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Characterization and variability analysis of rice germplasm accessions for morphological traits

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Abstract
The present study was carried out to characterize six hundred rice germplasm accessions on the basis of thirty nine morphological and twelve 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 600 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.

Keywords: Agro-morphological characters, germplasm, variability, rice

Introduction
To establish distinctness amongst rice germplasm accessions qualitative and quantitative traits were used for characterization. Qualitative traits are also known as morphological markers were used for identification of landraces of rice, because they are less influenced by environmental changes (Rebeira *et al*., 2014) [9]. Morphological description is the first step for classification and evaluation of the germplasm and it is an essential tool for selecting varieties or lines based on agronomical, morphological, genetic or physiological characters (Sarawgi *et al.*, 2016) [12]. The genotypes can be recognized on the basis of numerous qualitative behaviors *viz.* Basal leaf sheath colour, Leaf: Anthocyanin coloration, Leaf: pubescence of blade surface, Collar colour etc. (Satrawgi *et al.*, 2013) [10]. 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 be 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 while, assessment of quantitative traits have been utilized for the measurement of yield and its important traits as well as their performance can be tested for higher yielding capacity in irrigated conditions**.** A significant amount of quantitative variation was displayed by the germplasm accessions for most of the traits examined irrigated condition.
Agro-Morphological characterization should eventually lead to a system of recording and storing useful data that can be readily retrieved and made available to others and help in planning breeding programmes. Keeping in view the importance of aforesaid aspects, the present investigation was undertaken to characterize the seventy landraces of rice.

Material and methods
A total of 600 core rice accessions were evaluated in transplanted condition. Among the rice accessions thirty nine qualitative traits were used for phenotypic characterization along with twelve yield and yield contributing traits used in transplanted condition. These genotypes were evaluated in augmented design with seven national check Annada, IR64, Pusa Basmati1, Swarna, NDR97, Jaya and Karma Mahsuri selected during *kharif* 2016 at Research cum Instructional farm, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, Chhattisgarh. 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.

Result and Discussion

Morphological characterization

Qualitative characters are important for plant description (Rana *et al.*, 2008) and mainly influenced by the consumers preference, socioeconomic scenario and natural selection (Roy *et al*., 2014) [8]. Frequency distribution for 39 qualitative traits is depicted in Table 1 and frequency distribution showed in Figure 1 and 12 quantitative traits.

Concerning basal leaf: sheath colour, green colour was observed in most of the accessions (82%) Regarding leaf: intensity of green colour, 13% leaf: anthocyanin colouration, 99% accessions having no colouration while 1% accessions *i.e.,* IC114771 IC123261 IC135262 and IC206322 having colouration of leaf while the trait leaf: distributions of anthocyanin colouration, 74% accessions were found anthocyanin colouration on tip only, Consequently, 80% accessions were found sheath anthocyanin colouration and 20% whereas 81% were found very week colouration, 4% weak, 6% medium 7%strong and 2% accessions were found very strong sheath intensity of anthocyanin colouration. leaf pubescence of blade the whole accessions were categorized into five categories, in which 1 accession (IC 207308) had no pubescence of blade surface, 39% accessions having strong pubescence and leaf auricle, all accessions showed auricle presence however, the intensity of anthocyanin colouration of auricle was found *i.e.,* 83% accessions showed colourless auricle, 0.66% accessions showed light purple auricle colour and 16 % accessions showed purple auricle colour. All the accessions exhibited the presence of panicle secondary branching. Majority of accessions (74.84%) were of strong branching and remaining was of weak (25%) in nature and one accession *i.e.,* IC 453708 was found clustered type panicle. Panicle exertion was the most conspicuous character for identification of the rice cultivars. Panicle: exertion having three groups *viz.,* partly, mostly and well exertion. Most of the accessions having well panicle exertion (71%), one hundred sixty nine accessions were found mostly exertion (28%) and five accessions *i.e.,* IC 380055 IC 380118,IC 380145,IC 387054 and IC 387062 were found partly panicle exertion. Panicle attitudes of branches were categorized in five categories *i.e.,* erect, erect to semi erect, semi erect, semi erect to spreading and speeding attitude of branches. Erect type panicle was observed in 2.66% accessions, however, erect to semi erect were found in 40%, semi-erect in 24%, semi-erect to spreading (22.5%) whereas, spreading type was observed in 10.5% accessions, respectively which showed numerous variation Among the accessions 51 characters observed for 39 qualitative and 12 quantitative traits, early seedling vigour, basal leaf sheath colour, leaf: intensity of green colour, leaf: distribution of anthocyanin colouration, leaf: sheath intensity of anthocyanin colouration, pubescence of leaf blade surface, leaf: shape of ligule, leaf: colour of ligule, flag leaf attitude (early observation), culm: attitude, spikelet: density of pubescence of lemma, lemma: anthocyanin colouration of keel, lemma: anthocyanin colouration of below apex, lemma: anthocyanin colouration of apex of lemma, spikelet: colour of stigma, stem: anthocyanin coloration of nodes, flag leaf attitude of blade (late observation), Panicle: curvature of main axis, panicle: length of longest awn, distribution of awns, panicle: exertion, secondary branching of panicle and panicle exsertion panicle: present of secondary branching, panicle attitude of branches, leaf: senescence, sterile lemma colour, lemma and palea colour, decorticated grain colour, anthocyanin colouration of nodes and internodes, stem length, grain length and kernel shape day to 50% flowering, panicle length of main axis, panicle: numbers of per plant, grain length and grain width, leaf length and leaf width value showed a wide variation among different accessions. For the traits coleoptile colour, leaf auricle, leaf: collar, anthocyanin colouration of collar, leaf sheath anthocyanin colouration, leaf: ligule, stem: anthocyanin colouration of internodes, two alternative forms or types were observed and exhibited low variation.

Thus, phenotypic characterization of germplasm accessions established distinctiveness on the basis of 39 qualitative and 12 quantitative traits. These results are corroborated by (Bisne and Sarawgi, 2000; Shobharani *et al*., 2006) [1, 13]. The present findings are also supported by (Sarawgi *et al*. 2016) [12] who characterized seventy one aromatic rice accessions for twelve morphological characters and found a wide range of variability for all the morphological traits studied. Similarly, the findings of (Shobharani *et al*. 2015) supported the current findings, who characterized fifty-five traditional rice varieties for the grain morphological traits and reported a wide variation for grain size and shape, anthocyanin colouration of lemma-palea and kernel, presence or absence of aroma and awning characteristics. (Pathak *et al*., 2018) [6] also characterized the twenty two traits for assessment of genetic diversity in various qualitative and quantitative characters in rice germplasm which is supported the current findings.

Among the quantitative traits, significant amount of variation have been observed. Most of the traits *i.e.,* days to 50% flowering, flag leaf length, flag leaf area, panicle length, number of tillers and grain yield showed high magnitude of variation. The finding of (Sarawgi *et al.,* 2016) [12] supported current finding, they also observed the significant variation among yield and its contributing traits in low land rice varieties under drought situation. Grain yield is important and complex character and its expression under specific environment depends on one or more yield components. However characterization is an essential requirement to assess phenotypic diversity among germplasm collection. It creates the source to ensure effective exploitation of the crop germplasm by both farmers and plant breeders, otherwise unevaluated germplasm remain mere curiosities to the rice improvement programs.

(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 98.86 days and a wider range of 63-142 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 (76-182 cm) of variation with a mean value of 148 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 (Chaudhari *et al.,* 2014) [4]. IC 380139 (76 cm) and IC 576902 (89 cm) were the two accessions which falls under very dwarf group. The maximum and minimum plant heights were recorded 76 cm (380139) and 198 cm (IC124546) respectively with a grand mean of 148.0cm. 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 (Nascimento *et al*., 2012) [5].

Panicle length: The average of panicle length was 24.63cm. and range between 10-35cm. was recorded and classify in five category *i.e.*, very short (<16 cm), short (16-20 cm), medium (21-25 cm), long (26-30 cm) and very long (>30 cm). Out of which, 3.5% accessions came under very short group whereas 7,55, 33 and 2.17% accessions fall under short, medium, long and very long group, respectively. IC388349 (35.0 cm.) was recorded maximum panicle length.
Although it contributes positively yet maximum panicle length is not the only factor responsible for higher grain yield. 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 (Meshram *et al*., 2017) [3].

Net effective tillers: It is another yield attributing trait (Bisne, *et al*., 2000) [1]. The maximum number of tillers to be found in IC 207534 (26 tillers) IC 206613 (25 tillers) and IC 206671 (25 tillers). However, minimum number of tillers was found in IC 125328 (4) and IC145843 (5) with grand mean of 8 tillers/plant.

Spikelet fertility: It is a further yield attributing trait (Sarawgi *et al.,* 1994) [11]. The filled and unfilled grain was found great variability. And range between (26-99%) of the spikelet fertility with the mean range of 76%. IC 38044 and IC 38086 recorded the highest 99% spikelet fertility. The lowest spikelet fertility accession may be use as a sterile line used as a female in hybrid seed production. (Muhammad *et al*., 2015) [4]

1000 grain weight: High variability was recorded in 1000 grain weigh range between 10-46g. With the mean of 24g. Lines with high grain weight (> 3g) were also observed in this set of germplasm IC 388433 had maximum 1000 grain weight (46 g).

Grain length: Grain length is an important quality parameter. Rice grain can be classified as extra long, long, medium and short (Chaudhari *et al.,* 2014) [4]. It exhibited high range (5.4-13.0 mm) with mean of 8.0 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. IC134248 was observed with maximum grain length (13.0 mm) followed by IC124606 (12.9mm) and IC 124690 (12.7mm.) It shows the performance better from check Pusa Basmati 1.

Grain width: It exhibited range between (1.2-3.0 mm) with mean of 3.0 mm. In the present material, most of the lines were in the maximum width was recorded in IC I25368 (3.0mm.) was observed with maximum grain width (3.0 mm).

Grain length breadth ratio: The mean of 3.24mm. With the range between (4.60-6.92mm.). The maximum length breadth ratio was recorded in IC 386277 (6.92mm.) and lowest IC207534 (1.67mm.).

Grain yield /plant: The important trait grain yield per plant (g.) was recorded in IC 388991 (48 g.), IC206496 (46.60g.) IC 389173 (45.0g.) and IC 454040 (42.40g) and minimum was IC 125450 (16.20g.) with grand mean of 21.80g.
After evaluation of 600 accessions for eight quantitative characters, on the basis of mean values, top ten accessions were identified for the yield ancillary traits (Table2.1). IC 207534 (26) had the highest number of effective tillers per plant followed by IC 206613 (25) and IC 206671 (25). Similarly, IC 388433 (46 g.) had the highest rank for 1000 grain weight followed by IC 124672 (44 g) therefore the IC 388991 (48 g.), followed by IC 389173 (45.0g.) and IC 454040 (42.40g) (Table 3.1) Identifying germplasm accessions for different agronomical characters in phenotypically divergent sources would help in prebreeding and breeding programs.

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Table 1.1: Frequency distribution and percentage value of various qualitative and quantitative traits (descriptors) used in phenotypic characterization of 600 accessions of rice

S. No.	Agromorphological characters	Observed phenotypic class	Frequency	Proportions (%)
1	Coleoptile colour	Green-	491	81.83
		Purple-	109	18.17
2	Early seedling vigour	Poor-	93	15.50
		Good-	319	53.17
		Very good-	188	31.33

3	Basal leaf sheath colour	Green-	492	82.00
		Light purple-	35	5.83
		Purple lines-	62	10.33
		Uniform purple-	11	1.83
4	Leaf: Intensity of green colour	Light-	79	13.17
		Medium-	228	38.00
		Dark-	293	48.83
5	Leaf: Anthocyanin colouration	Absent-	596	99.33
		Present-	4	0.67
6	Leaf : Distributions of anthocyanin colouration	On tips only-	442	73.67
		On margin only-	148	24.67
		In blotches only-	7	1.17
		Uniform-	3	0.50
7	Leaf: Sheath anthocyanin colouration	Absent-	483	80.50
		Present-	117	19.50
8	Leaf: Sheath Intensity of anthocyanin colouration	Very weak-	489	81.50
		Week-	21	3.50
		Medium-	37	6.17
		Strong-	39	6.50
		Very strong-	14	2.33
9	Leaf : Pubescence of Blade surface	Absent-	2	0.33
		Weak-	43	7.17
		Medium-	131	21.83
		Strong-	231	38.50
		Very strong-	193	32.17
10	Leaf: Auricle	Present-	600	100.00
11	Leaf: Anthocyanin colouration of auricle	Colourless-	488	81.33
		Light purple-	4	0.67
		Purple-	98	16.33
12	Leaf: Collar	Present-	600	100.00
13	Leaf: Anthocyanin colouration of Collar	Absent-	479	79.83
		Present-	121	20.17
14	Leaf: Ligule	Present-	600	100.00
15	Leaf: Shape of Ligule	Truncate-	2	0.33
		Acute-	3	0.50
		Split-	595	99.17
16	Leaf: Colour of Ligule	White-	523	87.17
		Light purple-	9	1.50
		Purple-	68	11.33
17	Culm: Attitude	Erect-	168	28.00
		Semi Erect-	188	31.33
		Open-	158	26.33
		Spreading-	86	14.33
18	Flag leaf attitude(Early observations)	Erect-	269	44.83
		Semi erect-	265	44.17
		Horizontal-	49	8.17
		Drooping-	17	2.83
19	Spikelet : Density of pubescence of lemma	Absent-	15	2.50
		Weak-	36	6.00
		Medium-	311	51.83
		Strong-	128	21.33
		Very strong-	110	18.33
20	Lemma: anthocyanin colouration of keel	Absent/very weak-	331	55.17
		Weak-	17	2.83
		Medium-	112	18.67
		Strong-	122	20.33
		Very strong-	18	3.00
21	Lemma: anthocyanin colouration area below apex	Absent-	414	69.00
		Weak-	4	0.67
		Medium-	103	17.17
		Strong-	77	12.83
		Very strong-	2	0.33
22	Lemma :anthocyanin	Absent-	447	74.50
	colouration of apex	Weak-	15	2.50
		Medium	86	14.33
		Very strong-	52	8.67
23	Spikelet: Colour of stigma	White -	463	77.17
		Purple-	137	22.83
24	Stem: Anthocyanin coloration of nodes	Absent-	472	78.67

		Present-	128	21.33
25	Stem: Intensity of Anthocyanin coloration of nodes	Weak-	489	81.50
		Medium-	60	10.00
		Strong-	51	8.50
26	Stem: Anthocyanin coloration of internodes	Absent-	491	81.83
		Present-	109	18.17
27	Flag leaf: attitude of blade (late observation)	Erect-	183	30.50
		Semi erect-	162	27.00
		Horizontal-	229	38.17
		Deflexed-	26	4.33
28	Panicle: Curvature of main axis	Straight-	37	6.17
		Semi-straight-	310	51.67
		Deflexed-	233	38.83
		Drooping-	20	3.33
29	Panicle: Awns	Absent-	483	80.50
		Present-	117	19.50
30	Panicle: length of longest awns	Very short-	58	9.67
		Short-	12	2.00
		Medium-	26	4.33
		Long-	18	3.00
		Very long-	3	0.50
		Awnless-0	483	80.50
31	Panicle: Distribution of awns	Tip only-	53	8.83
		Upper half only-	14	2.33
		Whole length-	48	8.00
		Awnless -	483	80.50
32	Panicle : Present of secondary branching	Present-	600	100.00
33	Panicle: secondary branching	Weak-	150	25.00
		Strong-	449	74.83
		Clustered-	1	0.17
34	Panicle: Exertions	Partly exerted-	5	0.83
		Mostly exerted-	169	28.17
		Well exerted-	426	71.00
35	Panicle: attitude of branches-	Erect-	16	2.67
		Erect to semi erect-	242	40.33
		Semi erect-	144	24.00
		Semi erect to spreading-	135	22.50
		Spreading-	63	10.50
36	Leaf: Senescence:	Early-	85	14.17
		Medium-	354	59.00
		Late-	161	26.83
37	Sterile lemma colour	Straw-	570	95.00
		Red-	12	2.00
		Purple-	18	3.00
38	Lemma and palea colour	Straw-	426	71.00
		Gold and gold furrow on straw-	120	20.00
		Brown Furrow on Straw-	35	5.83
		Brown towny-	7	1.17
		Purple furrow on straw-	8	1.33
		Black-	4	0.67
39	Decorticated grain colour	White-	521	86.83
		Light brown-	60	10.00
		Brown-	8	1.33
		Red-	7	1.17
		Purple-	4	0.67
40	Days to 50% flowering (Days)	Very early (< 71)-	9	1.50
		Early (71-90)-	175	29.17
		Medium (91-110)-	274	45.67
		Late (111-130)-	140	23.33
		Very late (>131)-	2	0.33
41	Plant height (cm)	Very short (< 91 cm)-	14	2.33
		Short (91-110 cm)-	49	8.17
		Medium (111-130)-	388	64.67
		Long (131-150 cm)-	140	23.33
		Very long (>150 cm)-	9	1.50
42	Panicle length (cm)	Vey short (<16 cm)-	21	3.50
		Short (16-20 cm)-	40	6.67
		Medium (21-25 cm)-	331	55.17
		Long (26-30 cm)-	195	32.50

		Very long (>30 cm)-	13	2.17
43	Number of tillers	Few (<11)-	358	59.67
		Medium(11-20)-	230	38.33
		Many(>20)-	12	2.00
44	Grain: length (mm)	Very short (<6.0 mm)-	9	1.50
		Short (6.1-8.5 mm)-	358	59.67
		Medium (8.6-10.5 mm)-	211	35.17
		Long (10.6-12.5 mm)-	19	3.17
		Very long (>12.5)-	3	0.50
45	Grain: breadth (mm)	Vary narrow <2.0 mm	32	5.33
		Narrow(2.1-2.5 mm)-	208	34.67
		Medium(2.6 3.0 mm)-	360	60.00
46	1000 grain weight (g.)	Very low (<15g)-	23	3.83
		Low (15-20 g)-	124	20.67
		Medium (21-25 g)-	219	36.50
		High (26-30)-	157	26.17
		Very high (>30g)-	77	12.83

Table 2.1: Top ranking accessions for yield ancillary traits.

PH	PL	NET	GLB Ratio	TGW	GYP
IC380139 (76.0).	IC453695 (29.50)	IC123088 (12)	IC125764 (4.64)	IC390045 (32)	IC389003 (35.20)
IC135425 (81.0)	IC126146 (33.06)	IC386193 (13)	IC214289 (4.65)	IC389092 (36)	IC389370 (36.40)
IC123728 (83.0)	IC134850 (28.90)	IC324594 (14)	IC206339(4.67)	IC389397 (38)	IC388962 (36.80)
IC449793X (86.0)	IC206420 (29.62)	IC331959 (15)	IC206449 (4.71)	IC388737 (39)	IC377700 (37.20)
IC386277 (88.0)	IC206714 (33.40)	IC380149 (16)	IC379109 (4.73)	IC124065 (40)	IC389192 (39.20)
IC137463 (90.0)	IC379389 (31.60)	IC126476 (16)	IC387015 (4.80)	IC124735 (40)	IC454040 (42.40)
IC459199 (94.0)	IC379596 (30.08)	IC380140 (17)	IC331662 (5.13)	IC134248 (40)	IC389173 (45.0)
IC378834 (97.0)	IC386705 (30.98)	IC206613 (25)	IC378059 (5.33)	IC124606 (42)	IC390392 (45.32)
IC124929 (100.0)	IC388349 (35.0)	IC206671 (25)	IC379058 (5.65)	IC124672(44)	IC206496 (46.68)
IC126484 (102.0)	IC388960 (28.90)	IC207534 (26)	IC386277 (6.92)	IC388433(46)	IC388991 (48.0)

Table 3.1: Genetic variability among the accessions (600) for various quantitative traits of rice accessions.

S. No	Trait	Mean	Range		Standard error	Standard deviation	Coefficient of variation%
			Minimum	Maximum			
1	DTF	98.86	63	142	0.59	14.42	14.57
2	FLL	28.73	13.66	47.23	0.21	5.11	17.78
3	FLW	1.33	0.97	2.23	0.010	0.25	18.51
4	PH	148	76	182	0.99	24.30	16.36
5	PL	24.63	10.70	35.00	0.14	3.42	13.89
6	NET	8	4	26	0.081	1.99	24.77
7	SPF	76	26	99	0.48	11.93	15.62
8	TGW	24	10	46	0.233	5.72	23.52
9	GL	8	5.4	13	0.045	1.09	12.90
10	GW	3	1.2	3.0	0.013	0.33	12.44
11	GLB Ratio	3.24	1.62	6.92	0.025	0.62	19.24
12	GYPT	21.80	16.20	21.80	0.21	4.98	22.43

Note: DTF; Days to 50%flowering; FLL: Flag leaf length; FLW: Flag leaf width; PH: Plant height; PL: Panicle length; NET: Net effective tiller; SPF: Spikelet fertility; TGW: Thousand grain weight; GL: Grain length; GW: Grain width; GLWR: Grain length breadth ratio; GYPT: Grain yield per plant

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