Agro Meteorological indices in relation to phenology and yield of promising aromatic rice varieties of Odisha under different dates of Transplanting

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Abstract - The present investigation entitled "Photothermal use efficiency of promising aromatic rice cultivars under staggered planting" was carried out during kharif 2017 and rabi 2017-18 at Research Farm of Department of Agricultural Meteorology, College of Agriculture, OUAT, Bhubaneswar. The experiment was conducted in a split plot design replicated twice with twelve dates of planting (16 July, 1 August, 16 August, 1 September, 16 September,1 October,16 October, 1 November, 16 November, 1 December, 16 December, 1 January) in the main plot and three varieties (Geetanjali, Poornabhog, Pusa Sugandh-II) in the sub-plots. The phenological study revealed that the number of days required for attaining particular phenophase varied significantly due to varieties and different dates of planting. The rice varieties planted on 1 and 16 November took maximum number of days to reach tillering almost 76-77 days which was 24-36 days more than other dates of transplanting during kharif season and 22-42 days more than other dates planted during rabi season. The phenophases like 50% flowering and physiological maturity was attained much later in November planted rice irrespective of varieties (106-112 DAT and 139-146 DAT respectively). Among the varieties Poornabhog required 10-11 days more than PusaSugandh-II and Geetanjali to attain maturity. Earlier planted crop (1 August) required highest GDD and decreased gradually up to 16 September planting during kharif season to attain maturity. Similarly in rabi season the GDD requirement increased drastically in November planted crop and decreased gradually up to 1 January planting. Poornabhog required GDD (1740.2 TO 2373.4) than Geetanjali and PusaSugandh-II (1562.4 TO 2022). The accumulation HTU and PTU followed the similar trend as in GDD. Among the varieties higher HUE was noticed in variety Poornabhog at all the stages of growth as compared to variety Geetanjali and PusaSugandh-II.

Rice (Oryza sativa L.) is one of the most important cereal crops in Asia, grown under different hydrological conditions. It is the principal source of food for more than half of the world population particularly in South and Southeast Asia, Latin America and Indonesia. Rice contributes around 45% of the total production and being the staple food for more than two third of the population, holds the key to sustain food sufficiency in India (Rai and Kushwaha, 2005).India holds the second position in production of rice in the world with production of 105.48 mt from 43,9mha with a productivity of 2390 kg/ha during 2016 (Economic Survey, 2016-2017). Rice productivity is highly dependent upon prevailing weather conditions. Some of the weather parameters like sunshine hours, rainfall and heat (measured as temperature) are important natural resources which affect the rice productivity to a greater extent. The crop growth response is influenced largely by the microclimate environment in the crop. Microclimate in the crop varies from top of the canopy to the soil surface and affects crop development and yield. Various environmental factors influencing crop growth are interception of photosynthetically active radiation (PAR), air and leaf temperatures, relative humidity, prevailing wind speed, CO2 concentration and soil moisture availability. The optimum utilisation of these natural resources by alternating date of planting of suitable rice cultivars will help in increasing the rice productivity. To study the extent and comparative utilisation of these resources some weather based agro indices have been developed. The commonly used indices are growing degree days (GDD), helio thermal units (HTU) and photo thermal units (PTU). Temperature and light play a key role in influencing the crop production. The occurrence of different phenological events during crop growth period in relation to temperature can be estimated by using accumulated heat units or growing degree-days (GDD). Knowledge of accumulated GDD can provide an estimate of harvest date as well as crop development stage. Thermal time is an independent variable to describe plant development. It can be used as a tool for characterizing thermal responses in different crops. Heat use efficiency (HUE), i.e., efficiency of utilization of heat in terms of dry matter accumulation, depends on crop type, genetic factors and sowing time and has great practical application. Initiation as well as duration of crop phenophases is an essential component of weather based dynamic crop growth and yield simulation models. Crop phenology can be used to specify the most appropriate date and time of specific development process. The duration of each phenophase determines the accumulation and partitioning of dry matter in different organs reported that the duration of a particular stage of growth was directly related to temperature and this duration of particular species could be predicted using the sum of daily air temperature. Temperature is an important environmental factor influencing the growth and development of crop plants. It influences the crop phenology and yield of crop. Plants have a definite temperature requirement to attain phenological stages. Hence, it becomes imperative to have knowledge of the exact duration of phenological stages in a particular crop-growing environment and their impact on yield of crop. Keeping all the above facts in view the present study was designed to study the phenology of aromatic rice varieties and estimate the agrometeorological indices (GDD, HTU, PTU, HUE) required to attain different phenophases under staggered planting.

I. MATERIALS AND METHODS

The field experiment was carried out during kharif 2017 and rabi season of 2017-18 at Research farm of College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar. It is situated at an elevation of 25.9 m above mean sea level at 20015’ N latitude and 85052 ’ E longitude and at about 64 km away from the Bay of Bengal. It comes under the East & South East Coastal Plain of Odisha. The experiment included twelve dates of planting (16 July, 1 August, 16 August, 1 September, 16 September,1 October,16 October, 1 November, 16 November, 1 December, 16 December, 1 January) as main plot treatments and three varieties (Geetanjali, Poornabhog, Pusa Sugandh-II) as sub-plot treatments, resulting in 36 treatment combinations. The experiment was laid out in a split plot design with two replications. As the 1 and 16 October planted aromatic rice varieties resulted with complete sterility, they are excluded from the final statistical analysis i.e. statistical analysis was done using 10 dates of planting instead of 12 dates.

II. PHENOLOGICAL OBSERVATIONS

Observations on dates of occurrence of different phenological stages viz. tillering, panicle initiation, heading, 50% flowering and physiological maturity were observed visually with daily visit to the field and noted.

Growing degree days (GDD) concept assumes that there is a direct and linear relationship between growth and developments of plants and temperature and the growth is dependent on the total amount of heat units to which it is subjected during its life time. The growing degree days was computed by using following formula

$$GDD = [(T_{max} + T_{min}) / 2 - T_{base}]$$

Where,

T_{max} = Daily maximum temperature

T_{min} = Daily minimum temperature

T_{base} = Base temperature

The base temperature is defined as, “The temperature below which no plant physiological activity takes place” which is considered as 10^0C for *Kharif* rice.

Photothermal unit (PTU)

PTU was calculated by multiplying GDD with day length (N).

PTU= [GDD × N]

Where, N = Day length

Heliothermal unit (HTU)

HTU was estimated by multiplying GDD with bright sunshine hours (n).

HTU = [GDD × n]

Where, n = Bright sunshine hour.

Heat use efficiency (HUE)

Heat use efficiency for total dry matter was obtained as under

HUE (g/m ^{2}/ ^{0}day) = [Biomass (g/ m^2) / GDD (^{0} day)]

III. RESULTS AND DISCUSSION

Aromatic rice crop and weather

In the present study complete sterility observed in all the three varieties planted on 1 and 16 October where the crops had been exposed to <15^0C night temperature during major part of the crop growth and <12^0C during heading, flowering and grain filling stages even approaching to 9.8^0C intermittently. Very high sterility was also noticed in November planted crops. Exposure of rice plants to <15^0C night temperature during most part of vegetative growth and panicle initiation induces high sterility as reported by Yoshida (1981). Similarly complete sterility was also reported by De Souza *et al*. (2017) in some of the rice cultivars when the micro-sporogenesis stage exposed to 9^0C, when the temperature increased to 12^0C instead of complete sterility there was probability of very high sterility >50%. They opined that such condition may not induce sterility if it occurs over a period shorter than 48 hours, but causes 100% sterility when exposed to more than six days under such stress, depending upon the genotype sensitivity. Besides, complete sterility may also be developed when the anthesis and pollen shedding exposed to relative humidity less than 60% as reported by Xue *et al*. (2018). Under such condition the pollen began to shrink becoming dehydrated, as a result the pollen did not adhere to the stigma and pollen tube elongation arrested at a very stage. They established the fact that the deficiency in triterpenesynthase enzyme leads to failure in pollen coat formation which did not allow further germination of pollen tube. As the aromatic rice varieties in the present study have never been exposed to <60% mean RH condition which clearly illustrated that the exposure of crops to low temperature during PI, heading and flowering was most probably the reason for complete sterility in 1 and 16 October planting and very high sterility in November planted crops.

Phenology

The rice varieties planted on 1 November took maximum number of days to reach tillering (77 days) which was 24-36 days more than other dates of transplanting during *kharif* and 22-42 days more than the other varieties planted during *rabi* season (Table 1). This is due to incidence of low temperature during planting on 1 October-16 November which inhibited tillering and prolonged crop duration.In case of 50 % flowering and physiological maturity, highest number of days was recorded in the rice varieties planted on 16 November, i.e., 114 days and 146 days respectively .This is in conformity with the findings of Chopra and Chopra (2004) who observed that under delayed planting condition it required more calendar days in ripening phase to attain physiological maturity. But planting during 1 November and 16 November all the phenological stages were achieved late by 25-35 days. Among the varieties Poornabhog reached the phenophases 10 days late than Geetanjali and PusaSugandh-II. Similarly, Bhat *et al.* (2015) also reported earlier that the significant difference in number of days taken to attain different phenophases in two rice cultivars was due to the differential genetic makeup and duration of varieties.

Growing Degree Days (GDD)

Highest GDD were accumulated in 1 August planting during *kharif* which was almost identical with 16 July planted crop but decreased gradually thereafter up to 16 September (Table 2). During *rabi* the accumulated

GDD value of November planted crop was highest due to experience of low temperature which inhibits tillering and duration was prolonged. Least value of accumulated GDD was observed in 1 January in all the varieties from transplanting to maturity at all the phenophases. Such variation in GDD requirement for attainment of different phenophases in rice was mostly because of the differential duration to attain the physiological stages. This finding confirms the earlier findings of Abhilash *et al.,* 2017 and Satish *et al*., 2017 who have also reported that higher number of degree days required for attaining different phenophases in early planted rice as compared to delayed planting during *kharif* season. Variety Poornabhog accumulated highest GDD value (2373.4) to attain physiological maturity followed by PusaSugandh –II and Geetanjali (2022 each) mostly because of the differences in duration. Similar varietal differences in accumulated GDD to attain different phenophases were also reported earlier by Sreenivas *et al*., 2010.

Table.1 Effect of different dates of transplanting on attainment of different phenophases (DAT) of rice variety

Treatment	Tillering	PI	Heading	50% flowering	Maturity
Dates of transplanting					
16 July	42	52	64	80	109
1 August	47	59	71	87	115
16 August	41	51	62	78	110
1 September	43	55	67	82	110
16 September	53	62	75	89	114
1 November	77	87	95	109	140
16 November	76	87	100	114	146
1 December	56	66	80	97	125
16 December	45	57	70	85	115
1 January	36	49	62	77	105
CD (p=0.05)	2.8	2.3	2.7	2.2	2.9
Varieties					
Geetanjali	48	59	70	86	115
Poornabhog	59	71	83	97	126
PusaSugandh –II	48	58	70	86	115
CD (p=0.05)	1.4	1.2	1.4	1.1	1.5

Heliothermal unit (HTU)

Heliothermal unit was computed by multiplying the GDD value with the actual sunshine hours. The accumulated HTU at different phenophases vary as per the number of days required and the variation in temperature and actual sun shine hours in *kharif* (July, August and September) and *rabi* (November, December and January) planting (Table 3). Relatively higher HTU was available to *rabi* rice as compared to *khraif* rice. This was mostly because of the cloudless clear sky in *rabi* which increased the possibility of availability of actual bright sun shine hours. Besides, the variation in accumulated HTU in different dates of planting can also be ascribed to the corresponding variation in GDD under different dates. Similar results were also reported earlier by Praveen *et al*., 2013. In *kharif* Poornabhog had accumulated HTU value of 12683.9 from emergence to physiological maturity followed by Geetanjali and Pusa Sugandh-II (11065.9). This confirmed the results of Sreenivas *et al*. (2010).

Photothermal unit (PTU)

Photothermal unit was estimated by multiplying the GDD values with the day length. The accumulated PTU followed the similar trend of accumulated HTU during both the season. On an average the day length available during May, June, July and August was 13 hours, March, April and September was 12 hours, October, November and January was 11 hours whereas only 10 hours in December. Such variations in day length over the months obviously created the variations in PTU in addition to the differences in GDD under different dates of planting (Table 4). The varietal differences observed in accumulated PTU for attaining the physiological maturity was also confirmed earlier findings of Kaur and Dhaliwal, 2014.

Heat use efficiency (HUE)

Total heat energy available to any crop is never completely converted to dry matter even under most favourable agro climatic conditions and is presented in Table 5. HUE is the conversion of heat energy into dry matter and depends upon crop type, genetic factors and sowing time (Rao *et al*, 1996). In different dates of transplanting, the HUE increased progressively with the advancement of crop age up to 90 days after transplanting and decreased gradually thereafter in all the dates of planting excepting the December and January planting where maximum HUE was noticed at 60 and 45 DAT respectively. Rice crop transplanted on 1 September exhibited maximum heat use efficiency (1.67 g ha^{-1} $^0C^{-1}$ day^{-1}) during *kharif* season and during *rabi* 1 January planted crop registered highest heat use efficiency. This was ascribed to the fact of higher biological yield and relatively lower GDD requirement as compared to other dates. Similar findings were also reported in 2015 by Bhat *et al.* Among the varieties Poornabhog recorded highest HUE (1.64 g ha^{-1} $^0C^{-1}$ day^{-1}) followed by PS-II (1.51 g ha^{-1} $^0C^{-1}$ day^{-1}) and Geetanjali (1.35 g ha^{-1} $^0C^{-1}$ day^{-1}) during crop season. Variation in rice genotypes with respect to HUE were also observed by Shamim *et al.* (2013).

Yield

Early transplanting during 16 July to 16 August recorded higher grain yield (3.7 to 4.1 t/ha) than late transplanting on 16 September (1.6 t/ha). The crop transplanted on 1 August received optimum environmental conditions required for better growth and development and delayed in transplanting could not provide sufficient time to complete the vegetative stages. So the crop could not accumulate sufficient dry matter and photosynthesizing area (source) that could have been very useful in partitioning assimilates towards the sink (Dongarwar *et al*., 2005). Significant yield reduction was noticed in 16 September to 16 November planting due to reduction in favourable growing period temperature which starts falling during end of September/beginning of October and reproductive phase coincide with low temperature, thus affected badly, leading to poor grain filling and low yield (Gill *et al*. 2016). The poor performance of 1 and 16 November planting can be better explained by the fact that prevailing low temperature during 10 days before panicle initiation and low temperature during heading, flowering grain filling stage resulted in less number of filled grains per panicle. Similar findings were also reported by Akram et al., (2007). Among the varieties Pusa Sugandh -II recorded the highest grain yield (3.5 t/ha) which was significantly superior to Poornabhog (3.1 t/ha) and Geetanjali (2.5 t/ha). Pusa Sugandh-II recorded almost 40% higher yield than Geetanjali mostly because of higher values of yield attributing characters and lowest sterility percentage (Table 6). The temperature and environmental factors was very suitable for Pusa Sugandh –II. The interaction effect of dates of planting and aromatic rice varieties on grain yield clearly indicated that the cultivar Pusa Sugandh –II out yielded the rest of the two varieties at all the dates of planting. Maximum grain yield of 4.7 t/ha was produced by PS –II when planted on 1 January which was at par with the yield obtained from same variety planted on 1 August and also from the variety Poornabhog planted on 1January. Yield is a function of genetic character might be favourable to the prevailing temperature and environmental conditions. So that the genetic parameters are better expressed and reflected in the form of yield.

Aromatic rice planted in 1 August produced maximum grain of 4.1 t/ha whereas, during *rabi* the 1 January planted crop produced the maximum yield (4.3 t/ha). Pusa Sugandh-II and Poornabhog are two suitable cultivars of aromatic rice which can be grown during both the season producing a grain yield of almost 4.3-4.7 t/ha. During kharif, planting can be delayed maximum up to 16 August without much sacrificing of yield and 1 January is the most suitable time during rabi.

Table.2 Accumulated GDD (degree days) requirement to attain different phenophases of aromatic rice cultivars under staggered planting

Dates of transplanting	16 July			1 August			16 August			1 September			16 September		
Varieties / Phenological stages	Geetanjali	Poornabhog	PS-II	Geetanjali	Poornabhog	PS-II	Geetanjali	Poornabhog	PS-II	Geetanjali	Poornabhog	PS-II	Geetanjali	Poornabhog	PS-II
Tillering	712.5	943.8	712.5	818.3	1112.6	818.3	700.5	987	700.5	734	1015.1	734	889.3	1072.5	889.3
Panicle Initiation	943.8	1183.3	943.8	1051.5	1332.9	1051.5	913.3	1195.9	913.3	962.1	1202.1	962.1	1026.8	1223.5	1026.8
Heading	1183.3	1418.6	1183.3	1280.4	1469.4	1280.4	1156.9	1412.3	1157	1187.8	1396.8	1187.8	1200.7	1367.5	1200.7
50% Flowering	1512	1735.7	1512	1576.5	1755	1576.5	1412	1643.3	1412	1384.5	1545	1384.5	1368	1501	1368
Physiological Maturity	2011	2244.9	2011	2022	2373.4	2022	1840	1995.6	1840	1748	1872.1	1748	1691	1826.1	1691

Dates of transplanting	1 November			16 November			1 December			16 December			1 January		
Varieties / Phenological stages	Geetanjali	Poornabhog	PS-II	Geetanjali	Poornabhog	PS-II	Geetanjali	Poornabhog	PS-II	Geetanjali	Poornabhog	PS-II	Geetanjali	Poornabhog	PS-II
Tillering	918.7	968.5	918.7	824.9	932.8	824.9	543.2	696.4	543.2	425.4	516.2	425.4	333.4	476.8	333.4
Panicle Initiation	1020.7	1075.3	1020.7	932.8	1136.3	932.8	672.2	815.9	672.2	555.8	687	555.8	516.7	619.6	516.7
Heading	1109.2	1225.7	1109.2	1136.3	1346	1136.3	853.2	1019.6	853.2	744	894.7	744	724.4	873.1	724.4
50% Flowering	1252.6	1411.8	1252.6	1326.6	1606.4	1326.6	1169	1258	1169	1008	1176	1008	1024.4	1158.7	1024.4
Physiological Maturity	1781.2	1977.7	1781.2	1971.6	2287.5	1971.6	1700.9	1872.3	1700.9	1594.6	1794.8	1594.6	1562.4	1740.2	1562.4

Table.3 Accumulated HTU (degree day hours) requirement to attain different phenophases of aromatic rice cultivars under staggered planting

Dates of transplanting	16 July			1 August			16 August			1 September			16 September		
Varieties / Phenological stages	Geetanjali	Poornabhog	PS-II	Geetanjali	Poornabhog	PS-II	Geetanjali	Poornabhog	PS-II	Geetanjali	Poornabhog	PS-II	Geetanjali	Poornabhog	PS-II
Tillering	3012.8	4067.2	3012.8	4313.6	5732.1	4313.6	3694.9	4609.3	3694.9	3229.6	5018.4	3230	4590.8	6260.9	4590.8
Panicle Initiation	4067.2	5576.5	4067.2	5326	6204.8	5326	4449.7	5827.1	4449.7	4663.1	6556.3	4663	5887.2	6883	5887.2
Heading	5576.5	6648.5	5576.5	6040	7088.9	6040	5489.8	7341.9	5489.8	6420.4	8090.6	6420	6688	7959.3	6688
50% Flowering	6796.9	7653	6796.9	7638.3	9164.7	7638.3	7342	9395	7342	8091	8907	8091	7959.4	8785	7959.4
Physiological Maturity	9689	11742.2	9689	11066	13384.4	11066	10355	11523	10355	10193	11128.5	10193	10152	11160	10152

Dates of transplanting	1 November			16 November			1 December			16 December			1 January		
Varieties / Phenological stages	Geetanjali	Poornabhog	PS-II	Geetanjali	Poorna bhog	PS-II	Geetanjali	Poornabhog	PS-II	Geetanjali	Poornabhog	PS-II	Geetanjali	Poornabhog	PS-II
Tillering	6402.4	6800.4	6402.4	5522.5	6498.2	5522.5	3776.7	5009.5	3776.7	3163.6	3916.1	3164	2473.7	3533	2473.7
Panicle Initiation	7212.4	7594.5	7212.4	6498.2	8054.2	6498.2	4777.1	5931.6	4777.1	4282.2	5203.8	4282	3882.6	4787.9	3882.6
Heading	7912	8856.1	7912	8054.2	9720.6	8054.2	6157.1	7651.1	6157.1	5709.8	7060.6	5710	5739.5	6888.4	5739.49
50%Flowering	8971.3	10375.4	8971.3	9716.6	11519	9716.6	8895.1	9527.5	8895.1	7940	9115.5	7940	7881.7	8665	7881.7
Physiological Maturity	13093	14445.7	13093	13946	16696	13946	12283	13581	12283	11730	13379.5	11730	11507	13158	11507

Table.4 Accumulated PTU (degree day hours) requirement to attain different phenophases of aromatic rice cultivars under staggered planting,

Dates of transplanting	**16 July**			**1 August**			**16 August**			**1 September**			**16 September**		
Varieties / Phenological stages	**Geetanjali**	**Poornabhog**	**PS-II**	**Geetanjali**	**Poornabhog**	**PS-II**	**Geetanjali**	**Poornabhog**	**PS-II**	**Geetanjali**	**Poornabhog**	**PS-II**	**Geetanjali**	**Poornabhog**	**PS-II**
Tillering	8917	11692	8917	9880	13411.8	9880	8406	11724.8	8406	8628	11720	8628	10038	12053	10038
Panicle Initiation	11692	14566	11692	12679	15875.3	12679	10906	14015	10906	11137	13777	11137	11550	13714	11550
Heading	14566	17390	14566	15298	17376.8	15298	13586	16395.4	13586	13620	15919	13620	13465	15213	13465
50% Flowering	18457	20917	18457	18554	20517.4	18554	16396	18968.4	16396	15783	17549	15783	15213	16544	15213
Physiological Maturity	23946.5	26519.3	23946.5	23454.4	25815.2	23454.4	21097.9	22986.7	21097.9	19612.3	20856.3	19612.3	18446.3	19900	18446.3
Dates of transplanting	**1 November**			**16 November**			**1 December**			**16 December**			**1 January**		
Varieties / Phenological stages	**Geetanjali**	**Poornabhog**	**PS-II**	**Geetanjali**	**Poornabhog**	**PS-II**	**Geetanjali**	**Poornabhog**	**PS-II**	**Geetanjali**	**Poornabhog**	**PS-II**	**Geetanjali**	**Poornabhog**	**PS-II**
Tillering	9664.2	10212	9664.2	8632.4	9819.3	8632.4	5533.7	7218.9	5533.7	4418.1	5416.9	4418.1	3576.4	5153.8	3576.4
Panicle Initiation	10786.2	11386.8	10786.2	9819.3	12057.8	9819.3	6952.7	8533.4	6952.7	5852.5	7295.7	5852.5	5592.7	6724.6	5592.7
Heading	11759.7	13041.2	11759.7	12057.8	14364.5	12057.8	8943.7	10774.1	8943.7	7922.7	9580.4	7922.7	7877.4	9513.1	7877.4
50% Flowering	13337.1	15088.3	13337.1	14151.1	17301.4	14151.1	11382.4	13018.1	11382.4	12246.8	12246.8	12246.8	10334.8	12322.8	10334.8
Physiological Maturity	19170.5	21529.1	19170.5	21684.4	25475.2	21684.4	18632.8	20689.6	18632.8	17717.6	20120	17717.6	17184.6	19805.4	17184.6

Table.5 Heat use efficiency of aromatic rice cultivars at various growth intervals under staggered planting (g ha^{-1} $^{o}C^{-1}$ day^{-1})

Treatment	15	30	45	60	75	90	105	Harvest
Dates of transplanting								
16 July	0.12	0.54	1.17	1.41	1.44	1.58	1.41	1.33
1 August	0.12	0.53	1.16	1.42	1.45	1.62	1.46	1.40
16 August	0.13	0.55	1.13	1.42	1.48	1.62	1.49	1.45
1 September	0.11	0.45	1.03	1.33	1.40	1.67	1.55	1.52
16 September	0.10	0.43	0.94	1.26	1.33	1.43	1.33	1.29
1 November	0.08	0.46	0.96	1.12	1.19	1.23	1.09	0.85
16 November	0.08	0.45	1.11	1.31	1.37	1.43	1.22	0.85
1 December	0.08	0.48	1.38	1.54	1.50	1.46	1.21	0.95
16 December	0.06	0.50	1.48	1.57	1.45	1.40	1.17	1.09
1 January	0.06	1.00	1.75	1.72	1.60	1.53	1.10	1.30
CD (P=0.05)	0.021	0.018	0.066	0.033	0.024	0.019	0.017	0.038
Varieties								
Geetanjali	0.08	0.44	1.06	1.23	1.24	1.35	1.20	1.13
Poornabhog	0.11	0.62	1.37	1.61	1.59	1.64	1.44	1.24
Pusa Sugandh –II	0.09	0.55	1.22	1.40	1.43	1.51	1.33	1.23
CD (P=0.05)	0.011	0.009	0.034	0.017	0.012	0.010	0.009	00.019

Table.6 Yield and yield attributes of different aromatic rice cultivars under staggered planting

Treatment	Grain yield(t/ha)	Straw yield(t/ha)	HI(%)	Sterility (%)	Panicle length(cm)	Total grains/ panicle	EBT/m^2	Test wt(g)
Dates of transplanting								
16 July	3.7	5.2	40.7	20.0	26.9	110.3	360.7	21.8
1 August	4.1	6.0	40.3	18.5	26.9	124.8	349.7	21.8
16 August	3.8	5.7	39.7	20.9	25.1	108.0	345.3	21.8
1 September	3.7	5.4	40.5	29.5	24.8	111.7	306.7	21.8
16 September	1.6	3.5	30.2	54.4	22.7	97.3	307.3	19.3
1 November	0.8	3.6	18.9	64.0	19.5	82.5	287.3	15.2
16 November	1.7	4.0	29.2	52.6	21.3	82.3	267.0	16.8
1 December	3.0	4.4	40.3	21.2	23.4	84.5	271.2	22.5
16 December	3.4	5.2	39.7	15.7	24.3	96.0	299.8	24.3
1 January	4.3	6.3	40.6	13.7	24.8	100.7	333.2	24.2
CD (P=0.05)	0.19	0.18	1.65	2.39	0.33	6.85	20.76	0.98
Varieties								
Geetanjali	2.5	4.5	34.2	31.7	22.9	86.8	295.5	21.1
Purnabhog	3.1	5.1	35.2	34.1	24.6	110.1	311.9	19.5
Pusa Sugandh –II	3.5	5.2	38.6	27.3	24.3	102.6	331.1	22.4
CD (P=0.05)	0.10	0.09	0.83	1.21	0.17	3.46	10.48	0.49

Table.7 Interaction effect of dates of planting and rice cultivars on grain yield

Dates of transplanting	Geetanjali	Poornabhog	Pusa Sugandh -II	Mean
16 July	2.6	4.1	4.2	3.7
1 August	3.3	4.4	4.6	4.1
16 August	2.7	4.3	4.4	3.8
1 September	2.8	4.1	4.3	3.7
16 September	1.8	0.8	2.2	1.6
1 November	0.8	0.6	1.1	0.8
16 November	1.3	1.7	2.0	1.7
1 December	2.6	3.2	3.3	3.0
16 December	3.2	3.5	3.7	3.4
1 January	3.6	4.6	4.7	4.3
Mean	2.5	3.1	3.5	3.0
	D	V	DXV	VXD
CD(p=0.05)	0.19	0.10	0.23	0.16

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