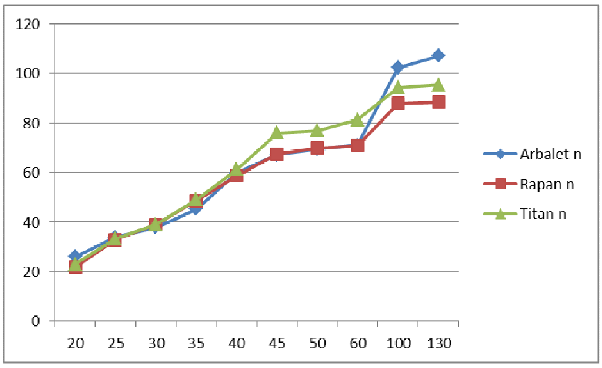

Fig.2 : Growing of 3 rice varieties under low water layer

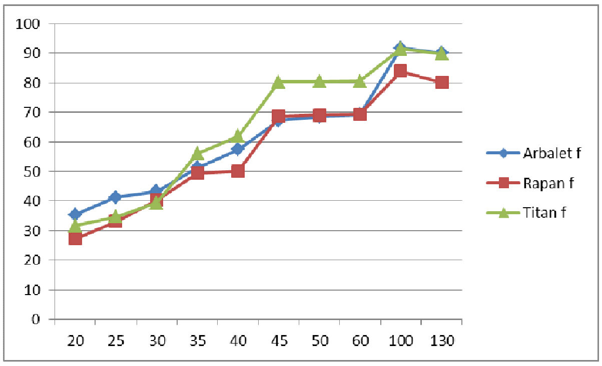

Fig.3 : Growing of 3 rice varieties under flooding at 15cm

The growth rate of Titan and Rapan, two varieties with intermediate maturity, is clearly the same throughout the development phase. In the middle of the tillering phase, all the varieties have an appearance with no significant difference, under the two flooding conditions.

When varieties are growing under the conditions of lack of oxygen, they quickly develop in order to reach the upper level of the water and benefit from oxygen intake [19, 23]. When the varieties are growing in flooding conditions, the constraints they undergo lead to a decrease in the photosynthetic capacity [19]. Similar situation is observed in our experiments. These statements lead us to conclude that the varieties with 5cm water layer are more developed at the end of the growing cycle. Further analyses, which are not the subject of this article, can give more information about the quality of grain produced under the two different regimes of flooding.

Considering the height of the varieties, our experimentation shows that at the full maturation all three varieties are 80 cm and 110 cm tall under the two different flooding conditions. Indeed, Arbalet had the height from 89 cm to

107 cm, Titan was 89 cm to 95,5 cm and Rapan was 80 cm to 88,5 cm tall (Table 1).

Table 1. Average height of studied rice varieties at the ripening stage

	5cm flooding plot		**15cm flooding plot**	
	Height	**Difference with standard**	**Height**	**Difference with standard**
Rapan (st)	86,59	0	81,6	0
Arbalet	104,28	+17,61	90,75	+9,15
Tutan	101,20	+14,69	93,63	+12,03
LSD_{05}	10,35		7,07	

Several authors proved that short height is a strategy of increasing the production [14, 20, 22]. The height average can lead us to classify our varieties as belonging to the type of the new variety recently created and named “New Plant” or “Super Rice”. Indeed, these new varieties have among others as adaptation characters, short height, and high degree of yielding. These new varieties, called deep water rice varieties, can remain short when the water is shallow and grow tall in response to increased water depths [20].

Ideotype breeding aimed at modifying plant architecture is a time-tested strategy to achieve increases in yield potential. Thus, the practice of short statured cereals like wheat, rice and sorghum leads to the results of doubling yield potential [14]. However, only the external characteristics of the plant alone are not enough to lead to a high yield. Variety itself has an important contribution (around 50 %) for yielding [20, 22, 23].

The comparison of the two flooding conditions shows that height of rice plants in 15 cm water layer plots are close to the same average when those in plots with 5 cm water layer are very different. The height of Arbalet and Titan is more appreciating under 15 cm flooding condition.

Correlation of Photosynthetic Parameters with the Growth of Rice Plants

The vegetative organs are strongly involved in the growth of a plant. In the case of the rice plant, in addition to the leaves, the young stem contributes to the photosynthesis process.

The following table 2 presents the average of sum of the area of the three last leaves at the end of the maturity. Under 5 cm flooding condition, the average area of leaves is important for Titan and is similar for Arbalet and Rapan. Under 15 cm flooding condition, Rapan is leading with an important area leaves.

Table 2. Average leaves area at full maturity (cm^2)

5cm flooding condition	Average leaves area at full maturity (cm^2)	Difference with the standard (st)		15cm flooding condition	Average leaves area at full maturity (cm^2)	Difference with the standard (st)
Arbalet y	124,56	-0,88		Arbalet z	116,51	-4,93
Titan y	138,33	+ 12,89		Titan z	110,67	-10,77
Rapan y (st)	125,44	0		Rapan z (st)	121,44	0

The following table 3 and 4 shows that there is correlation between height and leaf area.

Table 3. Correlation between height and leaf area at panicle initiation

Average height at panicle initiation under 5cm flooding condition	Average sum of leaf length on main stem, cm	Flag leaf area, cm^2	Sub flag leaf area, cm^2	3rd leaf area, cm^2		Average height at panicle initiation under 15cm flooding condition	Average sum of leaf length on main stem, cm	Flag leaf area, cm^2	Sub flag leaf area, cm^2	3rd leaf area, cm^2
Arbalet n	0,914**	0,913**	0,900**	0,943**		Arbalet f	0,904**	0,880**	0,909**	0,927**
Titan n	0,920**	0,968**	0,955**	0,897**		Titan f	0,933**	0,932**	0,942**	0,956**
Rapan n	0,839**	0,857**	0,853**	0,863**		Rapan f	0,890**	0,912**	0,836**	0,886**

Table 4. Correlation between height and leaf area at full maturity

Average height at full maturity under 5cm flooding condition	Average sum of leaf length on main stem, cm	Flag leaf area, cm^2	Sub flag leaf area, cm^2	3rd leaf area, cm^2		Average height at fully maturity under 15cm flooding condition	Average sum of leaf length on main stem, cm	Flag leaf area, cm^2	Sub flag leaf area, cm^2	3rd leaf area, cm^2
Arbalet n	0,914**	0,913**	0,900**	0,943**		Arbalet f	0,639**	0,695**	0,607**	0,677**
Titan n	0,920**	0,968**	0,955**	0,897**		Titan f	0,601**	0,628**	0,601**	0,597**
Rapan n	0,839**	0,857**	0,853**	0,863**		Rapan f	0,554**	0,595**	0,381*	0,496**

**. The correlation is significant at 0.01 (bilateral)

*. The correlation is significant at 0.05 (bilateral)

These tables show that for all varieties, the average height and the leaf area under two different flooding conditions are highly correlated. But Titan shows the best result under 15 cm flooding condition. If we can combine the results of height and the correlation between the height and photosynthetic organs, we can conclude that Titan can easily grow under 15 cm flooding condition.

Further yield analysis could prove that statement.

Conclusion

This article shows that:

1. All the three varieties can easily grow under 15 cm flooding conditions. Under that condition, they can develop all organs need for producing yield.

2. The average height of the three varieties is shorter which is one of the adaptations to lodging and producing high yield.

3. The comparison between the three varieties shows that Titan is more adapted for 15 cm flooding condition. It can be strongly recommended for breeding in the sanitarian areas.

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