BREEDING SHORT GROWTH DURATION OF RICE DERIVED FROM A CROSS BETWEEN INDICA CULTIVAR IR24 (*ORYZA SATIVA* L.) AND *ORYZA RUFIPOGON* SPECIES

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Ngày gửi bài: 16.03.2013 Ngày chấp nhận: 22.11.2013

ABSTRACT

The cross between indica cultivar IR24 (*Oryza sativa* L.) and an accession of *Oryza rufipogon* Griff., was backcrossed to the recurrent parent (IR24) for four generations followed by repeated selfing and selection for short growth duration lines. A total of 19 backcross lines at BC_4F_5 generation were evaluated at spring crop seasons of 2011 in Ha Noi and 23 BC4F6 were further evaluated for agronomical traits in 2011 autumn cropping seasons in Hanoi, Thai Nguyen, and Lao Cai provinces. Among the introgression lines (IL), four lines (IL3-4-2-1-1, IL3-4-2-7-1, IL3-4-7-2 and IL19-4-3-8-2) showed shoter growth duration (10-12 days) than that of the recurrent parent IR24 and the control variety Khang dan 18 (10 -12 days), but grain yield was significantly higher than IR24 and Khang dan 18.

Keywords: Introgression, *Oryza rufipogon*, short growth duration, yield components.

Chọn tạo giống lúa ngắn ngày từ tổ hợp lai giữa giống lúa trồng IR24 và loài lúa dại *Oryza rufipogon*

TÓM TẮT

Trong nghiên cứu này, chúng tôi sử dụng phương pháp chọn lọc phả hệ để chọn các dòng ngắn ngày năng suất cao từ phép lai giữa giống lúa IR24 và loài hoang dại *Oryza rufipogon*. Kết quả đã chọn 19 dòng có mang đoạn nhiễm sắc thể loài hoang dại *Oryza rufipogon* được chọn đến thế hệ BC_4F_4. Qua đánh giá các dòng này trong vụ xuân năm 2011 tại Hà Nội và đã chọn được 23 dòng ở thế hệ BC_4F_5 . Các dòng BC_4F_5 được đánh giá các tính trạng nông sinh học trong vụ Mùa tại các tỉnh Thái Nguyên, Lào Cai và Hà Nội. Phân tích các tính trạng số lượng đã cho thấy, bốn dòng được ký hiệu là IL3-4-2-1-1, IL3-4-2-7-1, IL3-4-2-7-2, IL19-4-3-8-2có thời gian sinh trưởng ngắn hơn IR24 và Khang dân18 từ 10 đến 12 ngày, các yếu tố cấu thành năng suất đều cao hơn so với IR24 và Khang dân 18 ở tất cả các điểm thí nghiệm.

Từ khoá: Lai xa, lúa dại *Ogryza rufipogon*, thời gian sinh trưởng ngắn, năng suất hạt

1. INTRODUCTION

The introgression of genes from related wild species into cultivated germplasm via hybridization is important for the improvement of desirable traits of plants, with target genes, or quantitative trait loci (QTLs) controlling desirable characters (Tan *et al.* 2007; Cheema *et al.* 2008).

The wild rice relative, *Oryza rufipogon*, is believed to be the direct ancestor of *O. sativa* species (Morishima 1963, Oka 1974b, Second 1982), and widely distributed across Southeast Asia, Latin America, Australia and Africa. *O. rufipogon* is a valuable genetic resource to improve cultivated rice with desirable traits, such as QTLs for improving yield-related traits (Cheema *et al.* 2008), QTL for aluminium tolerance (Nguyen *et al.* 2003), and drought tolerance (Zhang *et al.* 2006). Therefore, utilizing desirable QTLs that control the

important agronomical traits from *O.rufipogon* is of crucial significance to cultivated rice breeding. A great deal of studies about this germplasm has been published (Tian *et al.* 2005, Tan *et al.* 2007).

Genetic resource of *Oryza sativa* is very rich and widely distributed, but concentrated in Asian countries. The process of domestication and breeding by man reduces the genetic variability of cultivated rice. In addition, large areas planted to a single or a few cultivars with a similar or narrow genetic background may lead to vulnerability to pests.

Heading date is an important trait for adaptation to different growing areas and cropping patterns. Therefore, geneticists and breeders have been concentrating to investigate this trait. However, heading date is a complex trait in rice because it is controlled by multiple genetic factors and largely affected by environment, such as temperature and day length. To date, 13 heading date genes have been identified so far (Lin *et al.* 1998, Lin et al. 2002, Yamamoto *et al.* 2000) and these genes are very useful in rice improvement. In practice, the short growth duration varieties have proved to be effective for crop rotation. Objectives of present study were to evaluate the short growth duration lines derived from a cross between an *indica* cultivar IR24 and wild relative of rice *O. rufipogon* for their agronomic traits in different eco-systems.

2. MATERIALS AND METHODS

Line development: The BC_4F_3 seeds derived from a cross between IR24 (recurrent parent) and *O. rufipogon* (donor parent) introduced from Japan were self-pollinated to generate BC_4F_4 seeds. Based on phenotypic data, 19 inbred lines (IL) BC_4F_4 generation, IL3-4-2-1, IL3-4-2-5, IL3-4-2-6, IL3-4-2-7, IL3-4-2-8, IL3-4-2-9, IL3-4-2-10, IL3-4-3-2, IL3-4-3-8, IL3-4-3-10, IL19-4-3-1, IL19-4-3-2, IL19-4-3-3, IL19-4-3-4, IL19-4-3-5, IL19-4-3-6, IL19-4-3-7, IL19-4-3-8 and IL19-4-3-10 were selected. They were planted with the check variety IR24 and popular variety Khang dan 18 (KD18) in Ha Noi University of Agriculture in 2011 spring season After evaluating the growth duration and agronomical traits based on data collected from ten individuals each line, 23 lines (BC_4F_5) were selected for further evaluation in Ha Noi, Thai Nguyen and Lao Cai in 2011 autumn season.

Phenotypic evaluation: In all experiments, the selected lines were arranged without replication; the control variety was planted in every 10 lines, fifteen plants per row, with 20 cm between and within rows. At the heading time, ten plants of each line were recorded when the first panicle emerged. At harvesting time, ten plants in second row of each line, excluding border plants were selected to evaluate grain yield and related traits including the number of panicles per plant, number of grains per panicle and percentage of filled grain rate. The final grain yield and yield components were taken as the mean of ten individuals and these mean values were used for subsequent analyses.

3. RESULTS

Growth duration: The growth duration of the BC_4F_4 lines in spring season varied between 128 and 134 days, shorter than IR24 (136 days) and much shorter than Khang dan 18 (142 days) (Fig. 1). In BC_4F_5 lines grown in autumn season, the growth duration of the lines ranged from 97 to 101 days, 94-98 days and 94-97 days in Ha Noi, Thai Nguyen and Lao Cai provinces, respectively (Fig. 2). All of the 23 BC_4F_5 lines showed growth duration of 10 to 12 days shorter than that of IR24 at three sites in 2011 autumn cropping season. It is notable, that in Lao Cai the growth duration of the lines was the shortest, it might be the effected by mountainous condition.

Plant height: The average plant height of the BC_4F_5 lines was higher than that of recurrent parent IR24 but shorter than that of KD18 (Table 1). Interestingly, the plant height of these lines in autumn season was different between three sites, with highest value in Ha

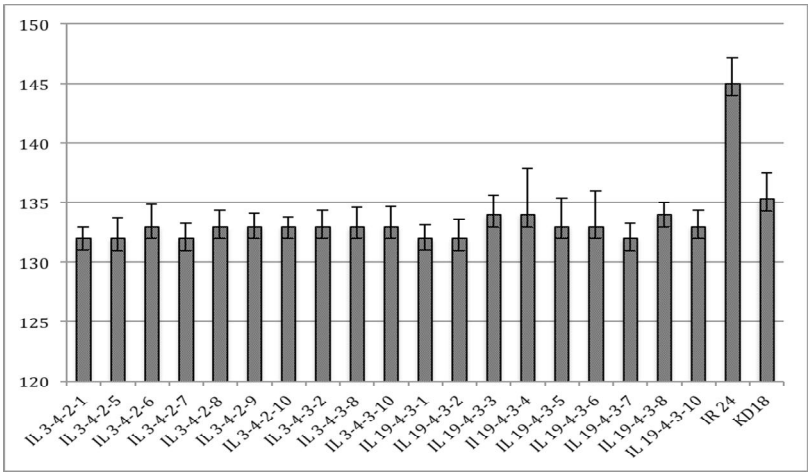

Figure 1. Growth duration of 19 selected BC_4F_4 lines, IR24 and KD18 in 2011 spring season in Hanoi site (vertical bars indicate standard error)

Table 1. Agronomical traits of selected lines (BC_4F_4) and check varieties at Ha Noi in 2011 spring cropping season

Line	Plant height (cm)	Number of panicles hill^{-1}	Number of filled grains panicle^{-1}	Percentage of filled grain (%)	1000-grain weight (g)	Grain yield (g hill^{-1})
IL 3-4-2-1	107.9	6.1	248.5	92.5	18.3	25.1
IL 3-4-2-5	108.0	6.9	250.5	92.2	18.5	24.0
IL 3-4-2-6	106.1	7.0	263.3	91.8	20.1	25.3
IL 3-4-2-7	108.7	6.7	253.5	94.3	18.6	23.4
IL 3-4-2-8	106.4	7.4	261.2	90.2	19.4	32.0
IL 3-4-2-9	108.0	7.4	247.1	92.7	20.4	28.0
IL 3-4-2-10	107.7	7.5	260.7	93.2	18.9	27.3
IL 3-4-3-2	108.0	8.2	259.7	94.6	19.2	26.2
IL 3-4-3-7	107.2	8.8	275.9	95.5	19.1	28.8
IL 3-4-3-8	108.8	7.8	272.7	90.7	18.2	32.9
IL 3-4-3-10	110.2	6.5	260.3	92.3	18.8	28.4
IL 19-4-3-1	107.9	6.7	256.4	88.6	19.2	24.3
IL 19-4-3-2	108.7	6.5	247.3	87.4	18.8	25.2
IL 19-4-3-3	109.3	7.2	243.1	90.0	18.7	22.2
Il 19-4-3-4	110.7	7.3	274.0	88.5	18.5	23.4
IL 19-4-3-5	108.7	7.9	237.1	89.8	19.0	29.5
IL 19-4-3-6	108.1	9.0	250.2	92.2	18.3	30.5
IL 19-4-3-7	109.2	7.1	245.6	87.6	20.1	25.3
IL 19-4-3-8	106.6	6.3	240.7	86.1	19.9	24.3
IL 19-4-3-10	109.5	8.1	256.1	85.2	18.2	27.5
Average	*108.3*	*7.3*	*255.2*	*90.8*	*19.0*	*26.7*
KD18	115.5	9.3	225.6	90.1	20.0	25.5
IR24	94.0	9.2	133.0	78.4	26.2	21.0
CV%	*1.8*	*11.6*	*10.1*	*4.5*	*1.1*	*1.1*

Table 2. Agronomical traits of selected lines (BC_4F_5) and check varieties in 2011 autumn season

	Ha Noi					Thai Nguyen					Lao Cai				
Line	Plant height (cm)	Number of panicles hill^{-1}	Number of filled grains panicle^{-1}	1000-grain weight (g)	Grain yield (g hill^{-1})	Plant height (cm)	Number of panicles hill^{-1}	Number of filled grains panicle^{-1}	1000-grain weight (g)	Grain yield (g hill^{-1})	Plant height (cm)	Number of panicles hill^{-1}	Number of filled grains panicle^{-1}	1000-grain weight (g)	Grain yield (g hill^{-1})
IL 3-4-2-1-1	104.9	6.0	176.9	18.3	19.47	89.0	8.6	144.9	19.2	23.6	84.6	8.8	129.5	18.3	20.9
IL 3-4-2-1-2	102.2	5.7	155.0	18.6	16.58	86.4	9.7	143.4	17.8	23.6	86.5	7.6	98.4	18.2	13.7
IL 3-4-2-1-3	101.2	5.3	180.5	18.6	18.15	85.6	8.0	101.9	35.2	18.8	94.2	7.3	109.9	18.3	14.7
IL 3-4-2-5-1	105.8	5.6	160.2	18.4	16.76	87.5	7.8	124.4	19.8	18.9	98.3	6.6	144.5	17.7	17.7
IL 3-4-2-5-2	100.8	5.7	157.1	18.6	16.76	87.7	8.8	134.5	18.9	22.1	98.4	7.1	130.8	18.4	17.0
IL 3-4-2-5-3	104.5	5.8	163.7	18.2	17.25	88.8	6.8	158.9	18.6	20.1	98.8	6.2	155.6	17.9	17.2
IL 3-4-2-7-1	105.0	6.2	162.0	18.2	18.04	84.0	9.8	127.4	18.0	22.8	102.4	6.5	148.3	18.0	17.3
IL 3-4-2-7-2	106.7	6.2	187.7	18.5	21.25	84.2	8.1	136.9	19.3	20.7	100.2	6.9	143.2	18.5	18.2
IL 3-4-2-7-3	103.2	5.9	161.7	18.5	17.63	84.5	7.7	121.0	19.7	18.1	99.4	6.9	134.4	18.9	17.2
IL 3-4-3-2-1	102.4	6.4	154.3	17.9	17.52	80.4	8.9	142.3	18.7	23.8	97.8	7.3	128.9	19.1	17.6
IL 3-4-3-2-2	105.5	6.3	168.0	18.6	19.57	84.3	8.8	103.0	19.9	18.1	97.0	6.4	133.7	19.1	16.4
IL 3-4-3-2-3	101.8	5.3	163.0	18.9	15.95	85.4	9.0	149.8	19.3	26.0	86.3	7.8	121.7	18.7	17.7
IL 3-4- 2-8-1	104.2	5.6	172.5	18.2	17.25	85.7	9.3	140.7	19.4	25.3	94.4	5.9	124.6	18.2	13.4
IL 3-4- 2-10-1	99.7	5.5	164.4	18.1	16.62	86.3	7.4	119.8	19.6	17.3	92.8	6.6	128.5	17.7	15.0
IL 19-4-3-1-1	103.3	6.0	143.6	18.3	15.29	85.7	9.6	118.8	19.3	21.8	98.6	8.2	138.9	19.2	20.6
IL 19-4-3-1-2	102.9	5.6	151.6	17.9	14.53	87.9	9.8	125.2	18.8	23.1	99.2	6.6	131.2	18.3	15.8
IL 19-4-3-1-3	101.1	5.1	164.0	17.9	14.90	86.4	8.7	137.0	19.9	23.8	96.4	7.4	114.4	18.2	15.1
IL 19-4-3-1-4	104.2	5.9	153.6	18.0	16.01	82.2	10.4	141.3	19.1	27.7	95.7	7.4	105.4	18.0	14.0
IL 19-4-3-3-2	103.0	5.3	167.1	18.7	16.21	81.1	8.9	104.7	18.8	17.8	98.5	7.7	121.7	17.7	16.7
IL 19-4-3-3-3	101.8	5.3	156.8	18.3	15.82	86.1	8.8	118.5	19.7	23.3	99.0	6.4	129.2	18.5	15.2
IL 19-4-3-8-1	100.6	5.6	156.3	18.2	15.81	85.9	7.4	127.9	17.3	16.8	98.8	7.4	133.6	17.2	17.1
IL 19-4-3-8-2	105.3	6.1	168.3	18.7	19.29	86.2	9.3	114.4	19.3	20.2	95.6	7.8	118.4	18.7	17.3
IL 19-4-3-8-3	102.6	5.5	150.3	18.0	14.58	86.7	8.7	123.5	19.1	20.6	91.9	7.1	108.4	18.7	14.6
Average	***103.2***	***5.7***	***162.5***	***18.3***	***17.0***	***85.6***	***8.7***	***128.7***	***19.8***	***21.5***	***95.9***	***7.1***	***127.5***	***18.3***	***16.5***
IR24	76.7	7.9	83.9	23.2	15.31	74.25	9.1	136.5	24.5	16.4	74.5	8.4	125.3	23.4	15.3
KD18	100.6	6.0	155.6	19.0	17.77	78.05	8.5	112.3	19.4	17.5	76.4	7.4	113.2	19.6	16.7
CV%	2.9	2.7	6.8	5.9	1.8	2.2	1.9	5.7	3.3	2.3	3.5	1.4	5.5	4.5	1.2

Noi, ranged from 99.7 cm to 105.3 cm (IL3-4-2-10 and IL19-4-3-8). The average plant height of the lines Thai Nguyen (85.6 cm) and Lao Cai (95.9 cm) were shorter than that in Ha Noi (Table 2). Plant height is one of the most useful agronomical traits in rice, which relates to lodging tolerance and productivity. The difference in plant height at three sites this experiment may be attributable to the weather condition and soil fertility.

Number of panicles per hill: In spring season at Hanoi, the average number of panicles per plant in the BC_4F_4 lines was lower than that of IR24 and KD18 (Table 1). Similar trend was also found in BC_4F_5 lines at all experimental locations in autumn season. The number of panicles per hill ranged from 5.1 (IL19-4-3-1) to 6.4 (IL3-4-3-2) in Ha Noi, from 7.4 (IL19-4-3-8) to 10.4 (IL19-4-3-1) in Thai Nguyen and from 6.2 (IL3-4-2-5) to 8.8 (IL3-4-2-1) in Lao Cai (Table 1, 2).

Number of filled grains per panicle: The number of filled grains is one of the components that has direct effect on grain yield in rice. The number of filled grains per panicle in BC_4F_4 lines ranged from 237.1 (IL19-4-3-5) to 275.9 (IL3-4-3-7) while the figure for IR24 and KD18 was 133.0 and 225.6, respectively (Table 1). In BC_4F_5 lines, the average number of filled grains per hill in all selected lines was 162.5, 128.7 and 127.5 in Ha Noi, Thai Nguyen and Lao Cai, respectively. That value was higher than that of KD18 in all locations. However, in comparison to IR24, it was only higher in Ha Noi, whereas lower in both Thai Nguyen and Lao Cai. It means that IR24 is more suitable for this trait than KD18 in high land and mountainous region.

1000 - grain weight: The 1000-grain weight of all BC_4F_4 lines was similar to that of KD18 but lower than that of IR24 (Table 1). Similar trend was also found in BC_4F_5 lines (Table 2). The average 1000-grain weight of selected lines was 18.3, 19.8 and 18.3 g in Ha Noi, Thai Nguyen and Lao Cai, respectively.

Grain yield: Individual grain yield per hill is one of the yield components that contributes to yield of particular variety. This component depends on between hill spacing and number of effective tillers. In general, the grain yield per hill of rice plant in autumn season was lower than that of spring season because growth duration of the lines in spring season was longer than that in autumn season. The average grain yield of experimental lines was similar to that of KD18 but higher than that of IR24 in both spring season and autumn season at all locations (Table 1, 2). In comparison to KD18, the number of lines showed higher grain yield than KD18 was 5, 21 and 12 in Hanoi, Thai Nguyen and Lao Cai, respectively. Grain yield per hill in BC_3F_4 lines in spring season of 2011 was in the range from 22.2 g (IL19-4-3-3-3) to 32.9 g (IL3-4-3-8) while this of IR24 and KD18 was 21.0 g and 25.5 g, respectively. In Autumn season, the average grain yield of BC_3F_5 lines was higher in Thai Nguyen (21.5g) than that in Hanoi (17.0 g) and Lao Cai (16.5 g). In our study, the growth duration of the lines was shorter in Lao Cai than the growth duration in Hanoi and Thai Nguyen. The average grain yield of experimental lines was higher in Thai Nguyen than that in both Hanoi and Lao Cai due to the larger number of filled grain per panicle. This is quite interesting and should be deeply analyzed in the future. In BC_3F_5 lines, the grain yield per hill was in a range from 14.5 g (IL19-4-3-1-2) to 19.6 g (IL3-4-2-1-1) in Hanoi, from 16.8 g (IL19-4-3-8-1) to 27.7 g (IL19-4-3-1-4) in Thai Nguyen and from 13.4 g (IL3-4-2-8-1) to 20.9 (IL3-4-2-1-1) in Lao Cai. The grain yield of four lines (IL3-4-2-1-1, IL3-4-2-7-1, IL3-4-2-7-2, IL19-4-3-8-2) was higher than that of KD18 and IR24 at all locations. Furthermore, most of the lines evaluated showed better growth and grain yield than IR24 and KD18 under mid-land and mountainous regions.

4. CONCLUSIONS

Four BC_4F_5 lines (IL3-4-2-1-1, IL3-4-2-7-1, IL3-4-2-7-2, IL19-4-3-8-2) with shorter growth duration showed better agronomical traits and grain yield than check varieties (IR24 and Khang dan 18) at all experimental locations. These lines can be further evaluated for release as promising short-growth duration varieties for mountainous regions in North Vietnam.

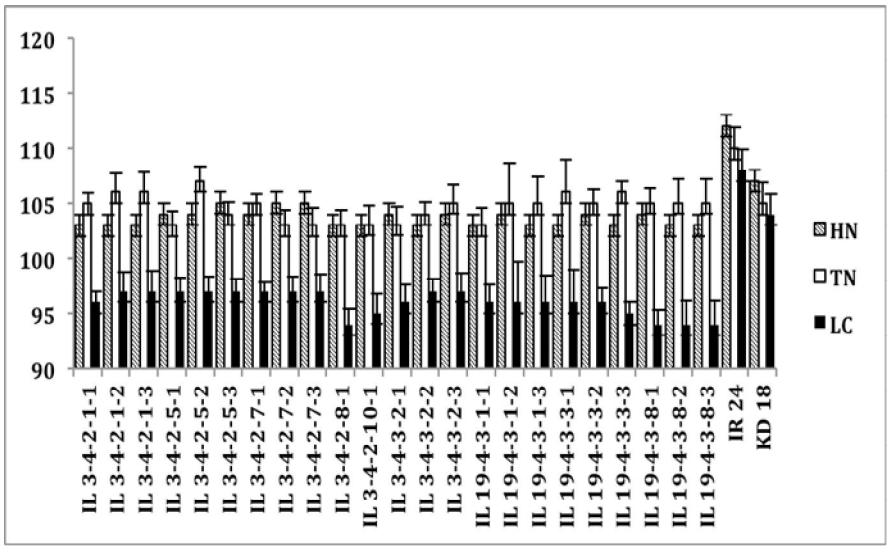

Figure 2. Growth duration of 23 selected BC_4F_5 lines, IR24 and KD18 in 2011 autumn season at three locations: Ha Noi (HN), Thai Nguyen (TN) and Lao Cai (LC) (Vertical axis indicates the growth duration (days), while the horizontal axis indicates the lines). (Vertical bars indicate standard error)

ACKNOWLEDGEMENT

This study was financed by JICA-JST-HUA Project.

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