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Research Paper

Effect of High Temperature on Yield and Yield Attributes in Rice

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A B S T R A C T

An experiment was conducted at Regional Agricultural Research Station, Pattambi during the year 2019-2020 for understanding the effect of weather variables on the yield of rice variety Jyothi. Correlation studies were used to estimate the impacts of weather on rice yield from 50% flowering to physiological maturity. Increase in maximum and minimum temperature showed significant negative effects on rice yield. Yield attributes like number of spikelets per panicle, number of filled grains per panicle and thousand grain weight which contributes to yield also reduced significantly with increase in temperature. Study indicated that high temperature during critical growth stages affects the crop growth and yield negatively.

***Key words*:** Rice yield, Open condition, Climate controlled greenhouse, Max temperature, Min temperature

Rice (*Oryza sativa* L.) is one of the most important crops for global food consumption, especially in Asia. Climate change is affecting cereal production all over the world due to increased temperature. Rice cultivation in Kerala started in 3000 BC [1] and is the staple food crop of the state. Forty per cent of the state's total paddy area is in Palakkad district with 83,000 ha under paddy cultivation which is known as the rice granary. Though lot of efforts has been made to stabilize area under paddy in the state, its cultivation has been in steady decline, from 8,500,000 hectares in 1980–81 to 1,980,000 hectares in 2017 [2]. It is reported that fluctuations in temperature has considerable effects on rice yield. Heat stress may shorten the period of grain development which leads to insufficient grain filling and yield reduction in cereals [3]. About 10% reduction in rice yield will occur for every 1°C increase in average temperature [4]. The final yield can be negatively affected by high temperatures [5]. Lower seed yield in rice grown under heat stress condition and high temperatures during panicle development, anthesis and seed set, adversely affect crop physiological parameters and yield attributing parameters, causing drastic reduction in seed yield of summer rice [6]. The investigation was carried out with the aim of revealing the relationship between temperature and rice yield.

MATERIALS AND METHODS

Rice variety Jyothi was cultivated in Regional Agricultural Research Station, Pattambi in completely randomized design with two factors. Seedlings were raised under different dates of planting, viz. June 1st, June 30th, October 1st, October 30th and January 1st in open and climate-controlled greenhouse during 2019-20. Jyothi is a short duration variety with 110-115 days duration and is the second most cultivated variety of rice in Kerala. Jyothi was evolved by the cross between PTB-10, the short duration improved local strain and IR 8, the internationally famous high yielding genotype which is cultivated in all the three seasons and in a wide range of field conditions because of its wide adaptability.

Weather parameters were recorded under open and climate-controlled greenhouse conditions during the experiment and the effect of temperature on rice yield and yield attributes were examined. The dates of initiation of various phenological stages of the crop *viz.*, tillering, panicle initiation, booting, heading, 50% flowering and physiological maturity were identified visually in randomly selected plants. Correlation between stage wise weather data during the crop growth period from the date of sowing to harvesting with observed yields and yield attributes has been established.

RESULTS AND DISCUSSION

The result obtained in the study revealed that the effect of date of planting on yield and yield attributes is represented in (Table 1). October 30th planting showed significantly higher yield in both open condition (7038.8 kg ha^{-1}) and climate-controlled greenhouse (4083.3 kg ha^{-1}). June 1st, June 30th, October 1st and January 1st planting were on par [7]. Interaction between dates of planting and growing condition was significant with respect to grain yield. Yield recorded was maximum under open conditions. Interactions between dates of planting and growing conditions were found to be significant. Number of spikelets (77) recorded during October 1st planting was on par with October 30th planting (84.8). Effect of growing condition on number of spikelets was found to be significant [8]. Number of filled grains per panicle was significantly influenced by planting dates. Numbers of filled grains per panicle at different planting dates for both the growing conditions, October 1st (58.1) and October 30th (66) planting were on par and that recorded during June 1st (29),

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June 30th (32) and January 1st (43.2) plantings were on par. Number of filled grains per panicle for different growing conditions showed significant difference with respect to different dates of planting. Significant difference was observed between thousand grain weight under different growing conditions. Thousand grain weight recorded was maximum under open conditions. Thousand grain weight recorded during June 1st planting (25.3g) was on par with June 30th planting (25.4g). Interactions between dates of planting and growing conditions were found to be significant [9].

Table 1 Effect of date of planting on yield and yield attributes

Date of planting	Grain yield (kg/ ha^{-1})			Number of spikelets per panicle			Number of filled grains per panicle			Thousand grain weight (g)		
	O	GH	Mean	O	GH	Mean	O	GH	Mean	O	GH	Mean
D_1	5345.2^{b}	2380.9^{d}	3863.0^{b}	62.1^{b}	54.3^{c}	58.2^{b}	42.9^{b}	15.2^{c}	29.0^{b}	25.7^{a}	24.8^{b}	25.3^{a}
D_2	6150.0^{ab}	2576.8^{d}	4199.0^{b}	64.6^{bc}	60.3^{bc}	62.4^{b}	43.9^{b}	20.1^{c}	32.0^{b}	25.8^{a}	25.1^{b}	25.4^{a}
D_3	5686.9^{b}	1934.8^{d}	3810.8^{b}	84.9^{a}	69.1^{b}	77.0^{a}	70.6^{a}	45.6^{b}	58.1^{a}	24.8^{b}	23.9^{c}	24.3^{b}
D_4	7038.8^{a}	4083.3^{c}	5360.7^{a}	87.8^{a}	81.9^{ab}	84.8^{a}	72.9^{a}	59.1^{ab}	66.0^{a}	24.7^{b}	23.1^{d}	23.9^{bc}
D_5	4131.0^{c}	2760.7^{d}	3445.9^{b}	62.8^{bc}	62.1^{bc}	62.4^{b}	47.3^{b}	39.1^{b}	43.2^{b}	23.9^{c}	22.7^{e}	23.3^{c}
CD	1064.1		475.9	14.1		10	17.1		12.1	0.5		1.0

Table 2 Effect of growing conditions on yield and yield attributes

Growing conditions	Grain yield (kg ha^{-1})	Number of spikelets per panicle	Number of filled grains per panicle	Thousand grain weight (g)
O	5670.4^{a}	72.4^{a}	55.5^{a}	25.0^{a}
GH	2747.3^{b}	65.6^{b}	35.8^{b}	23.9^{b}
CD	475.9	6.3	7.6	0.7

Effect of growing condition on different yield and yield attributes are represented in (Table 2). Grain yield was found to be higher in open condition (5670.4 kg ha^{-1}) compared to climate-controlled greenhouse (2747.3 kg ha^{-1}). Yield attributes like number of spikelets per panicles, number of filled grains per panicle and thousand grain weights were less under climate-controlled greenhouse compared to open condition. Grain yield and yield contributing factors were less under climate-controlled greenhouse compared to open condition [10].

Correlation between maximum and minimum temperature with yield and yield attributes from 50 percent flowering to physiological maturity are represented in (Table 3). Minimum temperature had significant negative correlation with grain yield, number of spikelets per panicle and number of filled grains per panicle in open as well as climate controlled green house. As the maximum temperature increases, thousand grain weight showed a significant negative trend in both open condition and climate-controlled greenhouse. Further, negative effect of maximum temperature on thousand grain weight from 50% flowering to physiological maturity also contributed to lesser yield. High temperature during grain filling period also showed significant negative influence on grain yield [11].

Table 3 Correlation between maximum and minimum temperature with yield and yield attributes from 50% flowering to physiological maturity

Growing condition	Temperature	Yield and yield attributes: Grain yield	Number of spikelets per panicle	Number of filled grains per panicle	Thousand grain weight
Open condition	T_{max}	-0.253	0.105	0.040	-0.865**
	T_{min}	-0.577*	-0.672**	-0.632*	0.105
Climate controlled greenhouse	T_{max}	0.357	0.526*	0.743**	-0.765**
	T_{min}	-0.552*	-0.697**	-0.576*	0.142

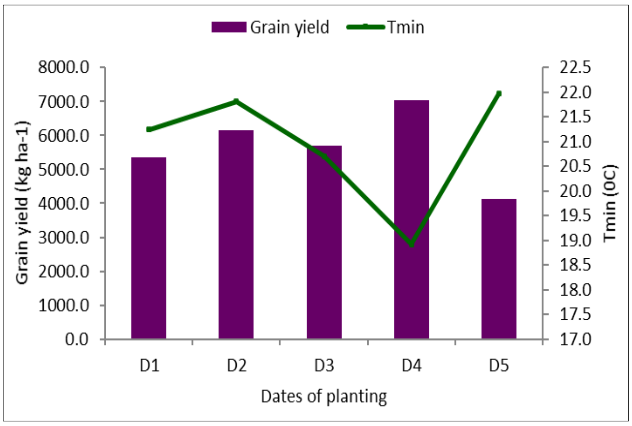

Fig 1 Effect of minimum temperature on grain yield in Jyothi under open condition from 50% flowering to physiological maturity

D_1- June 1st, D_2- June 30th, D_3- October 1st, D_4- October 30th, D_5-January 1st

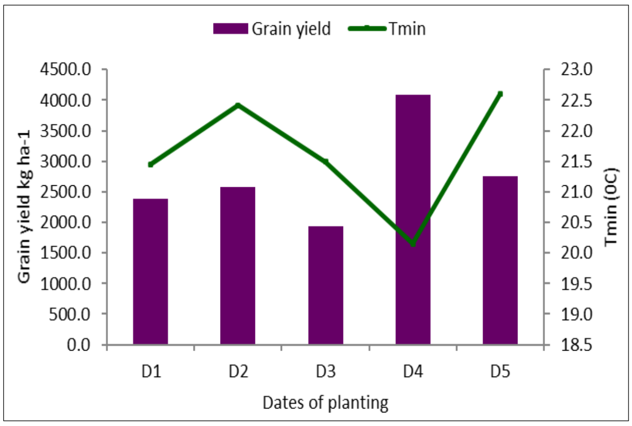

Fig 2 Effect of minimum temperature on grain yield in Jyothi under climate-controlled greenhouse from 50% flowering to physiological maturity

D_1- June 1st, D_2- June 30th, D_3- October 1st, D_4- October 30th, D_5-January 1st

Effect of minimum temperature on grain yield in Jyothi under open condition and climate-controlled greenhouse from 50% flowering to physiological maturity as planting days advances is represented in (Fig 1-2). As the minimum temperature increases grain yield decreases significantly in both the situations [12]. Effect of minimum temperature on number of spikelets per panicle in Jyothi under open condition and climate-controlled greenhouse from 50% flowering to physiological maturity is depicted in (Fig 3-4), respectively. Number of spikelets per panicle decreased as the minimum temperature went up. High day and night temperature affect floret meristem formation and development which may leads to variable reduction of spikelet numbers per panicle [13]. Heat stress occurs during vegetative stage affect tiller formation and heat exposure during booting stage will impact spikelet meristem differentiation.

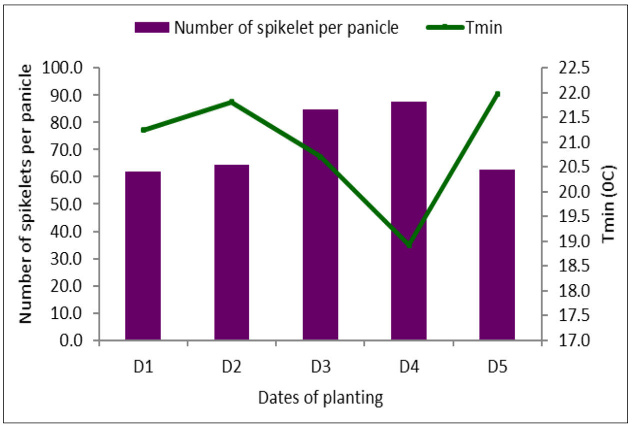

Fig 3 Effect of minimum temperature on number of spikelets per panicle in Jyothi under open condition from 50% flowering to physiological maturity

D_1- June 1st, D_2- June 30th, D_3- October 1st, D_4- October 30th, D_5-January 1st

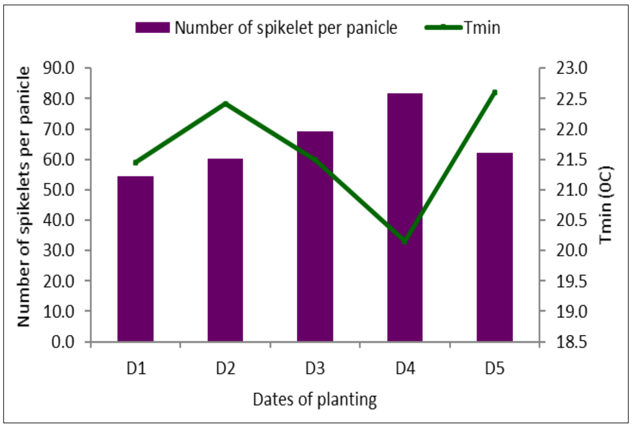

Fig 4 Effect of minimum temperature on number of spikelets per panicle in Jyothi under climate-controlled greenhouse from 50% flowering to physiological maturity

D_1- June 1st, D_2- June 30th, D_3- October 1st, D_4- October 30th, D_5-January 1st

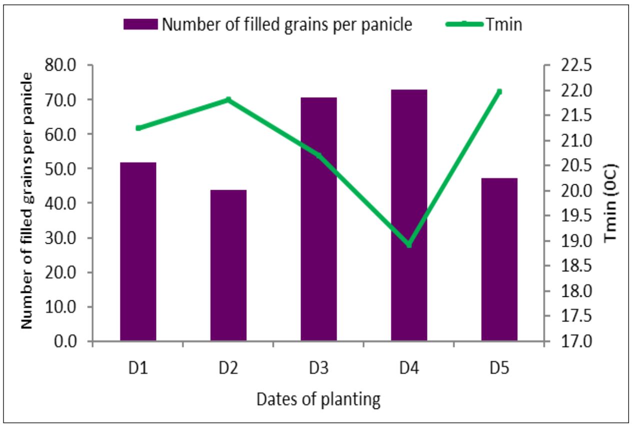

Fig 5 Effect of minimum temperature on number of filled grains per panicle in Jyothi under open condition from 50% flowering to physiological maturity

D_1- June 1st, D_2- June 30th, D_3- October 1st, D_4- October 30th, D_5-January 1st

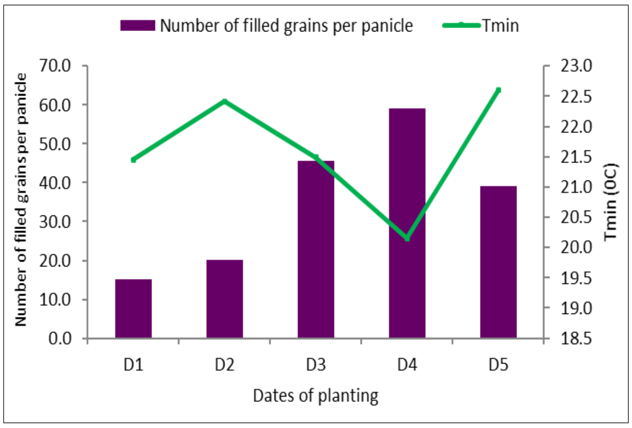

Fig 6 Effect of minimum temperature on number of filled grains per panicle in Jyothi under climate-controlled greenhouse from 50% flowering to physiological maturity

D_1- June 1st, D_2- June 30th, D_3- October 1st, D_4- October 30th, D_5-January 1st

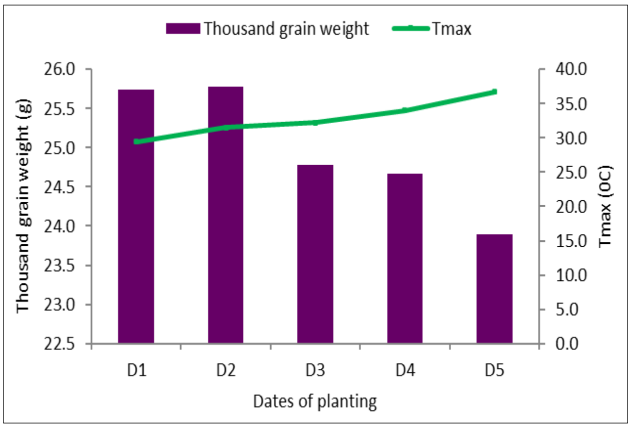

Fig 7 Effect of maximum temperature on thousand grain weight in Jyothi under open condition from 50% flowering to physiological maturity

D_1- June 1st, D_2- June 30th, D_3- October 1st, D_4- October 30th, D_5-January 1st

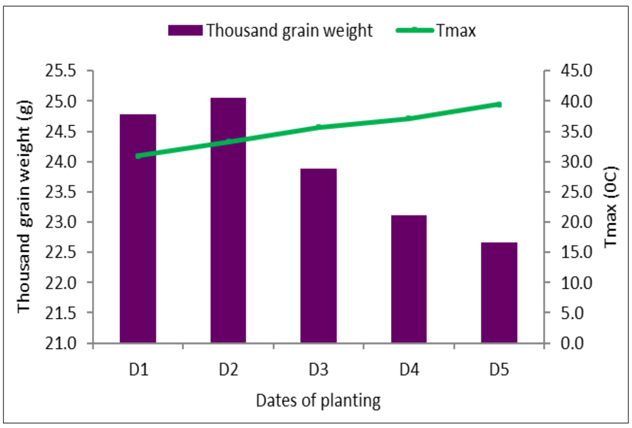

Fig 8 Effect of maximum temperature on thousand grain weight in Jyothi under climate-controlled greenhouse from 50% flowering to physiological maturity

D_1- June 1st, D_2- June 30th, D_3- October 1st, D_4- October 30th, D_5-January 1st

Similarly, with the increase in minimum temperature, number of filled grains per panicle decreased in both open condition and climate-controlled greenhouse and this is represented graphically in (Fig 5-6), respectively. A greater degree of degeneration of spikelets at the top of the panicles under high temperature condition [14]. High temperature stress, significantly reduce both panicle number and spikelet number. Grain appearance and quality was affected negatively by high temperature [15].

Maximum temperature had a significant negative effect on thousand grain weight under open condition and climate-controlled greenhouse and this is represented in (Fig 7-8), respectively. High (daytime/nighttime temperatures were 32.8/31°C) temperature promotes respiration [16] and limits photosynthesis [17], which would lead to decreased sink, and cause a lower thousand grain weight. This shows that high night and day time temperatures have adverse effect on yield and yield contributing factors in rice.

CONCLUSIONS

Temperature had significant effect on number of spikelets per panicle, number of filled grains per panicle, thousand grain weights and grain yield. This may be due to the negative influence of maximum and minimum temperature on yield and yield attributes from 50% flowering to physiological maturity. The study reveals that high temperature during critical growth stages affects the crop growth and yield negatively. To alleviate heat stress and to obtain higher yields ion substitution of temperature-sensitive cultivars with heat tolerant ones, adoption of best sowing time and selection of varieties with a growth duration avoiding peak stress periods can be followed.

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