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Morphological characterization of F_3 mapping population of rice for BPH resistance (*Oryza sativa* L.)

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Abstract
The investigational material comprised of 34 F_3 plant population along with two parents CG Zn Rice I and IR64 of rice which have been studied for morphological traits. Variability was recorded for 31 qualitative and 14 quantitative traits. All considered morphological and quality descriptors showed remarkable differences in their distribution and amount of variations within them. The magnitude of phenotypic coefficient of variation was found to be higher than the genotypic coefficient of variation for all the traits indicating the significant role of environmental factor. The high amount of genotypic and phenotypic coefficient of variation with high genetic advance as percentage of mean was observed for leaf length, filled spikelets per panicle, unfilled spikelets per panicle and economic yield. High heritability coupled with high genetic advance as percentage of mean was observed for 100 seed weight, unfilled spikelets, seed length and seed width. High heritability coupled with high genetic advance indicated that most likely the heritability is due to additive gene effects and selection may be effective for these characters based on phenotypic values in order to obtain maximum genetic gain for yield improvement in rice by simple selection process.

Keywords: morphological characterization, F_3 generation, mapping population, BPH resistance, rice

Introduction
Rice crop is grown nearly 43.79 million ha of land in the country with the production of 116.42 MT and productivity of 2.2 t/ha which is less than the productivity of many countries. In India direct seeded rice has grown in the area of 7.2 M ha. In Chhattisgarh, rice occupies average of 3.77 million ha with the productivity of the state ranging between 1.2 to 1.6 t/ha depending upon the rainfall and the production is 8.58 MT. Chhattisgarh state has 7th rank for rice production with 6608.83 thousand tones in all over India Paddy is one of the most important cereal crops in the country. Chhattisgarh occupies a prominent place in paddy cultivation. Chhattisgarh will be producing 9.54 MT of rice in the *kharif* season 2018-19. The target set is about 8.5 per cent of the national target for the rice production set at 113 MT.

Fu *et al*. (2010) [1] reported significant positive correlations of grain yield per plant with spikelets per panicle, 1000 seeds weight, number of panicles per plant and percentage seed set; whereas number of panicles per plant had significant negative correlations with spikelets per panicle, seeds per panicle and 1000 seeds weight.

Moosavi *et al*. (2015) [2] found that grain yield per plant showed significant correlation with panicle number, harvest index, dry weight and panicle length these traits can be used as indicators for indirect selection of grain yield.

Evaluation and characterization of innumerable germplasms and genetic stocks, which are suitable in one or more aspects, are a pre-requisite for any crop improvement program. In any crop genetic materials plays as an important source and provides scope for wide variability. Characterization of these materials is of great importance for current and future agronomic and genetic improvement of the crop. Genetic variability underscores the need to collect landraces for ex-situ conservation and to characterize them for future rice breeding programs based on agro-morphological traits because the evaluation of phenotypic diversity usually reveals important traits of interest to plant breeders (Pandey and Kar, 2019) [3]. Rice breeding strategy involves the assembling or generating variable genetic materials and selection of superior genotypes from these materials for utilizing them to develop a superior variety.

Sarawgi *et al*. (2015) [4] reported positive and significant correlation of leaf length and leaf width, effective tillers and plant height with grain yield. The study of path analysis for yield related traits revealed that leaf length, leaf width, days to 50% flowering, effective tillers, plant height, panicle length and days to maturity had positive direct effect on grain yield/plant. It may be concluded that the characters like leaf length, leaf width, panicle length and effective tiller could be used as direct selection criterion for higher grain yield.

It is essential to estimate the various types of gene action for the selection of appropriate breeding procedure to improve the quantitative and qualitative characters (Sathya and Jebaraj, 2013) [5]. Keeping in view the genetic studies in aerobic rice were undertaken to compute the heritability, coefficients of variability and genetic advance in F_2 segregating populations of the 15 crosses for 14 characters, and also the response of selection for yield and its component characters through mean, percentage of population mean and through parent progeny correlation and regression method in between F_2 and F_2 generations.

Materials and Methods

The material for the present investigation consisted of 34 rice F_3 plants during *Kharif* 2019 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 32 morphological and 14 agronomical traits. The traits studied were Coleoptile colour, Basal leaf sheath colour, Leaf colour, Auricle, Collar, Ligule, Leaf margin colour, Stigma colour, Leaf intensity of green colour, Leaf anthocyanin colouration, Leaf distribution of anthocyanin colour, Leaf pubescence of blade surface, Leaf auricle, Leaf anthocyanin colouration of auricle, Leaf collar, Leaf anthocyanin colouration of collar, Ligule, Shape of ligule, Colour of ligule, Flag leaf attribute of blade, Stem anthocyanin colouration of nodes, Stem anthocyanin colouration of internodes, Panicle awn, Panicle curvature of mains axis, Panicle presence of secondary branching, Leaf length (cm), Leaf width (cm), Plant height (cm), Panicle length (cm), Number of tillers per plant, Number of effective tillers per plant, Biological yield (g), Economic yield (g), Harvest index, Filled spikelets per panicle, Unfilled spikelets per panicle, 100 Grains weight (g), Seed length (mm) and Seed width (mm). F_3 plants were characterized using morpho-agronomic descriptors according to DUS guidelines. 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

1. Morphological characterization

Any variety can be identifying through its distinguished stable morphological traits. These traits may be monogenic or polygenic. The stable morphological traits can be used as reliable morphological markers for identification of a variety. Each variety must have certain novel diagnostic features which will distinguish a variety from others. Such diagnostic characters should uniformly present in the population and should be inherited in next generation then only the character is supposed to be stable and can be used as morphological marker traits to distinguish that variety from others. The 32, F_3 plants (16 resistant and 16 susceptible) of rice and two checks (CG Zn Rice I and IR64) were characterized on the basis of agro-morphological characters. The result of agro-morphological characterization as observed in 34 F_3 plants along with parents. Frequency distribution and percentage value of agro-morphological characters (fig.1) of 34 F_3 plants of rice along with 2 checks studied Table 1.1.

Table 1.1: Frequency distribution and percentage value of agro-morphological characters

S. No.	Characteristics	States	No. of lines	Frequency %
1.	Coleoptile colour	White	34	100
		Green	Nil	0
		Purple	Nil	0
2.	Basal leaf sheath colour	Green	25	74
		Light Purple	9	26
		Purple	Nil	0
		Uniform purple	Nil	0
3.	Leaf: Intensity of green colour	Light	5	15
		Medium	24	70
		dark	5	15
4.	Leaf: Anthocyanin colouration	Absent	22	65
		Present	12	35
5.	Leaf: Distribution of Anthocyanin colouration	On tips only	Nil	0
		On margins only	12	100
		In blotches only	Nil	0
		Uniform	Nil	0
6.	Leaf Sheath: Anthocyanin colouration	Absent	25	74
		Present	9	26
7.	Leaf Sheath: Intensity of Anthocyanin colouration	Very weak	Nil	0
		Weak	7	78
		Medium	1	11
		Strong	1	11
		Very strong	Nil	0
8.	Leaf: Pubescence of blade surface	Absent	0	0
		Weak	4	12
		Medium	17	50
		Strong	12	35
		Very strong	1	3
9.	Leaf: Auricles	Present	34	100
		Absent	Nil	0
10.	Leaf: Anthocyanin colouration of auricles	Colourless	33	97

		Light purple	1	3
		Purple	Nil	0
11.	Leaf: Collar	Absent	Nil	0
		Present	34	100
12.	Leaf: Anthocyanin colouration of collar	Absent	32	94
		Present	2	6
13.	Leaf: Ligule	Absent	Nil	0
		Present	34	100
14.	Leaf: Shape of ligule	Truncate	Nil	0
		Acute	Nil	0
		Split	34	100
15.	Leaf: Colour of ligule	White	34	100
		Light purple	Nil	0
		Purple	Nil	0
16.	Leaf: Length of blade	Short	2	6
		Medium	24	70
		Broad	8	24
17.	Leaf: Width of blade	Narrow	7	20
		Medium	20	60
		Broad	7	20
18.	Flag leaf: Attitude of blade (early observation)	Erect	14	41
		Semi-erect	16	47
		Horizontal	4	12
		Drooping	Nil	0
19.	Stem: Anthocyanin colouration of nodes	Absent	31	91
		Present	3	9
20.	Stem: Intensity of Anthocyanin colouration of nodes	Weak	Nil	0
		Medium	3	100
		Strong	Nil	0
21.	Stem: Anthocyanin colouration of internodes	Absent	34	100
		Present	Nil	0
22.	Flag leaf: Attitude of blade (late observation)	Erect	14	41
		Semi-erect	15	44
		Horizontal	Nil	0
		Deflexed	5	15
23.	Panicle: Curvature of main axis	Straight	Nil	0
		Semi-straight	19	56
		Deflexed	15	44
		Drooping	Nil	0
24.	Panicle: No. per plant	Few	1	3
		Medium	28	82
		Many	5	15
25.	Panicle: Awns	Absent	30	88
		Present	4	12
26.	Panicle: Colour of awns	Yellowish white	Nil	0
		Yellowish brown	Nil	0
		Brown	34	100
		Reddish brown	Nil	0
		Light red	Nil	0
		Red	Nil	0
		Light purple	Nil	0
		Purple	Nil	0
		Black	Nil	0
27.	Panicle: Distribtion of awns	Tip only	4	100
		Upper half only	Nil	0
		Whole length	Nil	0
28.	Panicle: Presence of secondary branching	Absent	Nil	0
		Present	34	100
29.	Panicle: Secondary branching	Weak	9	26
		Strong	22	65
		Clustered	3	9
30.	Panicle: Attitude of branches	Erect	Nil	0
		Erect to semi erect	31	91
		Semi erect	3	9
		Semi erect to spreading	Nil	0
		spreading	Nil	0
31.	Panicle: Exsertion	Partly exserted	6	18
		Mostly exserted	22	66
		Well exserted	6	18

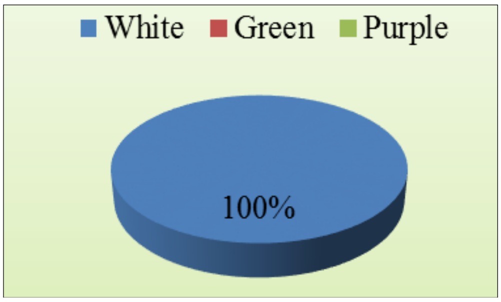

Fig 1.1: Coleoptile colour

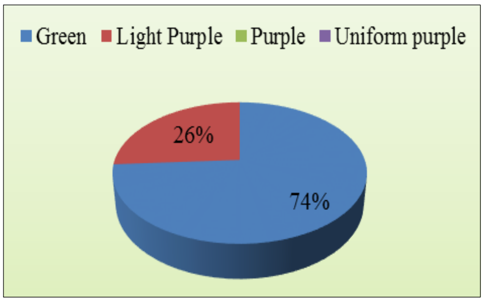

Fig 1.2: Basal leaf sheath colour

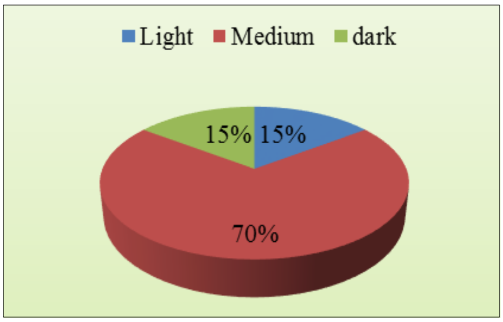

Fig 1.3: Leaf: Intensity of green colour

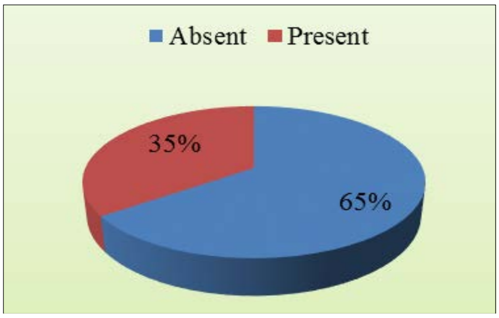

Fig 1.4: Leaf: Anthocyanin colouration

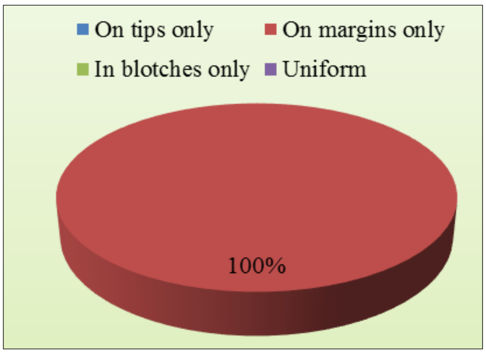

Fig 1.5: Leaf: Distribution of Anthocyanin colouration

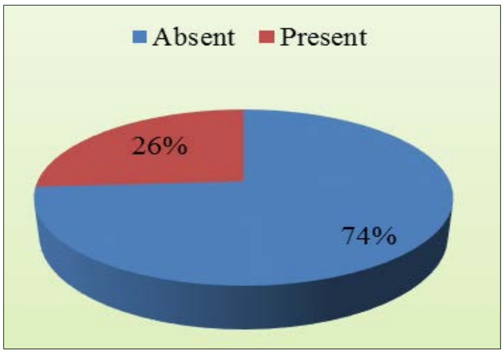

Fig 1.6: Leaf Sheath: Anthocyanin colouration

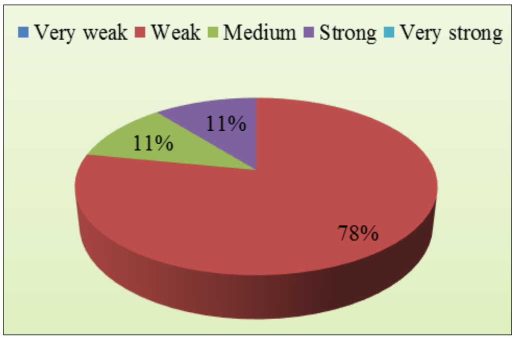

Fig 1.7: Leaf Sheath: Intensity of Anthocyanin colouration

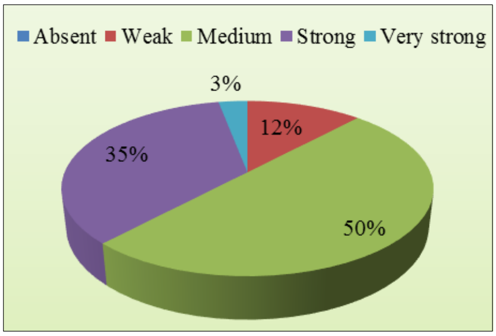

Fig 1.8: Leaf: Pubescence of blade surface

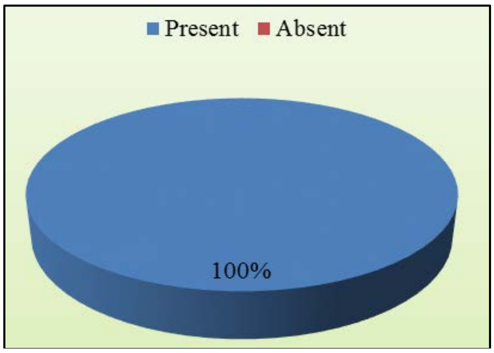

Fig 1.9: Leaf: Auricles

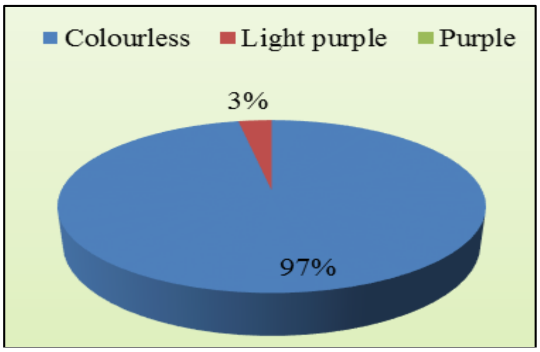

Fig 1.10: Leaf: Anthocyanin colouration of auricles

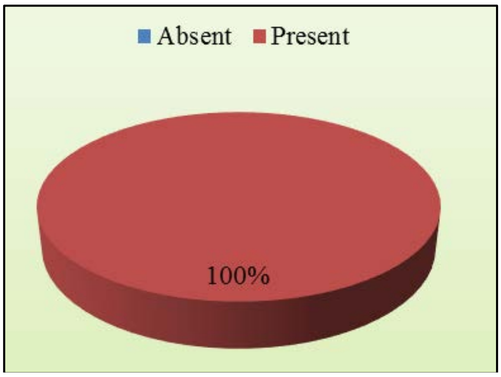

Fig 1.11: Leaf: Collar

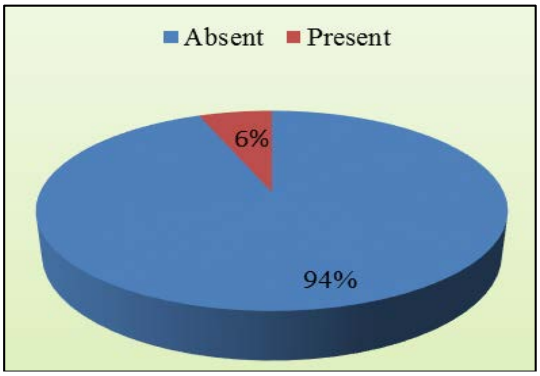

Fig 1.12: Leaf: Anthocyanin colouration of collar

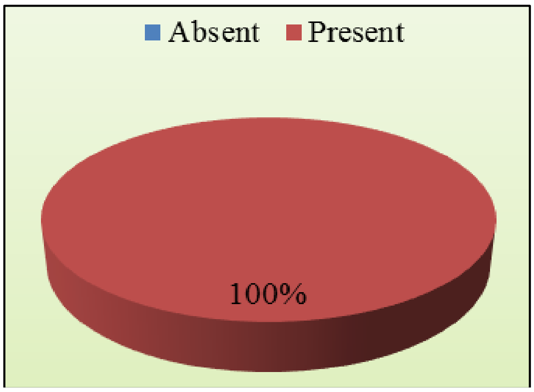

Fig 1.13: Leaf: Ligule

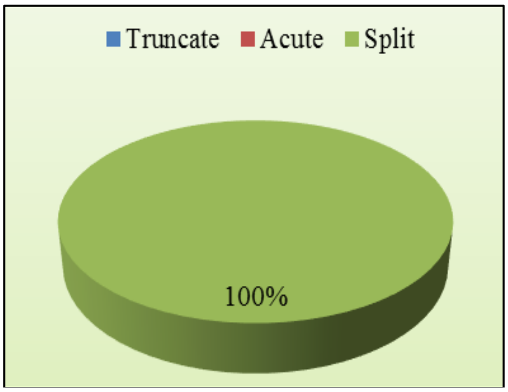

Fig 1.14: Leaf: Shape of ligule

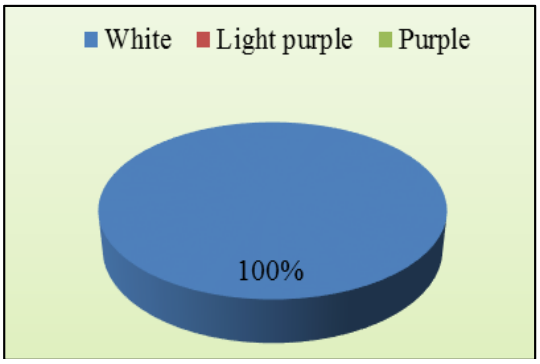

Fig 1.15: Leaf: Colour of ligule

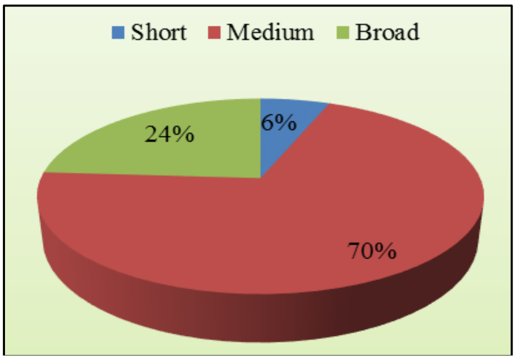

Fig 1.16: Leaf: Length of blade

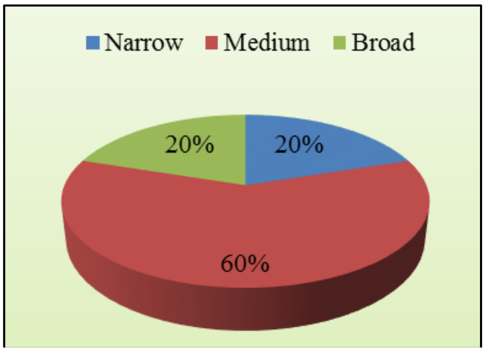

Fig 1.17: Leaf: Width of blade

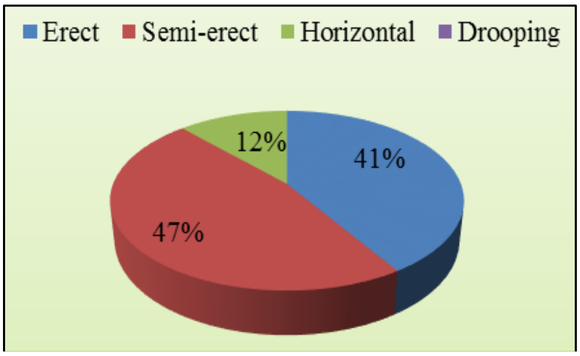

Fig 1.18: Flag leaf: Attitude of blade (early observation)

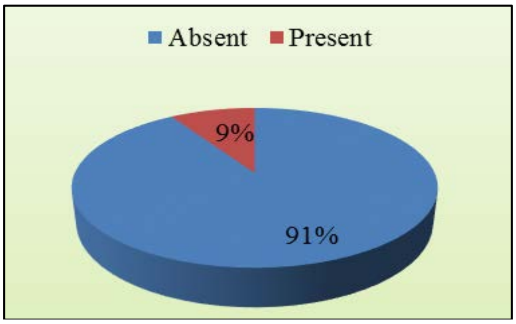

Fig 1.19: Stem: Anthocyanin colouration of nodes

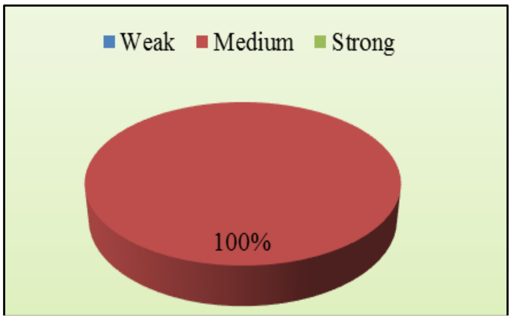

Fig 1.20: Stem: Intensity of Anthocyanin colouration of nodes

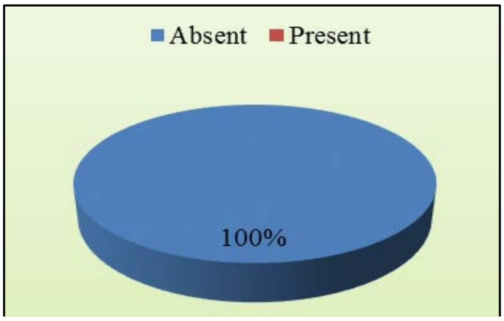

Fig 1.21: Stem: Anthocyanin colouration of internodes

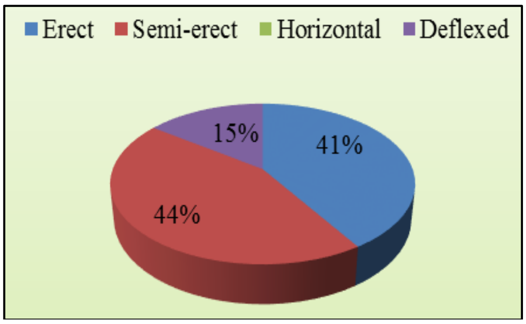

Fig 1.22: Flag leaf: Attitude of blade (late observation)

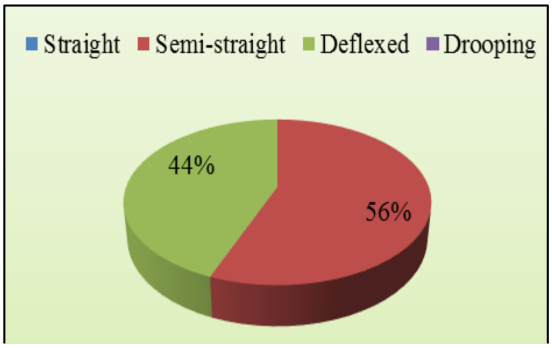

Fig 1.23: Panicle: Curvature of main axis

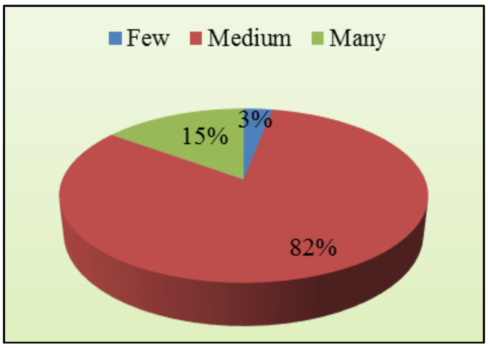

Fig 1.24: Panicle: No. per plant

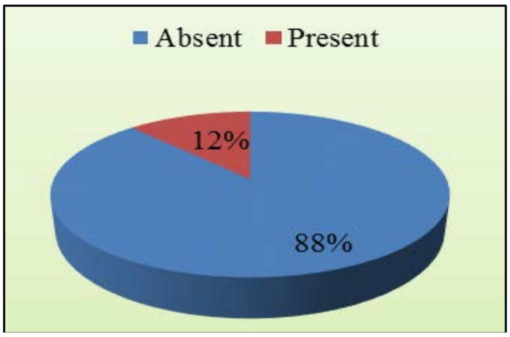

Fig 1.25: Panicle: Awns

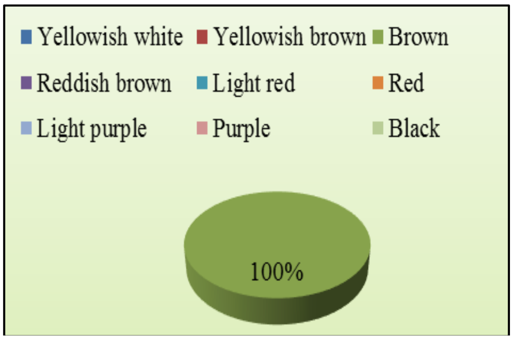

Fig 1.26: Panicle: Colour of awns

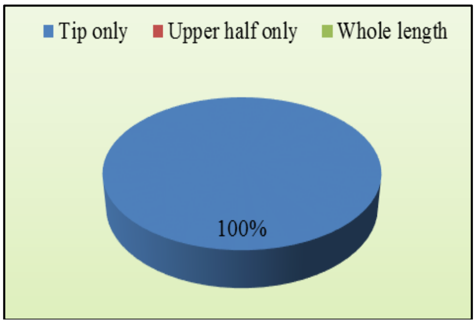

Fig 1.27: Panicle: Distribtion of awns

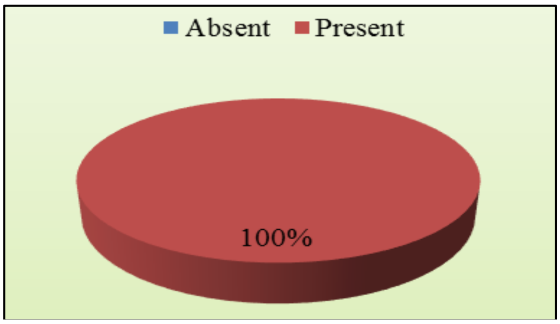

Fig 1.28: Panicle: Presence of secondary branching

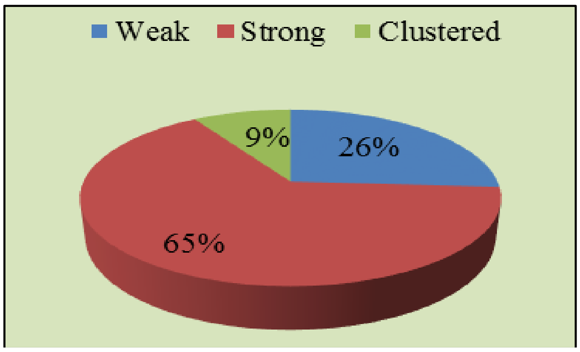

Fig 1.29: Panicle: Secondary branching

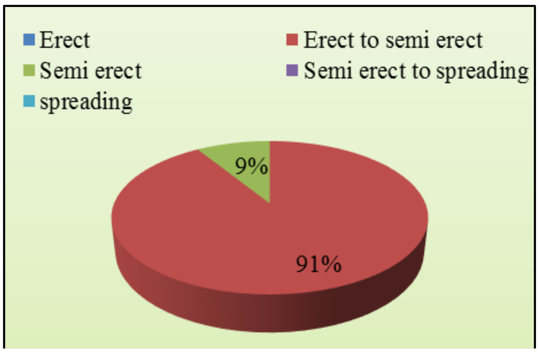

Fig 1.30: Panicle: Attitude of branches

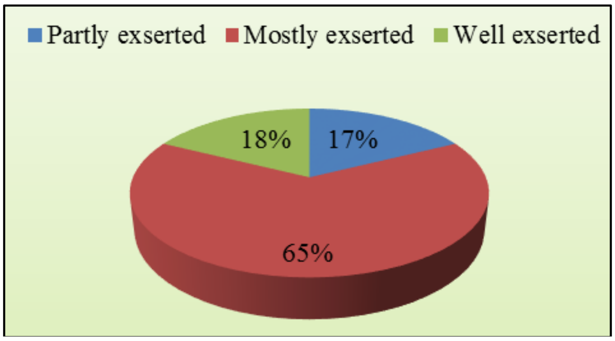

Fig 1.31: Panicle: Exsertion

Fig 1: Frequency distribution of F_3 population based on morphological characters

2. Agronomical characterization

Leaf length of blade ranged from 19.06 cm to 48.16 cm with a mean value of 31.46 cm. The maximum leaf length was recorded in F_3 plant no. 7 (60 cm) followed by F_3 plant no. 30 (48.16 cm) and minimum in F_3 plant no. 19 (19.06 cm). Leaf width of blade ranged from 1.06 cm to 1.5 cm. The maximum leaf width was observed in F_3 plant no. 1, 8 and 9 (1.5 cm) and minimum in F_3 plant no. 29 (1.06 cm). The character plant height (cm) varied between 83.23 (cm) to 137.36 (cm) with a mean of 101.89cm. The mean performance of panicle length (cm) is 26.40 and varied between 20.16 and 30.73. The mean performance of total tillers/plant is 10.10 and varied between 7 and 13.66. The mean performance of effective tillers/plant is 9.32 and varied between 7 and 13. The mean performance of biological yield (g) is 68.17 and varied between 40.99 and 95.43. The mean performance of economic yield (g) is 34.68 and varied between 19.64 and 51.33. The character harvest index (%) varied between 39.05 to 63.00 with a mean of 50.71. The character Filled spikelets/panicle varied between 70.66 to 221 with a mean of 142.27. The character unfilled spikelets/panicle varied between 0.67 to 20.33 with a mean of 7.97. The character 100 grains weight (g) varied between 1.69 to 3.08 with a mean of 2.67. The character seed length (mm) varied between 7.36 to 9.9 with a mean of 8.19. The character seed width (mm) varied between 2.0 to 3.0 with a mean of 2.33.

Table 2.1: Descriptive statistics of studied 32 rice F_3 plants and two parents

S. No.	Characters	Range						
		Mean	Min.	Max.	h^2 (%)	GCV (%)	PCV (%)	GA (%)
1.	Leaf length (cm)	31.46	19.06	48.16	47.22	20.62	30.01	9.18
2.	Leaf width (cm)	1.31	1.06	1.5	8.23	4.04	14.09	0.03
3.	Plant height (cm)	101.89	83.23	137.36	67.57	9.83	11.96	16.96
4.	Panicle length (cm)	26.40	20.16	30.73	57.92	7.15	9.39	2.96
5.	Number of tillers per plant	10.10	7	13.66	14.33	11.08	29.27	0.87
6.	Number of effective tillers per plant	9.32	7	13	6.72	7.79	30.07	0.38
7.	Biological yield(g)	68.17	40.99	95.43	60.92	19.51	24.99	21.38
8.	Economic yield (g)	34.68	19.64	51.33	49.71	22.97	32.59	11.57
9.	Harvest index (%)	50.71	39.05	63.01	26.65	9.21	17.85	4.97
10.	Filled spikelets per panicle	142.27	70.66	221	97.26	25.99	26.36	75.14
11.	Unfilled spikelets per panicle	7.970	0.67	20.33	85.21	69.11	74.872	10.475
12.	100 Seeds weight (g)	2.67	1.69	3.08	99.13	11.41	11.46	0.62
13.	Seed length (mm)	8.19	7.36	9.90	94.74	6.58	6.76	1.08
14.	Seed width (mm)	2.33	2.0	3.0	88.01	13.01	13.86	0.58

Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) are categorized as low (less than 10%), Moderate (10-20%) and high (more than 20%) as suggested by Sivasubramanian and Madhavamenon (1973) [6]. The estimated GCV and PCV helped in getting a clear understanding of the variability present among the various genotypes. Highest phenotypic and genotypic coefficient of variation was recorded for Leaf length (PCV= 30.01%; GCV=

20.62%), Filled spikelet's per panicle (PCV= 26.36%; GCV= 25.99%), Unfilled spikelet's per panicle (PCV= 74.87%; GCV= 69.11%) and Economic yield (PCV=32.59%, GCV=22.98%). This indicated possibility of obtaining higher selection response in respects of these traits.

The PCV and GCV was observed moderate for the traits namely, 100 Grains weight (PCV= 11.46%; GCV= 11.41 and Seed width (PCV= 13.86%; GCV= 13.01%). Whereas No. of effective tillers per plant exhibited high PCV and low GCV (PCV=30.07%, GCV=7.79%). The No. of total tillers per plant exhibited high PCV and moderate GCV (PCV=29.27%, GCV=11.08%) and Biological yield (PCV=24.99%, GCV=19.51%). The moderate PCV and lower GCV was observed for the traits namely, Harvest index (PCV= 17.85%; GCV=9.21, Leaf width (PCV= 14.09%; GCV= 4.04%) and Plant height (PCV= 11.96%; GCV= 9.83%). The PCV and GCV less was observed for the traits namely, Panicle length (PCV= 9.39%; GCV= 7.15 and Seed length (PCV= 6.76%; GCV= 6.58%).

The estimation of phenotypic and genotypic components of variation is of primary importance to get an idea of relative extent of heritable and non-heritable variation. For most of the characters studied, the magnitude of phenotypic coefficient of variation was little higher than the genotypic coefficient of variation. It indicates that there was little influence of environment in the expression of traits. Characters like seed yield and number of primary branches per plant exhibited high PCV and GCV.

Table 2.2: Analysis of variance for different quantitative characters

S. No.	Characters	Mean sum of squares		
		Replication (d.f.= 2)	Treatment (d.f.= 33)	Error (d.f.= 66)
1.	Leaf length (cm)	33.12559	173.3732**	47.0563
2.	Leaf width (cm)	0.050098	0.039742	0.03131
3.	Plant height (cm)	33.57029	349.2904**	48.15928
4.	Panicle length (cm)	3.558922	13.29127**	2.591043
5.	Number of tillers per plant	0.480392	11.26708	7.500594
6.	Number of effective tillers per plant	0.029412	8.918895	7.332442
7.	Biological yield(g)	337.5327	644.2392**	113.4704
8.	Economic yield (g)	70.69559	254.9027**	64.27591
9.	Harvest index (%)	98.46	125.6677**	60.11983
10.	Filled spikelet's per panicle	7.95098	4143.302**	38.53684
11.	Unfilled spikelet's per panicle	3.058	96.311**	5.266
12.	100 Seeds weight (g)	0.002526	0.280836**	0.000817
13.	Seed length (mm)	0.044412	0.888963**	0.016129
14.	Seed width (mm)	0.019216	0.289091**	0.012549

** Significant at 1% *Significant at 5%

The analysis of variance revealed that the mean sum of square for the rice F_3 plants were significant for all characters except Leaf width, Number of tillers per plant and Number of effective tillers per plant. This is the indication of sufficient variability present among the different F_3 plants and varieties under morphological study. The character Leaf length (cm) varied between 19.06 (cm) to 48.16 (cm) with a mean of 31.46 and having standard error mean 3.96. F_3 plant no.30 (48.16 cm) showed the highest mean performance and F_3 plant no.19 (19.06 cm) showed lowest mean performance for this trait. Leaf width had mean of 1.06 (cm) and having minimum range of 1.5 (cm) and maximum range of 1.8 cm. F_3 plant no. 1, 8 and 19 showed highest mean 1.5 (cm) and F_3 plant no. 29 showed lowest mean 1.06 (cm) performance for this trait.

The character Plant height (cm) varied between 83.23 (cm) to 137.36 (cm) with a mean of 101.89 cm and having standard error mean 4.006. The highest mean performance was recorded for F_3 plant no.15 (137.36 cm) whereas the lowest mean performance was recorded for F_3 plant no.25 (83.23 cm). Plant height in rice is a complex character and is the product of several genetically controlled factors called internodes. The mean performance of Panicle length (cm) is 26.40 cm and varied between 20.16 to 30.73. Panicle length showed the highest mean performance of (30.73 cm) for F_3 plant no.26 and F_3 plant no.25 (20.16 cm) showed the lowest mean value. Number of total tillers per plant had mean of 10.10 having minimum range 7 and maximum range 13.66. F_3 plant no.2 showed highest mean performance (13.66), however the lowest mean value of this particular trait was recorded in CG Zn Rice I (7) tillers per plant. Number of effective tillers per plant varied between 7 to 13 having mean average of 9.32. For this character F_3 plant no.27 (13) showed the highest mean performance however the lowest mean performance for this particular character was showed by CG Zn Rice I (7). Biological yield had mean value 68.17 (g) and having minimum range 40.99 (g) and maximum range 95.43 (g). F_3 plant no.2 showed highest mean 95.43 (g) and F_3 plant no.5 showed lowest mean 40.99 (g) performance for this trait. Economic yield had mean value 34.68 (g) and having minimum range 19.64 (g) and maximum range 51.33 (g). F_3 plant no.1 and 2 showed highest mean 51.33 (g) and F_3 plant no.16 showed lowest mean 19.64 (g) performance for this trait. Harvest index having mean value 50.72 and varied in range of 39.05 to 63.01. The character Filled spikelets per panicle with a mean of 142.27 varied between 70.67 to 221. CG Zn Rice I showed the highest mean performance 221 and F_3 plant no.25 showed lowest mean performance 70.67 for this trait. Unfilled spikelets per panicle varied between 0.67 to 20.33 with a mean of 7.97. F_3 plant no.4 and 8 showed the lowest mean performance 0.67 and F_3 plant no.31 showed highest mean performance 20.33 for this trait. The character 100 Seed weight of rice having range 1.69 (g) and 3.08 (g) with average 2.67 (g). The character Seed length having range in between 7.37 (mm) and 9.90 (mm) with an average 8.19 (mm). Seed width having mean value 2.33 (mm) and varied in range of 2.0 to 3.0 (mm).

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