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Influence of Micro Climatic Indices on Growth and Yield of Direct Seeded Upland Rice (*Oryza sativa* L.) Varieties in Assam

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ABSTRACT

Background: Rice (*Oryza sativa* L.) is the major cereal crop grown in India. Rice plays a pivotal role in the socio-cultural life of the people of Assam. The main objective of this study to investigate the influence micro climatic indices in relation to crop growth and yield of upland rice varieties with different dates of sowing in Assam.

Methods: A field experiment was carried out at Instructional cum Research Farm, Assam Agricultural University, Jorhat during autumn season of 2017. The experiment consisted of four micro-climatic regimes (M) along with four different rice varieties (V).

Result: The results of the experiment revealed that micro climatic indices *viz*., canopy temperature, growing degree days, soil moisture content, soil temperature, light intensity, depth of ground water table associated with 1st April sown crop recorded positive effect on growth and yield parameters in terms of plant height, leaf area index, number of filled grains per panicle, test weight, harvest index and grain yield (3004 kg/ha), followed by the micro-climate associated with 16th March sown crop. Among the varieties evaluated, CR-Dhan 203 recorded the highest grain yield of 2860 kg/ha and was significantly superior to that of other varieties except Inglongkiri.

Key words: Canopy temperature, Growing degree days, Leaf area index, Light intensity, Seeding date, Soil temperature.

INTRODUCTION

Rice is one of the chief grains of India. Rice consumes much more water than other cereals and nearly 3000-5000 liters of water is required to produce one kilogram of rice (Bouman, 2009). Among many food grains produced in India, rice has the pride of being cultivated over an area of 44.40 million hectare with a production of 109.32 million tones and average productivity is 2.27 t/ha (Agricultural Statistics, 2016). Assam is traditionally a rice growing state. Rice plays a pivotal role in the socio-cultural life of the people of the state. In Assam, rice is cultivated in 2.48 million hectare with a production of 5.12 million tones and productivity of 2.08 t/ha varying with districts and agro-climatic zones (Statistical Handbook of Assam, 2016). The state has its climatic and physiographic features favorable for rice cultivation and the crop is grown in a wide range of agro-ecological situations. Rice is cultivated in three distinct seasons in Assam *viz., ahu* or (autumn rice) (grown during February/March-June/July), *Sali* or (winter rice) (grown during June/July-November/December) and *boro* or (summer rice) (grown during November/December-May/June). *Ahu* or autumn rice is grown mostly aerobically in upland areas and it covers around 1.9 lakh hectares, production is 2.5 lakh tones with average productivity of 1.32 t/ha (Agricultural Statistics, 2016). This system of rice cultivation saves water by eliminating wetland preparation necessary to avoid seepage and percolation and by reducing evaporation. This crop has certain advantages; for example, the utilization of solar energy is more efficient as most of the time in this season, the sky remains clear and this crop normally escapes the risk of flood damage which is very important in flood prone areas. Aerobic rice is a production system in which potentially high yielding, fertilizer responsive rice varieties are grown in fertile aerobic soils that are non-puddled and have no standing water. Supplementary irrigation, however, can be given in the same way as to any other upland cereal crop (Wang *et al.,* 2002). Since rice is the major consumer of fresh water, it also leads to destruction of soil aggregates, nutrient losses through leaching. To make paddy cultivation cost effective and eco-friendly, direct seeded rice provides an option which save not only labor required for seedling raising in the nursery, uprooting and transplanting of seedlings but also helps to preserve natural resources especially underground water.However, to make this technology viable, proper micro-climate through appropriate sowing time of suitable varieties needs to be identified for various agro ecological conditions. Considering the above facts, the experiment was carried out to find out optimum micro-climate regimes for different promising varieties of rice for realizing higher yields under aerobic condition.

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MATERIALS AND METHODS

A field experiment was conducted at the Instructional cum Research (ICR) Farm of Assam Agricultural University,

Jorhat, Assam during autumn season of 2017 on performance of different rice varieties grown at different dates of sowing in relation with crop growth, yield and micro climatic indices. The experiment was laid out in split plot design tested with three replications having plot size of 4×3 m^2. The experiment was comprised of sixteen treatment combinations, *viz*., four micro-climatic regimes (M) (M_1: 15th February, M_2: 1st March, M_3: 16th March and M_4: 1st April) assigned in main plots and four varieties (V) (V_1: CR-Dhan 205, V_2: CR-Dhan 203, V_3: CR-Dhan 204 and V_4: Inglongkiri) were in sub-plots. All the production practices were followed as per Assam Agricultural University, Jorhat recommendation for the state.The soil of the experimental field was sandy loam in texture, acidic in reaction (pH:5.2), medium in organic carbon content (0.62%), medium in available nitrogen (311.5 kg/ha), low in phosphorus (15.85 kg/ha) and medium in available potassium (194.0 kg/ha). The climatic condition of Jorhat is humid sub-tropical with hot summer and cool winter. The weather parameters *viz*., mean maximum and minimum temperature, mean relative humidity, mean daily sun shine hours, evaporation and weekly total rainfall were recorded at Agro-meteorological observatory of Assam Agricultural University, Jorhat and presented in Fig 1. The micro climatic indices like canopy temperature, growing degree days, light intensity, soil moisture content, soil temperature, depth of water table and crop growth and yield attributes like plant height, leaf area index, number of filled grains per panicle, test weight, harvest index and grain yield were recorded and statistically analyzed at 5% level of significance. The cost of cultivation, net returns and B:C ratios were worked out based on the prevailing local market price.

RESULTS AND DISCUSSION

Influence of sowing dates on micro climatic indices

Plants respond to the climate where they are growing. Micro climate refers to the climatic conditions of a small, specific place, where conditions may differ from those of the larger surrounding space. Three main parameters to define a microclimate within a crop environment are temperature, humidity and sunshine hours (Jagadish *et al.* 2017).

Different sowing dates significantly influenced the canopy temperature at all the growth stages of the crop (Fig 2). The highest values were recorded on 1st April sown crop. During the entire crop growth period 1st April received less stress condition as compared to the other sowing dates and this might be due to difference between ambient temperature and canopy temperature were in the range of 3 to 5.75°C and among which the 1st April sown recorded the lowest range (3 to 5.4°C). The trend in the deviation of canopy temperature from ambient temperature indicated better. Therefore, 1st April sown crop resulted higher in growth and yield attributing characters, this might be due to activation of some enzyme under favourable canopy temperature such as sucrose phosphate synthase, which helps in grain filling process and ultimately helps in increasing the yields.

Growing degree days were more in 1st April sown crop (Fig 3), which means 1st April sown absorbed more heat units than other sowing dates. This might be due to 1st April sown crop received more number of degree days to complete its growing period. Due to delay in sowing from 15th February to 1st April, the heat units increased gradually throughout the growing period.

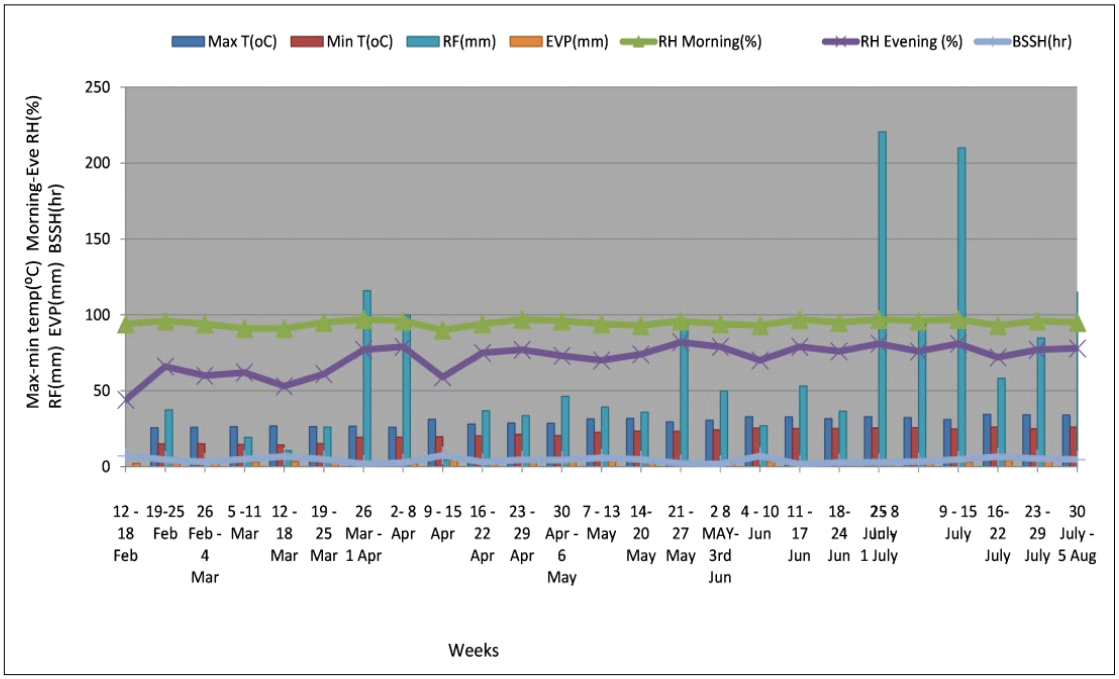

Fig 1: Graphical representation of the weekly meteorological data observed during the crop growth period.

The morphological, physiological and yield parameters of rice have showed variation due to differed light intensity among the different date of sowing where 1st April sown crop recorded high light intensity and thus lead to higher photosynthesis which helped in increasing the crop growth and yield (Fig 4). Murty *et al.* (1976) amply demonstrated that the movement of photosynthates to aerial part was enhanced under lower light intensity but the available photo assimilates was low due to impaired photosynthesis under reduced light intensity. The high light resulted in grain filling by increasing the number of spikelets.

Soil moisture and temperature are the important climatic parameter for better growth of a crop. These two parameters are interrelated. At a very low soil temperature, moisture intake by crop stops. Soil moisture and temperature influence the germination of seeds. Excessively high amount is harmful to roots and extreme low amounts decrease nutrients uptake and also extreme low values influences the soil microbial population and rate of organic matter decomposition (Yoshida *et al.,* 2007). A very high soil temperature of more than 35°C during tillering to panicle initiation would affect the grain filling process in addition to the grain setting process. A high soil temperature before the heading stage would significantly affect the grain filling (Sato *et al.,* 1973; Kobata *et al.,* 2004). In rice, photo synthesis decreases when temperarture is more than 35°C at the later ripening stage, while grain filling is insensitive to high root temperature. The adverse effect of extreme soil temperature during ripening on grain filling would be more prominent if the sink demand were large, as in the case of

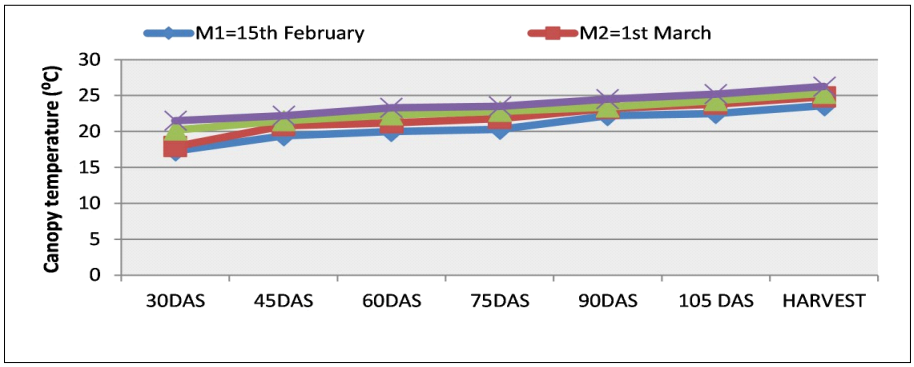

Fig 2: Canopy temperature influenced by different dates of sowing.

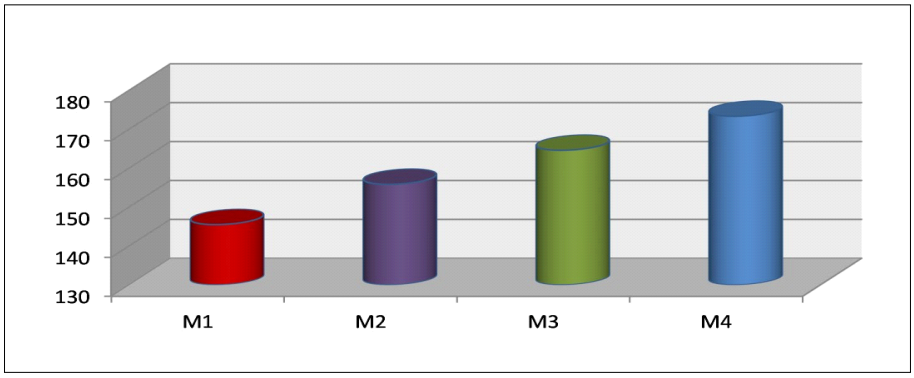

Fig 3: Effect of date os sowing on GDD of aerobic rice.

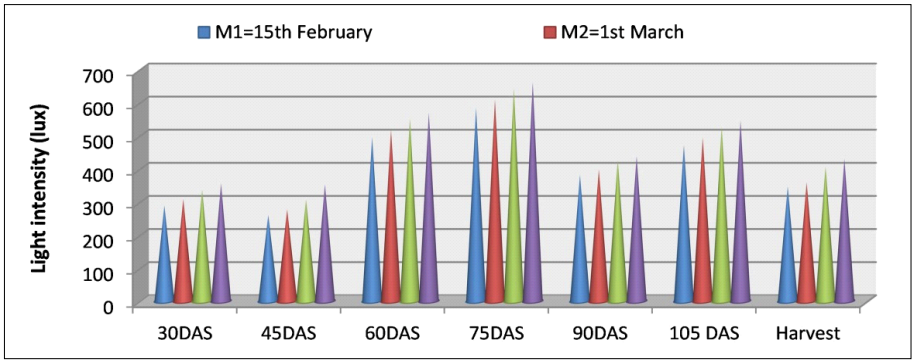

Fig 4: Light intensity influenced by different dates of sowing.

high spikelet numbers (Sanoh *et al.*,2010). Results of this study revealed that 1st April sown crop recorded higher productivity due to the favourable soil temperature (21-30°C) during the growth period up to harvest of the crop (Fig 5, 6).

Influence of sowing dates and varieties on growth parameters

The growth parameters recorded periodically have showed variations due to different micro-climatic regimes and varieties. Plant height at all the growth stages was not influenced by different dates of sowing, however, 1st April sown crop recorded higher values. High rainfall during the growth period on April 1st sown crop during its vegetative growth might have increased the height. Among the varieties tested, highest plant height at all the growth stages was recorded in Inglongkiri which might be due to the genetic character of the variety (Table 1) as plant height depends on genetic makeup of a plant and environmental conditions. A similar findings was reported by Asif *et al.* (2014), Ramachandra *et al.* (2015) and Kannan *et al.* (2015). Leaf Area Index was recorded highest in 1st April sown crop and sowing date significantly affected this physiological parameter. Tiwari (2015), found that time of sowing in paddy crop is utmost importance due to variation in duration and climatic condition of the area. The leaf area index was also found to be significantly affected by different rice varieties. Highest LAI was observed in case of rice variety CR-Dhan 203. The variation in LAI among rice varieties might be due to the variation in genetical characteristics among the varieties (Table 1).

Influence of sowing date and varieties on yield attributes and yield

The yield attributes are the most important parameters of any crop which directly influence the crop yield. These yield attributes and yields are likely deviate up to considerable extent as a result of variability in the crop management practices for increased crop production.

The number of filled grains/panicle showed a better response with delay in sowing because in early sowing the plants might have suffered from unfavourable temperature which ultimately resulted in shedding of pollen; therefore, reduced the number of filled grains/panicle and ultimately the grain yield (Table 1). This might be attributed to better plant growth leading to significantly more number of filled grains/panicle and better partitioning of photosynthesis compared to other sowing dates. Moreover, due to favourable climatic condition such as optimum temperature (23 to 30°C), average weekly rainfall (76.8 mm) might have resulted in higher uptake of nutrients as well as post photosynthetic contribution in respect to other sowing dates. Similar, findings were reported by Khalifa 2009, Dawadi and Chaudhary (2013), Sidhu *et al.* (2014) and Sivapalan (2014). Different rice varieties significantly affected the yield attributing characters of rice. Rice variety CR-Dhan 203 produced significantly higher number of grains/panicle which

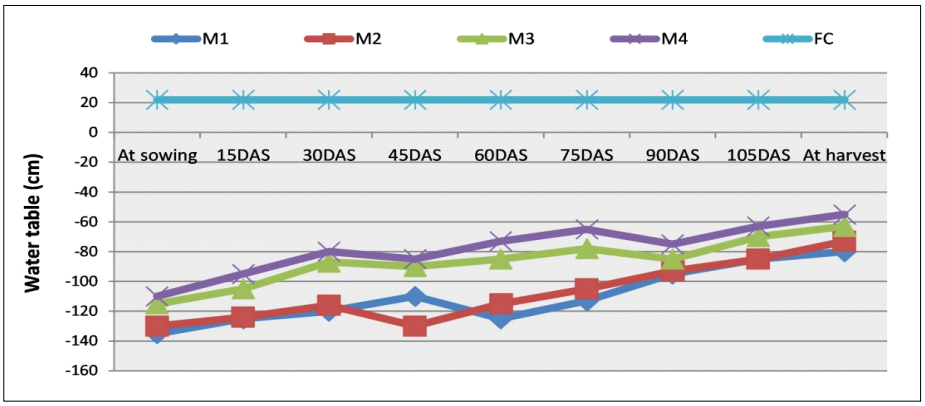

Fig 5: Water table status through out the experimentation.

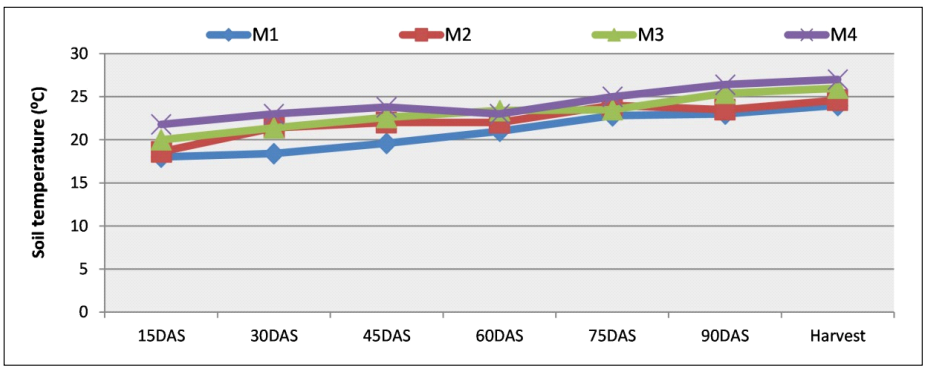

Fig 6: Soil temperature at 0-15 cm depth through out the experimentation.

Table 1: Influence of date of sowing and varieties on plant height, leaf area index, number of filled grain/panicle, test weight, harvest index and grain yield and economics of direct seeded upland rice.

Treatment	Plant height (cm)				Leaf area index				No. of filled grains per panicle	Test Wt (g)	Harvest index (%)	Grain yield (kg/ha)	Cost of cultivation (₹/ha)	Gross return (/ha)	Net return (/ha)	B:C ratio
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest								
Micro-climatic regime (M)																
M_1=15th February sown crop	26.3	76.0	99.6	107.0	1.4	3.3	4.4	4.0	76.9	18.5	37.3	2138	23635	40954	30139	1.27
M_2=1st March sown crop	28.1	78.8	101.3	109.1	1.6	3.6	4.7	4.4	81.7	19.3	35.8	2400	23235	46828	38723	1.66
M_3=16th March sown crop	28.9	79.7	104.3	111.7	1.7	3.9	4.9	4.6	89.4	19.7	36.9	2648	22435	51107	44457	1.97
M_4=1st April sown crop	30.7	81.3	106.9	114.2	1.8	4.0	5.5	4.8	95.3	21.0	38.2	3004	22435	57331	51755	2.30
SEm±	1.4	3.1	3.9	4.2	0.1	0.1	0.2	0.1	3.3	0.69	1.48	111	-	-	-	-
CD (P=0.05)	NS	NS	NS	NS	0.2	0.5	0.7	0.5	11.5	NS	NS	386	-	-	-	-
Variety (V)																
V_1= CR-Dhan 205	31.8	83.9	110.2	116.4	1.5	3.5	4.4	4.0	79.2	18.5	34.9	2236	22935	58818	35883	1.56
V_2= CR-Dhan 203	19.9	63.2	84.2	90.1	1.9	4.3	6.0	5.7	92.6	20.9	39.0	2860	22935	69800	46865	2.05
V_3= CR-Dhan 204	29.7	81.4	104.3	114.2	1.3	3.3	3.8	3.6	82.9	19.4	38.0	2439	22935	60596	37661	1.64
V_4= Inglongkiri	32.5	87.2	113.4	121.3	1.6	3.6	5.4	5.0	88.8	19.6	36.3	2654	22935	67602	44667	1.95
SEm±	1.1	2.5	2.7	3.2	0.1	0.1	0.2	0.1	2.8	0.58	1.32	93	-	-	-	-
CD (P=0.05)	3.3	7.3	7.9	9.3	0.1	0.3	0.5	0.4	8.0	1.68	NS	273	-	-	-	-
	NS	NS	NS	NS					NS	NS	NS					

DAS: Days after sowing, NS= Non significant.

was followed by variety Inglongkiri and this is probably due to more effective tillers/m^2 and higher length of panicle exhibited by CR-Dhan 203 over rest of the varieties and also might be due to variation in genetical character of the variety. The significant differences in yield attributes among the rice varieties have also been reported by Brar and Bhullar (2013), Dawadi and Chaudhary (2013), Ramachandra *et al*. (2015), Kumar *et al*. (2015) and Tiwari (2015). The crop sown on 1st April produced higher values in all the attributes and yield followed by 16th March sown crop. This might be due to high light intensity amount in the micro-climatic regime. The variety CR-Dhan 203 resulted in highest grain yield. This might be due to the higher value of yield attributing characters and genetic yield potential of the rice variety in aerobic condition (Table 1).

Influence of dates of sowing and varieties on economic indices

Relatively late sowing positively influenced the yield and thereby net income in the experiment. Among the micro-climatic regimes, the 1st April sown crop of aerobic rice gave the highest net income (Rs. 51755.36 /ha) and a B- C ratio (2.3) andthis might be due to higher yield. CR-Dhan 203 proved its superiority by giving highest net income (Rs. 46865.01/ha) and a B:C ratio (2.04) followed by Inglongkiri. This is attributed to net income in relation to the crop productivity and the gross income received. The increase in net income and benefit-cost ratio might be due to positive effect of the treatments on growth and yield attributes results in higher grain and straw yield (Table 1).

CONCLUSION

All the micro climatic indices associated with 1st April sown crop positively influenced the crop growth and yield followed by mid March sown crop. Treatment combination of crop sown on 1st April with variety CR-Dhan 203 recorded the highest net return and B:C ratio.

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Conflict of interest

All authors declare that they have no conflict of interest.

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