Morpho-agronomic Analysis of New Rice Germplasm at Agriculture Research and Development Centre, Bajo

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ABSTRACT

Extensive use of high yielding varieties has greatly reduced the genetic diversity in breeding germplasm of major food crops in the world. It is necessary to evaluate new rice germplasm to select superior lines of early maturing, high yielding, and resistance to biotic and abiotic stress breeding materials as strategy for rice improvement. This study was carried out to evaluate the morpho-agronomic characters of new rice germplasm and to compare the grain yield between 18 different rice germplasm, including the standard check BajoKaap 2. The experiment was conducted at the Agriculture Research and Development Centre, Bajo, Wangduephordang from April to October 2016. It followed a Randomized Complete Block Design with 18 treatments and three replications per treatment. The germplasm were evaluated based on 12 qualitative and 12 quantitative traits following the Descriptor for Rice Oryza sativa L and the standard evaluation systems during the different growth stages of the rice plant. Differences between the germplasm were observed in characters such as awning and flag leaf angle. Out of 18 treatments, eight had erect flag leaf angle while the rest exhibited intermediate type and only four had awns. Significant differences were observed between the treatments ($P<0.05$) in terms of plant height, leaf length, leaf width, number of tillers per hill, 50% flowering, panicle length, grain length, grain width and 1,000 grain weight. However, there was no significant difference in yield. Sinice these new rice germplasm are in the initial evaluation phase, further assessment may be required to ascertain their overall performance.

Keywords*: Descriptors for Rice, Germplasm, Quantitative trait, Qualitative trait, Rice, Yield*

1. Introduction

Rice is one of the most important food crops in the world. More than half of the world's population depends on rice for food and nutrition and in Bhutan, it is consumed three times a day and hence it is the staple crop. However, the domestic production of rice has not been able to meet the demand of the growing population due to low productivity. Today the self-sufficiency of rice is only 47% and the rest of the demand is met from imports. Bhutan imported 79,306 tons of rice in 2014 incurring a total cost of Nu 1787.60 million (NSB, 2016).

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Ghimiray (2012) pointed that low productivity and production in the country is due to limited wetland, use of low yielding traditional varieties, low input of inorganic fertilizers, lack of irrigation water and shortage of labour. He also recommended that one of the ways to increase rice production is to breed and develop high yielding varieties that can adapt to specific growing environments. Khush (2005) stated that to meet the challenges of producing more rice from the existing lands, varieties with higher yield potential and greater stability are needed and for that a rich genetic diversity is important in securing food and for sustainability as it allows the breeder to select appropriate genetic materials that can adapt to a specific location. Further, the wider the diversity the lesser the chance of pest and disease occurrence, so that loss to pest and disease can be minimized (NBC, 2008).

Bhutan has been introducing foreign germplasm since the 1960s and pedigree analysis of rice varieties indicated that 74% of the released varieties originated in other countries (Ghimiray & Vernooy, 2017). At the moment there are 23 improved rice varieties in the country. However, some of these varieties have lost resistance to the blast disease due to decades of cultivation. So, the need of the hour is to introduce as many rice lines or germplasm as possible to increase the gene pool, and to breed varieties that are resilience to biotic and abiotic stresses in the future. Screening and selection of new rice lines for identification is important to exploit the genetic diversity within rice germplasm. So the objectives of this study are to (1) To evaluate the morpho-agronomic parameters of new rice germplasm using descriptor for rice developed by IBPGR-IRRI Rice Advisory Committee and (2) To compare grain yield between 18 different breeding lines.

2. Materials and Methods

2.1 Experimental site

The study was conducted in the research field of the Agriculture Research and Development Centre (ARDC), Bajo, during the 2016 rice season. The site is located at 1,200 – 1,300 masl between 27^0 29’24.40’’N and 28^0 53’53.53’’E. The area falls under warm temperate-subtropical zone which is characterized by heavy rainfall during June to September and scanty during rest of the year.

2.2 Soil

The soil type of the experimental plot was fine sand to clay loam with neutral to slightly acidic pH, near total base saturations. It has low organic carbon, total N and available P contents. The low levels of organic matter are thought to be mostly due to long use of the soils for wetland rice.

2.3 Design and layout

The experiment was laid out in randomised complete block design (RCBD). The field was divided into three blocks, which were further subdivided into 54 plots where treatments or germplasm were randomly assigned. The plot size was 5m x 2m or 10 m^2. Row to row and plant to plant spacing were 20 cm x 20 cm.

2.4 Treatments

There were 18 treatments: IR 06M 144, IR 06M 150, IR 96 120, IR 11A 208, IR 10F 336, IR 09A 228, IR 09A 220, IR 10N 269, IR 05A 235, PK 3445-3-2, CB 08 514, IR 06N 170, IR 10A 134, IR 09 N 522, IR 08N 210, CT 16658-5-2-3SR-2-1-MMP, Salabhagi and Bajo Kaap 2 (BK 2) (Standard check) with three replications each.

2.5 Nursery, field preparation, transplantation, intercultural operation and aftercare

The nursery was raised on 23rd of April 2016. The field was ploughed and levelled thoroughly. The seeds were sown in line on the prepared beds and the beds were mulched and tagged. Seedbeds were irrigated as and when required to maintain the moisture.

Field preparation such as ploughing, harrowing, levelling and the application of basal dose of fertilizers were done a day prior to transplanting operation. The 45-day old seedlings were transplanted at 20 cm x 20 cm spacing and optimum water level of 4 - 6 cm was maintained.

All necessary intercultural operations were carried out during the cropping period for proper growth and development of the seedlings. A day after the transplanting, butachlor was applied at the rate 0.5 kg ai ha^{-1} to control grasses and sedges followed by hand weeding two weeks after planting. Hand weeding was targeted to uproot obnoxious rhizomes of Shochum/pondweed (*Potamogeton distinctus)* and other weeds from the field, and also to prepare the field for incorporation of urea fertilizer. Irrigation was done as and when required throughout the cropping season.

2.6 Data collection

The 18 germplasm were evaluated during the particular stages of the rice plant following the descriptors published by International Rice Research Institute and International Board for Plant Genetic Resources (IRRI, 1980). A total of 12 qualitative and 12 quantitative morpho-agronomic traits were used. The qualitative traits were: leaf sheath colour, flag leaf angle, panicle exertion, panicle type, presence of awn, presence of apiculus, apiculus colour, panicle shattering, lemma and palea colour, grain category, threshability and aroma/scent. The quantitative traits were: effective tillers per hill, plant height, days to heading, days to flowering, days to maturity, panicle length, leaf length, leaf width, 1,000 grain weight, grain length, grain width and grain yield.

2.6.1 Grain yield

Grain yield (t/ha) was measured at 85% maturity or when 85% of the grains had matured. From each experimental plot of 10 m^2 crop cut was taken from an area of 8.6 m^2 (excluding the border rows) and was calculated using the following formula:

$$\text{Grain yield (t ha-1) at 14\% MC} = \frac{\frac{\text{yield}}{\text{plot}} \text{ x } 10{,}000 \text{ m}^2 \text{ x MC(adj)}}{\text{plot size}(8.64 \text{ m}^2) \text{ X } 1{,}000}$$

2.6.2 1,000 grain weight

The average weight was then multiplied with the adjusted moisture content. Moisture content was adjusted to 14% derived from the formula:

$$MC\ (adj) = \frac{(100\text{-}MC)}{100\text{-}14}$$

where MC = Moisture constant

2.7 Data analysis

Excel spread sheets of Microsoft office 2013 was used for data entry, segregation, descriptive statistics reporting and basic graphical presentations. All quantitative data have undergone Analysis of Variance (ANOVA) to verify the variation in the traits measured using the statistical software Statistix 8. A dendrogram was constructed from 1,000 grain weight, grain length and grain sizes in SPSS using ward linkage to cluster the germplasm.

3 Result and Discussion

3.1 Agronomical characterization

3.1.1 Days to 50% flowering

The study showed that days to 50% flowering for the entries ranged from 117 to 133 days (Table 1). Out of 18 entries, IR 11A 208 (133 days) took the longest period for flowering followed by PK 3445-3-2 with 128 days. Whilst IR 09A 220 took the minimum days for flowering at 117 days. The standard check BK 2 took 121 days. In rice plant, the days to heading starts three days before the flowering and the grains mature after 30 days from flowering. Environmental factors especially temperature affect the rice flowering dates and maturity (McKenzie, Rutger & Peterson, 1980).

3.1.2 Tillers per hill

The range of effective tillers was 9.23 to 12.87 as shown in Table 1. The highest number of effective tillers per hill was produced by IR 10A 134 (12.87) which was followed by IR 06M 150 (12.13). On the other hand germplasm IR 05A 235 (9.23) and Salabaghi (9.70) produced the minimum number of effective tillers. Effective number of tillers is one component that is attributed to increase in yield (Aslam, Akram & Ashraf, 1995). Out of 18, 11 germplasm had more effective no of tillers than BK 2.

3.1.3 Plant height (cm)

The plant height ranged from 95.2 to 108.13 cm (Table 1). Salabhagi was the tallest variety 108.13 cm followed by IR 05A 235 (106.93 cm) while CT 16658-5-2-3SR-2-1-MMP was the shortest (95.27 cm) followed by IR 96 120 (97.63 cm). Reduction in plant height may improve their resistance to lodging and reduce substantial yield losses associated with this trait (Aslam et al., 1995).

3.1.4 Panicle length (cm)

The range of panicle length was 22.84 to 28.28 cm (Table 4.1). The highest panicle length 28.28 cm was recorded in the germplasm IR 09A 228 which was closely followed by IR 09A 220 (27.90 cm). The lowest panicle length 22.84 cm was recorded in IR 05A 235 and closely followed by CT 16658-5-2-3SR-2-1-MMP with 22.97 cm. Although, panicle length contributes positively yet maximum panicle length is not the only factor responsible for higher grain yield (Aslam al., 1995).

3.1.5 1,000 grain weight (g)

The range of 1,000 grain weight was 16.77 to 32.59 g (Table 1). The highest grain weight 32.59 g was obtained from IR 06M 144 and was followed by IR 10N 269 with 32.15 g. The lowest weight 16.77 g was obtained from CB 08 514 and was followed by IR 05A 235 with 21.03 g. Yoshida (1981) stated that grain growth during ripening is characterized by the increase in size and weight of kernels as starch and sugars are translocated from culms and leaves.

3.1.6 Leaf length (cm) and leaf width (cm)

Leaf length ranged from 27.08 to 38.78 cm (Table 2). The highest length 38.78 cm was measured from IR 05A 235 followed by IR 09A 220 with 33.29 cm. The lowest length 27.08 cm was measured from IR 10F 336 and BK 2 with 27.16 cm. Leaf width ranged from 1.40 to 1.91 cm (Table 4.2). The highest length 1.91 cm was found in CT 16658-5-2-3SR-2-1-MMP and the lowest 1.40 cm in IR 06N 170. Thakur (1981) reported leaf angle as erect, horizontal or droopy and was largely influenced by leaf length. The wider the angle, the more the spread of leaves for light interception, especially in the lower leaves.

3.1.7 Grain length and grain width (mm)

Grain length ranged from 6.93 to 10.82 mm and grain width ranged from 2.31 to 2.76 mm (Table 2). The longest grain length was measured from IR 09A 220 (10.82 mm) followed by IR 10A 134 (10.39 mm) and the shortest from CB 08 514 (6.93 mm) and IR 05A 235 (7.84 mm). The widest grain width was measured from Salabhagi (2.76 mm) followed by IR 11A 208 (2.73). And the least wide was measured from CB 08514 (2.31 mm) and IR 09A 220 (2.34 mm). Grain length and width is the strongest determinant of grain size (Takeda, 1986). Increasing grain size has been proposed as one of the means to increase not only paddy yield but also the milling yield of rice (Venkateswarlu, Vergara, Parao & Visperas, 1986).

Table 1.Traits of days to 50% flowering, plant height, no. of tillers per hill, 1,000 grain weight and panicle length for 18 rice germplasm

Treatments	Days to 50% flowering	Plant height (cm)	No. of tillers per hill	1,000 Grain weight (g)	Panicle length (cm)
IR 06M 144	119^{ef}	104.87^{ab}	11.33^{abc}	32.59^{a}	27.68^{a}
IR 06M 150	120^{def}	106.83^{a}	12.13^{a}	27.69^{bcde}	25.31^{ab}
IR 96 120	120^{def}	97.63^{de}	11.40^{abc}	25.98^{cde}	24.23^{ab}
IR 11A 208	133^{a}	102.10^{bc}	9.90^{bcd}	27.69^{bcde}	25.66^{ab}
IR 10F 336	120^{def}	102.03^{bc}	11.63^{abc}	28.83^{abcde}	25.91^{ab}
IR 09A 228	120^{def}	99.23^{cde}	11.93^{ab}	25.31^{def}	28.28^{a}
IR 09A 220	117^{g}	102.13^{bc}	12.20^{a}	27.07^{cde}	27.90^{a}
IR 10N 269	121^{de}	99.20^{cde}	11.63^{abc}	32.15^{ab}	26.48^{ab}
IR 05A 235	123^{c}	106.93^{a}	9.23^{d}	21.03^{fg}	22.82^{b}
PK 3445-3-2	128^{b}	106.50^{a}	11.27^{abcd}	28.20^{abcde}	27.79^{a}
CB 08 514	120^{ef}	98.57^{cde}	10.80^{abcd}	16.77^{g}	24.12^{ab}
IR 06N 170	120^{def}	100.87^{bcd}	11.63^{abc}	26.78^{cde}	26.06^{ab}
IR 10A 134	121^{d}	100.80^{bcd}	12.87^{a}	28.19^{abcde}	27.86^{a}
IR 09N 522	121^{de}	99.33^{cde}	10.93^{abcd}	30.18^{abc}	25.84^{ab}
IR 08N 210	119^{ef}	101.30^{bcd}	11.40^{abc}	25.08^{ef}	26.18^{ab}
CT16658-5-2-3SR2-1MMP	127^{b}	95.27^{e}	9.77^{cd}	29.76^{abcd}	22.97^{b}
Salabhagi	119^{ef}	108.13^{a}	9.70^{cd}	26.22^{cde}	25.12^{ab}
BK 2(Standard check)	121^{d}	97.73^{de}	11.00^{abcd}	29.72^{abcd}	23.98^{ab}
P<0.05	**	**	**	**	**
C.V	0.51	4.57	20.64	5.38	10.05

Means followed by the same letter in the column are not significant at Tukey test (*P*<0.05)

Table 2.Traits of leaf length, leaf width, grain length and grain width for 18 rice germplasm

Varieties	Yield ($t\ ha^{-1}$)	Leaf length (cm)	Leaf width (cm)	Grain length (mm)	Grain width (mm)
IR 06M 144	6.12^{a}	29.07^{b}	1.62^{ab}	9.93^{cd}	2.69^{abc}
IR 06M 150	5.55^{a}	30.32^{b}	1.53^{ab}	9.22^{efg}	2.55^{cde}
IR 96 120	6.34^{a}	28.22^{b}	1.48^{ab}	9.63^{de}	2.71^{abc}
IR 11A 208	6.67^{a}	30.01^{b}	1.67^{ab}	9.19^{fg}	2.73^{ab}
IR 10F 336	5.98^{a}	27.08^{b}	1.48^{ab}	9.61^{def}	2.65^{abc}
IR 09A 228	5.40^{a}	30.72^{ab}	1.51^{ab}	9.87^{cd}	2.59^{bcd}
IR 09A 220	6.28^{a}	33.29^{ab}	1.46^{b}	10.82^{a}	2.34^{f}
IR 10N 269	6.16^{a}	32.31^{ab}	1.68^{ab}	9.69^{d}	2.63^{abc}
IR 05A 235	6.18^{a}	38.78^{a}	1.80^{ab}	7.84^{h}	2.66^{abc}
PK 3445-3-2	6.04^{a}	28.17^{b}	1.67^{ab}	8.99^{g}	2.44^{def}
CB 08 514	5.55^{a}	31.37^{ab}	1.79^{ab}	6.93^{i}	2.31^{def}
IR 06N 170	6.40^{a}	30.46^{ab}	1.40^{b}	9.78^{d}	2.59^{bcd}
IR 10A 134	5.76^{a}	32.18^{ab}	1.69^{ab}	10.39^{ab}	2.39^{ef}
IR 09N 522	6.40^{a}	30.20^{b}	1.50^{ab}	9.24^{efg}	2.65^{abc}
IR 08N 210	5.78^{a}	27.23^{b}	1.50^{ab}	10.26^{bc}	2.43^{def}
CT 16658-5-2-3SR-2-1-MMP	5.46^{a}	28.53^{b}	1.91^{a}	9.74^{d}	2.68^{abc}
Salabhagi	6.18^{a}	30.62^{ab}	1.54^{ab}	8.87^{g}	2.76^{a}
BK 2 (Standard check)	6.00^{a}	27.16^{b}	1.59^{ab}	9.12^{g}	2.67^{abc}
$P<0.05$	Ns	**	**	**	**
C.V	9.19	16.76	16.65	5.34	7.35

Means followed by the same letter in the column are not significant at Tukey test ($P<0.05$)

3.2 Grain yield

There was no significant difference ($P<0.05$) between 18 germplasm in terms of grain yield ($t\ ha^{-1}$). However, the grain yield in absolute values ranged between 5.40 $t\ ha^{-1}$ and 6.67 $t\ ha^{-1}$ (Table 2 and Figure 1). Insignificant difference in grain yield was expected as seven test entries were the elite selections from the two years of vigorous on-station evaluation trial (ARDC-Bajo, 2015; ARDC-Bajo, 2016).

In 2013-2014, ARDC- Bajo has received a total of 80 advanced lines as part of IRRI nursery and has undergone introductory and observation nurseries in the past two years. Thus, the test entries were the best selections from the previous two years of varietal evaluations at the research station, and their insignificant difference in grain yield is normal since there are many other parameters considered for evaluation and screening (IRRI, 1996).

Among the germplasm tested in the current experiment, IR 11A 208, IR 06N 170 and IR 09N 522 were the top three performers with grain yield record at 6.67 t ha^{-1}, 6.40 t ha^{-1}, and 6.40 t ha^{-1} respectively. Lowest grain yield was recorded in IR 09A-228 (5.40 t ha^{-1}) and CT 16658-5-2-3SR-2-1-MMP (5.46 t ha^{-1}), and their values were also below that of the standard check (BK 2) which produced 6 t/ha^{-1}. IR 06M-150, IR 9L-120, IR 09A-220, IR 10N-269, IR 05A-235, and Salabhagi yielded slightly over 6 t h^{-1}. The grain yield of these entries agrees with the reports of Brennan and Malabayabas (2011) who reported yield range of 5.5 - 7.0 t ha^{-1} for the modern varieties in the recent years in South East Asia.

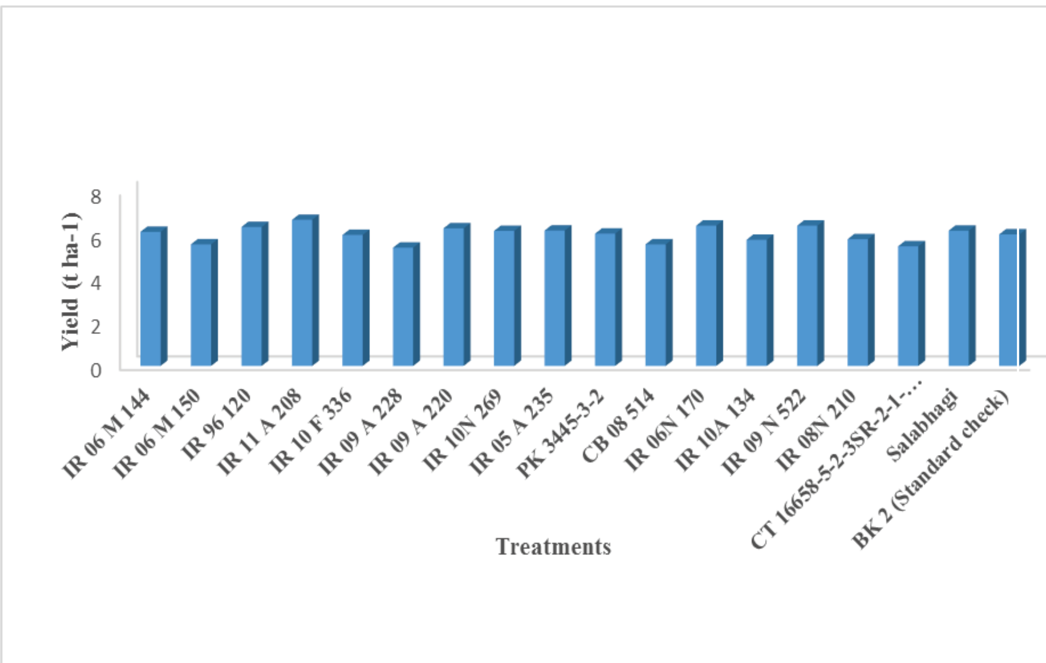

Figure 1.Grain yield of the germplasm materials

3.3 Clustering of the genotypes based on 1,000 grain weight, grain length and grain width

The dendrogram given in Figure 2 was constructed from 1,000 grain weight, grain length and grain width in SPSS using wards linkage. The dendogram showed two clusters. In cluster I there are ten germplasm (IR 09N 522, BK 2, IR 10F 336, CT 16658-5-2-3SR-2-1-MMP, IR 06M 114, IR 10N 269, IR 11A 208, Salabhagi, IR 96 120, IR 05A 235) and in cluster II there are eight germplasm (IR 09A 220, IR 10A 134, IR 08N 210, IR 09A 228, IR 06N 170, IR 06M 150, PK 3445-3-2, CB O8 514). The two main clusters are further subdivided into five clusters. The clustering of the varieties represents the similarities in grains: shape, size and weight. IR 09N 522 and the standard check BK 2 are clustered together which means the grains from these two varieties are similar meaning IR 09N 522 can be categorized as a slender grain type since BK 2 has a white slender grains. However the grains from the germplasm CB 08 514 showed a contrast to BK 2 and has small, round and bold shape and this could also mean that the grains which falls in cluster II and the II-subdivisions range from medium to round shape.

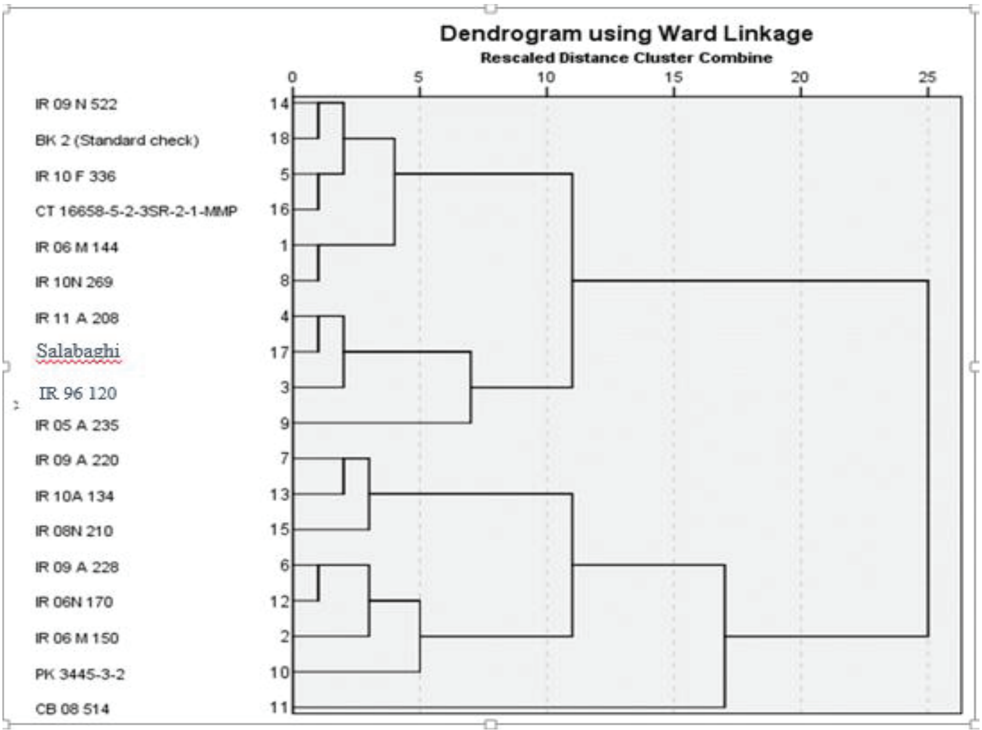

Figure 2.Cluster dendrogram showing similarities and dissimilarities among 18 germplasm in terms of 1,000 grain weight, grain length and grain width.

3.4 Morphological characterization

3.4.1 Basal leaf sheath colour

In all the 18 germplasm, the sheath colour was found green (Table 3). In rice, purple leaf sheath as well as purple apiculus and stigma is common in wild species and landraces; however, green leaf sheath (GSH) is prevalent in modern cultivars (Chin et al., 2016).

3.4.2 Flag leaf angle

Out of 18, eight entries about 44% showed erect leaf angle while the rest of the germplasm exhibited intermediate angle (Table 3). Flag leaf is very important for photosynthesis. Erect leaf angle is a desirable trait for high-yielding varieties. A plant community with vertically oriented leaves gives better light penetration and higher carbon assimilation per unit of leaf area (Tanaka, 1976).

3.4.3 Awn

Out of 18 entries, only four (22%) of the germplasm had awns present on the grains (Table 3) while the rest were without awns. The presence of awns is considered important trait in rice domestication (Hussain et al., 2014). Grains of wild rice have long awns that protect the grains from animal pilfering. The varieties with long awn or strongly awned are more resistant to bird attack than the varieties with no awns. On the other hand, cultivated rice varieties have short awns allowing for easier harvesting than varieties with long awns (Hussain et al., 2014).

3.4.4 Panicle type, panicle exertion, panicle shattering, apiculus, lemma and palea colour

All the entries were of intermediate panicle type, showed well exerted panicles and low panicle shattering. Out of 18 germplasm 14 (78%) had straw colour, three (17%) had brown and only one (6%) had red apiculus colour. Sixteen (89%) out of 18 germplasm had straw coloured lemma and palea except two (11%), which exhibited brown furrows on straw (Table 3).

Table 3.Qualitative traits showing pre-dominate state observed

Treatments	A	B	C	D	E	F	G	H	I	J	K	L
IR 06M 144	1	2	1	1	2	2	Absent	Present	2	1	1	2
IR 06M 150	1	1	1	1	2	2	Absent	Present	2	1	1	2
IR 96 120	1	2	1	1	2	2	Absent	Present	2	1	1	2
IR 11A 208	1	2	1	1	2	2	Absent	Present	2	1	1	2
IR 10F 336	1	1	1	1	2	2	Absent	Present	2	1	1	2
IR 09A 228	1	2	1	1	2	2	Absent	Present	2	1	1	2
IR 09A 220	1	2	1	1	2	2	Present	Present	2	1	1	2
IR 10N 269	1	1	1	1	2	2	Absent	Present	3	1	1	2
IR 05A 235	1	2	1	1	2	2	Absent	Present	3	1	1	2
PK 3445-3-2	1	2	1	1	2	2	Absent	Present	2	4	1	2
CB 08 514	1	2	1	1	2	2	Absent	Present	4	1	4	2
IR 06N 170	1	1	1	1	2	2	Present	Present	2	1	1	2
IR 10A 134	1	1	1	1	2	2	Present	Present	2	1	1	2
IR 09 N 522	1	2	1	1	2	2	Absent	Present	2	1	1	2
IR 08N 210	1	1	1	1	2	2	Present	Present	2	1	1	2
CT 16658-5-2-3SR-2-1-MMP	1	2	1	1	2	2	Absent	Present	2	1	1	2
Salabhagi	1	1	1	1	2	2	Absent	Present	3	1	1	2
BK 2 (Standard check)	1	1	1	1	2	2	Absent	Present	2	4	1	2

A. **Presence of awn:** Present, absent
B. **Basal leaf sheath colour:** Green (1), Purple lines (2), light purple (3), purple (4)
C. **Flag leaf angle:** Erect (1), Intermediate (2), Horizontal (3), Descending (4)
D. **Panicle Exertion:** Well exerted (1), moderately exerted (2), just exerted (3), Partly exerted (4), enclosed (5)
E. **Panicle shattering**: Low (1), Moderate (2), Moderately high (3), High (4)
F. **Panicle type**: Compact (1), Intermediate (2), Open (3)
G. **Threshability:** Difficult (1), Intermediate (2), Easy (3)
H. **Presence of apiculus:** Present, absent
I. **Apiculus colour:** White (1), Straw (2), Brown (twany) (3), Red (4), Purple (5)
J. **Lemma and palea colour:** Straw (1), glod furrows on straw background (2), Brown spots on straw (3), Brown furrows on straw (4), Brown (twany) (5), Reddish to light purple (6)
K. **Grain category:** Slender(1), Medium(2), Bold (3) , Round (4)
L. **Scent:** yes (1), No (2)

4 Conclusions

Morpho-agronomic characterization is an important prerequisite to evaluate phenotypic diversity within germplasm collection. It creates the basis to ensure effective utilization of the crop germplasm by both farmers and breeders amongst other users.

Evaluation of 18 rice germplasm revealed genetic variability in some of the traits. Differences among the germplasm were observed in characters such as: awning and flag leaf angle. Out of 18, eight (44%) treatments exhibited erect flag leaf angle while the remaining had intermediate leaf angle. Only four (22%) had awns while the rest showed awnlessness. All 18 germplasm showed well exerted panicles, low panicle shattering and intermediate panicle types respectively. These phenotypic traits could be explored for rice improvement in the future.

There was no significant difference in yield although other yield components were significant. The grain yield in absolute values ranged from 5.40 to 6.67 t ha^{-1}. Since the treatments included were the improved advance lines selected from the IRRI nursery and the introductions from India, higher yield was expected even under multi-environmental conditions and this could be the reason for performing well in terms of yield. This study is still in its initial phase, so all the treatments need to be selected and promoted to the next level advance evaluation trial for proper evaluation.

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