

## Research Article

# Biometric and phenological responses of rice genotypes during the kharif season in northern Kerala

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## Abstract

An experiment was undertaken at the Regional Agricultural Research Station, Pilicode of Kerala Agricultural University to study the growth, yield and phenological responses of 14 rice genotypes during the Kharif season. The study indicated that, under suitable management conditions, certain traditional varieties can produce yields comparable to or higher than high yielding varieties. Among the varieties studied, 'Karuthanjavara', 'Jaiva' and 'Thavalakannan' recorded higher grain yields, while the highest harvest index was observed in 'Jaiva'. Among the growth stages evaluated, the duration of booting and the total crop duration were found to have a greater influence on plant height, biomass and yield. Among the biometric parameters, height and biomass at various growth stages exhibited a positive influence on crop yield.

**Keywords:** Growth and yield, Phenology, Booting, Productive tillers, Organic production

## Introduction

The distribution and adaptation of rice genotypes are strongly influenced by topography, soil type and climatic conditions. Potential annual rice productivity is significantly higher in the tropics than in temperate regions, as tropical environments offer considerable flexibility for cultivating rice throughout the year. In India, rice is grown across an exceptionally wide range of habitats, from areas below sea level in parts of Kerala to elevations above 2,000 meters in Kashmir (Yoshida, 1981).

Sustained economic return is the major concern of the farmers in selecting suitable varieties for cultivation, which is identified based on various growth and yield characteristics of the crop. Rice is one of the most important cereal crops, possessing a rich genetic diversity. Since the growth and yield of all genotypes are influenced by genetic and environmental factors, a precise knowledge of these characters is highly beneficial in varietal selection and commercial crop production.

The growing demand for food grains, together with shrinking farmland and rising population, has created the need to increase crop productivity. Although conventional farming is effective in ensuring higher productivity, concerns about soil health and ecological sustainability have prompted many farmers towards organic farming. Kumari and Shanmugham (2020) reported that high yielding varieties which are responsive in a conventional production system may not always be suitable for organic farming and varieties differ considerably when grown under an organic production system with respect to grain yield, quality and economics compared to conventional farming. According to Manickam *et al.* (2024), before recommending traditional varieties for organic farming, they should be evaluated for their suitability under an organic production

system. Based on the above rationale, an experiment was undertaken to study and compare different rice varieties with respect to their growth, yield and phenology under an organic production system during the kharif season in northern Kerala.

## Materials and methods

The study was undertaken at the Regional Agricultural Research Station, Pilicode (12.20°N, 75.16°E), Kasaragod of Kerala Agricultural University. Fourteen rice genotypes, including both released varieties from Kerala Agricultural University and traditional varieties, were selected for the study. The experiment was conducted during the kharif season of 2022. The experiment was laid out in a Randomized Block Design with three replications. The varieties used as treatments in the experiment are 'Ezhome 2', 'Jaiva', 'Manuratna', 'Rakthashali', 'Njavara', 'Karuthanjavara', 'Karinellu', 'Punjapparuthi', 'Chempav', 'Thavalakannan', 'Valankunjuvith', 'Vellathondi', 'Kothambarikayama' and 'Japan violet'. There were 42 individual plots in the experiment, each with a plot size of 7.3 m<sup>2</sup> (4 m x 1.8 m) with a block to block distance of 2 m and plot to plot distance of 1 m. 25 day old seedlings were transplanted to the main field using a walking type 4 row transplanter on 20<sup>th</sup> June. Three seedlings were planted per hill with a spacing of 30 x 20 cm. The experiment was conducted in organic wetland blocks of the station and organic methods were adopted throughout the experiment period for crop production and protection.

Among the different growth stages of rice crop development, easily identifiable stages, *viz.*, booting, heading, milking, soft dough stage and harvest maturity were considered in this study and these stages were noted when 50% of the plant population reached that specific

growth stage and the number of days taken for the transition from one stage to another was also determined. Plant height was recorded at specific growth stages *viz.*, booting, heading and crop maturity and it was measured from the base of the plant to the tip of the longest leaf in a hill during booting and heading stages and from the base of the plant to the tip of the tallest panicle during the crop maturity stage. Grain yield was noted in g hill<sup>-1</sup> and it was later converted into t ha<sup>-1</sup>. Similarly, the number of productive tillers was counted per hill and converted into productive tillers per square meter. Crop biomass was calculated as the dry weight of above ground plant parts per hill and converted into t ha<sup>-1</sup> and it was determined during different crop growth stages *viz.*, 15 days after transplanting, booting, heading and harvesting stages. Harvest index was calculated as the ratio of grain yield to biological yield. Five hills per plot were tagged for recording biometric observations at the specified growth stages, except for biomass determination, for which plants were selected randomly, excluding the border rows.

The daily weather experienced during the experiment period was collected from the Agromet observatory of the Regional Agricultural Research Station, Pilicode and consolidated into weekly weather according to the standard meteorological weeks. The average maximum and minimum temperature, morning and afternoon relative humidity, bright sunshine hours and total rainfall during the field experiment are presented in Figure 1. Analysis of variance was done to determine the significant differences among the treatments and for a significant treatment effect; the LSD test was done to group the treatments. Correlation analysis was performed and Pearson's correlation coefficient was calculated using biometric and phenological observations to determine the strength and direction of linear relationships between these parameters, followed by tests for determining the significance of correlations. All the statistical procedures were performed using GRAPES 1.1.0 online data analysis tool following Gopinath *et al.* (2021).

## Results and discussion

### Biometric observations

The different biometric parameters like plant heights during booting, heading and harvesting stages, biomass during 15 days after transplanting, booting, heading and harvesting stages, number of productive tillers, yield and harvest index are presented in Table 1. At the time of booting, the highest plant height was recorded in 'Thavalakannan' which was on par with 'Chempav', 'Jaiva', 'Karuthanjavara' and 'Kothambari kayama'. At the time of heading, these varieties also recorded highest height along with 'Njavara' and 'Valankunjuvithu'. During the harvesting stage, the highest plant height was observed in 'Thavalakannan' (164.4 cm) which was on par with 'Karuthanjavara', 'Valankunjuvithu' and 'Njavara'. The plant height was found to be the lowest in 'Japan violet', 'Manuratna', 'Punjapparuthi' and 'Rakthashali' during booting and heading stages, but at the time of harvest, the lowest heights were observed in 'Manuratna' (91 cm) and 'Japan violet' (91.5 cm).

The rice varieties used in the study were classified according to plant height based on the IRRI (2013) evaluation system. Accordingly, 'Manuratna', 'Japan Violet', 'Punjapparuthi' and 'Rakthashali' were categorized as semidwarf, 'Vellathondi' was classified as intermediate and all other varieties, namely, 'Thavalakannan', 'Karuthanjavara', 'Valankunjuvithu', 'Njavara', 'Kothambarikayama', 'Karinellu', 'Ezhome 2', 'Jaiva', and 'Chempav' were placed in the tall category. All tall varieties across all replications exhibited varying degrees of lodging at crop maturity.

With respect to the crop biomass, no significant difference was found among the 14 varieties at 15 days after transplanting. At the booting stage, 'Chempav' (6.86 t ha<sup>-1</sup>) attained the highest biomass, whereas seven varieties exhibited similarly low biomass values with

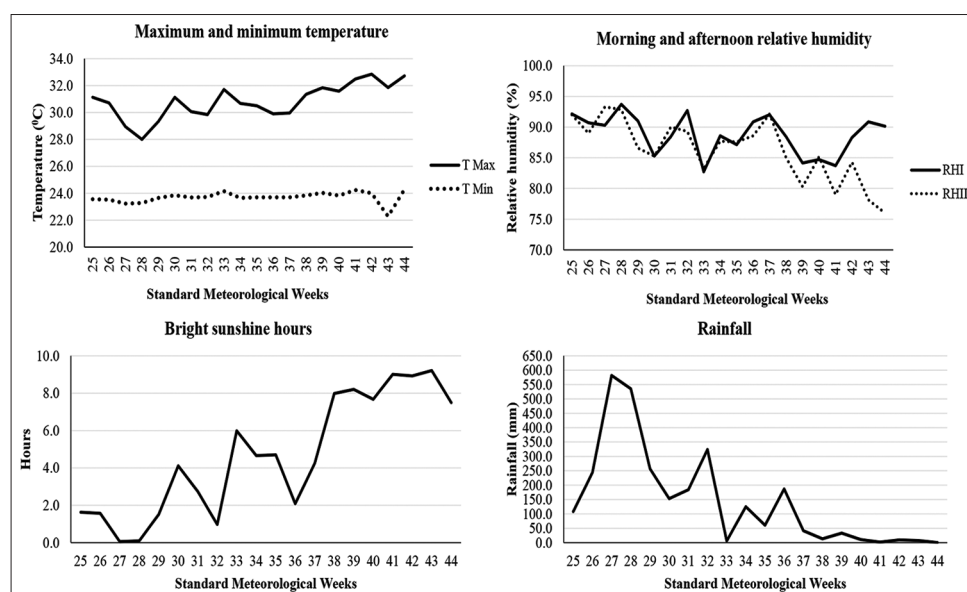


Figure 1: Weekly weather parameters during the experiment

**Table 1:** Biometric observations of rice varieties

Treatment	Height at booting (cm)	Height at heading (cm)	Height at harvest (cm)	Biomass at 15 DAT (t ha <sup>-1</sup> )	Biomass at booting (t ha <sup>-1</sup> )	Biomass at heading (t ha <sup>-1</sup> )	Biomass at harvest (t ha <sup>-1</sup> )	Productive tillers per m <sup>2</sup>	Yield (t ha <sup>-1</sup> )	Harvest Index
T1 Ezhome 2	107.4 <sup>bc</sup>	113.3 <sup>de</sup>	144.2 <sup>cde</sup>	0.03	4.55 <sup>bc</sup>	7.10 <sup>bc</sup>	14.11 <sup>a</sup>	190.2 <sup>cd</sup>	4.12 <sup>cde</sup>	0.30
T2 Jaiva	120.1 <sup>abc</sup>	139.2 <sup>a</sup>	142.5 <sup>de</sup>	0.06	3.79 <sup>cde</sup>	8.83 <sup>a</sup>	8.92 <sup>cd</sup>	202.7 <sup>bcd</sup>	5.59 <sup>ab</sup>	0.63
T3 Manuratna	80.0 <sup>d</sup>	89.1 <sup>f</sup>	91.0 <sup>h</sup>	0.05	2.79 <sup>efg</sup>	3.42 <sup>e</sup>	6.95 <sup>d</sup>	177.8 <sup>d</sup>	2.54 <sup>g</sup>	0.37
T4 Rakthashali	87.2 <sup>d</sup>	101.2 <sup>ef</sup>	108.6 <sup>g</sup>	0.04	3.53 <sup>def</sup>	3.75 <sup>e</sup>	8.52 <sup>cd</sup>	270.2 <sup>a</sup>	3.08 <sup>fg</sup>	0.39
T5 Njavara	105.9 <sup>c</sup>	135.1 <sup>ab</sup>	154.6 <sup>abcd</sup>	0.04	4.26 <sup>bcd</sup>	5.76 <sup>cd</sup>	9.97 <sup>bcd</sup>	156.4 <sup>d</sup>	4.78 <sup>bc</sup>	0.49
T6 Karuthanjavara	116.7 <sup>abc</sup>	131.3 <sup>abc</sup>	161.7 <sup>abc</sup>	0.06	5.21 <sup>b</sup>	8.78 <sup>a</sup>	13.91 <sup>ab</sup>	186.7 <sup>d</sup>	5.84 <sup>a</sup>	0.44
T7 Karinellu	107.5 <sup>bc</sup>	118.3 <sup>cd</sup>	146.2 <sup>cde</sup>	0.04	2.39 <sup>g</sup>	4.81 <sup>de</sup>	9.29 <sup>cd</sup>	172.4 <sup>d</sup>	4.37 <sup>cde</sup>	0.48
T8 Punjapparuthi	84.7 <sup>d</sup>	97.5 <sup>f</sup>	104.4 <sup>g</sup>	0.03	2.79 <sup>efg</sup>	3.84 <sup>e</sup>	10.23 <sup>abcd</sup>	277.3 <sup>a</sup>	3.64 <sup>def</sup>	0.36
T9 Chempav	122.5 <sup>ab</sup>	138.3 <sup>a</sup>	140.9 <sup>c</sup>	0.05	6.86 <sup>a</sup>	8.59 <sup>ab</sup>	11.74 <sup>abc</sup>	241.8 <sup>abc</sup>	3.88 <sup>cdef</sup>	0.33
T10 Thavalakannan	132.2 <sup>a</sup>	140.2 <sup>a</sup>	164.4 <sup>a</sup>	0.07	4.00 <sup>cd</sup>	4.94 <sup>de</sup>	13.35 <sup>ab</sup>	170.7 <sup>d</sup>	4.83 <sup>abc</sup>	0.37
T11 Valankunjuvith	108.3 <sup>bc</sup>	133.5 <sup>abc</sup>	154.9 <sup>abc</sup>	0.04	2.69 <sup>fg</sup>	5.70 <sup>cd</sup>	10.61 <sup>abcd</sup>	158.2 <sup>d</sup>	4.23 <sup>cde</sup>	0.43
T12 Vellathondi	107.1 <sup>bc</sup>	122.9 <sup>bcd</sup>	127.2 <sup>f</sup>	0.04	3.38 <sup>defg</sup>	5.72 <sup>cd</sup>	13.30 <sup>ab</sup>	190.2 <sup>cd</sup>	4.47 <sup>cd</sup>	0.34
T13 Kothambari	116.0 <sup>abc</sup>	130.0 <sup>abc</sup>	151.1 <sup>bcd</sup>	0.04	2.46 <sup>g</sup>	4.98 <sup>de</sup>	11.36 <sup>abc</sup>	188.4 <sup>cd</sup>	4.50 <sup>cd</sup>	0.40
kayama										
T14 Japan violet	77.2 <sup>d</sup>	87.0 <sup>f</sup>	91.5 <sup>h</sup>	0.03	2.84 <sup>efg</sup>	3.56 <sup>e</sup>	9.04 <sup>cd</sup>	250.7 <sup>ab</sup>	3.35 <sup>efg</sup>	0.38
SE (m)+	5.587	5.241	4.251	0.011	0.344	0.574	1.359	18.955	0.353	0.058
CD (0.05)	16.241	15.235	12.357	NS	0.999	1.668	3.952	55.101	1.026	NS

DAT-Days after transplanting. Treatments with same alphabet as superscripts in a column do not differ significantly

less than 3.5 t ha<sup>-1</sup>. During the heading stage, 'Jaiva', 'Karuthanjavara' and 'Chempav' showed the highest biomass. At harvest, eight varieties viz., 'Ezhome 2', 'Karuthanjavara', 'Thavalakannan', 'Vellathondi', 'Chempav', 'Kothambarikayama', 'Valankunjuvithu' and 'Punjapparuthi' produced more than 10 t ha<sup>-1</sup>, while the remaining varieties exhibited lower, yet comparable biomass. Among them, 'Ezhome 2' reached the highest biomass of 14.11 t ha<sup>-1</sup>, whereas 'Manuratna' recorded the lowest of 6.95 t ha<sup>-1</sup>.

The number of productive tillers per square meter was highest in 'Punjapparuthi' (277.3) which was statistically on par with 'Rakthashali', 'Japan violet' and 'Chempav'. The remaining varieties recorded lower but comparable numbers of productive tillers. The highest grain yield was recorded in 'Karuthanjavara' (5.84 t ha<sup>-1</sup>) which was on par with 'Jaiva' (5.59 t ha<sup>-1</sup>) and 'Thavalakannan' (4.83 t ha<sup>-1</sup>). The lowest grain yields were observed in 'Manuratna' (2.54 t ha<sup>-1</sup>), 'Rakthashali' (3.08 t ha<sup>-1</sup>) and 'Japan violet' (3.35 t ha<sup>-1</sup>).

At harvest, 'Karuthanjavara' and 'Thavakannan' exhibited higher crop yield and biomass along with taller plant height, whereas 'Jaiva' achieved a higher yield despite having lower biomass and shorter plant height. This may be attributed to the ability of 'Jaiva' to perform well in organic management. According to Manjunatha *et al.* (2016), 'Jaiva' is the first organic rice variety developed by Kerala Agricultural University through an organic plant breeding programme. 'Manuratna', a high yielding variety at Kole lands of central Kerala, exhibited the lowest yield in this experiment, which may be attributed to differences in climatic conditions, its limited adaptability to the agroecology of the study area or its relatively high nutrient requirement.

The harvest index did not differ significantly among the varieties, with values ranging from 0.30 in 'Ezhome 2' to 0.63 in 'Jaiva'. Since harvest index reflects the efficiency of biomass partitioning towards the economically

valuable plant part (Li *et al.*, 2012; Asefa, 2019), 'Jaiva' can be considered as the superior variety among all the genotypes used in the experiment in terms of potential economic return to the farmers. The lower harvest index observed in 'Ezhome 2' may be attributed to its allocation of photosynthates primarily to straw, despite producing the highest total biomass. Asefa (2009) reported that the harvest index varies with crop varieties, crop growing season, crop management, plant population and with weather parameters experienced. Hence, the selection of genotypes with a higher harvest index will be useful in improving yield productivity.

### Phenological observations

The duration of different stages of rice growth and development is presented in Table 2. 'Chempav' took 77.7 days to reach booting, which was on par with 'Jaiva' (76 days), whereas 'Manuratna' reached booting in only 54.3 days. The duration from booting to heading was longest for 'Njavara' (15.7 days) which was on par with 'Jaiva' and 'Valankunjuvithu' and shortest in 'Manuratna' (6 days), which was statistically similar to eight other varieties used in the study. The duration from heading to milking varied from 11.3 days in 'Chempav' to 5.3 days in 'Japan violet'.

The varieties used in the experiments were found to be statistically similar with respect to the period from milking to soft dough stage and it ranged from 8 days in 'Njavara' to 15 days in 'Karinellu'. The duration from soft dough to maturity was longest in 'Kothambarikayama' (27.3 days), 'Jaiva' (26 days) and 'Karinellu' (25 days), whereas this period was only 10.6 days in 'Rakthashali' and 'Punjapparuthi' and was on par with 'Thavalakannan' (12.6 days), 'Vellathondi' (13.3 days) and 'Ezhome 2' (13.6 days). The duration from transplanting to maturity varied from 98.7 days to 133.3 days. This duration was shortest in 'Manuratna' (98.7 days), 'Japan violet' (99.3 days), 'Rakthashali' (99.7 days), 'Punjapparuthi' (99.7 days) and 'Vellathondi' (102.7 days). The crop

duration was longest in 'Jaiva' (133.3 days), 'Chempav' (131.3 days) and 'Karinellu' (129.7 days).

The varieties took an average of 67.1 days to reach booting after transplanting, 9.8 days to reach heading after booting, 8.5 days to reach milking after heading, 10.9 days to reach soft dough stage after milking, and 17.5 days to reach maturity after soft dough stage. The average crop duration was 113.6 days and the average number of days to reach maturity from booting was 46.5 days.

### Correlation analysis

The linear correlation analysis between different biometric parameters is presented in Table 3. The study revealed that height at different growth stages has a significant correlation with other growth and yield parameters except the biomass at 15 days after transplanting and harvest index. The crop height at booting, heading and harvesting stages exhibited very highly significant positive correlations with crop yield and biomass at the heading stage. Plant height also showed significant positive correlations with biomass at booting and harvest. Similar findings indicating a significant correlation between plant height and biomass were reported by Solomon and Wegary (2016). A positive correlation between plant height and grain yield in indica ecotypes was reported by Li *et al.* (2019). A significant positive association of plant height

with yield was also observed by Fageria (2007), Solomon and Wegary (2016) and Zhao *et al.* (2020). The heights at various stages also showed positive and highly significant intercorrelations. Likewise, biomass at different growth stages was positively intercorrelated, except for biomass at 15 days after transplanting. The experiment indicates that 15 days of crop growth is not a significant parameter for distinguishing different rice varieties.

The number of productive tillers exhibited significant negative correlations with plant height at different growth stages. Similar negative influence of plant height on productive tillers was also reported by Limbongan *et al.* (2023) in an experiment using diverse F3 lines of black rice. Although a higher number of productive tillers are generally regarded as an important yield-contributing trait during varietal screening, no significant correlation between productive tillers and grain yield was observed in the present study. This lack of association may be attributed to the high tillering ability of the semidwarf and short-duration traditional varieties evaluated, which produced comparatively lower grain yields. Therefore, in addition to the number of productive tillers, other yield components such as the number of grains per panicle and individual grain weight need to be considered to better elucidate the relationship between productive tillers and grain yield. The harvest index exhibited a highly significant positive

**Table 2:** Duration of various growth stages in rice varieties

Treatment	Transplanting to booting (days)	Booting to heading (days)	Heading to milking (days)	Milking to soft dough (days)	Soft dough to maturity (days)	Transplanting to harvest (days)
T1 - Ezhome 2	70.3 <sup>bc</sup>	9.3 <sup>bcd</sup>	10.3 <sup>ab</sup>	12	13.6 <sup>dc</sup>	115.7 <sup>c</sup>
T2- Jaiva	76.0 <sup>a</sup>	12.7 <sup>ab</sup>	6.3 <sup>cde</sup>	12.3	26.0 <sup>a</sup>	133.3 <sup>a</sup>
T3 -Manurathna	54.3 <sup>h</sup>	6.0 <sup>e</sup>	10.3 <sup>ab</sup>	10	18.0 <sup>bc</sup>	98.7 <sup>e</sup>
T4 - Rakthashali	62.7 <sup>cf</sup>	8.3 <sup>cde</sup>	7.7 <sup>bcd</sup>	10.3	10.6 <sup>c</sup>	99.7 <sup>e</sup>
T5- Njavara	65.3 <sup>de</sup>	15.7 <sup>a</sup>	6.0 <sup>de</sup>	8	15.6 <sup>cd</sup>	107.3 <sup>d</sup>
T6 - Karuthanjavara	70.7 <sup>b</sup>	8.7 <sup>cde</sup>	9.7 <sup>abc</sup>	9.7	16.3 <sup>cd</sup>	115.0 <sup>c</sup>
T7 - Karinellu	71.0 <sup>b</sup>	9.0 <sup>cde</sup>	9.7 <sup>abc</sup>	15	25.0 <sup>a</sup>	129.7 <sup>ab</sup>
T8 - Punjapparuthi	63.3 <sup>ef</sup>	6.7 <sup>de</sup>	7.0 <sup>bcd</sup>	12	10.6 <sup>c</sup>	99.7 <sup>e</sup>
T9 - Chempav	77.7 <sup>a</sup>	9.0 <sup>cde</sup>	11.3 <sup>a</sup>	12.3	21.0 <sup>b</sup>	131.3 <sup>ab</sup>
T10 -Thavalakannan	72.3 <sup>b</sup>	8.7 <sup>cde</sup>	8.3 <sup>abcde</sup>	12.3	12.6 <sup>dc</sup>	114.3 <sup>c</sup>
T11 -Valankunjuvith	67.0 <sup>cd</sup>	12.7 <sup>ab</sup>	9.0 <sup>abcd</sup>	7.7	18.6 <sup>bc</sup>	115.0 <sup>c</sup>
T12 -Vellathondi	60.3 <sup>fg</sup>	11.7 <sup>bc</sup>	7.3 <sup>bcd</sup>	10	13.3 <sup>dc</sup>	102.7 <sup>e</sup>
T13 -Kothambari kayama	70.3 <sup>bc</sup>	10.0 <sup>bcd</sup>	10.3 <sup>ab</sup>	11	27.3 <sup>a</sup>	129.0 <sup>b</sup>
T14 -Japan violet	58.7 <sup>g</sup>	8.7 <sup>cde</sup>	5.3 <sup>c</sup>	10.3	16.3 <sup>cd</sup>	99.3 <sup>e</sup>
Mean	67.1	9.8	8.5	10.9	17.5	113.6
SE (m)+	1.245	1.212	1.214	1.833	1.264	1.487
CD (0.05)	3.619	3.522	3.53	NS	3.674	4.322

Treatments with same alphabets as superscripts in a column do not differ significantly

**Table 3:** Correlation between biometric parameters

	Height at booting	Height at heading	Height at harvest	Biomass at 15 DAT	Biomass at booting	Biomass at heading	Biomass at harvest	Productive tillers	Yield
Height at heading	0.915***								
Height at harvest	0.853***	0.881***							
Biomass at 15 DAT	0.232	0.233	0.201						
Biomass at booting	0.460**	0.459**	0.343*	0.136					
Biomass at heading	0.615***	0.672***	0.576***	0.185	0.667***				
Biomass at harvest	0.424**	0.395**	0.49**	0.329*	0.352*	0.459**			
Productive tillers	-0.378*	-0.453**	-0.5***	-0.029	0.017	-0.209	0.011		
Yield	0.696***	0.708***	0.724***	0.22	0.236	0.549***	0.372*	-0.29	
Harvest index	0.238	0.270	0.214	-0.081	-0.081	0.093	-0.543***	-0.244	0.548***

DAT-Days after transplanting, \*\*\* Significant at 0.001 level, \*\* Significant at 0.01 level, \* Significant at 0.05 level

**Table 4:** Correlation between biometric and phenological observations

	Duration of growth stages					
	Transplanting to booting	Booting to heading	Heading to milking	Milking to soft dough	Soft dough to maturity	Transplanting to harvest
Height at booting	0.719***	0.180	0.279	0.185	0.282	0.638***
Height at heading	0.679***	0.445**	0.158	0.054	0.317*	0.630***
Height at harvest	0.699***	0.426**	0.201	0.050	0.280	0.627***
Biomass at 15 DAT	0.206	-0.075	0.222	0.011	0.212	0.247
Biomass at booting	0.494***	0.003	0.232	0.065	-0.112	0.265
Biomass at heading	0.635***	0.273	0.199	0.128	0.283	0.584***
Biomass at harvest	0.298	0.114	0.197	0.027	-0.129	0.170
Productive tillers	-0.117	-0.301	-0.132	0.032	-0.227	-0.235
Yield	0.567***	0.295	-0.035	0.049	0.250	0.480**
Harvest index	0.255	0.156	-0.195	0.06	0.308*	0.285

DAT-Days after transplanting, \*\*\* Significant at 0.001 level, \*\* Significant at 0.01 level, \* Significant at 0.05 level

correlation with grain yield and a negative correlation with biomass, in agreement with the findings of Solomon and Wegary (2016).

Among the different phenological periods studied in this experiment, the duration from transplanting to booting was found to be more influential in crop growth and yield, as revealed by the correlation analysis between different biometric and phenological parameters (Table 4). The duration from transplanting to booting stage showed positive and very highly significant relationships with the plant height at different growth stages, crop yield and biomass at the booting and heading stages, however, no significant relationship was seen with the harvest biomass and harvest index. The total crop duration exhibited highly significant positive association with crop yield, which is in accordance with the findings of Li *et al.* (2019) that grain yield is positively correlated with the growing period, and varieties with longer duration are associated with higher yields. The total crop duration also showed a highly significant positive correlation with plant height at different stages and with biomass at the heading stage. A positive relationship between crop duration and plant height at harvest was also reported by Solomon and Wegary (2016). The durations from heading to milking and milking to soft dough and soft dough to maturity were not found to be significant in influencing the growth and yield characteristics of the crop.

## Conclusions

The study revealed that certain traditional varieties can achieve yields comparable to or even higher than high yielding varieties under organic management systems. Notably, 'Karuthanjavara', a traditional rice variety with medicinal properties produced a higher yield in this experiment along with the released variety 'Jaiva'. Along with the higher yield, 'Jaiva', the organic rice variety of Kerala Agricultural University, displayed a higher harvest index also. The favourable traits of these high performing genotypes need further detailed study and could be harnessed in future breeding programmes.

The study confirmed that plant height at various stages has a positive influence on yield and biomass, whereas it exhibited a negative relation with the number of productive

tillers. Based on height, the varieties *viz.*, 'Manuratna', 'Japan Violet', 'Punjapparuthi' and 'Rakthashali' were classified as semidwarf, 'Vellathondi' as intermediate and all other varieties as tall. The experiment further revealed that the durations to booting and to maturity are critical growth phases influencing plant height, yield and biomass accumulation.

## Author contributions

V. P. Karthika: Conceptualization of the study, investigation and conduct of experiments, formal analysis of data and preparation of the manuscript. P. K. Rethesh: Provision of laboratory facilities, provision of weather data, contribution to investigation, supervision of the study and review of the manuscript. T. Vanaja: Funding acquisition, allocation of field for experimentation, provision of seeds for the experiment, supervision of the study and review of the manuscript.

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