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Breeding for superior quality and better adaptability in rice (*Oryza sativa* L.)

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ABSTRACT

In order to blend the quality characters with high yield, IR 30 was crossed with Basmati 370 and pedigree breeding method was followed up to F_{10}^{th} generation and 18 stable recombinant inbred lines (RILs) were developed. They were evaluated along with two local popular high yielding varieties i.e., Satabdi (IET 4786) and Khitish (IET 4094) as check during kharif 2009 and boro 2009-2010. Five lines showed ≥ grain yield in comparison of standard checks. All the RILs showed early maturity (112-120 days) similar to the checks. Four lines possess strong pleasant aroma and among them two lines had grain yield equivalent to that of the checks. Nine lines possess extra-long slender grain (>7.5 mm grain length and > 3.0 L/B ratio) and rest of the lines belonged to long slender group (>6.5 mm grain length and > 3.0 L/B ratio).

Key words: Basmati rice, disruptive seasonal selection, extra-long slender grain, pleasant aroma, L/B ratio, recombinant inbred line

Rice production in India has almost trebled during the last fifty years but low yielding aromatic rice are the major casualty in green revolution. In order to meet the increasing demand for quality rice generated by the raised standard of living, the improvement of rice grain quality has became priority in rice breeding programmes. India produces some of the good quality rices known of this planet and Basmati rice is one of them. Among the Basmati rices which are mainly grown at the foothills of Himalaya is the best (Nene, 2003) and renowned for its exquisite quality characteristics, like strong pleasant aroma, high kernel length elongation after cooking, extra-long slender grain smooth and sweet to eating etc. but, yield of traditional Basmati varieties is as low as $1/3^{rd}$ of the semi-dwarf high yielding varieties (Sarial *et al.*, 2006). Physical properties of grain, like shape and size, mainly determine the market price of rice while aroma is highly preferred in middle-East and European countries that fetches premium from there. Thus, grain size and shape and as well as aroma were the principle criteria for quality improvement in rice. As the traditional basmati rice varieties are generally long duration and short day plant they can only be grown during *kharif* season as winter rice. However, disruptive seasonal selection in which segregating populations are raised in two contrasting seasons where large differences are existed in temperature, rainfall, humidity, day length etc. is an useful method for improving the general adaptability in autogamous crop, like rice (Oka, 1950). Keeping the above points in view, in the present investigation an attempt has been made to evolve high yielding extra-long slender aromatic rice with better adaptability at the Gangetic plains of West Bengal, following disruptive seasonal selection and utilizing elite Basmati rice cultivar in the breeding programme.

MATERIALS AND METHODS

Initially three high yielding varieties of rice *viz.*, *IR 30*, *Swarna* and *MTU 7029* were taken as female parent and crossed with Basmati 370 during *Kharif* 2001 at Regional Research Station (*Sub-Centre: Chakdaha*) of BCKV, Nadia, West Bengal. The experimental site was located at an elevation of 9.75m above mean sea level at 23^0 04′ N latitude and 88^0 31′ E longitude. The soil of the experimental field was typical Gangetic alluvium (Entisol) with clay loam texture, good water holding capacity and high fertility status. The area falls under sub-tropical humid climatic region. F_1' and F_2's were raised and evaluated during *Kharif* 2002 and *kharif* 2003, respectively. Due to lack of desirable plant types in the F_2 progenies of *Swarna* x *Basmati* 370 and *MTU* 7029 × *Basmati* 370 were discarded. Selection were made only among the F_2 progenies of *IR 30* × *Basmati* 370 cross derivatives based mainly on grain yield, earliness and grain shape i.e., grain length (L), grain breadth (B), grain L/B ratio. From the F_3 generation and onwards disruptive seasonal selection was practiced up to F_{10}^{th} generation among the early selected lines of the said cross derivatives. In disruptive seasonal selection, crop was raised in two contrasting seasons i.e. during *Kharif* season (June to December) as normal crop i.e., winter rice and during *boro* season (November-December to April) as summer rice. Finally, 18 stable recombinant inbred lines (RILs) were developed. They were designated as *Bidhan Moti* 1, *Bidhan Moti* 2, *Bidhan Moti* 3 etc. to *Bidhan Moti* 18 respectively. They were evaluated along with two popular high yielding varieties i.e. *Satabdi* (*IET 4786*) and *Khitish* (IET 4094) as local check during *Kharif* 2009 and *boro* 2009-2010 in randomized block design with two replications. Each entry consisted of 10 lines of 5m length. Normal agronomic practices were followed to obtain a good harvest. Observations were recorded on six characters *viz.* aroma, days to maturity, grain length (mm), grain

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breadth (mm), grain L/B ratio and grain yield. The aroma of rice grains were determined by a sensory evaluation panel according to the method of Sood and Siddiq (1978) with minor modification as made by Amarawati *et al*. (2008). Grain yield was recorded from each plot in Kilograms and converted to tones per hectare. Pooled data over two seasons were statistically analyzed against the biometrical characters.

RESULTS AND DISCUSSION

Analysis of variance showed highly significant differences among the RILs against the biometrical characters studied (Table 1). Pollen parent, Basmati 370 is the first pure line selection of Basmati rice developed at Kala Shah Kaku in erstwhile Punjab and released in 1933 for cultivation. It proved to be the most valuable traditional quality rice for export and stood up as a hallmark for basmati quality (strong pleasant aroma, long slender grain, nearly 7mm grain length and grain breadth of 1.86mm and very high linear kernel length elongation after cooking). In this regards, Sharma *et al*. (2008) reported the performance of Basmati 370 for grain yield 2.75 t ha^{-1}, 124.5 days to flowering, 165 cm plant height, 6.82 mm kernel length, 1.85 mm kernel breadth, 3.68 L/B ratio and 1.81 kernel length elongation ratio after cooking from their experiment on fine grained aromatic rice. Therefore, being tall, long duration, susceptible to lodging and disease or pest attack, it is ultimately poor yielder. On the contrary the female parent, IR 30 is a dwarf, high yielding, medium duration variety that possesses resistance against number of pests and diseases. All the RILs and check varieties were belonged to early maturity group (112-120 days). Four lines *viz*. *Bidhan Moti* 2 (Fig. 1), *Bidhan Moti* 4, *Bidhan Moti* 5 and *Bidhan Moti* 7 possessed strong pleasant aroma, nine lines i.e. *Bidhan Moti* 3, 6, 8, 9, 11, 13, 16, 17 and 18 had moderate aroma and rest of the lines had weak aroma. Large variation was observed for grain length, the minimum value being 6.50 mm in *Bidhan Moti* 18 and maximum value in *Bidhan Moti* 1 (Fig. 2, 8.82 mm) followed by *Bidhan Moti* 16 (8.68 mm), *Bidhan Moti* 7 (8.64 mm) and *Bidhan Moti* 13 (8.56 mm) respectively. Nine genotypes *viz*., *Bidhan Moti* 1, 2, 3, 4, 5, 8, 12, 13 and 17 had extra-long grain (> 7.5 mm) while rest of the genotypes, excepting *Bidhan Moti* 14 and 18, were belonged in long grain (6.61-7.5 mm) group.

Table 1: Mean performance of some recombinant inbred lines of rice

Lines	Aroma	Days to Maturity	Grain length (mm)	Grain breadth (mm)	L/B ratio	Grain yield (t ha^{-1})
Bidhan Moti-1	WS	113	8.82	1.78	4.95	4.5
Bidhan Moti-2	SS	114	8.00	1.74	4.60	4.2
Bidhan Moti-3	MS	114	7.86	1.76	4.47	4.0
Bidhan Moti-4	SS	115	7.77	1.74	4.46	4.5
Bidhan Moti-5	SS	115	7.60	1.82	5.17	4.4
Bidhan Moti-6	MS	115	6.53	1.84	3.55	2.7
Bidhan Moti-7	SS	113	8.64	1.66	5.20	4.1
Bidhan Moti-8	MS	120	6.68	1.65	4.05	2.5
Bidhan Moti-9	MS	120	6.84	1.78	3.84	2.4
Bidhan Moti-10	WS	116	7.42	1.80	4.12	2.7
Bidhan Moti-11	MS	113	7.04	1.94	3.63	4.1
Bidhan Moti-12	WS	112	7.90	1.76	4.49	4.9
Bidhan Moti-13	MS	116	8.56	1.76	4.86	4.5
Bidhan Moti-14	WS	112	6.54	1.64	3.99	2.9
Bidhan Moti-15	WS	112	6.86	1.72	3.99	2.5
Bidhan Moti-16	MS	113	8.68	1.80	4.82	4.0
Bidhan Moti-17	MS	113	6.80	1.74	3.91	2.5
Bidhan Moti-18	MS	113	6.50	1.86	3.49	3.1
IET 4786	NS	110	6.74	1.80	3.74	4.2
IET 4094	NS	113	6.68	1.88	3.55	4.4
Mean	**-**	**115**	**7.42**	**1.77**	**4.21**	**3.6**
LSD(0.05)	**-**	**4.38**	**0.37**	**0.12**	**0.40**	**1.4**

Note: SS = Strongly scented, MS = Moderately scented, WS = Weakly scent, NS= Non – scented

Grain breadth, one of the important features of rice which is most vital for the market price, showed comparatively lesser degree of variation in comparison to other characters. All the tested genotypes had less than 2 mm grain breadth that conformed with the *Basmati* rice. *Bidhan Moti* 14 recorded the minimum value (1.64 mm) for grain breadth followed by *Bidhan Moti* 8 (1.65 mm), *Bidhan Moti* 7 (1.66 mm) and *Bidhan Moti* 5 (1.72 mm) respectively. The L/B ratio that determines the grain shape was very high in all the genotypes. Highest L/B ratio was observed in *Bidhan Moti* 7 (5.2) followed by *Bidhan Moti* 1 (4.95), *Bidhan Moti* 13 (4.86), *Bidhan Moti* 17 (4.82) and *Bidhan Moti* 2

(4.6) respectively. The check varieties i.e., Satabdi and Khitish recorded the L/B value of 3.74 and 3.55 in this regard. All RILs except three *viz. Bidhan Moti* 6, 11 and 18 showed superior performance in respect of L/B ratio over the check varieties.

The genotypes varied considerably in the performance of grain yield. More than half of the recombinant lines (10) recorded a grain yield of 4 t ha^{-1} or more. Four lines *viz. Bidhan Moti* 12, 13, 1 and 4 showed superior performance over the check varieties. Other seven lines viz. *Bidhan Moti* 2, 3, 5, 7, 11, 17 and 18 were at par with the better check variety in this regard.

Photoperiod insensitivity and heading time (flowering time) which are mainly accountable for the crop growth duration are the principle characters that determine the regional and seasonal adaptation of crop varieties (Sato *et al*., 1988). A large number of loci (23) are involved for controlling the heading time in rice (Nishida *et al*., 2001) and seven quantitative trait loci have been reported for the same also (Yano *et al*., 1997; Yamamoto *et al*., 2000). Due to recombination and different kinds of interactions among the heading time genes, photoperiod sensitivity gene (Se5) and earliness genes, the RILs become early and photoperiod insensitive. Disruptive seasonal selection has made RILs equally adapted to *kharif* as well as *boro* seasons. Aromatic rice varieties differ in their degree of aroma and are broadly classified as strongly, moderately and weakly scented types (Singh *et al*., 2003). Indian consumers value aroma most (Singh and Singh, 1997) and it fetches premium in middle-East (Shobharani and Singh, 2003). Physical properties like grain shape and size mainly determine market acceptability

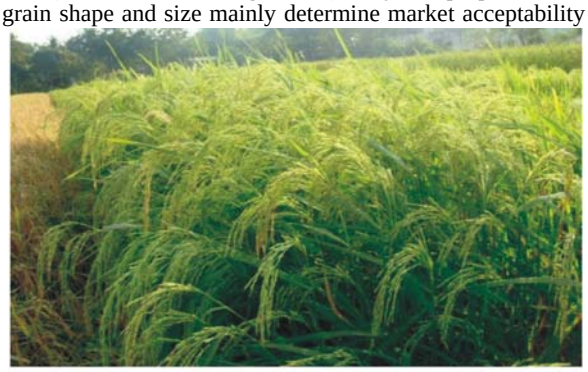

Fig. 1. A field view of *Bidhan Moti* 2

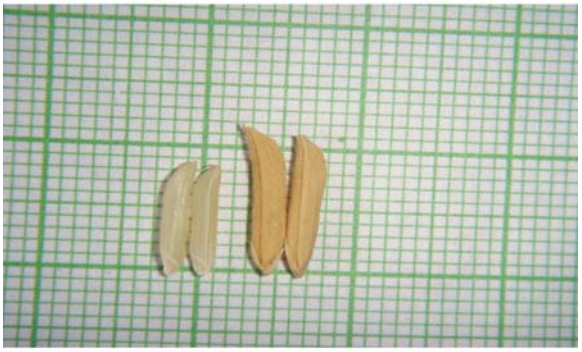

Fig. 2. Grain and brown rice of *Bidhan Moti 1*

of rice. In the present investigation, *Bidhan Moti* 1, 4, 12 and 13 have proved their superiority over check varieties in respect to grain yield, grain length, grain L/B ratio and aroma content. *Bidhan Moti* 2, 4, 5 and 7 possessed strong pleasant aroma and showed superiority over controls in respect to grain length and grain L/B ratio, where as their grain yield performance were at par with the check varieties.

From the present investigation, it has been revealed that the four recombinant lines i.e. *Bidhan Moti* 2, 4, 5 and 7 were the strongly scented rice and possessed extra long slender grain with average yield potentiality higher than 4 t ha^{-1}. More over, they were belonged to the early maturity group thus they could effectively be grown during *boro* and *Kharif* season. Therefore, these promising lines of rice can meet the long standing demand of high yielding quality rice in the Gangetic plains of West Bengal.

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