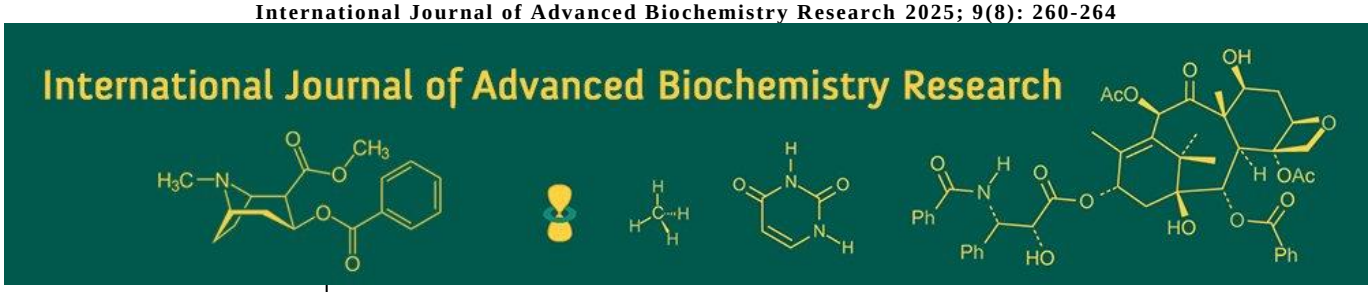

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Morpho-physiological characterization and yield attributes of aerobic rice (*Oryza sativa* L.)

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Abstract
The field experiment entitled "Morpho-physiological characterization and yield attributes of aerobic rice (*Oryza sativa* L.)" was conducted during *Kharif* 2024 at the Quality Seed Production Farm, Shendra 'A', Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani, Maharashtra. The experiment was laid out in a randomized block design with 14 rice genotypes including 2 checks and three replications. The objective was to study the variation in yield and its attributes, and morpho-physiological traits among rice genotypes.
Observations were recorded on morpho-physiological parameters viz., plant height, number of effective tillers, number of leaves, days to 50% flowering, days to maturity and yield attributes viz., panicle length, number of grains per panicle, 1000 grain weight, grain yield per hectare, and harvest index.
Maximum plant height was recorded in genotype PBNR 03-2, and minimum in PBNR 21-10. Maximum days to 50% flowering were observed in PBNR 21-4, while PBNR 21-12 showed the minimum. Avishkar required the longest duration to maturity, while PBNR 21-3 and PBNR 21-11 had the shortest. The highest number of tillers was recorded in PBNR 21-7, and the lowest in PBNR 21-9. Maximum number of leaves at 60 DAS were found in PBNR 03-2, followed by Avishkar; the minimum was in PBNR 21-8. PBNR 21-3 showed the highest grain yield and SPAD reading, followed by PBNR 21-7 and Avishkar. Lowest yield was in PBNR 21-12; lowest SPAD in PBNR 21-11. Highest harvest index was in PBNR 21-3, lowest was in PBNR 21-12. Based on results, PBNR 21-3 and PBNR 21-7 were the best performers, while PBNR 21-9 and PBNR 21-12 performed poorly in most parameters.

Keywords: Morpho-physiological, grain yield, genotypes, SPAD, HI, etc.

Introduction
Rice (*Oryza sativa* L.) is a major cereal crop and serves as a staple food for nearly half of the global population, particularly in developing countries. In India, archaeological records indicate rice cultivation dating back to 1500-1000 B.C., and it has long supported human civilizations across humid regions of Asia and West Africa. Its gradual adoption in Europe and the Americas has further increased its global dietary significance.
India ranks as the second-largest rice producer and the top exporter globally, with 478.32 lakh hectares under rice cultivation, producing 1357.55 lakh tons and achieving an average productivity of 2838 kg/ha during 2022-23 (Ministry of Agriculture and Farmers Welfare, 2023-24). In Maharashtra, rice was cultivated over 15.25 lakh hectares during *Kharif* 2024-25, with a production of 35.89 lakh tons and a productivity of 2.26 tons/ha (Chief Statistician, Commissionerate of Agriculture, Pune).
Traditional rice cultivation is highly water-intensive, often involving continuous flooding. Aerobic rice cultivation is a water-saving alternative where in rice is grown in non-puddled, well-drained soils with supplementary irrigation and appropriate fertilization. This method significantly reduces water usage, preserves soil micronutrients, and minimizes methane emissions, thereby improving water use efficiency and environmental sustainability.
Aerobic rice genotypes are valuable resources in breeding programs aimed at improving root systems, stress tolerance, and resistance to pests and diseases (Price *et al.*, 2002; Fukuoka & Okuno, 2001; Bernier *et al.*, 2008) [17, 4, 1]. Yield in rice is influenced by various morpho-physiological traits, including plant height, tillering ability, panicle length, grain number, and grain weight (Yoshida, 1983; IRRI, 1997; Oladosu *et al.*, 2018) [29, 7, 14]. Selection based on these yield components is essential for breeding high-yielding genotypes under aerobic

conditions. In this context, the present study, entitled "Morpho-physiological characterization and yield attributes of aerobic rice (*Oryza sativa* L.)" was undertaken with the primary objective of evaluating the morpho-physiological characteristics and yield-contributing traits of different rice genotypes under aerobic cultivation conditions.

Materials and Methods

The current study, "Studies on morpho-physiological and yield contributing traits of aerobic rice" of rice genotypes. This trial was conducted in *Kharif* 2024 at the Quality Seed Production Farm, Shendra 'A', VNMKV, Parbhani. The material for this present study comprised of 14 promising genotypes of rice including 2 check genotypes viz., PBNR-03-2 and Avishkar in table 1. The experimental material was collected from Upland Paddy Research Scheme, VNMKV, Parbhani. The experimental material was tested in randomized block design (RBD) with three replications.

The weekly mean maximum temperature during crop growth period *Kharif* 2024 was recorded as 32.36 °C, while the average minimum temperature was 21.74 °C. The mean relative humidity during crop growth period ranged from 25 to 95 percent. The mean sunshine hours ranged from 0.3 to 8.3 per day. The mean wind speed ranged from 0.8 to 7.5 km hr-1. The total rainfall received during monsoon period of 2024 between June to December was 882.5 mm.

The observations were recorded on morpho-physiological parameters viz., plant height, number of tillers, number of leaves, days to 50% flowering, days to maturity and yield attributes viz., panicle length, number of grains per panicle, test weight, grain yield per hectare and harvest index. Five random plants were selected from the two rows for recording observations. The average value was determined from these plants and these values were used for analysis.

The field data were analyzed statistically as per randomized block design and laboratory data were analyzed. Data of all entries in the experiment was subject to analysis of variance (Panse and Sukhatme, 1985) [16] for testing the significance of genotypes.

Table 1: List of entries

Sr. No	Genotypes	Sr. No	Genotypes
1	PBNR 21-1	8	PBNR 21-8
2	PBNR 21-2	9	PBNR 21-9
3	PBNR 21-3	10	PBNR 21-10
4	PBNR 21-4	11	PBNR 21-11
5	PBNR 21-5	12	PBNR 21-12
6	PBNR 21-6	13	PBNR 03-2
7	PBNR 21-7	14	Avishkar

Results and Discussion

The experiment entitled as "Morpho-physiological characterization and yield attributes of aerobic rice (*Oryza sativa* L.)" of rice genotypes. This trial was conducted during *Kharif* 2024 at Quality Seed Production Farm, Shendra 'A', Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani, Maharashtra.

1. Morpho-physiological observations

1.1. Plant height (cm)

Plant height was recorded at 30, 60, and 90 days after sowing (DAS), as well as at maturity for all fourteen experimental rice genotypes. The analysis revealed significant variation in plant height among the genotypes evaluated. The maximum plant height was observed in genotype PBNR 03-2 (91.57 cm) followed by PBNR 21-12 (89.43 cm) whereas the minimum plant height was recorded in genotype PBNR 21-10 (60.33 cm).

These findings are consistent with the results reported by Waghmare *et al.* (2008) [28], who also observed significant differences in plant height at harvest among various rice genotypes.

1.2. Days to 50% flowering

The analysis indicated a significant difference among the genotypes for days to 50% flowering. Genotype PBNR 21-4 required the maximum duration to reach 50% flowering (90 DAS) followed by PBNR 21-9 and Avishkar both of which took 86 DAS. The minimum duration was recorded in genotype PBNR 21-12, which reached 50% flowering in 75 DAS.

The present findings are in agreement with those of Chauhan *et al.* (1996) [2], who studied growth characteristics in rainfed upland rice and reported a positive and significant association between grain yield and dry matter accumulation at 50% flowering.

1.3. Days to maturity

The results demonstrated significant variation in days to maturity among the fourteen rice genotypes evaluated. Avishkar required the longest duration to reach maturity (118 days), while the shortest duration was recorded in genotypes PBNR 21-3 and PBNR 21-11, which matured in 108 days.

These findings are supported by Sarvan *et al.* (2016) [20], who analyzed sixty rice genotypes and reported a significant and positive correlation between days to maturity and grain yield per plant.

1.4. Number of effective tillers per plant

Significant variation was observed in the number of effective tillers among the rice genotypes studied. The number of tillers ranged from 11.00 to 19.33 per plant. Genotype PBNR 21-7 recorded the highest number of effective tillers (19.33 tillers plant^{-1}) followed by PBNR 21-3 (17.67 tillers plant^{-1}). The lowest number of effective tillers was observed in PBNR 21-9 (11.00 tillers plant^{-1}).

These findings align with those of Gallagher and Biscoe (1978) [5] and Miller *et al.* (1991) [11], who reported that the number of tillers has a direct influence on the number of panicles, which ultimately affects overall grain yield.

1.5. Number of leaves

Across all genotypes, the number of leaves increased from 30 to 60 days after sowing (DAS) followed by a decline as the crop approached maturity. The photosynthetic surface area, expressed in terms of leaf number, showed significant variation among the rice genotypes. The highest number of leaves was recorded in PBNR 03-2 (50.8 at 60 DAS) followed by PBNR 21-12 (44.5 at 60 DAS). The lowest number of leaves was observed in PBNR 21-8 (36 at 60 DAS, respectively).

These results similar with the findings of Kumar *et al.* (2012) [8] who reported significant genotypic variation in leaf number among different rice cultivars. Their study highlighted that rice genotypes exhibiting a higher number of leaves during the tillering stage also demonstrated increased dry matter production and grain yield.

2. Yield attributes

2.1 Number of grains per panicle

Significant variation was observed among the genotypes for the number of grains per panicle, ranging from 98.0 to 198.67 grains per panicle. The highest number of grains per panicle was recorded in genotype PBNR 21-3 (198.67) followed by PBNR 21-5 (188.33), while the lowest was observed in genotype PBNR 21-9 (98.0)

These findings are supported by Pandey *et al.* (2018) [15] and Nanda *et al.* (2019) [13], who reported a positive and highly significant correlation between the total number of grains per panicle and grain yield per plant.

2.2. Grain yield per hectare (q)

Grain yield per hectare varied significantly among the experimental rice genotypes. The highest grain yield was recorded in genotype PBNR 21-3 (29.79 q/ha) followed by PBNR 21-7 (26.01 q/ha), while the lowest yield was observed in genotype PBNR 21-12 (17.45 q/ha).

These findings align with those of Venkateswarlu *et al.* (1977) [27], who also reported significant variation in grain yield among rice genotypes, largely influenced by differences in yield-contributing traits.

2.3. Harvest index (%)

Data on harvest index revealed significant differences among the genotypes. The highest harvest index was recorded in genotype PBNR 21-3 (44.56%) followed by PBNR 21-7 (41.21%), while the lowest was observed in genotype PBNR 21-12 (28.36%). The superior harvest index in certain genotypes can be attributed to higher grain filling percentage and greater grain weight per hill compared to others.

This is supported by the findings of Guru *et al.* (2016), whose path coefficient analysis on 58 rice germplasm lines demonstrated that harvest index exerts a strong positive direct effect on grain yield.

2.4. Test weight (g)

Significant variation was observed among the rice genotypes for test weight. The highest 1000-grain weight was recorded in genotype PBNR 03-2 (24.50 g) followed by Avishkar (24.17 g), while the lowest was observed in genotype PBNR 21-8 (16.47 g).

These results are consistent with Singh *et al.* (2019) [22], who reported a significant positive correlation between test weight and grain yield in their study involving 101 rice genotypes.

2.5. Panicle length (cm)

Significant variation was observed in panicle length among the rice genotypes. The maximum panicle length was recorded in genotype Avishkar (28.50 cm), followed by PBNR 21-03 (25.43 cm) and PBNR 21-11 (25.30 cm), while the minimum panicle length was observed in genotype PBNR 21-9 (21.20 cm).

Similar trends have been reported by Singh *et al.* (2002) [23] and Kumhar *et al.* (2016) [9].

2.6. SPAD reading

Significant variation was observed in chlorophyll content, as measured by SPAD values, among the rice genotypes under upland conditions. The SPAD values ranged from 24.47 to 38.40 across the experimental genotypes. Genotype PBNR 21-3 exhibited the highest SPAD value (38.40), followed by Avishkar (36.80), while the lowest value was recorded in genotype PBNR 21-11 (24.47).

These results are consistent with the observations of Mian *et al.* (2009) [10], who reported significant genotypic variation in SPAD chlorophyll meter readings among rice genotypes. Moreover, Zhu *et al.* (2020) [30] established a positive association between average grain yield and mean SPAD values measured at various growth stages, indicating the potential of SPAD readings as a physiological indicator for yield estimation in rice.

Table 2: Performance of different genotypes for growth, yield, and physiological traits in rice.

Genotype	Plant Height at Maturity (cm)	No. of leaves at 60 DAS	Days to 50% flowering	Days to Maturity	Effective tillers	Length of panicle (cm)	No. of grains per panicle	Yield (q/ha)	Test weight (gm)	Chorophyll Content / SPAD reading	Harvest Index (%)
PBNR 21-1	65.13	41.8	83	114	11.33	22.20	119.67	22.88	22.97	33.10	38.17
PBNR 21-2	75.50	39.9	84	112	12.00	23.40	174.00	23.01	20.01	26.10	38.12
PBNR 21-3	83.03	40.8	78	108	17.67	25.43	198.67	29.79	21.97	38.40	44.56
PBNR 21-4	61.50	39.3	90	113	14.00	21.90	125.67	21.79	20.04	30.40	36.87
PBNR 21-5	87.57	40.9	78	114	11.67	23.47	188.33	20.23	18.97	28.20	33.17
PBNR 21-6	66.80	41.6	80	115	12.33	22.63	180.67	18.12	17.50	25.67	29.61
PBNR 21-7	83.33	38.8	84	110	19.33	25.27	187.00	26.01	22.60	35.00	41.21
PBNR 21-8	62.27	36.0	84	115	12.00	22.03	182.67	22.57	16.47	26.13	36.44
PBNR 21-9	68.87	37.3	86	113	11.00	21.20	98.00	20.34	22.50	27.13	34.61
PBNR 21-10	60.33	38.9	85	115	11.67	21.47	144.67	19.12	18.40	24.80	33.03
PBNR 21-11	83.10	36.3	85	108	13.67	25.30	173.33	23.46	22.07	24.47	36.21
PBNR 21-12	89.43	44.5	75	113	14.67	23.87	154.67	17.45	22.40	27.90	28.36
PBNR 03-2	91.57	50.8	78	109	15.00	22.97	132.00	20.12	24.50	34.43	31.74
AVISHKAR	86.13	48.0	86	118	16.00	28.50	156.00	23.50	24.17	36.80	29.82
SE(m)	1.66	0.66	0.76	0.87	1.02	0.56	3.17	1.34	0.67	1.31	1.62
C.D 5%	4.84	1.93	2.20	2.54	2.96	1.64	9.22	3.89	1.94	3.80	4.69

Conclusions

1. Based on above results it is concluded that the genotype PBNR 21-3 and PBNR 21-7 had the best morpho-physiological and growth performance. The genotype PBNR 21-9 and PBNR 21-12 found to be poorer performer in most of the parameters.
2. From the study it is concluded that higher yields were associated with plant dry weight, number of tillers, number of panicles per plant, number of grains per panicle, number of filled grains per panicle , NAR and harvest index.
3. The genotype PBNR 21-3 and PBNR 21-7 could be utilized in further breeding programme.

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