Assessment of Variability of Rice (*Oryza sativa* L.) Germplasm using Agro-morphological Characterization

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Abstract

The present study was carried out to characterize seven hundred eighty-two rice germplasm accessions on the basis of twenty-nine morphological and eight agronomical traits. Most of the morphological characters showed variation in different accessions except leaf : collar leaf : ligule and leaf : shape of ligule. A significant amount of variation was displayed for most of the agronomical traits examined. After evaluation of 782 accessions for eight quantitative characters, on the basis of mean values, top ten accessions were identified for the yield ancillary traits. These can be used to identify phenotypically divergent sources for traits of interest in breeding programmes.

Key Words: Agro-morphological characters, germplasm, variability, rice

Rice (*Oryza sativa* L.) is the world's most important cereal crop and serves as the primary source of staple food for more than half of the global population (Emani *et al.*, 2008). The large scale spread of modern, high yielding varieties has replaced the traditional varieties especially in the irrigated rice ecosystem leading to reduced genetic base and thus increased genetic vulnerability. In past few decades, increase in share of high yielding varieties and shrinkage in the area of local varieties have been reported in India (Hore 2005; Rana *et al*., 2009) as well as in several other countries (Chaudhary *et al*., 2006; Itani, 1993). There is an urgent need to broaden the genetic base of the important crop by introgressing genes from diverse sources. Thus, there is a need to collect, exploit and evaluate the untapped germplasm. In this context, an attempt was made to characterize a set of rice germplasm accessions for different morphological and agronomic trials and to identify the variability available in the collection.

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Materials and Methods

The material for the present investigations consisted of 782 rice germplasm accessions received from DRR Hyderabad and was evaluated under Multi location trial (MLT) during *kharif* 2011 at IGKV, Raipur. Each entry was sown in a plot comprising three rows having three meter length at spacing of 20 cm between rows and 15 cm between plants. The recommended agronomical

practices were followed to raise good crop in the season. Observations were recorded on five randomly chosen plants of each accession for thirty-seven morphological and agronomical traits. The traits studied were Basal leaf: sheath colour, Leaf: intensity of green colour, Leaf: anthocyanin colouration, Leaf sheath: anthocyanin colouration, Leaf sheath: intensity of anthocyanin colouration, Leaf: pubescence of blade surface, Leaf: auricles, Leaf: anthocyanin colouration of auricles, Leaf: collar, Leaf: anthocyanin colouration of collar, Leaf: ligule, Leaf: shape of ligule, Leaf: colour of ligule, Culm: attitude, time of 50% heading, Flag leaf: attitude of blade, Lemma: anthocyanin colouration of keel, Lemma: anthocyanin colouration of area below Apex, Lemma: anthocyanin colouration of apex, Spikelet: colour of stigma, Stem: length, Stem: anthocyanin colouration of nodes, Stem: intensity of anthocyanin colouration of nodes, Stem: anthocyanin colouration of internodes, Panicle: length of main axis, Panicle: curvature of main axis, Panicle: number per plant, Lemma and palea: colour, Panicle: awns, Panicle: presence of secondary branching, Panicle: attitude of branches, Panicle: exsertion, Time of maturity, Grain: weight of 100 fully developed grains, Grain: length, Grain: width and Decorticated grain: colour. Accessions were characterized using morpho-agronomic descriptors according to DUS guidelines (DRR, 2006). Frequency distribution was computed to categorize the accession into different classes. Simple statistics (means, ranges) was calculated to have an idea of the level of variation.

Results and Discussion

(A) Morphological characterization: Qualitative characters are important for plant description (Kurlovich, 1998) and mainly influenced by the consumers preference, socio-economic scenario and natural selection (Hien *et al*., 2007). Frequency distribution for 29 qualitative traits is depicted in Table 1 and its graphical representation of frequency distribution showed in Figure 1. Most of the morphological characters showed variation in different accessions except Leaf:collar, Leaf :ligule and Leaf : shape of ligule. A majority of accessions were found to possess Basal leaf: sheath colour (72% green), Leaf: intensity of green colour (60% dark green), Leaf: anthocyanin colouration (90% absent), Leaf sheath: anthocyanin colouration (82 % absent), Leaf sheath: intensity of anthocyanin colouration (83% very weak), Leaf: pubescence of blade surface (57% medium), Leaf: auricles (99.9% present), Leaf: anthocyanin colouration of auricles (59% light purple), Leaf: anthocyanin colouration of collar (90% absent), Leaf: colour of ligule (58% white), Culm: attitude (69% semi erect), Flag leaf: attitude of blade (75% semi erect), Lemma: anthocyanin colouration of keel (88% absent/very weak), Lemma: anthocyanin colouration of area below Apex (87% absent), Lemma: anthocyanin colouration of apex (72% absent), Spikelet: colour of stigma (68% white), Stem: anthocyanin colouration of nodes (94% absent), Stem: intensity of

anthocyanin colouration of nodes (53% medium), Stem: anthocyanin colouration of internodes (875 absent), Panicle: curvature of main axis (57% semi erect), Lemma and palea: colour (69.5% straw), Panicle: awns (91% absent), Panicle: presence of secondary branching (99% present), Panicle: attitude of branches (49.5% semi erect to spreading), Panicle: exsertion (57% well exserted) and Decorticated grain: colour (74% white). Similar type of work was also reported by Bisne and Sarawgi (2008) and Moukoumbi *et al.* (2011). Based on the morphological descriptors 782 accessions were classified for 29 characters. Some of the unique accessions with distinct features are presented in Table 2.

(B) Agronomical characterization:

Rice accessions were evaluated for agronomical traits viz., time of 50% heading, Stem: length, Panicle: length of main axis, Panicle: number per plant, Time of maturity, Grain: weight of 100 fully developed grains, Grain: length, Grain: width from five competitive plants of middle row of each entry.

Time to 50 % heading: It had mean value of 110 days and a wider range of 66-157 days. Almost 50% of the lines fall in the range of medium to late group (Fig. 2), whereas IC 464013 and IC 577310 accessions were found to be very early in duration with days to 50% heading of 66 and 68 days, respectively.

Plant height: It had wider range (73-190 cm) of variation with a mean value of 144.26 cm. Ali *et al*. (2000) have observed relatively greater range in plant height than the other characters. Plant height in rice is a complex character and is the end product of several genetically controlled factors called internodes (Cheema *et al*., 1987). IC 576897 (73 cm) and IC 576902 (89 cm) were the two accessions which falls under very dwarf group. More than 50% accessions were having plant height in the range of 131-150 cm and can be grouped as tall. Very few accessions exhibited semi dwarf nature and about 100 accessions showed semi tall stature. Reduction in plant height may improve their resistance to lodging and reduce substantial yield losses associated with this trait (Abbasi *et al*., 1995).

Panicle length: It exhibited reasonable amount of variation with range values of 19-34 cm. The average panicle length was 27.13 cm long. Most of the accessions fall under the range of 26-30 cm panicle length. The maximum panicle length was observed in IC 466454. Although it contributes positively yet maximum panicle length is not the only factor responsible for higher grain yield (Abbasi *et al*., 1995). So panicle length alone does not determine the high grain yield as traits such as grain size, grain shape, higher number of tillers/plant, longer panicles and greater number of grains/panicle ultimately contribute to higher grain yield (Akram *et al*., 1994).

Number of productive tillers per plant: It is another yield attributing trait (Abbasi *et al*., 1995). A great variability with high range (2-19.33) and mean value of 6.01 was exhibited for number of productive tillers/plant. IC 462373 had maximum value(19.33).

Days to maturity: It also exhibited high range (86-184 days) with a mean of 125.02 days IC

464013 had shorter maturity period (86 days) representing earliness. Minimum value for days to maturity represents that the variety has a benefit of early ripening. Most of the lines fall under mid early followed by medium and late duration.

100-grain weight: It is also a yield-attributing trait (Abbasi *et al*., 1995). Most of the lines were in the range of 2.1 – 2.5 g. Lines with high grain weight (> 3g) were also observed in this set of germplasm (Fig.2). IC 463274 had maximum 100 grain weight (4.32 g).

Grain length: Grain length is an important quality parameter. Rice grain can be classified as extra long, long, medium and short (Akram *et al*., 1994). It exhibited high range (6.0-11.8 mm) with mean of 8.4 mm. In the present material, more than 80% accessions falls in short to medium group, whereas few of the accessions were observed with long grain. IC464907 was observed with maximum grain length (11.8 mm).

Grain width: It exhibited high range (2-4.4 mm) with mean of 2.6 mm. In the present material, most of the lines were in the range of 2.1 – 3.0 mm. IC 460013 was observed with maximum grain width (4.4 mm).

After evaluation of 782 accessions for eight quantitative characters, on the basis of mean values, top ten accessions were identified for the yield ancillary traits (Table 3). IC 462373 (19.33) had the highest number of effective tillers per plant followed by IC 463424 (14.33). Similarly, IC 463274 (4.32 g) had the highest rank for 100 grain weight followed by IC 466455 (4.00 g). Identifying germplasm accessions for different agronomical characters in phenotypically divergent sources would help in prebreeding and breeding programs.

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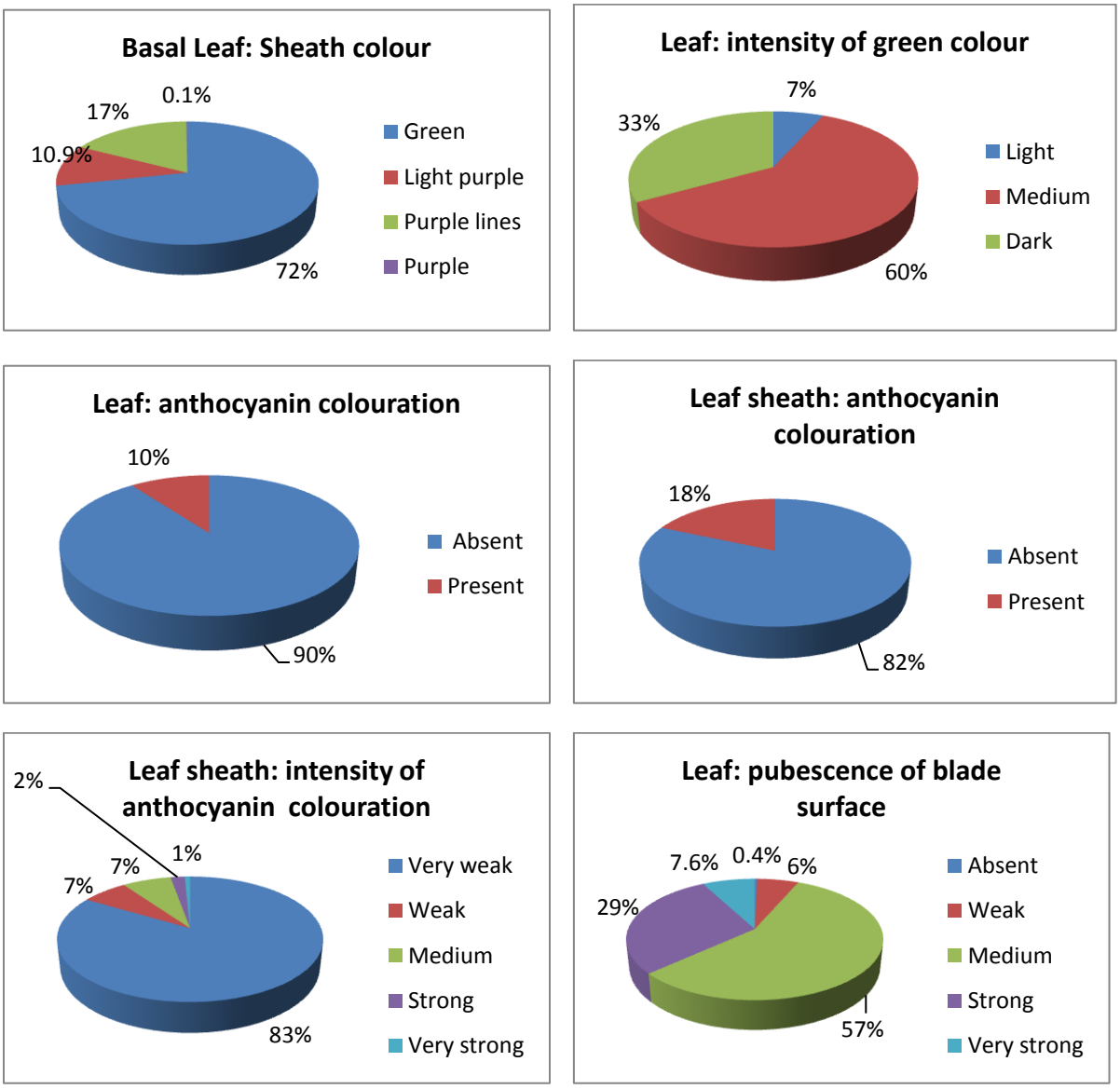
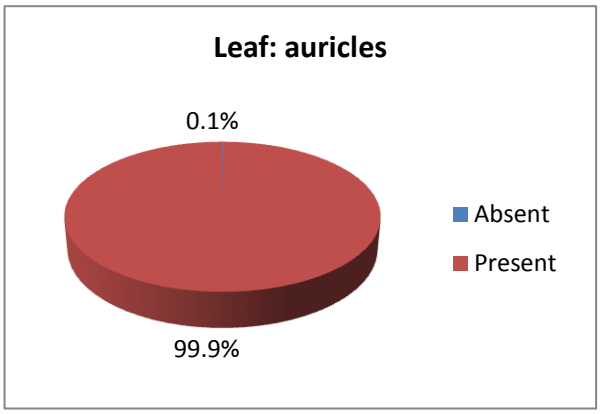
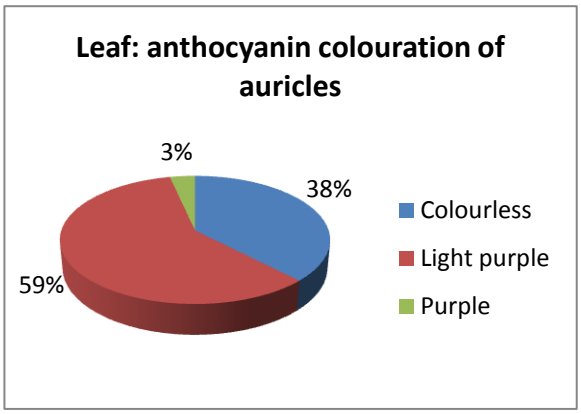
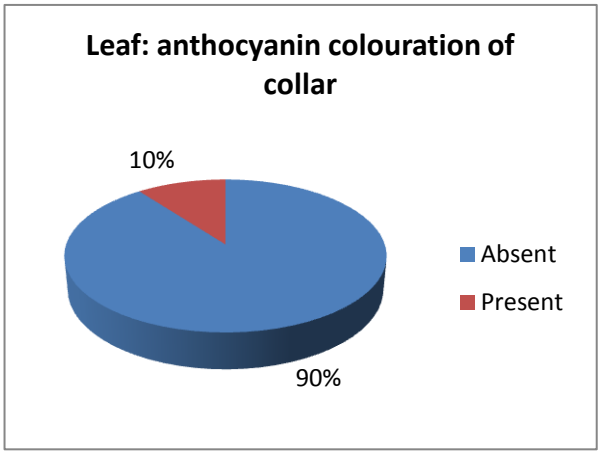
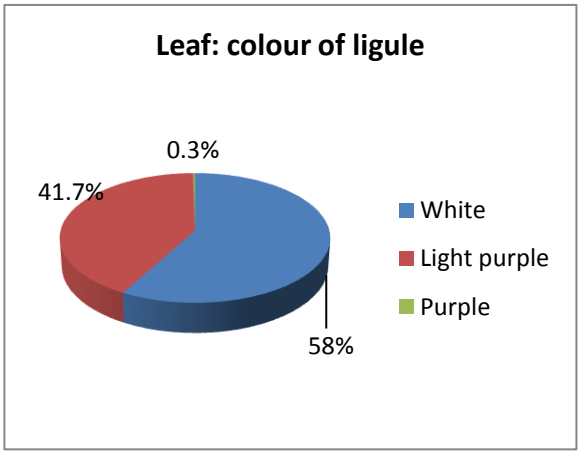
Figure 1: Frequency distribution of important morphological characters

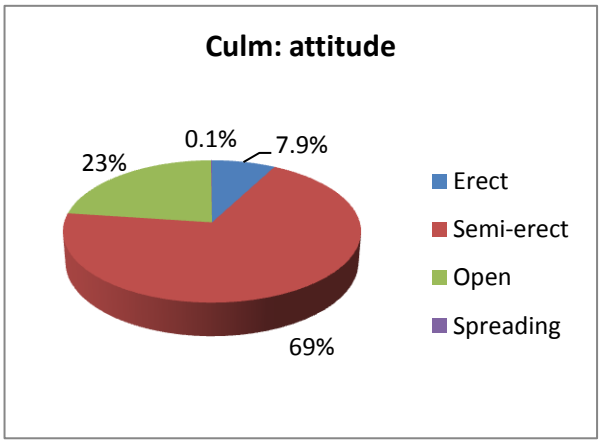


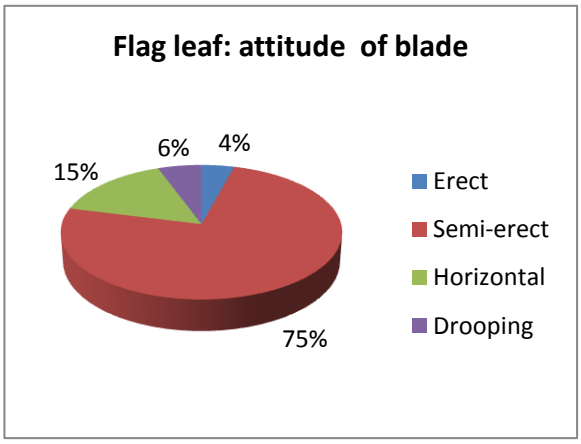

Leaf: auricles
0.1%
99.9%
Absent
Present

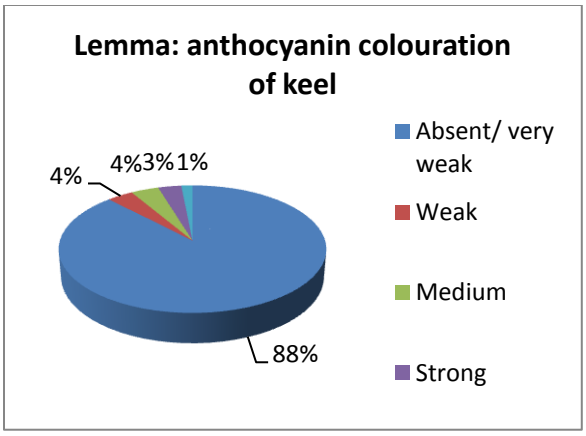

Leaf: anthocyanin colouration of auricles
3%
38%
59%
Colourless
Light purple
Purple

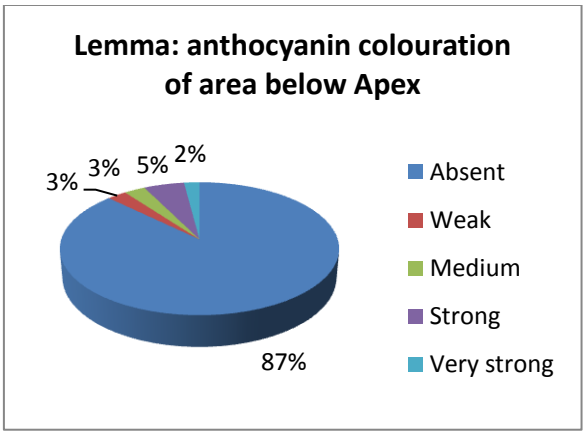

Leaf: anthocyanin colouration of collar
10%
90%
Absent
Present

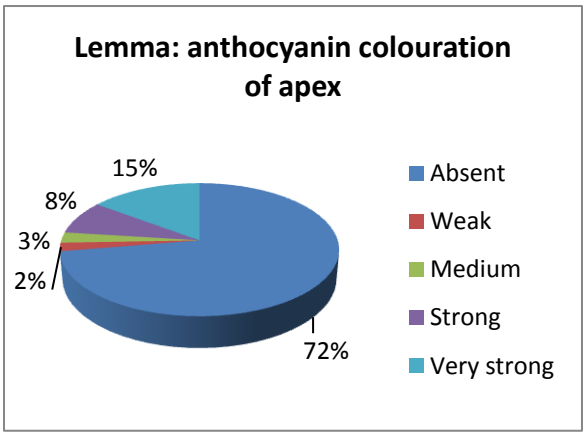

Leaf: colour of ligule
0.3%
41.7%
58%
White
Light purple
Purple

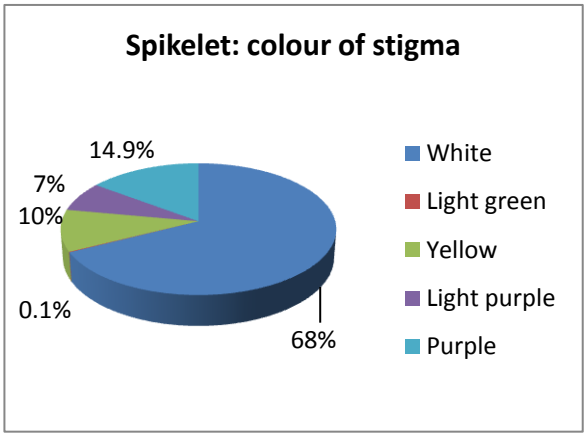

Culm: attitude
0.1%
7.9%
23%
69%
Erect
Semi-erect
Open
Spreading

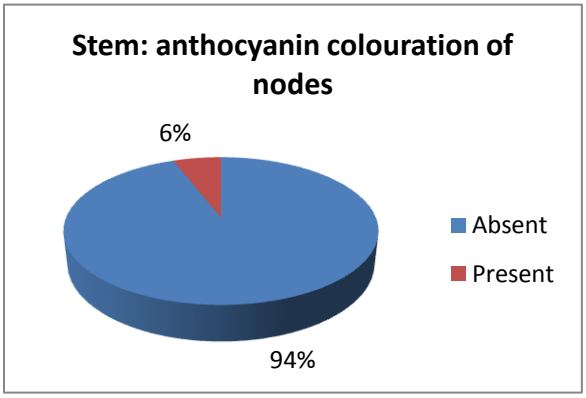

Flag leaf: attitude of blade
6%
4%
15%
75%
Erect
Semi-erect
Horizontal
Drooping

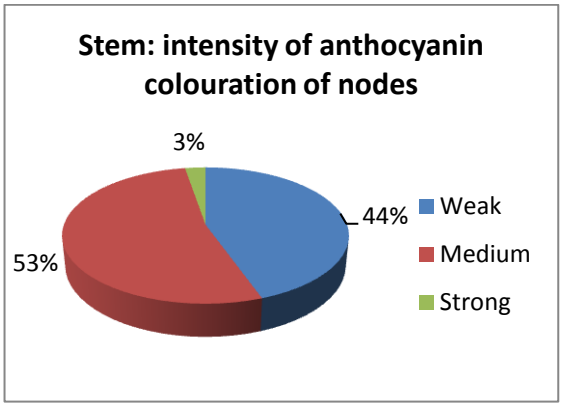

Lemma: anthocyanin colouration of keel
4%
4%3%1%
88%
Absent/ very weak
Weak
Medium
Strong

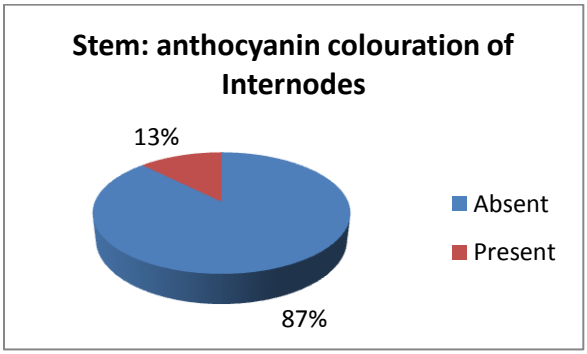

Lemma: anthocyanin colouration of area below Apex
3%
3%
5%
2%
87%
Absent
Weak
Medium
Strong
Very strong

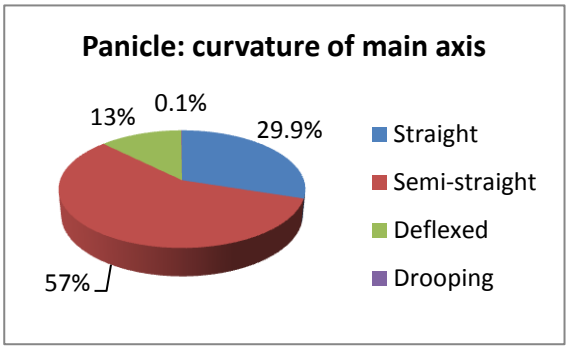

Lemma: anthocyanin colouration of apex
15%
8%
3%
2%
72%
Absent
Weak
Medium
Strong
Very strong

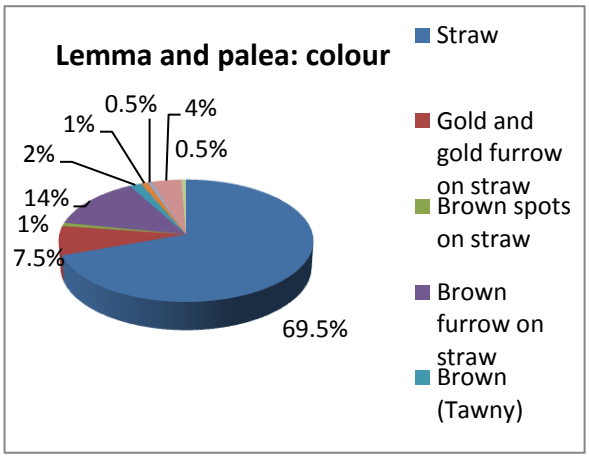

Spikelet: colour of stigma
14.9%
7%
10%
0.1%
68%
White
Light green
Yellow
Light purple
Purple

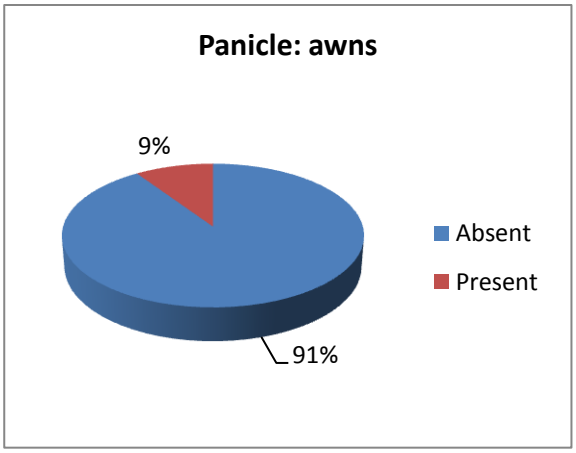

Stem: anthocyanin colouration of nodes
6%
94%
Absent
Present

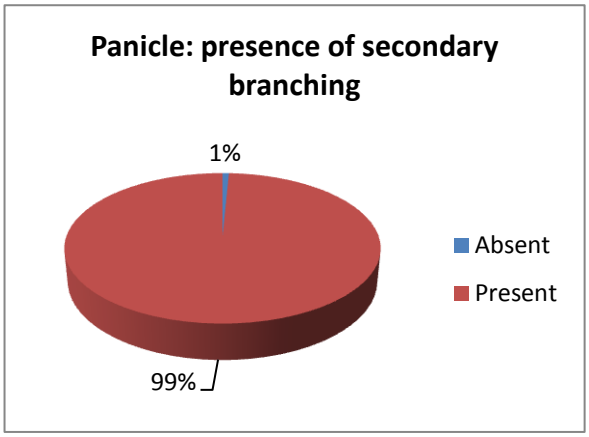

Stem: intensity of anthocyanin colouration of nodes
3%
44%
53%
Weak
Medium
Strong

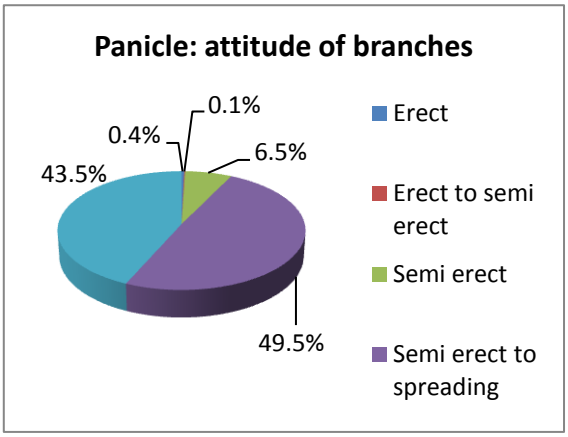

Stem: anthocyanin colouration of Internodes
13%
87%
Absent
Present

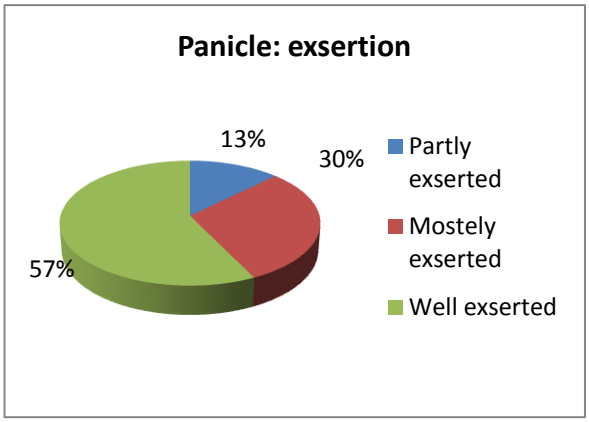

Panicle: curvature of main axis
13%
0.1%
29.9%
57%
Straight
Semi-straight
Deflexed
Drooping


Lemma and palea: colour
Straw
Gold and gold furrow on straw
Brown spots on straw
Brown furrow on straw
Brown (Tawny)
69.5%
7.5%
1%
14%
2%
1%
0.5%
4%
0.5%


Panicle: awns
Absent
Present
9%
91%


Panicle: presence of secondary branching
Absent
Present
1%
99%


Panicle: attitude of branches
Erect
Erect to semi erect
Semi erect
Semi erect to spreading
0.1%
0.4%
6.5%
43.5%
49.5%


Panicle: exsertion
Partly exserted
Mostly exserted
Well exserted
13%
30%
57%

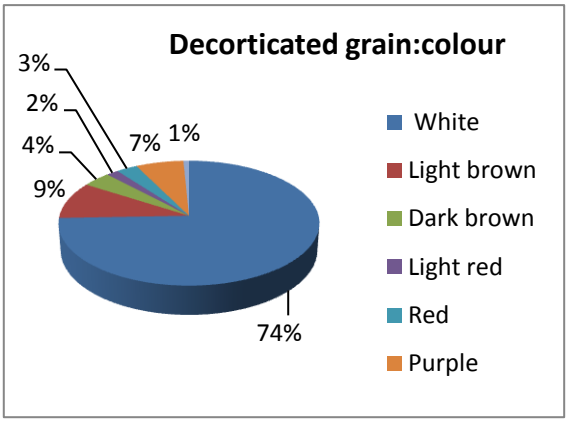

Decorticated grain:colour
White
Light brown
Dark brown
Light red
Red
Purple
3%
2%
4%
9%
7%
1%
74%

Figure 2: Frequency distribution of eight quantitative traits in rice accessions

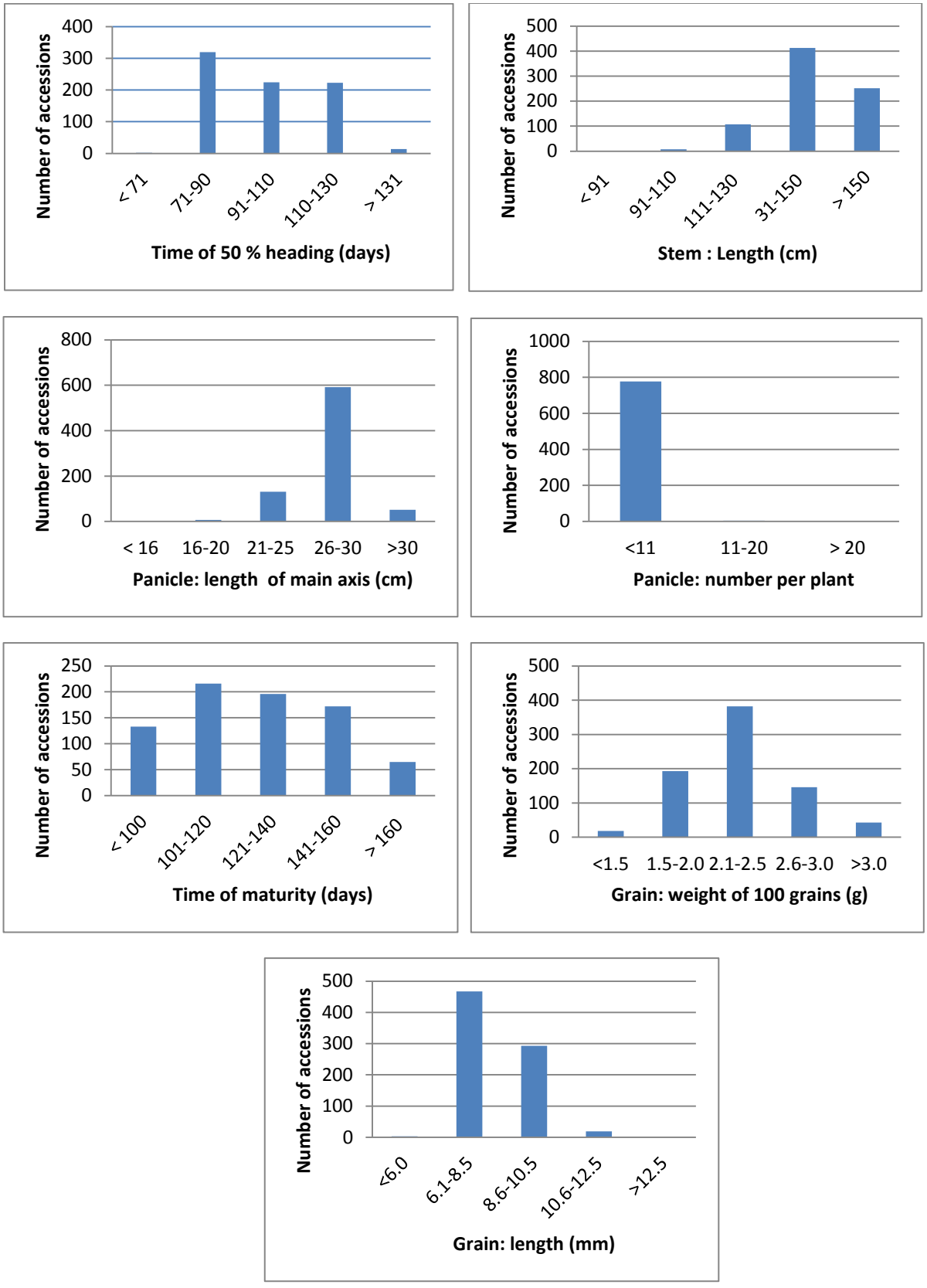


Table 1: Frequency distribution for agro-morphological characters in rice germplasm

S. No.	Morphological characters	Colour pattern/ type	Frequency
1	Basal leaf: sheath colour	Green	560
		Light purple	86
		Purple lines	135
		Purple	1
2	Leaf: intensity of green colour	Light	52
		Medium	471
		Dark	259
3	Leaf: anthocyanin colouration	Absent	702
		Present	80
4	Leaf sheath: anthocyanin colouration	Absent	638
		Present	144
5	Leaf sheath: intensity of anthocyanin colouration	Very weak	653
		Weak	52
		Medium	55
		Strong	16
		Very strong	6
6	Leaf: pubescence of blade surface	Absent	3
		Weak	48
		Medium	444
		Strong	226
		Very strong	61
7	Leaf: auricles	Absent	1
		Present	781
8	Leaf: anthocyanin colouration of auricles	Colourless	295
		Light purple	460
		Purple	27
9	Leaf: collar	Absent	0
		Present	782
10	Leaf: anthocyanin colouration of collar	Absent	701
		Present	81
11	Leaf: ligule	Absent	0
		Present	782
12	Leaf: shape of ligule	Truncate	0
		Acute	0
		Cleft/split	782
13	Leaf: colour of ligule	White	454
		Light purple	326
		Purple	2
14	Culm: attitude	Erect	61
		Semi-erect	542
		Open	178
		Spreading	1
15	Time of heading (50% of plants with panicles)	Very early (< 71)	2
		Early (71-90)	319
		Medium (91-110)	224
		Late (110-130)	223
		Very late (> 131)	14

16	Flag leaf: attitude of blade (early observation)	Erect Semi-erect Horizontal Drooping	33 584 121 44
17	Lemma: anthocyanin colouration of keel	Absent/ very weak Weak Medium Strong Very strong	687 28 30 25 12
18	Lemma: anthocyanin colouration of area below Apex	Absent Weak Medium Strong Very strong	682 20 22 42 16
19	Lemma: anthocyanin colouration of apex	Absent Weak Medium Strong Very strong	566 16 20 64 116
20	Spikelet: colour of stigma	White Light green Yellow Light purple Purple	528 1 80 57 116
21	Stem: length (excluding panicle, excluding floating rice	Very short (< 91 cm) Short (91-110 cm) Medium (111-130 cm) Long (131-150 cm) Very long (> 150cm)	2 8 107 413 252
22	Stem: anthocyanin colouration of nodes	Absent Present	736 46
23	Stem: intensity of anthocyanin colouration of nodes	Weak Medium Strong	348 413 21
24	Stem: anthocyanin colouration of Internodes	Absent Present	684 98
25	Panicle: length of main axis	Very short (< 16 cm) Short (16-20 cm) Medium (21-25 cm) Long (26-30 cm) Very long (>30m)	0 7 131 592 52
26	Panicle: curvature of main axis	Straight Semi-straight Deflexed Drooping	234 449 98 1
27	Panicle: number per plant	Few (<11) Medium (11-20) Many (> 20)	777 4 1
28	Lemma and palea: colour	Straw	544

		Gold and gold furrow on straw	60
		Brown spots on straw	7
		Brown furrow on straw	108
		Brown (Tawny)	13
		Reddish to light purple	8
		Purple spots/furrow on straw	4
		Purple	33
		Black	5
29	Panicle: awns	Absent	708
		Present	74
30	Panicle: presence of secondary branching	Absent	6
		Present	776
31	Panicle: attitude of branches	Erect	3
		Erect to semi erect	1
		Semi erect	53
		Semi erect to spreading	386
		Spreading	339
32	Panicle: exsertion	Partly exserted	99
		Mostely exserted	235
		Well exserted	448
33	Time of maturity	Very early (< 100)	133
		Early (101-120)	216
		Medium (121-140)	196
		Late (141-160)	172
		Very late (> 160	65
34	Grain: weight of 100 fully developed Grains	Very low (<1.5g)	18
		Low (1.5-2.0 g)	193
		Medium (2.1-2.5 g)	382
		High(2.6-3.0 g)	146
		Very high (>3.0 g)	43
35	Grain: length	Very short (<6.00mm)	3
		Short (6.10-8.50mm)	467
		Medium (8.60-10.50mm)	293
		Long (10.60-12.50mm)	19
		Very long (>12.50mm)	0
36	Grain: width	Very narrow (<2.0mm)	7
		Narrow (2.1-2.5mm)	348
		Medium (2.6-3.0mm)	330
		Broad (3.1-3.5mm)	78
		Very broad (>3.5mm)	19
37	Decorticated grain:colour	White	582
		Light brown	75
		Variegated brown	0
		Dark brown	31
		Light red	13
		Red	23
		Variegated purple	0
		Purple	52
		Dark purple	6

Table 2: List of unique accessions for different morphological traits.

S. No.	Morphological characters	Colour pattern/ type	Unique accessions
1	Basal leaf: sheath colour	Purple	IC 577118
2	Leaf: auricles	Absent	IC 577313
3	Leaf: colour of ligule	Purple	IC 463034, IC 462482
4	Culm: attitude	Spreading	IC 462373
5	Spikelet: colour of stigma	Light green	IC 450281
6	Panicle: curvature of main axis	Drooping	IC 466429
7	Lemma and palea: colour	Black	IC 463055, IC463190, IC 462453, IC 577162, IC 463796
8	Decorticated grain:colour	Dark purple	IC 545203, IC 459732, IC 463233, IC 462481, IC 463457, IC 466621

Table 3: Top ranking accessions for yield ancillary traits.

S. No.	Plant height (cm)	Panicle length (cm)	No. of effective tillers per plant	Grain length (mm)	Grain width (mm)	100 grain weight (g)
1	IC 576897 (73.00)	IC 466454 (34.00)	IC 462373 (19.33)	IC464907 (11.8)	IC 460013 (4.4)	IC 463274 (4.32)
2	IC 576902 (89.33)	IC 463586 (33.67)	IC 463424 (14.33)	IC 464895 (11.4)	IC 463446 (4.1)	IC 466455 (4.00)
3	IC 577060 (91.67)	IC 462413 (33.33)	IC 462467 (11.67)	IC 463032 (11.4)	IC 466502 (4.0)	IC 576987 (3.83)
4	IC 466394 (96.00)	IC 464906 (33.33)	IC 462256 (10.67)	IC 462498 (11.4)	IC 577035 (3.9)	IC 577061 (3.70)
5	IC 462427 (96.33)	IC 576987 (33.00)	IC 463902 (10.67)	IC 466599 (11.3)	IC 463414 (3.9)	IC 466502 (3.69)
6	IC 576898 (97.00)	IC 577027 (33.00)	IC 463331 (10.33)	IC 545218 (11.2)	IC 463312 (3.8)	IC 466613 (3.65)
7	IC 464979 (105.00)	IC 463212 (33.00)	IC 463400 (10.00)	IC 463214 (11.2)	IC 577488 (3.8)	IC 462498 (3.58)
8	IC 462471 (106.67)	IC 462482 (32.67)	IC 463896 (10.00)	IC 463791 (11.2)	IC 462496 (3.7)	IC 466454 (3.55)
9	IC 463457 (109.00)	IC 463235 (32.67)	IC 463438 (9.67)	IC 463068 (11.2)	IC 462476 (3.7)	IC 463780 (3.52)
10	IC 576900 (109.33)	IC 463643 (32.67)	IC 463367 (9.33)	IRGC21088 (11.2)	IC 463419 (3.7)	IC 463414 (3.48)