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Full Length Research Paper

A valuable source of productivity and earliness traits for the rainfed upland rice breeding program, WAB-450

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This study focused on evaluation of introgressed population for earliness in flowering and productivity under rainfed upland rice ecosystem. The population was derived from inter-varietal cross between early maturing Africa upland land rice *WAB-450*, an inter-specific derivative as donor and *Swarna*, a mega rice variety from India, as recurrent parent. One hundred and eighty eight (188) backcross inbred lines (BILs) with the two parents were evaluated during *kharif* 2011 at Mugad Agricultural Research Station (ARS), University of Agricultural Sciences Dharwad. The BILs showed significant improvement over *Swarna* for earliness in flowering and productivity under natural rainfed condition. The frequency distribution of days to 50% flowering observed in this study showed continuous variation. The distribution was normal indicating inheritance of a quantitative trait and influence of *WAB-450* genome contribution in one backcross in the expression of this trait. The BILs which flower between 90 and 100 days and mature around 120 to 135 days with high yield coupled with other desired traits such as grain quality have been identified for upland rice ecosystem.

Key words: Backcross inbred lines, *WAB-450*, population, flowering.

INTRODUCTION

Rice has a series of species and wild relatives that can be used to address specific breeding problems such as tolerance to biotic and abiotic stresses. However, one of the main limitations on the use of wild relatives in breeding programs is the lack of cross-ability between species due to chromosomal and genetic differences. One alternative to overcome these sexual barriers is to use embryo rescue and protoplast fusion, which are simple biotechnology techniques that have been used successfully in rice. Fertile cultivated rice *Oryza sativa* and *Oryza glaberrima* progenies were obtained through backcrossing and double haploid production by Jones et al. (1997). The NERICA varieties provide a good example of how these techniques were used to help address some specific breeding objectives.

Long before Asian rice (*O. sativa*) reached Africa's shores, local farmers had domesticated a local species to develop African cultivated rice (*O. glaberrima*). The domestication of *O. glaberrima* took place 3,500 years ago (Porteres, 1955). Thus, its local ancestry and numerous generations of selection *in situ* have made *O. glaberrima* well adapted to the African environment. On the other hand, *O. sativa* especially the Green Revolution semi dwarf varieties has been bred for intensive production and high yield, but outside of the African continent. The first Asian varieties arrived in Africa about 450 years ago, and they have subsequently replaced the local species in much of the rice-cultivated area (WARDA, 2001).

The Africa cultivated rice (*O. glaberrima*) is adapted to the African environment, but prone to lodging and grain shattering (Koffi, 1980; Jones et al., 1997; Dingkuhn et al., 1998). The Asian cultivated rice (*O.sativa*) is high yielding, but susceptible to the stresses of African ecologies (WARDA, 2001). Rice breeders had long since dreamed of combining the best traits of the two species, but previous attempts had failed, as the resulting offspring were all sterile. In the early 1990s, WARDA breeders turned to biotechnology in an attempt to overcome the infertility problem. The breakthrough came from embryo-rescue technique and anther culture; a new plant type was developed from almost sterile resultant plant by several backcrosses with the *sativa* parent. Embryo rescue technique was employed to obtain viable segregating populations (Jones et al., 1997). Since then, the techniques have been refined and streamlined, so that many new lines are generated each year; for example *WAB-450* progeny was developed from crosses of the existing released variety CG 14 (*O. glaberrima* Steud.) and *WAB56-104*, which belong to the subspecies japonica of *O*. *sativa* L., an upland improved variety (Somado et al., 2008).

Major advantageous traits from *glaberrima* that occur in some progenies of the new plant type are: early maturity, drought tolerance, resistance to diseases especially African rice gall midge, rice yellow mottle virus and blast disease. Other desirable characters include good taste, aroma and other grain qualities favored by farmers. Meanwhile, the *sativa* parents have also given their best to the *WAB-450*: non-shattering grains, good tillering and high yielding. *WAB-450* has a yield advantage over their *O. glaberrima* and *O. sativa* parents, and superior in earliness, weed competitiveness, drought tolerance, and pest or disease resistance (Africa Rice, 2011). The introgression of *WAB-450* genome in elite background could impart earliness, stress tolerance and productivity related traits thus the present investigation was undertaken to identify the introgression line with early maturity and higher yield suitable to rainfed upland condition.

MATERIALS AND METHODS

The investigation was carried out under natural rain situation at Agricultural Research Station (ARS) Mugad, University of Agricultural Sciences Dharwad, India. The Research Station is located at latitude of 15°15' North and longitude of 70°40' East and altitude of 695 m above mean sea level (MSL) belonging to Agro-climatic zone No. 8 of Karnataka State. The average rainfall of the Research Station is 1016.20 mm in 75 rainy days distributed mainly during *kharif* (June to October) season. Breeding material for this study is backcross population (BC_1F_6) developed in India by Barwale Foundation in Hyderabad using *WAB-450*, an inter-specific derivative as donor and *Swarna*, a mega rice variety in India, as recurrent parent. The population (188 BC_1F_6 lines) along with the two parents (*Swarna* and *WAB-450*) were evaluated under natural rainfed ecosystem for flowering duration and productivity in randomized block designs during *Kharif* 2011. Recommended agronomic practices were dully followed for raising a good and healthy crop using Package of practices for Paddy developed by University of Agricultural Sciences, Dharwad (UAS Dharwad, 2009). Data was taken and analyzed using simple analysis of variance (ANOVA) to determine the mean performance of the backcross inbred lines (BILs) and parents for days to 50% flowering and productivity traits.

RESULTS AND DISCUSSION

The ANOVA in respect of all the characters studied in BILs derived from a cross between *Swarna* × *WAB-450* indicate highly significant genotypes' mean sum of square (GMSS) for genotypes indicating wide genetic differences for all productivity traits studied besides days to 50% flowering and maturity (Table 1). Heritability (h^2) of traits like days to 50% flowering, days to maturity, plant height, productive tillers and spikelet fertility are higher, while it is moderate for other traits like grain yield, grain weight and harvest index (Table 1). Whereas heritability measure the portion of parent that is passed on to the progeny genetic advance (GA) is the amount of genetic gain resulting from the crossing of the two parents; the two genetic parameters (h^2 and GA) are useful indices of selection for desirable traits: the higher the heritability and GA of traits, the more effective the direct selection for that trait. The mean of BILs for days to 50% flowering, maturity as well as important productivity traits was intermediate, while the frequency distribution is normal distribution for days to 50% flowering. This may be due to higher dose of *WAB-450* genome resulting from one backcross.

The frequency distribution of days to 50% flowering in BILs shows a continuous distribution curve of a quantitative trait with a clear divergence between the two parents *WAB-450* and *Swarna.* In this study, 50% flowering of *WAB-450* was 82.5 days, while that of *Swarna* was 112 days. Days to 50% flowering data for the 188 BILs range between 82.5 and 125 (Figure 1). The mode of BILs distribution for this trait was a normal distribution; this suggest a possible conclusion that days to 50% flowering is under the control of relatively large number of genetic factors, each having relatively small effect. The range of BILs variation was apparently wider than the parental difference in the BC_1F_6 populations; similarly, the difference between BILs means and the parental means is significant. According to Swain et al. (2010), *Swarna* is a long duration lowland rice variety which matures in 150 days. *WAB-450* on the other hand is short duration varieties that mature between 95 to 100 days in tropical Africa upland ecosystem (Africa Rice, 2011). BILs developed from these two parents are expected to express a great deal of variability

Table 1. ANOVA for earliness in flowering and productivity related traits.

Trait	Genotype MSS	Error MSS	h^2	GA
Days to 50% flowering	101.109**	13.9	75.9	11.4
Days to maturity	136.635**	12.8	82.1	11.0
Plant height (cm)	97.81**	10.1	81.2	15.0
Number of tillers	9.04405**	1.2	76.9	29.0
Number of productive tillers	7.01845**	1.3	69.2	25.0
Panicle length (cm)	5.71549**	1.3	63.5	11.8
Panicle weight (g)	0.770921**	0.2	53.6	25.8
grain number per panicle	1381.07**	527.7	44.7	21.5
Grain weight per panicle	0.545154**	0.2	52.3	22.3
Spikelet fertility (%)	169.602**	24.7	74.6	18.0
Yield per plant	245.733**	52.8	64.6	43.0
Harvest index	32.2568**	10.7	50.3	11.9

**, Significant at 0.01 probability.

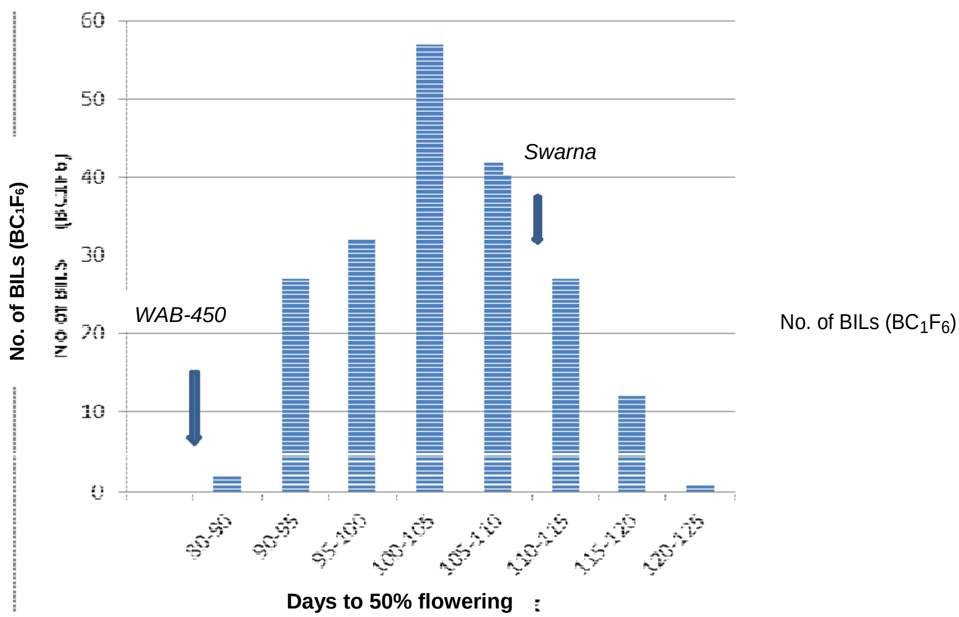

Figure 1. Frequency distribution of BILs at 50% flowering.

of variability as a result of intra- and inter-allelic interaction. The expression of transgressive segregants in this study was found to be skewed toward *Swarna* more than *WAB-450*; this may be due to larger genome contribution from *Swarna* which was used as the recurrent parent in the backcross programme. We can deduce from here that inter varietal crosses of *WAB-450* used as donor on *Swarna* background will result in recombinants with more of *Swarna* genome.

Percentage superiority over donor and recurrent parent in earliness to maturity and productivity under rainfed upland condition indicated that a number of BILs performed better than the two parents (Table 2). Some BILs were found to have superiority of 11.4 to 18.8% above *Swarna* and 5.4 to 30.7% above *WAB-450*. This may be due to expression of favorable alleles coming from the two parents; interaction between alleles or with the environment can result in better expression of trait in segregating population.

Conclusion

In this study**,** *WAB-450* contributed alleles for earliness in flowering and maturity. A number of promising BILs were identified based on productivity under rainfed upland condition and mature in 122 to 133 days (at least 8 to 10 days early). Top performing BILs namely BIL-149, BIL-

Table 2. Promising BILs derived from a cross between *Swarna* and *WAB-450* for earliness and yield under rainfed upland condition.

No. of BIL	Days to 50% flowering	Days to Maturity	Plant height (cm)	No. of panicle/plant	Panicle length (cm)	Panicle weight (g)	No. of grains/ panicle	Spikelet fertility (%)	Test grain weight	Harvest index (%)	Grain yield (kg/ha)	% superiority over	
												Swarna (Recurrent parent)	*WAB-450* (donor)
149	95.5	127.0	79.0	13.1	19.0	2.7	124.0	93.2	24.2	43.5	6904	18.8	30.7
188	108.5	130.0	86.4	11.3	21.9	3.3	127.1	79.5	25.3	43.8	6885	18.4	30.3
183	90.0	122.5	101.5	8.0	21.5	3.8	137.0	95.1	26.5	41.7	6848	17.8	29.6
150	107.0	133.5	84.0	10.9	22.5	4.1	140.8	70.9	23.2	40.4	6773	16.5	28.2
142	94.0	127.0	86.3	12.4	22.3	3.9	148.8	85.3	20.2	42.8	6624	13.9	25.4
60	109.5	138.0	83.1	13.8	21.6	3.4	136.8	78.4	22.0	41.5	6540	12.5	23.8
53	108.5	143.0	83.3	14.7	22.0	2.9	127.5	90.6	25.6	41.8	6494	11.7	22.9
6	104.5	127.0	80.9	15.3	20.9	2.9	99.7	63.8	22.7	45.5	6475	11.4	22.6
163	103.0	131.0	83.0	9.7	19.5	3.0	120.0	88.9	22.7	39.8	5823	0.2	10.2
5	109.5	143.0	88.8	11.9	23.5	3.4	141.4	80.4	20.3	44.5	5627	-3.2	6.5
118	103.0	127.0	80.7	12.0	19.7	2.6	115.8	90.9	22.4	40.0	5567	-4.2	5.4
174	94.5	127.0	81.2	10.8	20.7	2.2	95.7	94.0	25.3	42.3	5105	-12.2	-3.4
Parents													
Swarna	112.0	141.5	86.5	15.0	23.5	3.4	174.9	87.6	20.0	40.7	5813		
WAB-450	82.5	113.0	113.0	6.2	24.0	4.1	144.0	87.8	26.9	43.9	5283		
Mean of BILs	103.8	133.4	81.8	11.6	20.8	3.0	132.5	84.0	22.2	40.4	5165		
CD (5%)	7.3	7.0	6.3	2.2	2.2	1.0	45.3	9.8	3.2	6.4	1436		
CV (%)	4.0	3.0	4.0	10.0	5.0	16.0	17.0	6.0	7.0	8.0	18.0		

188, BIL-183 and BIL-150, BIL-142, BIL-60, BIL-53 and BIL-6 (Table 2) were found to be superior to recurrent parent *Swarna* (greater by 11%) and donor parent *WAB-450* (greater by 22%). These BILs which combined earliness and productivity could be evaluated in multi-location trials to assess the stability of these genotypes in target rainfed upland condition. These results clearly indicate the potentiality of *WAB-450* to contribute its genes for early maturity as well as productivity traits.

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