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Rice Artificial Pollination (Crossing) Methods and Hybrid Seed Formation Indicators

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Abstract: This article presents the results of obtaining hybrid seeds through crossing (artificial pollination) in rice under Karakalpakstan conditions and evaluating their effectiveness. In the studies, "Sanam", "Guliston", "Javohir", "Brilliant" varieties and several lines were involved as female and male parents.

Crossing work was carried out according to IRRI (International Rice Research Institute) methodology: emasculation was performed before flowering, male pollen was applied manually, and panicles were isolated with bags. The results showed that the formation rate of hybrid seeds varied from 1.87% to 4.85% depending on combinations. The highest efficiency was observed in combinations "65-06-1 × Guliston" (4.85%) and "Javohir × Sanam" (4.67%). The obtained results are of great importance for creating hybrid populations in the future and serve as genetic material for creating high-yielding, quality rice varieties.

Keywords: Rice, crossing, IRRI methodology, hybrid seed, breeding, combination efficiency.

Introduction: Rice (Oryza sativa L.) is considered one of the most important grain crops ensuring human food security worldwide. Today, rice is grown in more than 160 countries globally, with cultivated area exceeding 165 million hectares and annual gross yield surpassing 750 million tons. In the Republic of Uzbekistan, including the Republic of Karakalpakstan, rice cultivation occupies an important place in agricultural sectors. Rice cultivation areas and product quality in the region are of strategic importance in meeting people's needs and strengthening food security.

The Republic of Karakalpakstan is distinguished by its harsh continental climate. According to recent observations (2022-2024), the average air temperature in winter months is around -3.1°C, while in summer months it reaches values above +30°C. The annual average air temperature ranges between 14.0-14.9°C.

Precipitation in the region is very low, amounting to 50-135 mm throughout the year, which makes agriculture, especially rice cultivation, completely dependent on irrigation water. The main part of precipitation falls in spring and autumn months, while there is almost no precipitation in summer.

Air relative humidity also varies sharply across seasons: it reaches 70-80% in winter, but drops to 25-30% in summer. This condition causes strong transpiration processes in plants and severely tests rice's stress tolerance level.

Soil conditions consist mainly of alluvial-meadow and saline soils, with mechanical composition varying from medium sand to heavy sand. Secondary salinization and high groundwater levels in irrigated areas are among the main limiting factors in rice cultivation.

Therefore, in rice breeding research conducted under Karakalpakstan conditions, creating promising initial materials embodying early maturity, salinity and drought tolerance traits is an urgent task.

One of the most important stages of the breeding process in creating new rice varieties is crossing (artificial pollination, hybridization). Through crossing,

it becomes possible to combine positive traits and characteristics from different genetic sources and form new genotypes. Particularly, this method's role is invaluable in improving high productivity, large grain size, technological quality indicators, and resistance to diseases and stress factors.

Crossing is considered one of the main methods for creating new varieties in rice breeding. Extensive research on rice hybridization has been conducted worldwide. In particular, methodologies developed by IRRI (International Rice Research Institute, Philippines) specialists have been adopted as international standards today, enabling efficient implementation of emasculation, pollination and isolation processes (1).

Crossing methods in rice have also been extensively studied in the Russian breeding school. E.A. Avrorov, P.F. Rokitskiy, I.F. Lapin and their followers developed methodologies based on various mechanical and thermal methods for rice breeding, which were later aligned with IRRI methodology (2).

Literature indicates that the efficiency of hybrid seed formation as a result of inter-crossing rice varieties is usually in the range of 2-6%, and in some cases this indicator can achieve higher results (3, 4).

In research conducted on rice breeding under Karakalpakstan conditions, adapting the international IRRI methodology to local conditions, identifying promising combinations and creating hybrid populations based on them is considered an urgent scientific task.

Objectives: To obtain hybrid seeds through crossing rice varieties and lines and evaluate their effectiveness for creating promising initial samples that are early-maturing and resistant to the region's complex stress factors (salinity, high temperature, drought) under Karakalpakstan conditions. To study the effectiveness of emasculation and pollination methods in the crossing process. To determine the formation rate of hybrid seeds in various combinations. To select combinations showing the highest efficiency and designate them as initial material in breeding. To form genetic sources for creating promising hybrid populations embodying early maturity and stress resistance traits.

METHODS

To conduct hybridization work effectively, ensuring simultaneous flowering phases of female and male pairs is important. For this purpose, they were planted at two periods with 5-day intervals. When selecting male and female forms, special attention was paid to ensuring minimal levels of negative indicators.

Experiments were conducted under field conditions and in greenhouses, plants were planted sparsely in wide rows and cultivated under high agrotechnical conditions.

When maternal plants entered the initial flowering phase, panicles were thinned using scissors and 10-12 were left in the middle part. In the morning until 10:00, anthers in panicles were removed using tweezers (emasculation) and isolated with isolators and marked. Male form panicles were pollinated from 12:00 during the flowering period by rubbing their anthers on maternal stigmas. Subsequently, panicles were placed in water, covered with isolators and marked with labels.

In the studies, 100 panicles were used from each selected hybrid combination. Regionalized varieties "Sanam" and "Guliston" were used as testers in topcross method. Paternal and maternal lines participating in hybridization were previously studied under complex stress conditions (salinity, high temperature, drought) of Karakalpakstan, and forms showing high productivity were selected.

The research results showed that the formation rate of hybrid seeds ranged from 1.87% to 4.85% depending on combinations (Table 1). The highest efficiency was observed in combinations 65-06-1 × Guliston (4.85%) and Javohir × Sanam (4.67%). In some combinations, results were low, for example, in the D-55 (Brilliant) × Sanam combination, hybrid seeds constituted 1.92%.

These indicators correspond to data provided in international literature (Virmani, 1996; Khush, 2005), where it is noted that the formation rate of hybrid seeds in rice is usually in the range of 2-6%. Therefore, the obtained results show that the crossing process was effectively implemented under Karakalpakstan conditions.

Based on the results, combinations showing high efficiency can be used as an important genetic source for creating new breeding materials that are early-maturing and resistant to stress factors in the future.

Table 1

Crossing scheme for obtaining hybrid seeds and their results.

№	Hybrid combinations	Cut and pollinated flowers, pieces	Formed hybrid seeds, pieces	Seed formation percentage, %
1	36-98-4 × Sanam	106	3	2.83
2	8-04-8 × Sanam	100	2	2.00
3	D-55 (Brilliant) × Sanam	104	2	1.92
4	Javohir × Sanam	107	5	4.67
5	D-129 (D-178) × Sanam	100	4	4.00
6	K-5320 × Guliston	107	2	1.87
7	D-134 (D-139) × Guliston	102	4	3.92
8	sel. 203 × Guliston	105	3	2.85
9	65-06-1 × Guliston	103	5	4.85

CONCLUSION

As a result of research conducted on crossing (hybridization) rice varieties and lines under Karakalpakstan conditions, the formation rate of hybrid seeds ranged from 1.87-4.85% depending on combinations. The highest results were observed in combinations 65-06-1 × Guliston (4.85%) and Javohir × Sanam (4.67%), which are recommended as promising combinations for subsequent breeding stages. In some combinations, efficiency was low, for example, in the D-55 (Brilliant) × Sanam combination, this indicator was 1.92%. This shows that crossing efficiency is directly dependent on the genetic compatibility of parental lines and agroecological conditions. The obtained results correspond to international scientific data (Virmani, 1996; Khush, 2005) and confirmed that the formation rate of hybrid seeds in rice is usually in the range of 2-6%. The promising combinations identified as a result of crossing work serve as an important genetic source for creating new breeding materials that are early- maturing and resistant to stress factors under Karakalpakstan conditions.

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