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Study of the contribution of panicle architecture for maximization of sink capacity in rice (*Oryza sativa* L.) cultivars

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Abstract
Rice (*Oryza sativa* L.) is the "global grain" of the world. The research was carried out at the College of Agriculture, IGKV, Raipur (C.G.), where 36 enhanced cultivars were assessed throughout the *Kharif* seasons of 2021–2022 and 2022–2023 to determine the effects of panicle architecture on grain yield among rice cultivars with varying durations. The experiment was conducted in a Randomized block design (RBD) with two replications. The panicle architecture and yield attributes traits *viz*., panicle length, average fertile and sterile grains per panicle and number of primary and secondary branches per panicle, Seed yield plant^{-1}, and harvest index were noted during end at harvest during both years. The findings revealed that variety check MTU-1001, MTU-1224 (long-duration), MTU-1156, MTU-1155 (mid-duration), and MTU-1153, BINA-17 (short-duration) exhibited an average number of productive tillers, length of panicle, number of primary and secondary branches and a higher number of grains panicle^{-1}, greater harvest index, they also had a lower incidence of sterile grains, resulting in higher economic yields compared to the other long, medium, and short duration rice varieties.

Keywords: Rice, panicle length, and yield attributes

Introduction
Rice (*Oryza sativa*) is consumed as food by more than 85% population in the world and 90% of Asia and it belongs to the grass family Poaceae (Bagri *et al.*, 2022) [3]. It is the primary diet of Indian people around 60%, which also determines the nation's food security (Bagri *et al.*, 2022) [3]. Globally, the number of people who consume rice is rising every day by day, resulting in a rise in rice demand. An emerging gap between the demand for rice for consumption and the production of rice was noticed. The over-growing population is creating pressure for an increase in rice production (Kondi *et al.*, 2021 and Veronica, 2022) [9, 18]. In recent years, the development of improved high-yield rice varieties has shown better yield potential than the existing varieties mainly due to the presence of larger sinks (Bagri *et al.*, 2022) [3]. Chhattisgarh is the newly formed largest rice-producer state of India and is also acknowledged as the “Rice Bowl of Central India” and about 54 percent of the land is under agriculture. Present data showed that about 3.76 million hectares of land are under rice cultivation with 7.90 million tons of production (Agricultural Statistics at a Glance 2022).

The ideal rice plant architecture is mainly determined by low tiller number, moderate plant height, erect leaves arrangement, and panicle architecture, and briefly discuss the potential to use these advances in improving the super high-yielding rice (Sharma *et al.*, 2017) [15]. Panicle architecture is one of the most important traits related to rice grain yield and affects crop productivity. Panicle length strongly affects panicle architecture. Thus, panicle length is a key factor determining the diversity of panicle architecture in rice (Bai *et al*., 2016 and Agata *et al.*, 2020) [4, 1]. Panicle branching patterns that are mainly regulated by the number of primary and secondary branches directly determine the total grain number. Many high-yielding rice cultivars tend to have longer primary branches and produce more secondary branches than standard varieties. Therefore, panicle rachis length and primary branch length influence total grain number, rice productivity, and branching number (Mohapatra and Sahu, 1991) [13].

An extra-large panicle was found not ideal for grain filling because most of the grains on the spikelets on the secondary branches of the panicle become source-limited for assimilates, loss of apical dominance, and higher ethylene production. Spikelet survival usually depends on sink efficiency and grain development among individual spikelets of the panicle (Mohapatra, 2013) [12]. However, an increase in the number of spikelets does not always result in a high grain number and a yield benefit at maturity because the degree of grain filling of individual spikelets depends on the panicle position. The panicle size or height could have a detrimental effect on light interception and the rate of photosynthesis of the source leaves which are positioned beneath the panicle and supply assimilates to the grains during development.

Study area and planting materials

A total of 36 enhanced rice cultivars grown under irrigation were gathered from IGKV, Raipur (C.G.) as part of the IRRI project, and these were the materials used for the study. The 32 improved rice cultivars were accompanied by four local checks (MTU-1001, Rajeshwari, Swarna, and MTU-1010). The experiment was carried out in the Kharif seasons of 2021–2022 and 2022–2023 in the Department of Plant Physiology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Krishak Nagar, Raipur (C.G.). A randomized complete block design with two replications was used to set up the experiment. The observations on several panicle varieties and yield characteristics were noted. Searle's (1961) method of estimating panicle architecture with seed yield in rice crops was followed in the selection of these qualities, which were based on the standard assessment system for rice (IRRI, 1996). Data was then statistically analyzed. The many suggested cultural procedures were executed on schedule for the whole study.

Result and Discussion

Panicle architecture and Yield traits

The various panicle architecture and yield were pooled recorded data presented in tables, and discussed. In the group of long, medium, and long-duration varieties, check variety MTU-1001 (long), MTU-1156 (medium), and MTU-1153 (short) which were found superior in most of the observed yield contributing traits.

The data indicated in (Table 4.1.) that, check variety MTU-1001(11.50), MTU-1156 (10.25), and MTU-1153 (10.83) with optimum numbers of tillers at the harvest stage showed and had a high yield. Baloch *et al.* (2006) [5] pointed out that effective tillers also referred to as productive tillers are important because the number of panicles containing.

Table 1: Panicle architecture and yield traits at the harvest stage of rice varieties

S. N.	Variety	PT	PL	NPB	NSB	AFGP	ASGP	GY	HI
	Long duration								
1.	MTU-1001 (Check)	11.50	29.93	12.50	3.00	255.25	15.00	20.05	36.04
2.	Rajeshwari (Check)	10.50	27.06	10.67	3.83	222.31	26.98	17.65	34.96
3.	MTU-1224	11.50	29.41	12.00	3.67	251.76	22.06	19.95	35.79
4.	CR-802	11.50	28.46	12.00	.33	200.45	23.72	18.80	35.75
5.	DRR Dhan-50	10.50	27.53	12.00	33.83	226.40	25.63	17.65	35.70
6.	R-2284	10.25	26.21	11.83	2.83	212.54	24.33	16.70	35.04
7.	BRRI-69	10.25	26.59	12.00	3.33	183.69	28.14	15.60	34.80
8.	Raja Gold-88	11.25	26.59	11.67	3.33	167.08	34.20	15.85	34.77
9.	Jamuna	10.25	26.24	12.75	3.17	218.38	41.06	15.90	34.10
10.	Sampada	10.50	28.08	12.50	4.00	219.58	53.78	15.80	33.42
11.	C.G. Devbhog	10.33	25.72	11.17	2.67	162.73	36.97	15.30	30.86
12.	Dubraj Selection-1	7.50	28.41	10.17	3.50	176.28	33.11	12.00	26.31
13.	Vishnubhog Selection-1	6.50	30.72	9.42	2.50	144.84	34.32	12.10	28.54
14.	C.G. Madhuraj Dhan-55	7.00	28.13	9.42	3.33	177.86	31.50	13.80	29.14
15.	Badshabhog Selection-1	6.33	31.27	9.83	3.00	135.92	35.50	10.70	25.99
	Medium duration								
16.	Swarna (Check)	11.17	27.62	12.17	3.00	215.26	11.63	19.90	36.83
17.	MTU-1156	10.25	28.78	11.83	3.00	242.30	9.92	20.80	37.75
18.	MTU-1155	11.00	28.52	11.58	2.67	228.19	14.42	20.50	37.43
19.	Protezin	12.50	26.72	11.75	2.50	219.00	21.67	18.20	35.62
20.	Zinco Rice-MS	11.50	25.73	11.78	2.33	217.75	20.25	18.00	33.83
21.	R-2054	10.50	28.03	12.17	3.00	219.85	15.79	18.45	36.76
22.	MTU-1075	11.00	28.66	11.75	2.67	231.02	25.78	17.35	34.07
23.	R-1919	10.17	28.22	12.25	2.67	218.72	26.95	17.00	33.55
24.	Raja Signate-44	11.50	25.78	12.25	3.67	226.75	36.92	15.00	30.43
25.	DRR Dhan-45	11.25	28.02	11.75	3.00	220.01	38.82	16.30	33.44
26.	C.G. Zinc Rice-2	10.83	28.08	10.00	2.67	148.24	39.10	12.80	31.17
27.	BRRI-75	11.50	26.03	10.50	3.33	179.32	36.87	15.00	33.22
	Short duration								
28.	MTU-1010 (Check)	10.33	25.81	11.25	3.00	182.22	20.71	16.75	35.65
29.	C0-51	12.25	25.74	13.00	4.00	226.55	23.72	16.15	35.86
30.	BINA -17	10.50	26.40	11.25	3.17	181.30	15.16	18.40	35.85
31.	Indira Aerobic	10.33	26.88	11.33	3.17	180.26	25.08	16.20	31.66
32.	CR-310	11.25	27.08	11.58	2.67	190.81	25.47	16.50	35.26
33.	CR-311	10.50	27.45	9.58	3.00	162.26	26.88	15.40	32.26
34.	MTU-1153	10.83	28.90	11.25	2.50	211.48	14.31	19.40	35.89
35.	DRR-42	11.50	26.61	11.08	3.67	179.21	36.45	14.05	30.86
36.	C.G. Zinc Rice-1	10.50	25.46	9.92	2.83	153.30	30.88	12.10	30.71

	Min	6.33	25.46	9.42	2.33	135.92	9.92	10.70	25.99
	Max	12.50	31.27	13.00	4.00	255.25	53.78	20.80	37.75
	Mean	10.47	27.52	11.39	3.11	199.69	27.31	16.45	33.59
	SE m±	0.44	0.22	0.13	0.11	3.93	1.07	0.22	0.57
	CD	1.27	0.63	0.37	0.33	11.28	3.08	0.62	1.65
	CV	5.97	1.14	1.59	4.95	2.78	5.61	1.85	2.42

Note: PT = Productive tillers, PL= Panicle Length (cm), NPB= Number of primary branches panicle^{-1}, NSB= Number of primary branches penical^{-1}, AFGP= Average Fertile grains panicle^{-1}, ASGP= Average Sterile grains panicle^{-1}, GY= Grain yield plant^{-1} (gm), HI= Harvest Index (%).

Tillers ultimately determines the rice yield. The high-yielding variety such as, Check MTU-1001 (29.93, 12.50, 3.00), MTU-1156 (28.78, 11.83, 3.00), and MTU-1153 (28.90, 11.25, 2.50) has optimum number of primary and secondary branches panicle^{-1} at the harvest had a major impact on rice grain production in this experiment. According to (Laza *et al.* 2003) [11], cultivars with larger panicles performed better on average than cultivars with smaller panicles. However, large panicles do not always translate into larger yields. Plant height is also higher in cultivars with large panicles (Sarwar and Ali 1998) [14] worked on rice panicles and indicated a greater range in the number of primary and secondary branches as well as the length of the primary branches. Rice yield is impacted by panicle architecture features such as panicle length, number of primary branches, and number of secondary branches (Crowell *et al.* 2016) [7]. The above data of long (MTU-1001), medium (MTU-1156) and short (MTU-1153) duration varieties indicates that a higher grain yield was produced by lower number of sterile grains and higher number of fertile grains on primary and secondary branch panicle^{-1}. In this study, the number of filled grains panicle^{-1} plays an important role in grain yield. No matter how rice is cultivated, fertile grain plays a significant role in grain yield. According to (Singh *et al.* 2000) [16], grain yield is positively and significantly correlated with the panicle number of fertile grains. Grain yield is highly and directly impacted by harvest index and panicle of fertile grains. The number of filled spikelets in each panicle has a greater effect on yield. The high yield varieties secured lower sterile grains panicle^{-1}. For the later-initiated tillers, poor filling may have also played a role in the reduction in grain quality. Varieties such as Check MTU-1001, MTU-1156, and MTU-1153 with higher grain yield plant^{-1} at harvest were observed in this experiment. Grain yield variation may result from variations in yield components (Chandrasekhar *et al.* 2001 and Ashrafuzzaman *et al.*, 2009) [6, 2] reported that the correlation between grain yields and their component in rice lines was noted.

Conclusion
The experimental study panicle architecture of rice varieties of the groups long (Check MTU-1001, MTU-1224), medium (MTU-1156, MTU-1155), and mid-early (MTU-1153, BINA-17) showed that the expressing grain yield plant^{-1} relatively, these varieties exhibit high productivity. However, these varieties had ideal panicle length, moderate primary and secondary branches panicle^{-1}, which also exhibited a greater number of productive tillers. These also expressed a greater number of filled grains panicle^{-1} and a higher harvest index.

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Authors' Contributions
Every named author has contributed significantly, directly, and intellectually to the data collection, analysis, experimentation, and manuscript preparation.

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