



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(9): 127-131
Received: 03-07-2026
Accepted: 13-08-2026

Pradeep Chandra
Department of Plant Physiology,
Agricultural Biochemistry,
Medicinal and Aromatic Plants,
Collage of Agriculture, IGKV,
Raipur, Chhattisgarh, India

Pratibha Katiyar
Department of Plant Physiology,
Agricultural Biochemistry,
Medicinal and Aromatic Plants,
Collage of Agriculture, IGKV,
Raipur, Chhattisgarh, India

Corresponding Author:
Pradeep Chandra
Department of Plant Physiology,
Agricultural Biochemistry,
Medicinal and Aromatic Plants,
Collage of Agriculture, IGKV,
Raipur, Chhattisgarh, India

Evaluation of morphological and yield-related traits in rice (*Oryza sativa* L.) germplasm under irrigated conditions

Pradeep Chandra and Pratibha Katiyar

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i9b.6475>

Abstract

The present investigation was undertaken to assess the variability in morphological, physiological and yield-related traits among rice germplasm and to identify desirable traits associated with higher yield under irrigated conditions of the Raipur plain. For this purpose, 33 rice germplasm were evaluated under irrigated conditions during the kharif season. Observations were recorded on different morphological and yield-related attributes at their respective growth stages, including plant height, number of tillers per plant, number of leaves per plant, leaf area, flag leaf angle, test weight, economic yield, biological yield and harvest index. Significant differences were observed among the germplasm for the traits studied, indicating the presence of considerable variability. Plant height at flowering ranged from 88.67 to 128.33 cm, with the highest value recorded in IR24MD2927 and the lowest in IR24MD2916. Number of tillers per plant varied from 7.67 to 16.33, with IR24MD2916 recording the highest value. Maximum number of leaves per plant was observed in IR24MD3059, while the highest leaf area was recorded in IR24MD3928. Test weight ranged from 13.79 to 27.17 g, with IR16A3891 recording the highest value. Economic yield varied from 470.24 to 1071.62 g m⁻², and the highest value was recorded in IR24MD3928 followed by IR24MD2916 and IR24MD2911. Biological yield ranged from 1034.06 to 2496.76 g m⁻², with IR24MD2830 recording the highest value, whereas harvest index varied from 25.74 to 46.11%. Correlation analysis revealed that economic yield had significant positive associations with number of tillers per plant ($r = 0.419^*$), number of leaves per plant ($r = 0.406^*$) and leaf area ($r = 0.587^{**}$). Biological yield showed a significant positive correlation with leaf area ($r = 0.427^*$) and a highly significant positive correlation with economic yield ($r = 0.749^{**}$). Harvest index was significantly and positively associated with economic yield ($r = 0.416^*$) and significantly negatively correlated with plant height ($r = -0.382^*$). Overall, the study indicated substantial variation among the rice germplasm and identified number of tillers, number of leaves, leaf area and efficient biomass partitioning as important traits associated with yield performance. These traits may be considered useful selection criteria for the identification and improvement of high-yielding rice genotypes under irrigated conditions.

Keywords: Rice, germplasm, morphological traits, physiological traits, yield attributes, economic yield, biological yield, harvest index, correlation, irrigated conditions.

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops and belongs to the tribe Oryzeae, sub-family Pooideae, under the family Poaceae (Gramineae). According to modern biosystematic classification, the genus *Oryza* is divided into several sections, and *O. sativa* is belonging in the series *Sativa* of section *Sativae*. It is an Asian species with a diploid chromosome number of $2n = 24$ and possesses the AA genome. The genus *Oryza* comprises approximately 24 species, which are naturally distributed across tropical and subtropical regions of the world ^[1].

Rice is one of the most important food crops in the world and serves as a major pillar of global food security. It is the staple diet for more than half of the world's population, with nearly four billion people relying on rice as their primary source of food. Owing to its high nutritional value, rice contributes approximately 20% of the daily caloric intake and 15% of the protein requirement for the global population ^[2].

Morphological characteristics are important determinants of plant growth, development, and final grain yield in rice. Traits such as plant height, number of tillers, leaf size, leaf orientation, internode length, and biomass production influence the plant's capacity to capture solar radiation,

efficiently utilize available water and nutrients, and sustain effective grain filling. Consequently, the assessment of these morphological attributes is essential for evaluating the yield potential of different rice genotypes. Rice cultivars with high yield potential are generally characterized by higher chlorophyll content and enhanced photosynthetic capacity, which contribute to greater biomass accumulation and improved grain production [3]. Increased photosynthetic efficiency enhances plant growth and overall productivity [4], whereas higher biomass production provides a strong foundation for achieving superior grain yield [5]. The spatial arrangement of the upper leaves and the positioning of panicles within the plant canopy play a vital role in maintaining an efficient source-sink balance in rice. Panicles bearing nearly 150 spikelets are considered desirable because they enhance the sink capacity and thereby contribute to higher yield potential [6]. Among all leaves, the flag leaf is the most important photosynthetic organ during the grain-filling stage and makes a major contribution to grain development, resulting in increased grain weight. Rice plants possessing broad and erect flag leaves are generally associated with superior grain yield. Besides supporting the translocation of photosynthates from vegetative tissues to developing grains, an optimum flag leaf angle together

with a higher leaf area index during the grain-filling period improves spikelet fertility and facilitates the efficient movement of assimilates, ultimately enhancing grain production [7].

Materials and Methods

A field experiment was conducted during the *khariif* season of 2025 at Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.), India, using 33 rice (*Oryza sativa* L.) germplasm under irrigated conditions. The experiment was laid out in an alpha lattice design with two replications. Twenty-three-day-old seedlings were transplanted at a spacing of 20 × 15 cm (row-to-row × plant-to-plant). Recommended fertilizer doses of N, P₂O₅ and K₂O were applied at 120:60:40 kg ha⁻¹. All recommended agronomic practices were followed during the crop growth period, and no prominent disease incidence was observed. Data were recorded on plant height (cm), number of tillers plant⁻¹, number of leaves plant⁻¹, leaf area (cm²), flag leaf angle (°), 1000-grain weight (g), economic yield (g m⁻²), biological yield (g m⁻²) and harvest index (%). Weather data on temperature, relative humidity, rainfall and rainy days during the crop growing season from June to November 2025 are presented in Table 1. A total rainfall of 1165.4 mm was received during the experimental period.

Table 1: Meteorological data recorded during the growing season of 2025

Months	Mean temperature (°C)		Mean Relative Humidity (%)		Rainfall (mm)	Rainy days
	Maximum	Minimum	I	II		
Jun 04-10	39.8	27.8	65	36	0	0
11-17	37	26.9	74	50	37.8	1
18-24	33.2	26.3	76	57	0	0
25-01	30.1	24.3	90	76	88	5
July 02-08	27.9	24.5	92	87	146.2	4
09-15	30.2	25.6	88	69	90	2
16-22	32.6	25.6	91	68	62.2	4
23-29	30.1	25.1	90	83	187.4	3
30-05	31.1	25.9	87	69	18.4	3
Aug 06-12	32.8	25.6	87	66	33.4	1
13-19	31.9	25.7	88	70	59.2	5
20-26	28.8	24.8	90	77	38.8	2
27-02	31.5	25.2	92	69	38.2	3
Sep 03-09	31.4	24.9	92	74	44.4	4
10-16	31.8	25.6	92	73	39.8	2
17-23	32.4	25.3	92	64	29.2	3
24-30	30.3	25	93	72	105.2	3
Oct 01-07	30.5	24.2	94	76	112.8	5
08-14	30.6	23.6	89	67	25.6	2
15-21	31.1	21.9	89	53	0	0
22-28	31.7	23.6	87	55	0	0
29-04	30.1	22.9	84	64	8.8	1
Nov 05-11	30.5	16.2	87	38	0	0
12-18	28	10.7	89	26	0	0
19-25	29.5	13.9	90	37	0	0

Source: Department of Agricultural Meteorology, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.)- 492006

Results and Discussion

Data on morphological and yield-related attributes of the crop are presented in Table 2. Significant differences were observed

among the 33-rice germplasm for these characters at their respective growth stages.

Table 2: Data were recorded on various morphological, growth and yield-related attributes of the crop

Germplasm name	Plant height(cm).	Number of tillers per plant	Number of leaves per plant	Leaf area (cm ²)	Flag leaf angle (°)	1000 grain weight(g)	Economic yield (g/m ²)	Biological yield(g/m ²)	Harvest index (HI)
IR24MD2943	119.45	11.34	47.17	2386.36	13.00	17.75	966.50	2251.27	42.96
IR24MD2911	120.17	14.17	57.83	2575.80	11.83	15.00	1021.97	2222.47	46.04
IR24MD3059	115.08	16.17	66.50	2340.90	11.50	22.87	901.89	1965.74	45.97
IR24MD1858	126.58	13.83	57.00	2393.29	16.83	23.74	654.39	1977.92	32.98
IR24MD3951	100.53	13.50	55.00	2358.07	13.33	20.79	470.24	1034.06	45.65
IR24MD2927	128.33	10.50	47.17	1849.68	12.50	24.00	519.59	1238.68	42.03
IR24MD2989	110.35	9.67	41.67	2010.05	17.83	17.39	587.50	1354.78	43.44
IR24MD3137	114.83	8.34	34.50	2086.72	12.17	17.25	680.50	1585.63	42.72
DDR Dhan 44 (Check)	116.67	10.34	42.83	2390.85	15.83	15.10	772.20	1861.23	41.37
IR24MD2990	127.92	14.00	64.50	2216.88	13.17	25.15	750.26	1825.41	41.26
IR24MD3083	117.05	11.00	45.17	2244.19	11.67	24.60	674.02	1495.11	45.15
IR24MD1860	119.83	14.16	59.00	2310.87	16.50	19.75	825.78	2122.76	38.84
HRI174 (Check)	108.58	13.51	54.00	1913.02	8.83	24.75	683.19	1560.09	43.75
IR24MD3957	108.33	9.00	42.00	1579.86	14.50	21.69	672.52	1519.72	44.24
IRRI168 (Check)	115.00	13.17	56.33	2163.30	11.83	13.79	752.75	2200.93	34.11
IRRI123 (Check)	111.33	14.50	61.67	2568.42	15.17	23.89	813.57	1823.44	44.56
IR16A4261 (Check)	105.47	11.67	48.00	2394.83	12.00	20.60	770.06	1745.77	44.15
IR24MD3135	104.92	10.67	44.33	1855.96	11.67	26.47	740.86	1641.3	45.12
IR24MD2830	123.08	11.16	45.67	2060.20	12.17	26.15	642.84	2496.76	25.74
IR24MD3928	101.75	15.50	63.00	2931.51	13.83	17.10	1071.62	2360.25	45.40
IRRI104 (Check)	115.08	8.50	35.00	1560.13	15.33	17.52	766.77	1784.92	42.94
IRRI156 (Check)	116.42	8.84	36.33	1797.22	13.17	23.30	795.64	2144.04	37.27
NDR359 (Check)	101.50	9.66	42.67	1696.99	12.33	17.34	594.67	1629.74	36.40
IR24MD2946	105.92	10.66	43.83	2412.13	12.17	23.17	774.99	1693.36	45.60
IR24MD3074	111.67	9.83	41.00	2430.73	13.83	23.74	874.67	2029.02	43.15
IR153974	98.33	8.86	40.17	1884.21	14.67	17.52	792.52	1774.55	44.48
IR153967	104.87	8.16	44.33	2437.20	11.33	18.65	850.40	1999.48	42.40
IR24MD2982	110.83	7.67	36.50	1511.75	12.83	19.85	488.90	1637.64	29.86
IR24MD2972	107.25	10.36	46.33	1804.40	13.67	21.75	912.12	1978.38	46.11
IR24MD2916	88.67	16.33	65.33	2691.81	11.50	17.19	1062.27	2368.88	44.84
IR16A3891(Check)	115.92	9.17	36.67	1928.89	10.17	27.17	712.27	1600.36	44.56
C.G. Devbhog (Check)	118.83	12.66	50.17	2070.16	11.17	17.52	645.31	1696.01	38.09
IR24MD2855	118.58	10.51	48.00	2304.62	18.83	15.24	700.79	1697.52	41.34
LSD (0.05)	8.77	3.37	5.64	11.33	3.89	1.73	182.29	257.15	5.84
C.V. (%)	3.82	14.49	5.70	7.36	14.40	4.13	11.82	6.89	6.89

Plant height (cm) at flowering

Plant height was recorded at the flowering stage, and significant differences were observed among the tested germplasm. The recorded value ranged from 88.67 cm to 128.33 cm. Highest plant height was attained by germplasm IR24MD2927(128.33 cm), followed by IR24MD2990 (127.92 cm) and IR24MD1850 (126.58 cm). Lowest plant height was attained by germplasm IR24MD2916 (88.67 cm), followed by IR153974 (98.33 cm) and IR24MD3957 (100.53 cm).

Plant height in the majority of commercial rice varieties generally ranged from 1 to 2 m. However, excessive plant height may increase the risk of lodging, particularly under heavy rainfall during the early crop season. Therefore, reduction in plant height is considered desirable for improving lodging resistance. A negative association between plant height and grain yield has also been reported, which may be attributed to competition among sink components for the limited photosynthates produced by the source organs ^[8].

Number of tillers plant [-1] at flowering

Number of tillers per plant was recorded at the flowering stage, and significant differences were observed among the tested germplasm. The recorded value ranged from 16.33 to 7.67. Highest number of tillers per plant was attained by germplasm IR24MD2916 (16.33), followed by IR24MD3059 (16.17) and IR24MD3928 (15.50). Lowest number of tillers per plant was

attained by germplasm IR24MD2982 (7.67), followed by IR153967 (8.16) and IR24MD3137 (8.34).

Excessive tillering may lead to a higher rate of tiller abortion, smaller panicles and poor grain filling, whereas inadequate tillering can result in fewer productive panicles and consequently reduce grain yield. This indicates that an optimum number of tillers is essential for achieving better yield performance in rice ^[9].

Number of leaves plant⁻¹ at flowering

Number of leaves per plant was recorded at the flowering stage, and significant differences were observed among the tested germplasm. The recorded value ranged from 34.50 to 66.50. Highest number of leaves per plant was attained by germplasm IR24MD3059 (66.50), followed by IR24MD2916 (65.33) and IR24MD2990 (64.50).

Rice plants generally retain about five functional leaves from panicle initiation to heading, highlighting the importance of maintaining physiologically active leaves during the reproductive phase ^[10].

Leaf area per plant (cm²) at flowering

Leaf area per plant was recorded at the flowering stage, and significant differences were observed among the tested germplasm. The recorded value ranged from 2931.51 cm² to 1511.75 cm². Highest leaf area was measured by germplasm

IR24MD3928 (2931.51 cm²), followed by IR24MD2916 (2691.81 cm²) and IR24MD2911 (2575.80 cm²). Lowest leaf area was measured by germplasm IR24MD2982 (1511.75 cm²), followed by IRRI104 (Check) (1560.13 cm²) and IR24MD3957 (1579.86 cm²).

Excessive leaf area may result in increased mutual shading within the canopy, thereby reducing canopy photosynthesis and limiting sink development. Thus, an optimum leaf area is important for maintaining efficient light interception and photosynthetic activity [11].

Flag leaf angle (lo) at flowering

Flag leaf angle was recorded at the flowering stage, and significant differences were observed among the tested germplasm. The recorded value ranged from 18.83[o] to 8.83[o]. Highest flag leaf angle was measured by germplasm IR24MD2855 (18.83[o]), followed by IR24MD2989 (17.83[o]), and IR24MD1858 (16.83[o]). Lowest flag leaf angle was measured by germplasm HRI174 (Check) (8.83[o]) followed by IR16A3891(Check) (10.17[o]), and C.G. Devbhog (Check) (11.17[o]).

Flag leaf angle plays an important role in determining grain yield, as it is closely associated with leaf length and may influence canopy architecture and light interception [12].

Test weight (1000 seeds)

Test weight was recorded at the physiological maturity stage, and significant differences were observed among the tested germplasm. The recorded value ranged from 27.17 g. to 13.79 g. Highest test weight was measured by germplasm IR16A3891(Check) (27.17 g.), followed by IR24MD3135 (26.47 g.), IR24MD2830 (23.15 g.). Lowest test weight was measured by germplasm IRRI168 (Check) (13.79 g.), followed by IR24MD2911 (15.00 g.), DDR Dhan 44 (Check) (15.10 g.).

It represents the weight of an individual seed; however, direct measurement is difficult due to the small size of individual seeds [13].

Economical yield(g/m²)

Economic yield was recorded at the physiological maturity stage,

and significant differences were observed among the tested germplasm. The recorded value ranged from 1071.62 g/m² to 470.24 g/m². Highest economic yield was measured by germplasm IR24MD3928 (1071.62 g/m²), followed by IR24MD2916 (1062.27 g/m²), and IR24MD2911 (1021.97 g/m²). Lowest economic yield was measured by germplasm IR24MD3951 (470.24 g/m²), followed by IR24MD2982 (488.90 g /m²), and IR24MD2927 (519.59 g /m²).

Swarna exhibited higher yield potential, as reflected by its greater yield and higher values for yield-related traits, particularly the number of tillers and panicles, across all three environmental conditions [14].

Biological yield(g/m²)

Biological yield was recorded at the physiological maturity stage, and significant differences were observed among the tested germplasm. The recorded value ranged from 2496.76 g /m² to 1034.06 g /m². Highest biological yield was measured by germplasm IR24MD2830 (2496.76 g /m²), followed by IR24MD2916 (2368.88 g /m²), and IR24MD3928 (2360.25 g /m²). Lowest biological yield was measured by germplasm IR24MD3951 (1034.06 g /m²), followed by IR24MD2927 (1238.68 g /m²), and IR24MD2989 (1354.78 g /m²).

A linear relationship was observed between plant biomass production and water use efficiency [15].

Harvest index (%)

Harvest index was recorded at the physiological maturity stage, and significant differences were observed among the tested germplasm. The recorded value ranged from 46.11% to 25.74%. Highest harvest index was measured by germplasm IR24MD2972 (46.11%), followed by R24MD2911 (46.04%), and IR24MD3059 (45.97%). Lowest harvest index was measured by germplasm IR24MD2830 (25.74%), followed by IR24MD2982 (29.86%), and IR24MD1858 (32.98%).

The number of fertile grains per panicle and harvest index showed a significant and positive association with grain yield. Furthermore, both traits exhibited a high direct effect on grain yield, indicating their importance as potential selection criteria for improving yield in rice [16].

Table 3: Phenotypic correlation among the traits

	Plant height	No. of tillers per plant	No. of leaves per plant	Leaf area	Flag leaf angle	Test weight	Economical yield	Biological yield	Harvest index
Plant height	1								
No. of tillers per plant	-0.006	1							
No. of leaves per plant	0.008	0.963**	1						
Leaf area	-0.094	0.663**	0.648**	1					
Flag leaf angle	0.176	-0.093	-0.038	0.059	1				
Test weight	0.214	0.001	-0.021	-0.189	-0.308	1			
Economical yield	-0.232	0.419*	0.406*	0.587**	-0.072	-0.233	1		
Biological yield	0.043	0.344	0.332	0.427*	-0.030	-0.188	0.749**	1	
Harvest index	-0.382*	0.156	0.140	0.286	-0.079	-0.008	0.416*	-0.279	1

Correlation analysis revealed significant associations among several morphological and yield-related traits of the rice germplasm (Table 3). Number of tillers per plant exhibited a highly significant and positive correlation with number of leaves per plant ($r = 0.963^{**}$) and leaf area ($r = 0.663^{**}$), indicating that genotypes producing more tillers also tended to maintain a greater number of leaves and larger leaf area. Similarly, number of leaves per plant showed a highly significant positive association with leaf area ($r = 0.648^{**}$), suggesting that increased leaf production contributed to greater total leaf area. Economic yield exhibited a

significant positive correlation with number of tillers per plant ($r = 0.419^{*}$) and number of leaves per plant ($r = 0.406^{*}$), while its association with leaf area was highly significant and positive ($r = 0.587^{**}$). This indicates that greater tillering, leaf production and leaf area may contribute to enhanced assimilatory capacity and ultimately higher economic yield in rice. Biological yield was significantly and positively correlated with leaf area ($r = 0.427^{*}$) and showed a highly significant positive association with economic yield ($r = 0.749^{**}$), indicating the important contribution of vegetative biomass accumulation towards final

economic productivity. Harvest index exhibited a significant negative correlation with plant height ($r = -0.382^*$) and a significant positive correlation with economic yield ($r = 0.416^*$), suggesting that comparatively efficient partitioning of biomass towards economic yield was associated with higher harvest index. In contrast, plant height showed a non-significant negative association with economic yield ($r = -0.232$). Test weight showed non-significant correlations with most of the studied traits, including economic yield ($r = -0.233$). Overall, the correlation analysis indicated that number of tillers per plant, number of leaves per plant and leaf area were important traits associated with economic yield, while leaf area and economic yield also contributed substantially to biological yield. These relationships may be useful in identifying desirable traits as selection criteria in rice breeding programmes.

Conclusion

The study revealed considerable variation among the rice germplasm for plant height, tiller number, number of leaves, leaf area, flag leaf angle, test weight, economic yield, biological yield and harvest index. The observed differences indicated substantial scope for selection of superior genotypes based on yield and associated morpho-physiological traits. Among the studied traits, higher tiller number, leaf number, leaf area, biological yield and harvest index were important contributors to productivity. The superior performance of selected germplasm for economic and biological yield suggests their potential for utilization in rice improvement programmes. Therefore, these morpho-physiological and yield-related traits can be considered important selection criteria for developing high-yielding rice genotypes under irrigated conditions.

Acknowledgement

The authors sincerely acknowledge the support and cooperation of the Department of Plant Physiology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.), India, for assistance in field management, observations, and data collection. The authors also express their gratitude to the reviewers and editor for their valuable suggestions and constructive comments in improving the manuscript.

References

1. Veasey EA, Karasawa MG, Santos PP, Rosa MS, Mamani E, Oliveira GCX. Variation in the loss of seed dormancy during after-ripening of wild and cultivated rice species. *Annals of Botany*. 2004;94(6):875-882.
2. Zain NAM, Ismail MR, Puteh A, Mahmood M, Islam MR. Impact of cyclic water stress on growth, physiological responses and yield of rice (*Oryza sativa* L.) grown in tropical environment. *Ciência Rural*. 2014;44(12):2136-2141. doi:10.1590/0103-8478cr20131154.
3. Peng S, Khush GS, Virk P, Tang Q, Yingbin Z. Progress in ideotype breeding to increase rice yield potential. *Field Crops Research*. 2008;108:32-38.
4. Masuda H, Suzuki M, Morikawa KC, Kobayashi T, Nakanishi H, Takahashi M, *et al.* Increase in iron and zinc concentrations in rice grains via the introduction of barley genes involved in phytosiderophore synthesis. *Rice*. 2008;1:100-108.
5. Yoshida H, Horie T. A process model for explaining genotypic and environmental variation in growth and yield of rice based on measured plant N accumulation. *Field Crops Research*. 2009;113(3):227-237.
6. Toriyama K, Heong KL, Hardy B. Rice is life: scientific perspectives for the 21st century. In: *Proceedings of the World Rice Research Conference*; Tokyo and Tsukuba, Japan. International Rice Research Institute and Japan International Research Center for Agricultural Sciences; 2005. p.130-134.
7. Tari DB, Gazanchian A, Hemmat H, Pirdashti HA, Nasiri M. Flag leaf morpho-physiological response to different agronomical treatments in a promising line of rice (*Oryza sativa* L.). *American-Eurasian Journal of Agricultural and Environmental Sciences*. 2009;5(3):403-408.
8. Chen WF, Xu ZJ, Zhang WZ, Zhang BL, Yang SR. Creation of new plant type and breeding rice for super high yield. *Acta Agronomica Sinica*. 2001;27(5):665-672.
9. Pandey P, Anurag PJ, Tiwari DK, Yadav SK, Kumar B. Genetic variability, diversity and association of quantitative traits with grain yield in rice (*Oryza sativa* L.). *Journal of Biosciences*. 2009;17:77-82.
10. Yoshida S. *Fundamentals of rice crop science*. Los Baños, Philippines: International Rice Research Institute; 1981.
11. Dingkuhn M, Penning de Vries FWT, De Datta SK, van Laar HH. Concepts for a new plant type for direct seeded flooded tropical rice. In: *Proceedings of the International Rice Research Conference*; Los Baños, Philippines. International Rice Research Institute; 1991. p.27-31.
12. Vangahun JM. Inheritance of flag leaf angle in two rice (*Oryza sativa* L.) cultivars [thesis]. Kumasi: Kwame Nkrumah University of Science and Technology; 2012.
13. Oladosu Y, Rafii MY, Abdullah N, Malek MA, Rahim HA, Hussin G, *et al.* Genetic variability and selection criteria in rice mutant lines as revealed by quantitative traits. *Scientific World Journal*. 2014;2014:1-19.
14. Dixit S, Grondin A, Lee CH, Henry A, Olds TM, Kumar A. Understanding rice adaptation to varying agro-ecosystems: trait interactions and quantitative trait loci. *BMC Genetics*. 2015;16:86:1-14.
15. Yang J, Zhang J. Grain-filling problem in 'super' rice. *Journal of Experimental Botany*. 2010;61(1):1-5.
16. Singh RK, Khush US, Khush GS, Rohilla R. Genetics and biotechnology of quality traits in aromatic rices. In: *Aromatic rices*. New Delhi: Oxford & IBH Publishing Co. Pvt. Ltd.; 2000. p. 47-69.