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Study on Backcross Population with Their Parents for Different Agro-Morphological Traits of Wild and Cultivated Rice (*Oryza sativa* L.) Species

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Abstract: Wild rice is a potential source of many biotic and abiotic stress tolerant genes that could be incorporated to improve cultivated rice. The present rice varieties have narrow genetic base, thus wild rice could serve to extend the genetic base of the cultivated cultivars. To study the inheritance and ancillitary characters of different back cross populations and landraces available among us, we performed line X tester cross followed by backcrossing with recurrent parents. We used both local landraces and cultivated inbreds as parents to fulfill our crossing demand. The crossing of cultivated rice with wild rice and their backcross behavior showed that wild rice consists some desirable traits which can be introgressed to cultivated rice if there is no linkage drag. Some most desirable traits such as flag leaf angle, leaf width, panicle length which are responsible for higher photosynthesis were found higher in backcross progeny which indicates that these genotypes can be utilized further in generation nursery.

Keywords: Backcross, Rice Hybridization, Traits, Generation Nursery and Progeny

1. Introduction

Wild rice is a potential source of genetic diversity for cultivated rice improvement. Wild rice is a source of many biotic and abiotic stress tolerant genes that could be incorporated in cultivated rice. Wild relatives of crop species have been given considerable attention in germplasm collections, because they are known tocontain a large proportion of the existing genetic variations. In rice, the majority of genetic variation in the genus *Oryza* still lies untapped in wild relatives [1]. This is presumably due to the genetic bottlenecks that accompanied the domestication process. Intensive modern breeding efforts have contributed to a narrowing of the gene pool by further concentrating favorable alleles already present in early domesticates [2, 3, 4].

Though wild and unadapted germplasm is phenotypically less desirable than modern varieties in its overall appearance and performance, breeders have long recognized the intrinsic value of wild speciesfor the improvement of simply inherited traits, including disease and insect resistance or cytoplasmic male sterility. Among themost successful examples of utilizing wild germplasm in the history of rice breeding include the use of *Oryza nivara* genes to provide long-lasting resistance to grassy stunt virus [5, 6] and the use of *O. spontanea* as the source of wild abortive cytoplasmic male sterility, which as provided the cornerstone for today's hybrid rice [7].

Despite these successes, it has been virtually impossible to utilize wild germplasm for the improvement of quantitatively inherited traits, such as yield, because the superior trait of interest cannot be identified phenotypically in the wild accessions. The overall phenotype of most wild species is agronomically undesirable, this germplasm has low breeding value; *i.e.*, there are no trait-enhancing alleles present in the genotype.

Nepal is being the center of diversity of rice; harbor the wild rice and its relatives in addition to diverse forms of landraces. Four wild rice species namely *Oryza nivara, O. rufipogon, O. granulata* and *O. officinalis* are found in different areas of the country. Weedy rice, *O. sativa* f. *spontanea* is found across in rice growing areas of the country. Thus the main objective of this research was to study the behaviour of back cross population of cultivated and wild rice.

2. Material and Methods

To study the inheritance and ancillitary characters of different back cross populations and landraces available among us, we performed line X tester cross followed by backcrossing with recurrent parents. We used both local landraces and cultivated inbreds as parents to fulfill our crossing demand. The recurrent parents were cultivated rice such as Jumli Marsi (JM), Pokhreli Masino (PM), Chainung-242 (C-242), Khumal-4 (K-4) and Taichung-176 (T-176). Similarly, wild rice landraces were used as donor parents such as *O. nivara* (NPGR-10197), *O. rufipogon* (NPGR-10219) and *O. nivara* (NPGR-10200). These donor parents were obtained from National Gene Bank, Khumaltar, Lalitpur, Nepal.

The hybridization trial was conducted at Agriculture Botany Division, Khumaltar, Lalitpur, Nepal. Donor and recurrent parents along with backcross-1 (BC1) were planted in buckets. Each bucket consisted two plants. The parents were planted in seven days interval to coincide the flowering time. Proper agronomic management was done timely.

The quantitative and qualitative data were recorded following International Rice Research Institute (IRRI) descriptor. Rice different morphological traits were studied such as leaf length (cm), leaf width (mm), leaf blade pubescence, leaf blade color, basal leaf sheath color, leaf angle, flag leaf angle, legule length (mm), 50% heading days, culm length (cm), internode color, panicle length (cm), panicle type, secondary branching, panicle exertion, panicle shattering, grain awning and maturity.

3. Result and Discussion

We used cultivated rice varieties as recurrent parents and wild landraces as donor. Each cultivated varieties were crossed to every donor parents. The F1 is produced in the first year (2014). This F1 seed is again used to cross with each of recurrent parents i.e. cultivated rice in the following next year (2015). The seed obtained is called Back cross-1 (BC-1).

Recurrent parents, donors and backcross-1 different qualitative and quantitative characters like leaf blade pubescence, leaf blade colour, basal leaf sheath colour, leaf angle, flag leaf angle, internode colour, panicle type, secondary branching, panicle exertion, panicle shattering and grain awning were observed and recorded (Table 1). All recurrent and donor parents showed leaf blade pubescence as glaborous and except backcross-1 of JM*2/*O. nivara* (NPGR-10200), C-242*2/ON-10200 (*O. nivara*) and C-242*2/OR-10219 (*O. rufipogon*). The intermediate pubescence may be due to transfer of inheritance from donor to BC1. Though the recurrent parents had green and pale green leaf blade but all the BC1 showed green colour. Similarly, leaf angle were erect for all genotypes except *O. nivara* (NPGR-10197) and *O. rufipogon* (NPGR-10219) (Table 1). In the same way, flag leaf angle was erect for all except Jumli Marshi, *O. rufipogon* (NPGR-10219), JM*2/*O. rufipogon* (NPGR-10219), K4*2/OR10219 (*O. rufipogon*) and T167*2/ON-10197 (*O. nivara*) as intermediate. Panicle was well exerted in all genotypes, moderately exerted in Khumal-4, JM*2/ON-10205, C-242*2/OR-10219 (*O. rufipogon*) and K4*2/OR10219 (*O. rufipogon*); and just exerted in *O. nivara* (NPGR-10197) PM*2/ON-10200 (*O. nivara*) and T167*2/ON-10197 (*O. nivara*). Long and fully awning was present in all BC1 whereas short and partly awned in Jumli Marsi, abscent in Pokherali Masino, Chainung-242, Khumal-4, Taichung-176 and PM*2/ON-10200 (*O. nivara*) and short and fully owned in C-242*2/OR-10219 (*O. rufipogon*) (Table 1). Similar results were obtained by [8, 9].

Table 1. *Qualitative traits expression in backcross progenies with respect to recurrent cultivated rice and non recurrent wild rice varieties.*

SN	Line	Leaf blade pubescence	Leaf blade color	Basal leaf sheath color	Leaf angle	Flag leaf angle	Internode color
1	Jumli Marshi (JM)	Glabrous	Green	Green	Erect	Intermediate	Light gold
2	Pokherali Masino (PM)	Glabrous	Pale green	Green	Erect	Erect	Light gold
3	Chainung-242 (C-242)	Glabrous	Pale green	Green	Erect	Erect	Light gold
4	Khumal-4 (K4)	Glabrous	Green	Green	Erect	Erect	Green
5	Taichung-176 (T176)	Glabrous	Pale green	Green	Erect	Erect	Light gold
6	O. nivara (NPGR-10197)	Glabrous	Green	Light purple	Horizontal	Erect	Purple lines
7	O. rufipogon (NPGR-10219)	Glabrous	Green	Purple	Horizontal	Intermediate	Purple lines
8	O. nivara (NPGR-10200)	Glabrous	Green	Light purple	Erect	Erect	Light gold
9	JM*2/O. nivara (NPGR-10200)	Intermediate	Green	Purple lines	Erect	Erect	Purple lines
10	JM*2/ON-10205	Glabrous	Green	Purple lines	Erect	Erect	Purple lines
11	JM*2/O. rufipogon (NPGR-10219)	Glabrous	Green	Purple lines	Erect	Intermediate	Purple lines
12	PM x O. nivara (O. nivara)/PM	Glabrous	Green	Purple lines	Erect	Erect	Green

SN	Line	Leaf blade pubescence	Leaf blade color	Basal leaf sheath color	Leaf angle	Flag leaf angle	Internode color
13	PM*2/ON-10200 (O. nivara)	Glabrous	Green	Green	Erect	Erect	Green
14	C-242*2/ON-10200 (O. nivara)	Intermediate	Green	Green	Erect	Erect	Green
15	C-242*2/OR-10219 (O. rufipogon)	Intermediate	Green	Green	Erect	Erect	Green
16	K4*2/OR10219 (O. rufipogon)	Glabrous	Green	Green	Erect	Intermediate	Purple lines
17	T176*2/ON-10197 (O. nivara)	Glabrous	Dark green	Green	Erect	Intermediate	Green

***Table 1.** Continue.*

SN	Panicle type	Secondary branching	Panicle exertion	Panicle shattering	Grain awning
1	Intermediate	Light	Well exerted	Low	Short & partly awned
2	Compact	Heavy	Well exerted	Very low	Absent
3	Compact	Heavy	Well exerted	Low	Absent
4	Compact	Heavy	Moderately well exerted	Very low	Absent
5	Compact	Heavy	Well exerted	Very low	Absent
6	Open	Absent	just exerted	High	Long & fully
7	Open	Absent	Well exerted	High	Long & fully
8	Compact	Absent	Partly exerted	High	Long & fully
9	Compact	Heavy	Well exerted	High	Long & fully
10	Compact	Heavy	Moderately well exerted	High	Long & fully
11	Open	Absent	Well exerted	High	Long & fully
12	Intermediate	Light	Well exerted	High	Long & fully
13	Intermediate	Light	just exerted	High	Absent
14	Open	Absent	Well exerted	Moderately high	Long & fully
15	Compact	Heavy	Moderately well exerted	High	Short & fully awned
16	Compact	Heavy	Moderately well exerted	High	Long & fully
17	Compact	Heavy	Just exerted	High	Long & fully

Total ten traits of JM*2/ON-10200 were studied where two was from recurrent parent type, four from donor parent and four was the new one. Similarly, nine traits were studied from JM*2/ON-10205, seven from JM*/OR-10219, nine from PM*2/ON-10197, eight from PM*2/ON-10200, ten from C242*2/ON-10205, eleven from C242*2/OR-10219, nine from K4*2/OR10219 and ten traits from T176*2/ON-10197 (Table 2).

***Table 2.** Trait expression frequencies in backcross progenies with respect to recurrent cultivated rice and non recurrent wild rice varieties.*

SN	Line	Recurrent parent type	Donor parent type	New type	Total trait studied
1	JM*2/ON-10200	2	4	4	10
2	JM*2/ON-10205	1	3	5	9
3	JM*2/OR-10219	1	5	1	7
4	PM*2/ON-10197	2	3	4	9
5	PM*2/ON-10200	2	2	4	8
6	C242*2/ON-10205	3	5	2	10
7	C242*2/OR-10219	5	2	4	11
8	K4*2/OR10219	5	4	0	9
9	T176*2/ON-10197	4	3	3	10

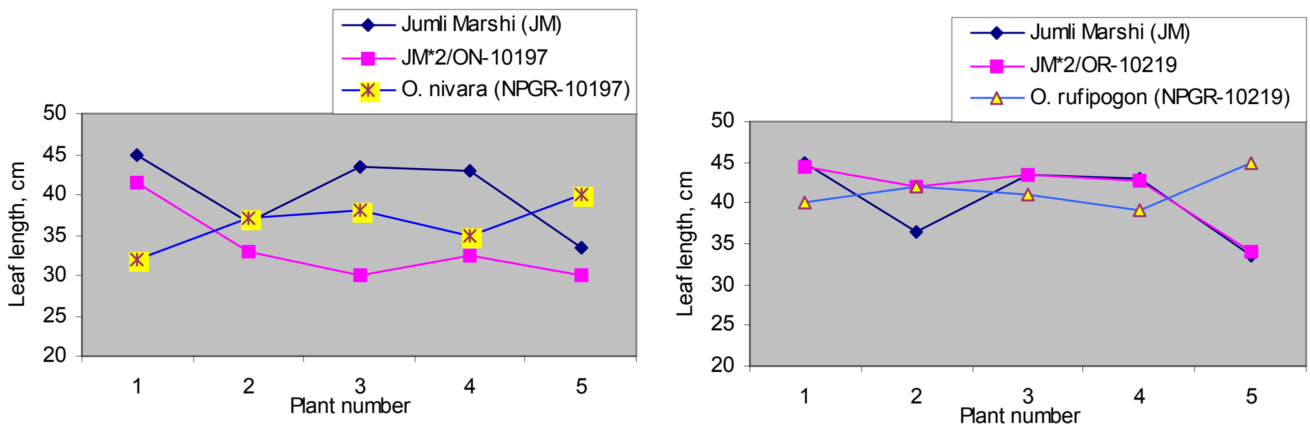

***Figure 1.** Trend in leaf length among parental rice varieties and their backcross progenies.*

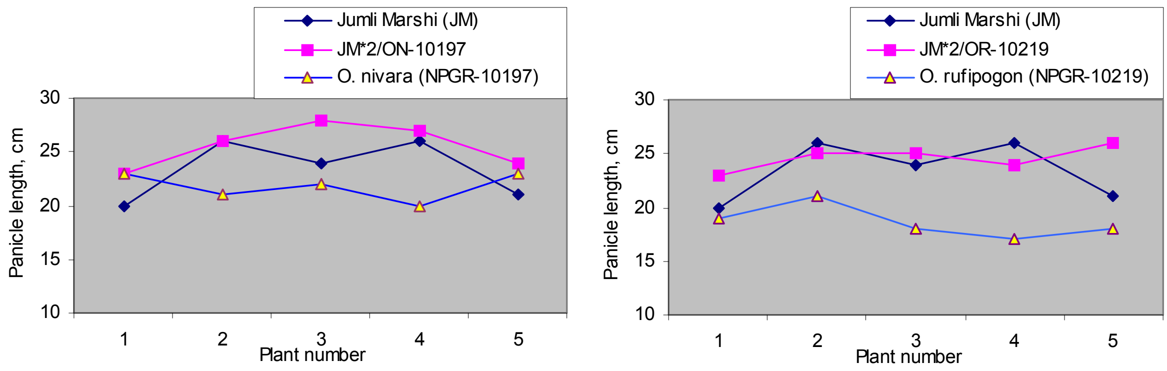

Figure 2. *Trend in panicle length among parental rice varieties and their backcross progenies.*

Longest leaf length was observed in Pokhreli Masino (49 cm) followed by *O. nivara* (43 cm) and shortest in C242*2/ON-10205 (20 cm) (Table 3 and Figure 1). Similarly leaf width was most wide in PM*2/ON-10200 (11 cm) and least wide in *O. nivara* (0.56 cm). Longest culm length was found in Pokhreli Masino (139 cm) and shortest in PM*2/ON-10200 (46 cm) (Table 3). Pokhreli Masino (27 cm) had longest panicle followed by JM*2/OR-10219 (24 cm) while shortest panicle was observed in PM*2/ON-10200 (16 cm). Different varieties traits are expressed in replicated form to reduce experimental error (Table 3). Similar results was revealed by Verica et al [10].

Table 3. *Means and significance test within family for 6 quantitative traits in parental rice varieties and their backcross progenies.*

SN	Line	Leaf length (cm)	Leaf width (mm)	Legule length (mm)	Culm length (cm)	Culm number	Panicle length (cm)
1	Jumli Marshi (JM)	40.30±5.01	1.060±0.089	1.50±0.29	135.00±5.52	13.80±3.962	23.40±2.793
2	JM*2/ON-10197	33.40±4.73	1.020±0.044	1.86±0.75	118.20±19.07	14.50±7.853	25.60±2.074
3	O. nivara (NPGR-10197)	36.40±3.05	0.560±0.114	12.60±1.67	70.00±3.61	14.20±5.263	21.80±1.304
4	P	0.079	<0.001	<0.001	<0.001	0.983	0.048
5	Jumli Marshi (JM)	40.30±5.007	1.060±0.0894	1.500±0.2915	135.00±5.52	13.80±3.962	23.40±2.793
6	JM*2/ON-10205	40.50±7.382	0.720±0.1789	2.060±0.3362	113.80±5.97	12.20±8.075	22.80±1.643
7	O. nivara (NPGR-10205)	30.20±3.347	0.720±0.0837	5.800±1.4832	64.40±3.65	25.60±5.030	18.40±2.074
8	P	0.018	0.001	<0.001	<0.001	0.007	0.008
9	Jumli Marshi (JM)	40.30±5.007	1.06±0.089	1.50±0.292	135.0±5.52		23.40±2.793
10	JM*2/OR-10219	41.34±4.207	1.08±0.084	1.64±0.167	131.0±12.02		24.60±1.140
11	O. rufipogon (NPGR-10219)	41.40±2.302	9.80±1.483	22.60±2.074	114.4±2.88		18.60±1.517
12	P	0.889	<0.001	<0.001	0.003		0.001
13	Pokherali Masino (PM)	49.60±9.147	0.940±0.2302	2.70±0.718	139.8±15.35	25.00±16.513	27.60±1.517
14	PM*2/ON (NPGR-10197)	36.40±3.050	0.560±0.1140	12.60±1.673	70.0±3.61	14.20±5.263	21.80±1.304
15	O. nivara (NPGR-10197)	43.10±6.456	1.000±0.1581	2.54±0.503	109.2±8.47	13.60±3.507	22.60±1.517
16	P	0.029	0.004	<0.001	<0.001	0.184	<0.001
17	Pokherali Masino (PM)	34.50±7.786	1.40±0.158	1.86±0.483	87.0±11.47		19.20±2.168
18	PM*2/ON-10200	41.80±2.588	11.60±1.140	11.80±1.789	46.2±3.63		16.20±1.924
19	O. nivara (NPGR-10200)	43.10±6.456	1.00±0.158	2.54±0.503	109.2±8.47		22.60±1.517
20	P	0.090	<0.001	<0.001	<0.001		0.001
21	Chainung-242 (C242)	40.46±11.636	1.120±0.1789	1.320±0.1924	97.20±2.39	14.20±3.421	17.00±1.000
22	C242*2/ON-10205	20.50±2.236	0.760±0.2881	0.840±0.3912	84.20±6.30	23.40±11.104	18.20±2.864
23	O. nivara (NPGR-10205)	30.20±3.347	0.720±0.0837	5.800±1.4832	64.40±3.65	24.00±2.915	18.40±2.074
24	P	0.003	0.016	<0.001	<0.001	0.079	0.546
25	Chainung-242 (C242)	40.46±11.636	1.12±0.179	1.32±0.192	97.2±2.39		17.00±1.000
26	C242*2/OR-10219	27.70±4.192	1.02±0.148	1.56±0.541	99.8±5.67		22.00±0.707
27	O. rufipogon (NPGR-10219)	41.40±2.302	9.80±1.483	22.60±2.074	114.4±2.88		18.60±1.517
28	P	0.020	<0.001	<0.001	<0.001		<0.001
29	Khumal-4 (K4)	45.76±8.144	1.14±0.134	2.38±0.449	120.6±4.39		26.4±1.817
30	K4*2/OR10219	31.80±3.818	1.02±0.045	2.32±0.370	89.0±12.83		22.0±1.581
31	O. rufipogon (NPGR-10219)	41.40±2.302	9.80±1.483	22.60±2.074	114.4±2.88		18.6±1.517
32	P	0.004	<0.001	<0.001	<0.001		<0.001
33	Taichung-176 (T176)	30.28±3.601	1.160±0.2966	0.98±0.370	93.20±6.834	22.00±13.856	23.00±2.236
34	T176*2/ON-10197	36.40±3.050	0.560±0.1140	12.60±1.673	70.00±3.606	14.20±5.263	21.80±1.304
35	O. nivara (NPGR-10197)	36.92±3.183	0.860±0.1140	1.48±0.130	89.80±6.181	4.00±0.707	16.60±1.342
36	P	0.013	0.001	<0.001	<0.001	0.016	<0.001

Note: Low (1-5%), High (more than 50%), Very low (less than 1%), Moderately high (26-50%)

Scatter plot analysis divided all the 17 genotypes into two groups based on principal component I and II. Principal component I (35%) divided the genotypes as JM, C-242, PM*2/ON1, PM*2/ON3, T-176, ON1 and C-242*2/OR 1; and PM,

JM*2/OR1, ON2, K4*2/OR1, C-242/ON2, T-176, ON3, OR1, JM*2/OR1 and K4 (figure 3). Similarly Principal component II at 17% also divided the genotypes into two groups where one group consisted four genotypes and rest genotypes to the other groups.

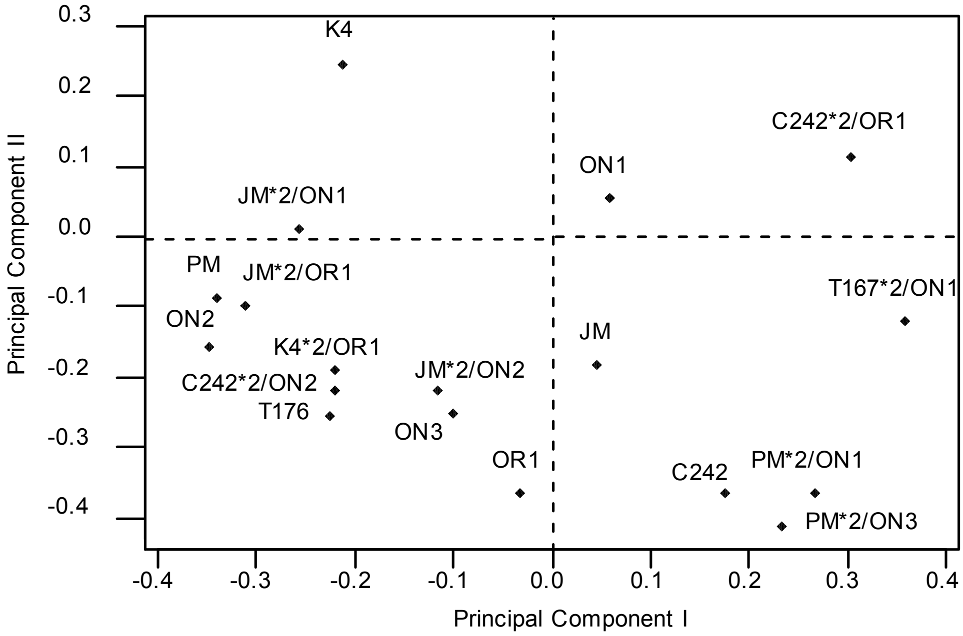

Figure 3. *Scatter plot of parental rice varieties and their backcross progenies by principal component I (35%) and principal component II (17%) based on the 17 different quantitative and qualitative traits.*

4. Conclusion

The crossing of cultivated rice with wild rice and their backcross behavior showed that wild rice consists some desirable traits which can be introgressed to cultivated rice if there is no linkage drag. Linkage drags carry some undesirable traits which also transferred with desirable traits in to cultivated rice. Some most desirable traits such as flag leaf angle, leaf width, panicle length which are responsible for higher photosynthesis were found higher in backcross progeny which indicates that these genotypes can be utilized further in generation nursery.

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