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Studies on Potential of Different Dates of Sowing and Varieties on Productivity of Aerobic Rice in Assam

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Authors' contributions

This work was carried out in collaboration between both authors. Author BB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript managed the analyses of the study. Author KP managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

An investigation was carried out to determine an optimum micro-climate regimes for different promising varieties of rice for realizing higher yields under aerobic conditions. A field experiment was conducted in the Instructional Cum Research (ICR) Farm of Assam Agricultural University, Jorhat, Assam during autumn season of 2017. The experiment was laid out in a split-plot design with three replications. The treatments consisted of four micro-climatic regimes (M) in main plot *viz*., sowing of seed on 15th February (M_1), 1st March (M_2), 16th March (M_3) and 1st April (M_4) along with four different rice varieties (V) *viz*., CR-Dhan 205 (V_1), CR-Dhan 203 (V_2), CR-Dhan 204 (V_3) and Inglongkiri (V_4) in sub plot. The results of the experiment revealed that among the different micro-climatic regimes, the micro-climate associated with 1st April recorded positive effect on micro-climate related and yield parameters in terms of canopy temperature, light intensity, soil moister content, soil temperature, dry matter accumulation, leaf area index, number of effective tillers 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 value in terms of number of

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effective tillers (187/m^2) followed by Inglongkiri, CR-Dhan 204 and CR-Dhan 205. The highest grain yield of 2860 kg/ha recorded in rice variety CR-Dhan 203 was significantly superior to that of other varieties except Inglongkiri. In terms of economics, the crop sown on 1st April recorded the highest net return (INR 51755 /ha) and B:C ratio (2.30) which was found to be the greatest.

Keywords: Upland rice; effective tillers; canopy temperature; light intensity; soil moisture; soil temperature.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the most important cereal crop of the country covering a cultivated area of 44.40 million hectare with a production of 109.32 million tones and average productivity of 2.27 t/ha [1]. In Assam, rice is cultivated in an area of about 2.48 million hectare. The total production and average productivity of rice in the state is 5.12 million tones and 2.08 t/ha, respectively [2]. The crop has enormous diversity in the region due to highly variable rice growing ecosystems. It is mostly grown under submerged condition resulting in low water use efficiency and emission of green house gases. With the global water crisis, it has become imperative to develop technologies that produce rice using lower quantities of water (Bouman 2001). Currently, sustainability of water resources is of major concern and declining water availability threatens the sustainability of traditional flood-irrigated rice ecosystems [3]. Aerobic rice is a production system wherein specially developed aerobic rice varieties are grown in well-drained, non-puddled and non-saturated soils [4]. Supplementary irrigation, however, can be given in the same way as to any other upland cereal crop [5]. In India rice is direct seeded around 28% of total cropped area [6]. In Assam Ahu or autumn rice is grown mostly aerobically in upland areas during February/March to June/July and it covers around 1,91,322 hectares, production is 2,56,729 tones with average productivity of 1.36 t/ha [1]. This system of rice cultivation saves water by eliminating wetland preparation necessary to avoid seepage and percolation and by reducing evaporation. 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 for future use. Considering the above facts, the present investigation was carried out to determine optimum micro-climate regimes for different promising varieties of rice for realizing higher yields under aerobic condition.

2. 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 under aerobic conditions. 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. The experiment was laid out in split plot design tested with three replications having plot size of 4×3. 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 (v311.5 kg/ha), low in phosphorus (15.85%) and medium in available potassium (194.0 kg/ha). Available nitrogen was estimated by Modified Kjeldahl method and expressed in kg/ha. Available phosphorus was estimated by Bray I method and Potassium was estimated by Flame photometric method and organic carbon (%) was estimated by wet digestion method. The pH of the soil solution was estimated by 1.25 (soil: water) suspension glass electrode pH meter method as described by Jackson (1973). The pH meter was calibrated with buffer solution of pH 4.0 and 9.2 and then the pH was determined by dipping the glass electrode in soil solution. Farm Yard Manure (FYM) (0.5 per cent N, 0.2 per cent P_2O_5 and 0.5 per cent K_2O.) were applied to each plot twenty five days prior to sowing of the seed at the rate of 2 t/ha. The FYM were mixed thoroughly with soil after application. Medium duration rice variety seeds were placed in a well prepared leveled seedbed with a spacing of 20 cm × 10 cm, thinning and gap filling operations were done at 15 days after sowing and maintained optimum plant population. The recommended fertilizer dose of 40 kg N, 20 kg P_2O_5 and 20 kg K_2O/ha was applied in the form of urea, single super phosphate and muriate of potash. Half of nitrogenous and potassic fertilizer were applied at 25 days after germination *i.e.* after first weeding as top dressing and remaining of half dose of nitrogenous and potassic fertilizers were applied at 50 days after germination *i.e.* after second weeding. Full dose of phosphatic fertilizer was applied as basal. Pretilachlor, a pre emergence herbicide was applied as weed control measure at the rate of 0.75 kg/ha and was sprayed at 3 days after sowing and first weeding was done at 25 days after sowing with a light hoeing and thinning was done by maintaining a plant to plant spacing of 8-10 cm. Irrigation was applied immediately after sowing to hasten the germination and crop establishment. Subsequent irrigations were given as and when needed so as to maintain the field at near saturation without stagnation. The observations on growth and yield parameter like canopy temperature, light intensity, soil moisture content, soil temperature, number of effective tillers 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.

3. RESULTS AND DISCUSSION

3.1 Effect of Micro-climatic Regimes on Canopy Temperature, Light Intensity, Soil Moisture, Soil Temperature

Different micro-climatic regimes significantly influence the canopy temperature at all the growth stages of the crop (Fig. 2). The highest values were obtained from 1st April sown crop followed by 16th March and 1st March sown crop. This might be due to highest minimum and maximum air temperature and highest bright sunshine hours during the crop growth period. Throughout the crop growing season it was observed that the 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), which implies that the crop sown on 1st April received less stress condition during its growth period as compared to the other sowing dates. The trend in the deviation of canopy temperature from ambient temperature indicated better. Therefore, 1st April sown crop resulted higher in growth parameters, yield attributing characters and yield, 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.

Light intensity of aerobic rice differed significantly among the micro-climatic regimes (Fig. 3). The morphological, physiological and yield attributing and yield parameters have showed variation due to differed light intensity. Number of effective tillers/m^2, leaf area index and dry matter accumulation increased due to high light intensity. These might be due to higher photosynthesis under high light intensity. Murty et al. [7] amply demonstration that the movement of photosynthates to aerial part is enhanced under lower light intensity but the available photo assimilates is low due to impaired photosynthesis under reduced light intensity. The high light resulted in grain filling by increasing the number of spikelets. Similar findings were reported by Nag [8], who reported that morphological, physiological, yield attributing characters significantly increased under high light condition.

Soil moisture content and soil temperature also differed with regard to different micro-climatic regimes. 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. Excessive 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 [9]. A very high soil temperature of more than 35°C in 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. Grain filling is supported by photosynthesis after heading and also by accumulated non-structural carbohydrate in the leaf sheath and culm before heading. Reduced grain size and deteriorated grain quality occur when the carbohydrate supply to the grain is insufficient [10,11]. After heading, soil temperature hardly affected grain filling in rice [12,13]. In rice, photosynthesis decreases in more than 35°C at the later ripening stage, grain filling was 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 high spikelet numbers [14]. 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 (Figs. 4, 5).

3.2 Effect of Micro-climatic Regimes and Varieties on Dry Matter Accumulation Gram per Square Meter

Dry matter accumulation was significantly affected by different micro-climatic regimes at 60 DAS, 90 DAS and at harvest. The highest dry matter accumulation was recorded at micro-climatic regime of 1st April sown crop which was at par with 16th March sowing. The higher dry matter accumulation was due to higher growth and uptake of nutrients resulted from higher dry matter partitioning forwarded by prevailing weather parameters (Table 1). Similar, findings were also reported by Matloob et al. [15], Dari et al. [16] and Singh and Singh [17]. So far the varieties are concerned, the highest dry matter accumulation was recorded in CR-Dhan 203 which was significantly higher than all other varieties and statistically at par with Inglongkiri and CR-Dhan 204. CR-Dhan 203 recorded the highest value which might be due to more vigorous growth and higher tillering nature of the rice variety. Sritharan et al. [18] also reported that total dry matter production varied significantly due to variety.

3.3 Effect of Micro-climatic Regimes and Varieties on Leaf Area Index

Leaf area index increased at a steady rate in all the treatments at all growth stages *i.e.* 30 DAS to harvest of the crop. Leaf area index (LAI) increased progressively up to 90 DAS and decreased thereafter in all sowing dates. Highest LAI was recorded in 1st April sown crop which was statistically at par with 16th March, 1st March sown crop at 30, 60 DAS and at harvest. The decrease in LAI at harvest was mainly due to senescence. Bharat, [19], Tiwari [20] and Pal et al. [21] also found that sowing date significantly affected this physiological parameter. The leaf area index was also found to be significantly

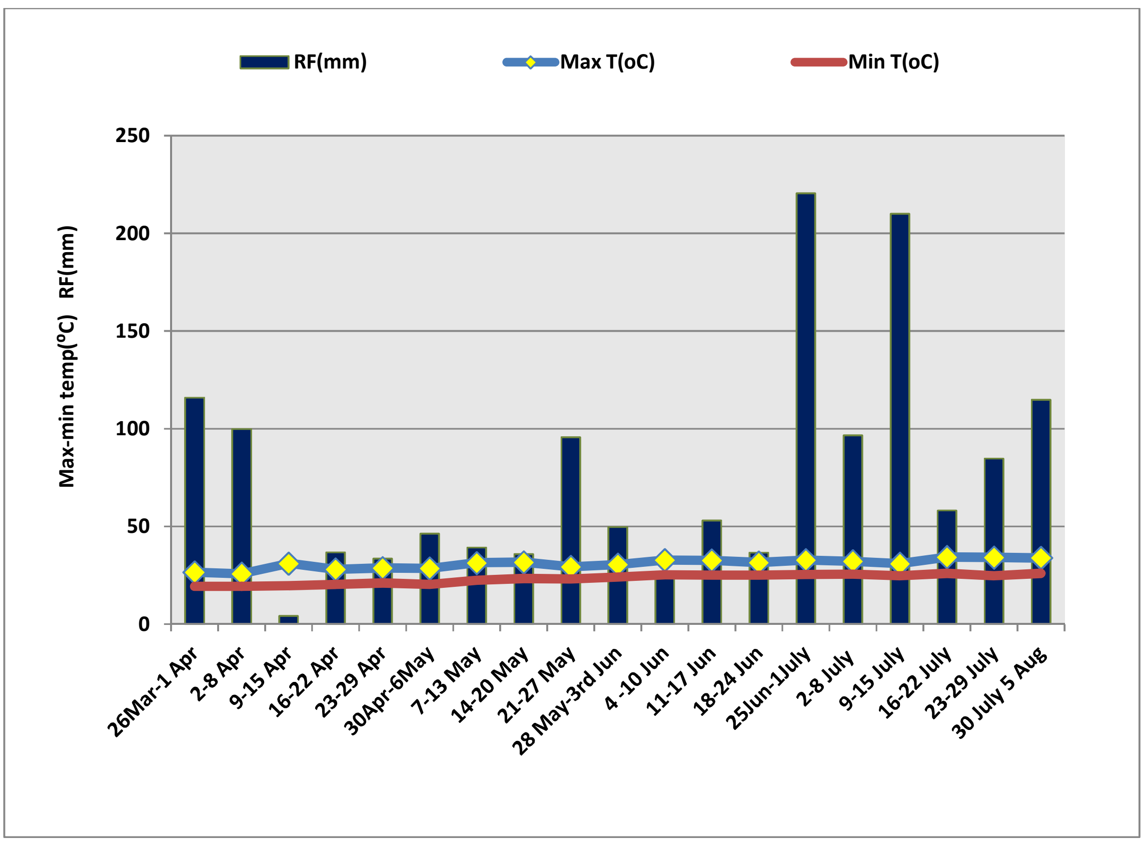

Fig. 1. Graphical representation of the weekly meteorological data observed during the crop growth period

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. Sritharan et al. [18] reported that highest LAI was observed at flowering stage for all cultivars. Asif et al. [22] reported that Leaf area index (LAI) showed periodic increase in rice cultivars and the maximum leaf area was recorded at 90 DAS which declined thereafter (Table 1).

3.4 Effect of Micro-climatic Regimes and Varieties on Effective Tillers per Square Meter

The higher number of effective tillers/m^2 was recorded on 1st April sown crop which was at par with 16th March and 1st March sown crop, which might be due to favorable climatic condition during the crop growth period that resulted in higher yield attributes than the earlier date of sowing. The number of effective tillers/m^2 showed a better response with delay in sowing because in early sowing the plants might have suffered from unfavorable temperature which ultimately resulted in shedding of pollen; therefore, reduced the number of effective tillers/m^2 (Fig. 1). Among the varieties the highest numbers of effective tillers/m^2 was recorded in CR-Dhan 203 which was at par with Inglongkiri. The difference in tiller production among cultivars may be attributed to varietal characters [23][Table 1].

3.5 Effect of Micro-climatic Regimes and Varieties on Grain Yield

In case of grain yield, out of different micro-climatic regimes, 1st April sown crop recorded the highest in grain yield which was 25.42% more than average grain yield of other micro-climatic regimes which, however, was at par with 16th March sown crop and this might be due to favorable 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. The lowest grain yield was recorded on 15th February sown crop. Among the varieties, the highest grain yield was recorded in rice variety CR-Dhan 203 which, however, was statistically at par with Inglongkiri and significantly higher than CR-Dhan 204, CR-Dhan 205. This might be due to the higher value of yield attributing characters and genetic yield potential of the rice variety in aerobic condition.

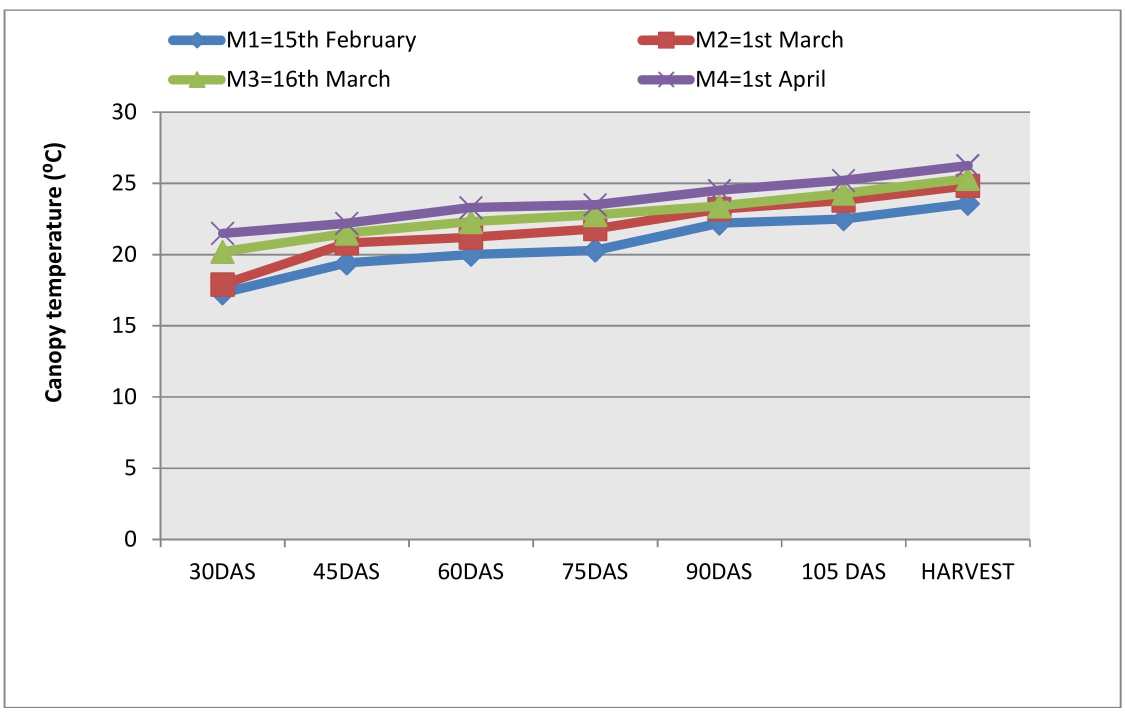

Fig. 2. Canopy temperature influenced by different micro-climatic reimes

Table 1. Effect of micro-climatic regimes and varieties on dry matter, leaf area index, effective tillers, grain yield and economics of aerobic rice

Treatment	Dry matter (g/m^2)				Leaf area index				Effective tiller ($No./m^2$)	Grain yield (Kg/ha)	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest						
Micro-climatic regime (M)														
M_1=15th February sown crop	61.9	266.4	516.8	631.8	1.4	3.3	4.4	4.0	157.4	2138	23635	40954	30139	1.27
M_2=1st March sown crop	66.5	276.6	612.9	727.1	1.6	3.6	4.7	4.4	171.1	2400	23235	46828	38723	1.66
M_3=16th March sown crop	69.3	309.5	663.0	769.4	1.7	3.9	4.9	4.6	180.0	2648	22435	51107	44457	1.97
M_4=1st April sown crop	72.5	320.0	708.9	832.8	1.8	4.0	5.5	4.8	188.3	3004	22435	57331	51755	2.30
SEm ±	2.5	11.2	25.6	30.2	0.1	0.1	0.2	0.1	5.8	111	_	_	_	_
CD (P=0.05)	NS	38.7	88.5	104.6	0.2	0.5	0.7	0.5	20.1	386	_	_	_	_
Variety (V)														
V_1= CR-Dhan 205	63.1	271.6	564.8	676.3	1.5	3.5	4.4	4.0	164.1	2236	22935	58818	35883	1.56
V_2=CR-Dhan 203	71.7	326.5	691.4	817.1	1.9	4.3	6.0	5.7	187.0	2860	22935	69800	46865	2.05
V_3=CR-Dhan 204	66.6	279.7	597.5	708.8	1.3	3.3	3.8	3.6	168.2	2439	22935	60596	37661	1.64
V_4= Inglongkiri	68.8	294.6	650.9	758.8	1.6	3.6	5.4	5.0	177.4	2654	22935	67602	44667	1.95
SEm ±	2.0	8.9	23.3	22.4	0.1	0.1	0.2	0.1	5.2	93	_	_	_	_
CD (P=0.05)	5.9	25.9	68.1	65.3	0.1	0.3	0.5	0.4	15.1	273	_	_	_	_

DAS: Days after sowing, NS= Non significant, ₹= Indian Rupee

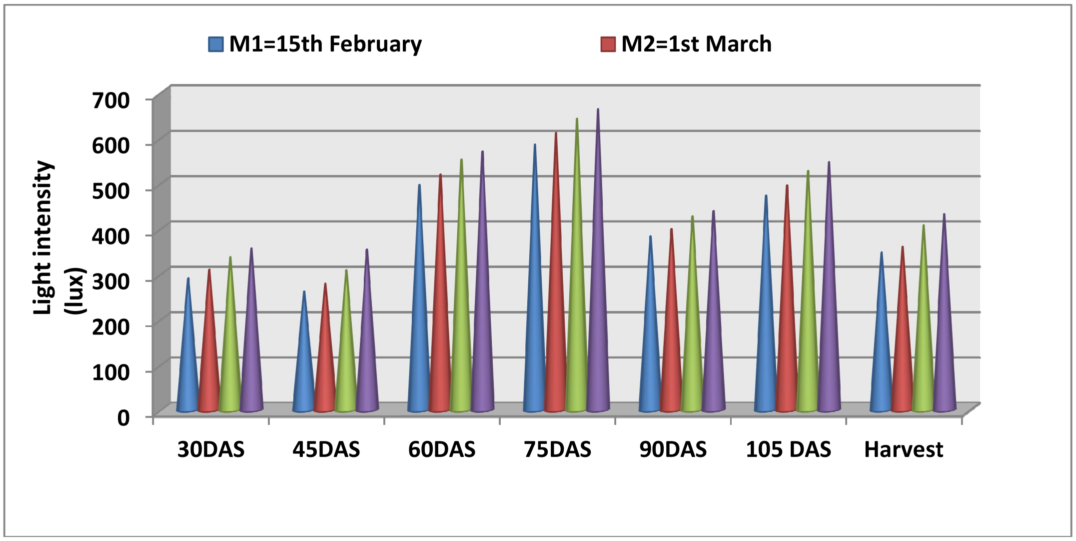

Fig. 3. Light intensity influenced by different micro-climatic regimes

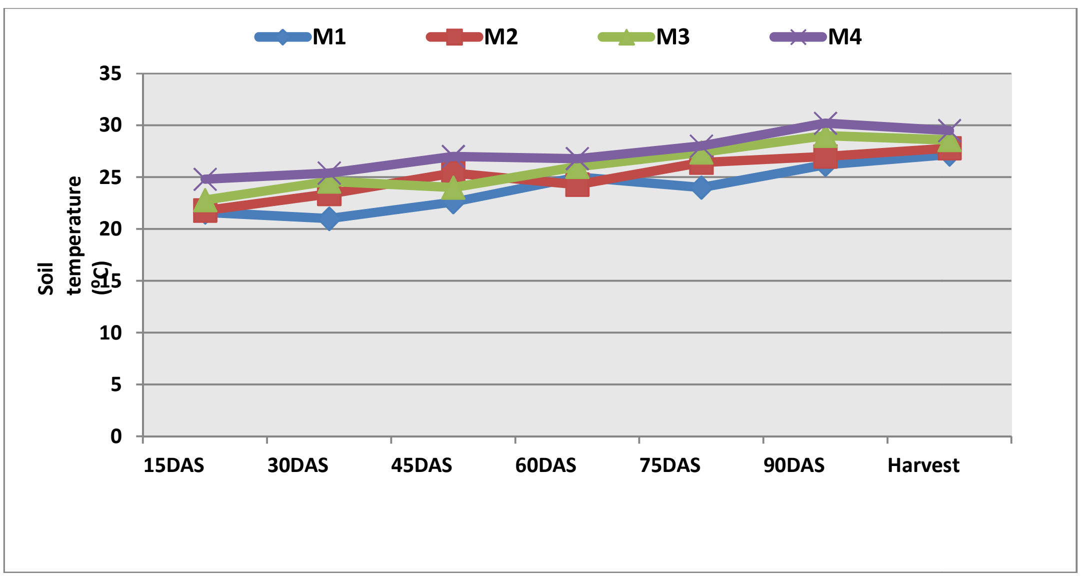

Fig. 4. Soil temperature at surface through out the experimentation

3.6 Economics of Aerobic Rice as Affected by Different Micro-climatic Regimes and Varieties

The aim of rice farmer ultimately is to have maximum income out of the resources use under upland rice growing conditions. A definite micro-climatic regime with suitable crop variety does not involve any extra expenditure but gives acceptable yield and net income. Keeping this point in view, it is important to know the extent of deviation in the sowing dates where the net income does not suffer.

In the present field work, relatively late sowing positively influenced the yield and thereby net income. The 1st April sown crop of aerobic rice gave the highest net income (Rs. 51755 /ha) and a B:C ratio (2.3), among the micro-climatic regimes this might be due to higher yield. In case of rice varieties, CR-Dhan 203 proved its superiority by giving highest net income (Rs. 46865 /ha) and a B: C ratio (2.05) followed by Inglongkiri giving net income of Rs. 44666 /ha with B:C ratio 1.94. This is attributed to net income in relation to the crop productivity and the gross income received (Table1).

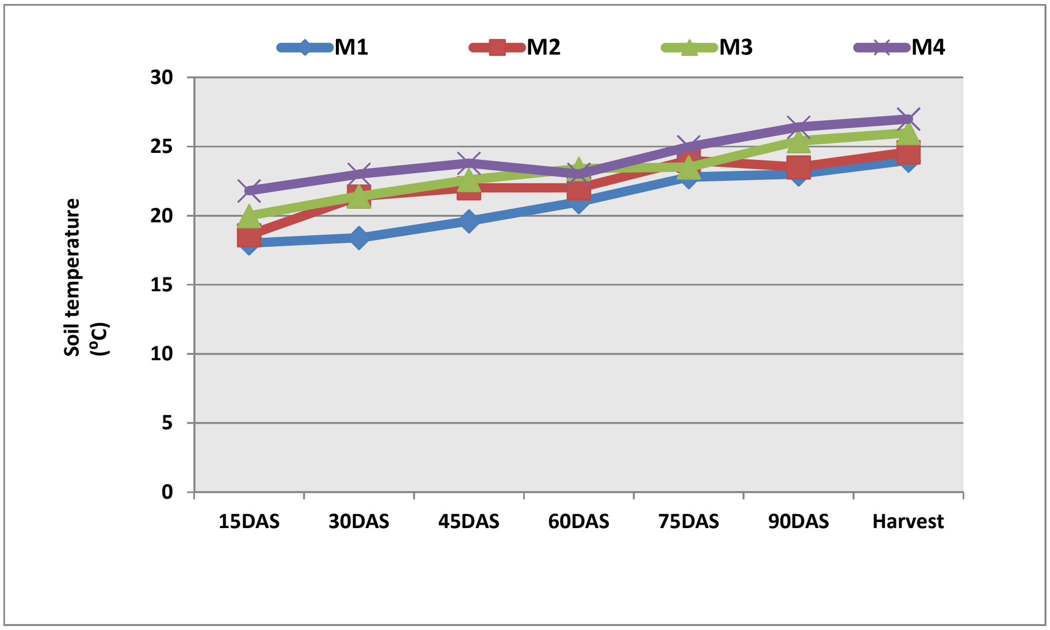

Fig. 5. Soil temperature at 0-15 cm depth through out the experimentation

4. CONCLUSION

It was observed that out of four micro-climatic regimes, micro-climate associated with 1st april sown crop recorded higher values of growth parameters, yield attributing characters, grain yield followed by 16th march sown crop under Jorhat condition of Assam. Among the varieties, CR-Dhan 203 resulted in maximum growth parameters, yield attributes, grain yield and net income. The rice variety CR-Dhan 203 sown between mid of march to first week of april was optimum for obtaining higher grain yield and net return under aerobic condition in Assam.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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