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Effect of Weather Parameters on rice in Central Agro-climatic zone of Kerala

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ABSTRACT
A field experiment was conducted during 2014 at the Regional Agricultural Research Station of the Kerala Agricultural University at Pattambi, Palakkad district, Kerala. The station is located at 10° 48' N latitude and 76° 12'E longitude at an altitude of 25.36 m above mean sea level in the central agroclimatic zone of Kerala.The experiments were conducted in three seasons, i.e. in January, 2014-15 by planting at fortnightly interval during the third crop season (December-January to March-April), first crop (April-May to September-October) and second crop (September-October to December-January) respectively. Two popular varietiesof Kerala Aathira and Vaisakh were selected for this study and the spacing adopted was 20 cm x 15 cm.Vaisakh has recorded highest number of panicles per square meter (357.00) in the third crop season (Jan 1st). Both the varieties in third season have shown the reduction in panicle number with delay in planting date. Highest number of filled grains per panicle has observed in June 30th crop of Vaisakh (147.3) and it is on par with the June 15th (141.7) transplanted crop of Aathira. High maximum temperature during the reproductive period might be the reason for lesser number of filled grains in third season crop. Maximum yield has observed in variety Vaisakh transplanted on January 1st (6.30) i.e summer crop. The summer crop is physiologically advantageous due to high photo-period, leading to higher productivity. But after that there is a sharp decline in the yield. The increase in the night temperature has shown significant negative correlation from panicle initiation to flowering. Highest yield in Aathira was observed in Oct 30th transplanted crop (5.86).The increase in yield may be due to low minimum temperature during ripening stage.Aathira also has shown significant negative correlation with minimum temperature from panicle initiation to the flowering. The maximum straw yield has observed in the variety Vaisakh transplanted during June 1st (7.86) and Aathira (6.30).The highest harvest index value was observed in January 1st planted crop of Vaisakh (49.12).
Key words: *Virippu(Monsoon),Mundakan (Rabi), Puncha(Summer), crop-weather relations*

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INTRODUCTION

Rice (*Oryza sativa* L.) is the major staple food for more than half of the world's population [2], accounting for approximately 30 percent of the total dietary intake, globally and in South Asia [3]. Rice production in the tropics is sensitive to climatic factors (temperature, rainfall, and solar radiation) which affect the crop in two various ways during different stages of its growth [7].India, with 1.28 billion people is the second most populous country in the world and will take the number one position by 2030. It is imperative to increase food production in order to meet the growing demand for food emanating from population growth. Although, there have been ups and downs in the domestic production of food grain. The diverse climatic phenomena like cyclone, drought, changing rainfall patterns and temperature; there has been a significant loss in food grain production in every year.The yield of rice is significantly influenced by temperature throughout the crop growth period and was more pronounced from flowering to anthesis period [1].Increase in the night temperature is causing the yield losses in rice throughout the world [4].During reproductive phase higher temperature coupled with speedy wind may cause poor setting of seed, consequently leads to pitiable harvest [5]. According to Vijayalakshmi *et al*. [6], yield reduction due to shading (50%) was 11-14 per cent in the shade-tolerant cultivars and 29-34 per cent in the susceptible ones compared to 100 per cent sunlight. Corresponding reductions in total dry matter accumulation were 8-13 and 23-25 per cent respectively. There is a wide gap between potential and actual grain yield of rice in the state and the growth and yield largely depends on the various weather factors like temperature,

rainfall, sunshine hours and relative humidity that prevail during the growing season. With a view to study these weather influences on rice we have done this study.

MATERIALS AND METHODS

The field experiment was conducted during 2014 at the Regional Agricultural Research Station of the Kerala Agricultural University at Pattambi, Palakkad district, Kerala. The station is located at 10° 48' N latitude and 76° 12'E longitude at an altitude of 25.36 m above mean sea level in the central agroclimatic zone of Kerala. The experiments were conducted in three seasons, i.e. in January, 2014-15by planting at fortnightly interval during the third crop season (December-January to March-April), first crop (April-May to September-October) and second crop (September-October to December-January) respectively. Accordingly, crop harvests were done during May, October and January for the above three seasons.

Two popular varietiesof Kerala Aathira and Vaisakh were selected for this study. Aathira and Vaisakh are photo insensitive varieties with the duration of 117-125 days and 113-120 days respectively. The experiment was laid out in Split plot Design with three replications. The Main plot treatments consists of three dates of planting i.e., 1st, 15th and 30th of January (*Puncha*), and two varieties i.e. Aathira and Vaisakh assubplot treatments. The plot size was 40 $m^2$and the spacing adopted was 20 cm x 15 cm.The experiment was laid out in Split plot Design with three replications. The Main plot treatments consists of three dates of plantingi.e., 1st, 15th and 30th of January (*Puncha*), June(*Virippu*) and October (*Mundakan*) and two varieties i.e. Aathira and Vaisakh assubplot treatments. The plot size was 40 $m^2$and the spacing adopted was 20 cm x 15 cm. Weather experienced during the study period was presented in table 5.

RESULTS AND DISCSSION

YIELD ATTRIBUTES

Number of panicles per m^2

Among all the treatments variety Vaisakh transplanted on January 1strecorded the highest number of panicles per plant(357.00).Whereas highest number of panicles observed in June 30th transplanted crop (347.00) in case ofAathira. Number of panicles per plant has significantly varied by the date of planting and the variety (Table 1). During the first crop season, number of panicles per plant was high for variety Aathira compared to Vaisakh. But in third crop season, the number of panicles per plant was more in Vaisakh compared to Aathira.

Number of filled grains per panicle

Number of filled grains per panicle has varied significantly with changes in dates of planting and the impact was different for different varieties (Table 1). The highest number of filled grains per paniclewas observed in June 30thplanted crop of Vaisakh (147.3) and it was on par with the June 15thplanted (141.7) crop of variety Aathira. The crops transplanted during the June have recorded the lowest number of filled grains per panicle and the performance of Aathirais better compared to Vaisakh in first and second crop seasons. Lowest panicle number was observed in January 30th transplanted crop of Aathira (99.73).Number of Filled grains per panicle in the variety Aathira during active tillering to panicle initiation number of filled grains has got significant correlation with evaporation (-0.814) and daily temperature range (-0.687). Only evaporation (-0.768) has significant correlation during panicle initiation to flowering, during flowering to physiological maturity maximum temperature (-0.790), afternoon relative humidity (0.692), and mean temperature (-0.895) has significant correlation.In case of variety Vaisakh number of filled grains per panicle has shown significant positive correlation with wind speed (-0.748) and evaporation (-0.698) during active tillering to panicle initiation, evaporation (-0.702) during panicle initiation to flowering, minimum temperature (-0.834) and evaporation (-0.766) during flowering to physiological maturity(Table 4).

Grain yield

It can be observed from Table 1, that both the varieties performed differently with changes in the weather factors. The highest yield of Vaisakh was recorded by the crop planted on January 1st(6.30t ha^{-1}). Whereas in Aathira crop planted on October30th(5.86) recorded the highest yield. Here we can observe that both the varieties were performing differently with the change in the environment. In the first season, yield of Aathira was high compared to Vaisakh, but in the second and third crop seasons, Vaisakh performed better compared to Aathira.The summer crop is physiologically advantageous due to high photo-period, leading to higher productivity. But after that there is a sharp decline in the yield. The Grain yield of both Aathira and Vaisakh was mainly influenced by minimum temperature. In Aathira minimum temperature during Panicle initiation to flowering stage (-0.840) had negatively influenced the grain yield. Whereas in the variety Vaisakh minimum temperature (-0.772) during active tillering to panicle initiation and panicle initiation to flowering (-0.830), influenced the grain yield (Table 2).The increase in the night temperature has shown significant negative correlation from panicle initiation to flowering. The increase in the night

temperature will increase the respiration there by leads to the reduction of carbohydrates available to transfer to sink. This may be the reason for yield reduction. Highest yield in Aathira was observed in Oct 30th transplanted crop (5.86).The increase in yield may be due to low minimum temperature during ripening stage.But in third crop season yield is considerably less. Aathira also has shown significant negative correlation with minimum temperature from panicle initiation to the flowering.

In case of Aathira increase in the night temperature during the panicle initiation to flowering stage has significantly affected the grain yield. Regression equation has developed for the prediction of the yield as,

Grain yield (Aathira) = Grain yield (tha^{-1})= 8.593 - 0.144 (T min) (R^2= 0.609)

Where,

T min= Minimum temperature from Panicle initiation to flowering (°C)

In case of Vaisakh also increase in the night temperature during the panicle initiation to flowering stage has significantly affected the grain yield. Wind has positive influence on the yield and sunshine has negative influence. Regression equation has developed for the prediction of the yield as,

Grain yield = 14.506 + 0.153 (wind) - 0.203 (T min) (R^2= 0.754)

Where,

Grain yield in (t/ha)

Wind = Wind speed from Panicle initiation to flowering (Km/hr)

T min = Minimum temperature from Panicle initiation to flowering (°C)

Straw yield

The highest straw yield has recorded by the variety Aathira transplanted during June 1st (7.86) and June 15th. It is on par with the June 30th transplanted crop of Vaisakh (7.80).Lowest straw yield was observed in Aathira transplanted on January 30th(6.30) which is on par with the January 15th crop (6.33) (Table 1).Crops taken during June (first season crops) experienced high relative humidity and low temperature range compared to third crop season. This is the reason for reduction in the straw yield.

Harvest Index (%)

The highest harvest index was observed in January 1st planted crop of Vaisakh (49.12). The lowest harvest index was observed in June 15th transplanted crop. The low harvest index values were observed in the first crop season in both the varieties. The harvest index values were high in the second season compared to other two seasons. Harvest index values are significantly changing with both the season and variety (Table1). Harvest index was high in second crop season compared to other seasons.This is due to the moderate temperatures (30-33°C) experienced throughout the growing period. In variety Aathira maximum temperature (0.775) and Bright sunshine hours (0.748) has a significant positive influence on Harvest index. Whereas afternoon relative humidity (-0.727) and rainfall (-0.850) had a significant negative influence during planting to active tillering stage. In variety Vaisakh there was no correlation between weather parameters and harvest index (Table 3).

Table 1.Yield components

Treatment	Grain yield (t ha^{-1})		Straw yield (t ha^{-1})		Harvest index		Number of Filled grainsPanicle^{-1}		Number of paniclesm^{-2}	
	Aathira	Vaisakh	Aathira	Vaisakh	Aathira	Vaisakh	Aathira	Vaisakh	Aathira	Vaisakh
June 1st	5.39^{c}	4.74^{d}	7.86^{a}	6.70^{bc}	40.69^{cd}	41. 44^{cd}	120.9^{ab}	102.7^{bc}	315.00^{g}	282.00^{n}
June 15th	5.03^{cd}	4.82^{d}	7.86^{a}	7.03^{b}	39.05^{cd}	40.68^{cd}	141.7^{a}	129.8^{a}	298.00^{j}	291.00^{k}
June 30th	5.34^{c}	5.01^{cd}	7.53^{ab}	7.80^{a}	41.67^{cd}	39.13^{cd}	127.2^{ab}	147.3^{a}	310.00^{h}	298.00^{j}
October 1st	5.20^{c}	5.40^{c}	6.73^{bc}	6.40^{bc}	43.63^{bc}	45.76^{b}	121.3^{ab}	132.0^{a}	316.00^{f}	323.00^{e}
October 15th	5.42^{c}	5.46^{c}	7.06^{b}	6.40^{bc}	43.45^{bc}	46.04^{b}	137.1^{a}	136.6^{a}	306.00^{i}	325.00^{d}
October 30th	5.86^{b}	5.50^{c}	6.90^{bc}	6.80^{bc}	45.95^{b}	44.71^{bc}	131.1^{a}	139.9^{a}	347.00^{b}	341.05^{c}
January 1st	5.26^{c}	6.30^{a}	7.53^{ab}	6.50^{bc}	41.11^{bc}	49.12^{a}	85.80^{c}	116.6^{ab}	306.00^{i}	357.00^{a}
January 15th	4.99^{cd}	4.93^{cd}	6.33^{c}	6.80^{bc}	44.12^{bc}	42.02^{c}	110.0^{b}	109.3^{b}	289.00^{l}	286.00^{m}
January 30th	4.93^{cd}	4.74^{d}	6.30^{c}	6.90^{bc}	43.93^{bc}	45.02^{b}	99.73^{bc}	109.2^{b}	273.00^{p}	275.00^{o}

Table 2. Correlation between Grain yield and weather during different phenophases

Weather parameter	Aathira				Vaisakh			
	TP-AT	AT-PI	PI-Fl	FL-PM	TP-AT	AT-PI	PI-Fl	FL-PM
T_{max}	NS	NS	NS	NS	NS	NS	NS	NS
T_{min}	NS	NS	-.840**	NS	NS	-.772*	-.830**	NS
RH-I	NS	NS	NS	NS	NS	NS	NS	NS
RH-II	NS	NS	NS	NS	NS	NS	NS	NS
Wind speed	NS	NS	NS	NS	NS	NS	NS	NS
Rainfall	NS	NS	NS	NS	NS	NS	NS	NS
BSH	NS	NS	NS	NS	NS	NS	NS	NS
Evaporatiom	NS	NS	NS	NS	NS	NS	NS	NS

Note: TP-transplating, AT-active tillering, PI- panicle initiation, FL-flowering, PM- Physiological maturity

Table 3. Correlation between Harvest Index and weather during different phenophases

Weather parameter	Aathira			Vaisakh		
	AT-PI	PI-Fl	FL-PM	AT-PI	PI-Fl	FL-PM
T_{max}	NS	NS	NS	NS	NS	NS
T_{min}	NS	NS	NS	-.818**	-.881**	NS
RH-I	NS	NS	NS	NS	NS	NS
RH-II	NS	NS	NS	NS	NS	NS
Wind speed	NS	NS	NS	NS	NS	NS
Rainfall	NS	NS	NS	NS	NS	NS
BSH	NS	NS	NS	NS	NS	NS
Evaporatiom	NS	NS	NS	NS	NS	NS

Note: TP-transplating, AT-active tillering, PI- panicle initiation, FL-flowering, PM- Physiological maturity

Table 4. Correlation between Filled grains and weather during different phenophases

Weather parameter	Aathira			Vaisakh		
	AT-PI	PI-Fl	FL-PM	AT-PI	PI-Fl	FL-PM
T_{max}	NS	NS	-.790*	NS	NS	NS
T_{min}	NS	NS	NS	NS	NS	-.834**
RH-I	NS	NS	NS	NS	NS	NS
RH-II	NS	NS	.692*	NS	NS	NS
Wind speed	NS	NS	NS	-.748*	NS	NS
Rainfall	NS	NS	NS	NS	NS	NS
BSH	NS	NS	NS	NS	NS	NS
Evaporatiom	-.814**	-.768*	NS	-.698*	-.702*	-.766*

Note: TP-transplating, AT-active tillering, PI- panicle initiation, FL-flowering, PM- Physiological maturity

Table 5.Weekly weather variables during the study period

WeeK NO.	Max temp	Min temp	RH I	RH II	Wind	Rainfall	BSH	Evaporation
1	33.1	20.0	82.7	45.6	4.7	0.0	8.6	34.1
2	33.4	22.6	77.6	38.4	5.2	0.0	7.9	35.1
3	33.5	21.6	71.1	37.6	5.5	0.0	7.7	38.4
4	33.0	22.5	71.0	38.0	7.6	0.0	8.6	48.5
5	33.9	21.1	71.1	42.7	7.0	0.0	9.2	40.2
6	35.7	18.1	90.4	39.3	3.6	0.0	8.9	36.2
7	33.9	21.1	90.4	47.9	2.9	0.0	7.4	33.4
8	35.3	23.0	83.1	43.4	5.5	4.2	6.7	39.8
9	35.7	23.5	85.1	50.0	5.6	0.0	8.6	47.7
10	35.4	23.9	76.6	43.9	5.4	0.0	7.0	43.9
11	38.1	20.7	75.7	21.9	5.1	0.0	9.6	50.5
12	37.9	24.4	85.0	29.0	3.3	0.0	9.0	44.5
13	38.6	23.6	82.9	34.1	3.6	0.0	8.9	46.6
14	36.8	25.5	83.3	50.4	3.5	0.0	7.5	38.9
15	35.3	24.1	86.7	51.3	2.8	22.6	5.3	28.7
16	35.9	25.5	85.7	49.0	3.0	1.2	8.0	38.5
17	36.1	26.2	85.0	52.4	3.0	0.0	4.9	36.6
18	35.9	24.7	81.0	47.0	3.6	0.0	7.8	10.6
22	33.3	24.8	93.0	65.4	2.5	45	5.1	18.8
23	31.1	24.2	92.0	77.1	2.2	58.6	4.3	36.2
24	31.1	24.1	93.3	73.6	2.4	181.9	4.2	27.1
25	30.7	24.1	94.3	75.4	3.0	170.1	3.2	16.9
26	31.6	24.3	93.6	68.0	2.7	180	5.8	14.7
27	31.5	23.6	91.9	91.9	3.2	44.1	5.3	11.7
28	28.6	23.0	95.0	95.0	2.7	5.1	0.7	11.3
29	29.8	23.2	94.1	83.4	2.4	208.4	2.1	16.6
30	30.1	23.2	94.0	78.7	2.6	136.8	1.8	10
31	28.6	22.9	95.7	85.9	2.2	356.9	0.8	21

32	28.8	22.8	95.2	79.6	1.9	63.3	0.7	10
33	30.9	24.2	92.9	64.6	2.6	18.3	6.3	12.1
34	31.7	23.4	94.3	70.4	2.3	108.4	5.5	7.4
35	26.8	22.9	95.6	77.6	2.8	162.7	2.6	10.5
36	30.3	23.0	93.6	73.0	2.2	38.9	4.6	21.3
37	31.3	23.1	94.0	67.7	2.9	21.1	7.8	19.3
38	31.4	23.7	93.6	66.0	2.9	0.6	7.9	8.8
39	33.6	23.2	92.9	68.6	2.5	80.2	6.7	16.7
40	32.2	23.7	94.2	73.7	1.8	80.7	5.3	24.2
41	30.8	24.4	95.0	72.7	1.6	79.6	5.1	26.7
42	32.9	23.1	93.6	67.6	1.9	137.0	5.4	14.9
43	32.2	23.6	92.7	62.1	2.4	43.3	5.4	4.9
44	32.3	24.8	93.4	61.7	1.3	83.9	4.7	15.4
45	32.8	22.6	96.0	62.0	1.5	18.5	5.9	16.9
46	32.5	23.0	91.4	54.0	4.6	5.4	7.5	22.6
47	32.3	21.9	89.1	54.9	3.0	2.4	5.7	16.3
48	30.9	20.9	85.7	58.6	2.4	0	2.4	26
49	33.0	20.8	86.0	60.4	3.3	0	7.7	27.7
50	33.7	22.3	89.4	56.6	3.2	0	6.9	21.2
51	32.4	22.9	86.6	61.6	6.8	0	5.8	13.2
52	32.2	22.1	88.0	62.6	2.8	0	5.2	23.1
1	33.3	20.4	96.1	53.0	2.0	0.0	8.1	22
2	32.8	19.3	84.4	45.1	4.0	0.0	8.2	28.7
3	33.4	19.9	69.9	43.1	4.7	0.0	8.4	21.2
4	33.3	20.6	86.1	55.6	5.5	0.0	8.6	23.7
5	33.2	21.6	85.3	67.0	4.8	0.0	8.0	28.5

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