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Research Article

Crop Weather Calendar for Short Duration Rice in the Central Zone of Kerala

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ABSTRACT

Crop weather calendars are efficient tools for agricultural planning and timely management. The study was conducted from 2013 to 2022, during which meteorological data, crop information, and pest and disease data were gathered and examined. The aim was to prepare a crop weather calendar for rice cultivation in the central zone of Kerala. Daily weather data for Thrissur district were utilized to calculate the weekly, monthly average and climatic normal of various meteorological parameters to analyze their impact on rice yield, based on field experiments conducted at the Agricultural Research Station, Mannuthy, Kerala Agricultural University. Crop weather calendar for rice was developed by combining weekly climatic normals, the ideal climatic conditions required for each phenophase of crop as well as for incidence of pest and diseases. Ideal weather conditions during each phenophase were determined from the field experiment by identifying the meteorological parameters required for obtaining assured yield. Crop weather calendar was then developed for rice using these data. Crop weather calendars serve as valuable tools for providing informed decisions to farmers regarding optimal sowing times, fertilizer applications, irrigation schedules, and plant protection measures.

Key words: Crop weather calendar, Meteorological parameters, Climatic normals, Assured yield and Pest

Introduction

Rice (*Oryza sativa* L.) is the primary staple crop after wheat and is the source of 50% calories for the almost 50% population of the world, and its demand will increase by 28% in 2050 (Zhu *et al.*, 2018). Climate change is causing considerable harm to rice cultivation globally, which in turn is causing a decrease in supply and a surge in demand. This situation is adversely affecting food security and the economies of nations. The increase in temperature and the occurrence of extreme weather events such as droughts, floods, tropical storms, unpredictable rainfall, rising sea levels, and the loss of agricultural land are all playing a role in exacerbating these difficulties (Fischer *et al.*, 2002). Sridevi and Chellamuthu (2015) observed that changes in temperature and rainfall patterns due to global warming are impacting the growing phases of crops. These changes are attributed to various weather elements such as temperature, rainfall, duration of daylight, and wind, all of which influence the growth and productivity of crops. Anusha *et al.* (2023) found that the temperature rise in future have significant impact on the duration of both 50% flowering and physiological maturity in rice varieties. The increase in temperature under future climate will result in drastic temperature increase during critical growth phases such as flowering and grain filling and it may speed up the growth progression in rice, resulting in rapid biomass accumulation and severe yield loss in rice (Aswathi *et al.*, 2022). Riya and Ajithkumar

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(2022) noticed that decrease in yield can be attributed to an increase in temperature, which negatively impacts on pollen germination, leaf senescence, and photosynthetic rate. Minimum temperature has a positive impact on the speed of leaf emergence, which shows increased rice production (Abbas *et al.*, 2021). It was found that the water requirement of rice varied with planting dates. The crop water requirement was found to be increasing with delay in planting dates, due to increase in maximum temperature and decrease in effective rainfall (Vysakh *et al.*, 2016). Kaur *et al.* (2011) investigated how various meteorological factors impact on rice yield, identifying optimal temperature and rainfall conditions during July and August across various locations in Punjab to maximize rice productivity. Sharma *et al*. (2018) highlighted the direct impact of weather variables like temperature, precipitation, and relative humidity on insect pest prevalence and reproduction. Mandal and Mandal (2018) suggested that a 10-20% variance in relative humidity between morning and evening raised the probability of stem borer infestations. Lenka *et al.* (2008) noted a direct relationship between both maximum and minimum temperature and the rate of evaporation, as well as the prevalence of sheath blight. Singh *et al*. (2012) identified that optimal meteorological conditions conducive to the proliferation of rice pests include cloudy skies, consistent rainfall, and higher humidity throughout the crop season. Planting delays have been correlated with increased occurrences of the green leaf hopper, as demonstrated by Yadav (2018).

In this context, crop weather calendar (CWC) is an important tool which can help in issuing timely agro advisory to the farmers. A CWC serves as a comprehensive guide detailing the entire life cycle of a crop, spanning from sowing to maturity. It encompasses crucial stages such as vegetative growth, flowering, grain development, and maturity. These calendars offer insights into expected weather patterns during each growth phase, warning based on prevailing weather conditionsand weather conditions conducive to pests and diseases. Their significance lies in aiding crop planning, irrigation scheduling, and implementing effective plant protection measures. (Kaur *et al.*, 2013). Crop weather calendar for crop management determines optimal irrigation dates by studying historical weather patterns. These calendars guide farming activities from planting to harvesting stages, ensuring efficient crop cultivation practices (Hill *et al.*, 1996). Understanding the specific crops cultivated in particular agro-climatic regions, as well as their management techniques, is crucial for agro-meteorologist to provide effective guidance to growers. India Meteorological Department (IMD) compiles thorough crop-related data and presents it in a visual format. Crop weather calendar comprise three primary components: regular crop management practices, typical weather patterns, and significant weather advisories (Varshneya and Pillai, 2008). The current study aimed to investigate the impact of meteorological factors on rice crop yield and to make a CWC for the central zone of Kerala.

Materials and Methods

Data collection

The daily weather data for central zone of Kerala were collected from Department of Agricultural Meteorology to calculate the weekly and monthly climatic normal from 1983 to 2022 (40 years). The daily weather data, i.e., rainfall (mm), number of rainy days (with rainfall of 2.5mm or more in a day), pan evaporation (mm), maximum temperature (°C), minimum temperature (°C), mean temperature (°C), bright sunshine (hours), solar radiation (W m^{-2}), forenoon relative humidity (%), afternoon relative humidity (%), mean relative humidity (%), and wind speed (km hr^{-1}) were computed. The crop data was collected from the field experiment conducted at Agricultural Research Station, Mannuthy from 2013 to 2022. The design used was split plot design with the main plot treatment as five dates of planting (June 5^{th}, June 20^{th}, July 5^{th}, July 20^{th} and August 5^{th}) and sub plot treatment as two short duration rice varieties Jyothi and Manu Ratna. The yield from obtained from these 10 years were categorized into low (less than 2683 kg ha^{-1}), medium (2683 to 5487 kg ha^{-1}) and high crop yield (greater than 5481 kg ha^{-1}) years for identification of assured yield.

Preparation of crop weather calendar (CWC)

Crop weather calendars are comprised of three parts (Fig. 1):

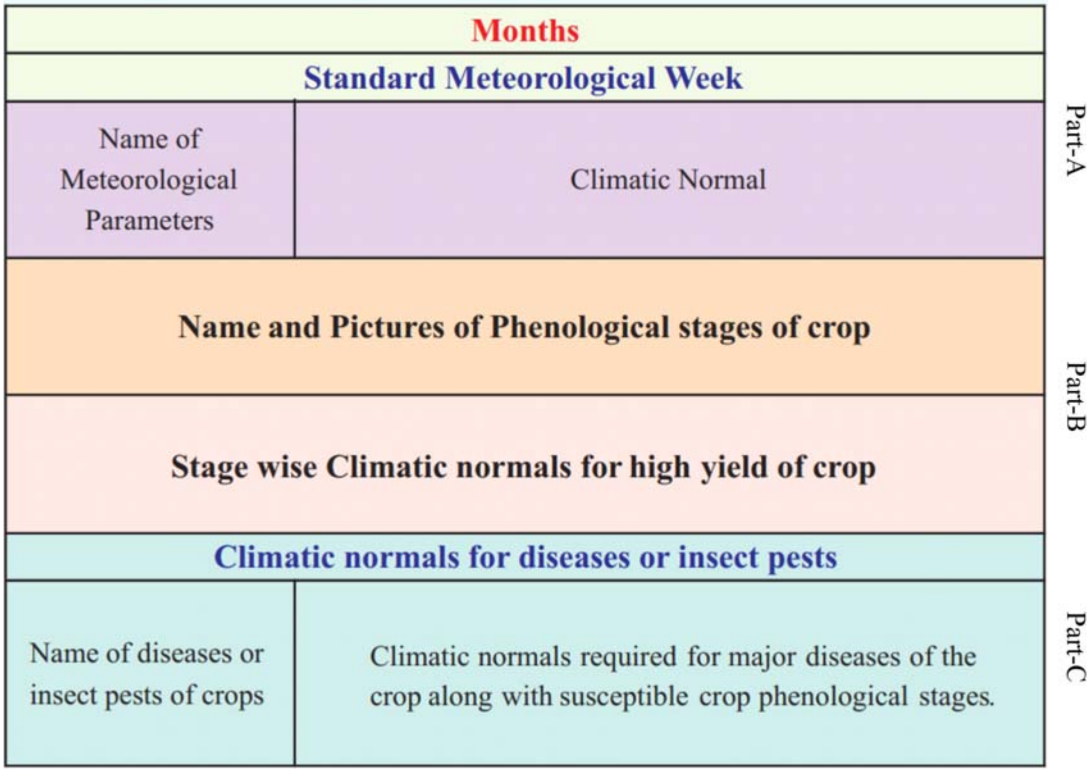


Fig. 1. Crop weather calendar

Part A: The top section of the calendar displays typical weather information for various months and the corresponding standard meteorological weeks (SMWs) specific to the location or station throughout the entire crop growth period. It includes different meteorological factors such as maximum and minimum temperatures, rainfall, rainy days (with rainfall exceeding 2.5mm in an day), forenoon and afternoon relative humidity, solar radiation or sunshine hours, which can be calculated based on long-term averages derived from at least 20 years of data. The months and standard meteorological weeks are indicated at top section of the calendar.

Part B: The central section displays a diagram depicting the typical life cycle of the crop. It highlights key growth stages specific to the crop variety, such as sowing, germination, transplanting (for crops like rice), vegetative growth, flowering and maturity. These phases are represented by horizontal bars, their durations influenced by variations in crop types, sowing times, and regional/ yearly differences. Additionally, this section delineates the ideal weather conditions necessary for optimal crop growth during each stage, leading to assured yield.

Part C: The lower section of the calendar displays weather conditions favourable for the occurrence of pests and diseases, along with the types of weather warning that can be issued. The horizontal bars represent specific periods when the crop is vulnerable. If the favourable weather conditions align with the presence of pathogens or insects during these periods, it could lead to the outbreak of that disease or pest. Using this data, an agrometeorologist can provide advice based on weather conditions to manage and control diseases or pest affecting the crop.

Results and Discussion

Climatic normal for rice

The climatic averages (weekly) for different weather parameters, for a 40-year period, are shown in Table 1. The climatic normals for rice were observed between the 20th and 36th meteorological weeks, covering the entire growth phases from

Table 1. Weekly average climatic normal for rice crop

Month	May		June					July				August				September	
SMW	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Tmax (°C)	33.2	33.1	32.2	30.9	30.0	30.0	29.8	29.9	29.4	29.3	29.6	29.7	29.4	29.8	30.2	30.2	30.4
Tmin (°C)	24.5	24.5	24.1	23.5	23.2	23.1	23.1	23.0	23.6	22.8	23.0	23.2	23.0	23.3	23.3	23.3	23.2
Tmean (°C)	28.9	28.8	28.2	27.2	26.6	26.6	26.4	26.5	26.5	26.0	26.3	26.5	26.2	26.6	26.7	26.8	26.8
RH I (%)	88.0	89.0	90.0	92.0	93.0	94.0	94.0	94.0	95.0	95.0	94.0	95.0	95.0	94.0	94.0	94.0	93.0
RH II (%)	63.0	63.0	69.0	73.0	77.0	77.0	77.0	78.0	81.0	79.0	76.0	76.0	76.0	75.0	73.0	72.0	71.0
RHmean (%)	75.0	76.0	79.0	83.0	85.0	85.0	85.0	86.0	88.0	87.0	85.0	85.0	85.0	84.0	83.0	83.0	82.0
WS (kmph)	3.6	3.6	3.6	3.4	3.5	3.3	3.2	3.2	3.1	3.1	3.1	3.2	3.0	3.1	3.1	3.1	2.9
BSS (hrs)	6.0	6.1	5.3	3.8	3.0	3.2	3.2	3.3	2.6	2.5	3.0	3.3	3.2	3.9	4.8	4.7	4.8
SRAD (MJ/m^2)	9.7	9.7	9.5	9.0	8.8	8.8	8.9	8.9	8.7	8.7	8.8	9.0	8.9	9.2	9.5	9.5	9.5
RF (mm)	51.9	49.5	86.5	139.2	179.3	157.1	168.1	130.4	159.4	164.0	121.0	128.2	131.5	108.8	71.1	79.4	73.1
Evp (mm)	28.9	27.4	25.5	21.2	19.4	20.3	19.7	20.2	19.4	17.9	20.3	20.0	19.6	20.9	22.3	22.9	21.8

sowing to harvesting shown in the upper portion of the crop weather calendar (Fig. 6). The peak of normal weekly rainfall was 179.3 mm recorded in the 24th standard meteorological week. Meanwhile, the highest normal maximum temperature (33.2°C) occurred in the 20th SMW and the lowest minimum temperature (22.8°C) was noted during the 29th SMW. Forenoon relative humidity peaked at 95 % and afternoon relative humidity 81 % in the 29th and 28th SMW, respectively, while the lowest mean relative humidity of 75 % was observed in the 20th SMW.

Phenophase wise weather for assured yield for rice

To study the influence of weather on rice production, weather data and crop data were collected from the Department of Agricultural Meteorology, College of Agriculture, Vellanikkara from field experiments of five dates of planting June 5th, June 20th, July 5th, July 20th and August 5th from 2013 to 2022 (10 years) thus including 50 dates of planting (5 date of plantings x 10 years) and the data was arranged in descending order for getting the assured yield. The assured yield and the optimum weather data for each phenophase were calculated by statistical analysis as well as scatter plot technique, which is reported in Table 2 and Fig. 2 (a, b, c, d, e & f) to 5 (a, b, c, d, e & f) for statistical analysis.

The emergence phase experienced a range of maximum temperature (Tmax) of 29.0-32.0°C, minimum temperature (Tmin) of 24-25°C, bright sunshine (BSS) 2.0 - 3.0 hrs and a range of rainfall between 60 - 180 mm. During transplanting, maximum temperature ranged between 29-31°C and 23-24°C for minimum temperature, bright sunshine hour ranging from 2.0 - 3.0 hrs and a rainfall range between 337 - 800 mm. Similarly, the active tillering phase experienced range of maximum temperature 29-31°C, minimum temperature 22-24°C, bright sunshine 1.6 - 3.9 hrs and a range of rainfall between 250 - 725 mm. During the panicle initiation period, maximum temperature ranged between 29-31°C and 22-24°C for minimum temperature, bright sunshine 0.6 - 5.0 hrs and rainfall range between 100 - 295 mm. During the booting stage, maximum temperatures ranged between 30 and 31°C and 22 to

Table 2. Phenophase wise weather for obtaining assured yield for rice

Planting date/ year	Yield (kg ha^{-1})	Tmax-P1 (°C)	Tmin-P1 (°C)	RF-P1 (mm)	BSS-P1 (hrs)	Tmax-P2 (°C)	Tmin-P2 (°C)	RF-P2 (°C)	BSS-P2 (hrs)	Tmax-P3 (°C)	Tmin-P3 (°C)	RF-P3 (mm)	BSS-P3 (hrs)
June 5th-2013	6712.5	28.4	22.7	903.6	0.9	30.5	23.4	65.6	3.6	28.3	22.6	580.1	0.7
July 20th-2013	6520.0	28.9	22.8	562.4	2.1	29.9	22.8	49.5	4.8	30.7	22.6	68.4	5.0
June 5th-2014	6440.0	30.7	24.2	475.2	2.6	28.6	22.9	302.6	0.8	29.1	23.0	578.1	0.9
July 20th-2017	6430.0	30.9	23.3	285.2	4.1	30.6	23.1	101.9	3.0	30.3	23.3	276.2	3.1
July 5th-2013	6405.0	28.3	22.7	744.3	0.8	28.7	22.9	270.2	2.0	30.6	22.9	75.5	5.2
June 5th-2015	5807.5	30.8	23.8	648.0	1.9	30.7	23.5	55.4	4.0	29.6	23.4	400.1	2.7
June 20th-2016	5782.5	29.4	21.0	495.4	3.4	30.2	21.4	89.0	0.3	30.4	23.1	126.9	3.9
June 5th-2017	5750.0	30.5	23.5	617.9	1.9	30.0	22.8	96.3	1.6	31.2	22.8	258.2	3.6
June 5th-2016	5700.0	29.7	21.6	467.5	1.6	29.6	21.4	97.9	6.2	30.0	21.7	294.5	2.9
June 20th-2013	5622.5	28.4	22.9	842.7	0.8	27.8	22.4	361.5	0.2	29.3	23.0	355.4	2.8
June 20th-2017	5590.0	30.2	22.8	567.1	1.7	30.8	22.1	158.8	2.2	31.0	23.5	210.5	4.4
August 5th-2017	5430.0	30.3	23.3	359.9	3.1	29.7	23.3	148.8	2.7	31.7	22.9	327.1	4.4
July 5th-2017	5320.0	30.8	22.7	327.8	2.7	31.7	23.9	23.9	6.2	30.2	23.3	517.5	3.0
July 5th-2022	5225.0	29.3	23.6	497.8	2.0	27.5	23.0	384.9	0.8	30.7	23.8	178.8	5.6
August 5th-2013	4835.0	30.0	23.0	147.6	4.8	30.8	22.4	62.4	4.0	29.6	22.3	268.5	3.3
June 20th-2014	4775.0	30.1	23.6	488.8	2.8	29.4	22.8	325.8	1.0	28.8	23.2	459.5	1.6
July 20th-2014	4700.0	28.9	23.1	741.3	1.1	31.1	23.9	108.2	5.0	29.9	23.1	293.2	3.7
July 5th-2016	4475.0	29.8	21.7	386.1	3.5	30.2	22.9	72.5	3.5	30.3	23.4	115.8	5.5
June 20th-2015	4380.0	30.8	23.9	527.2	3.4	28.5	23.1	314.4	0.3	30.6	23.8	197.0	4.2
June 20th-2018	4376.8	29.8	22.5	578.6	2.4	28.6	22.0	331.8	0.2	29.5	22.8	379.8	1.0
July 5th-2014	4195.0	29.2	23.1	741.3	1.1	28.1	22.8	251.6	0.2	30.0	23.4	417.4	3.2
July 20th-2015	4142.5	29.9	23.5	383.5	3.2	31.6	23.6	124.2	5.3	31.6	23.6	124.2	5.3
July 20th-2016	4092.5	30.3	22.7	209.2	3.0	30.6	23.6	67.4	5.7	30.3	23.3	28.5	6.6
August 5th-2014	4070.0	29.8	23.3	408.1	3.1	29.4	23.0	148.6	1.8	31.9	23.4	34.0	7.3
June 5th-2021	3950.0	31.0	23.6	355.5	3.7	29.2	22.2	105.5	4.6	28.8	23.1	580.5	1.1
August 5th-2020	3950.0	30.2	23.1	470.3	3.0	31.8	22.8	136.7	5.3	29.6	22.2	470.3	2.5
August 5th-2015	3805.0	31.0	23.7	318.6	4.8	32.1	24.0	81.4	6.1	31.8	23.7	130.8	5.5

P1- Transplanting to active tillering, P2- Active tillering to panicle initiation, P3- Panicle initiation to booting
Tmax- Maximum temperature, Tmin- Minimum temperature, RF- Rainfall and BSS- Bright sunshine hours

Table 2. Phenophase wise weather for obtaining assured yield for rice (contd.)

Planting date/ year	Yield (kg ha^{-1})	Tmax-P1 (°C)	Tmin-P1 (°C)	RF-P1 (mm)	BSS-P1 (hrs)	Tmax-P2 (°C)	Tmin-P2 (°C)	RF-P2 (mm)	BSS-P2 (hrs)	Tmax-P3 (°C)	Tmin-P3 (°C)	RF-P3 (mm)	BSS-P3 (hrs)
July 5th-2015	3792.5	30.0	23.5	479.7	3.3	30.7	23.6	87.0	3.9	31.3	23.9	236.8	5.7
June 5th-2020	3775.0	31.1	23.6	291.7	2.1	30.3	23.4	281.1	1.4	30.6	23.1	451.8	3.4
August 5th-2016	3717.5	30.4	23.2	160.8	5.0	30.0	23.0	16.1	5.0	30.5	23.7	69.9	5.8
June 5th-2019	3655.0	32.0	23.5	327.6	3.7	31.0	23.2	154.6	2.6	29.9	22.3	494.3	2.3
June 20th-2019	3609.0	31.3	23.3	372.5	3.0	28.8	21.9	369.4	1.7	29.6	22.3	682.7	2.0
July 20th-2022	3475.0	29.9	23.8	439.7	3.3	31.2	24.1	96.4	7.2	30.2	23.7	190.6	3.1
July 5th-2021	3450.0	29.6	23.5	596.1	2.1	30.4	23.3	119.1	2.5	30.0	23.4	393.4	2.3
August 5th-2022	3400.0	30.1	23.7	265.7	4.8	30.6	23.6	104.9	3.1	31.4	23.7	77.4	6.4
July 5th-2018	3174.3	29.2	22.5	804.6	1.1	29.7	22.7	225.1	1.3	29.8	22.1	689.1	4.4
June 20th-2021	3075.0	30.8	23.5	431.6	4.0	28.8	23.5	244.1	0.9	30.3	23.3	206.3	2.6
June 5th-2018	2808.3	29.7	23.1	707.4	1.7	30.6	22.8	242.5	4.0	29.0	22.4	564.8	0.5
July 5th-2019	2775.0	30.3	22.5	613.1	2.8	28.3	22.0	538.9	0.5	29.8	21.7	687.8	1.3
July 5th-2020	2675.0	30.8	23.3	276.2	3.2	28.9	22.6	691.7	0.7	31.1	23.2	135.8	4.5
July 20th-2021	2650.0	30.1	23.5	310.7	2.3	30.1	23.4	87.9	1.6	29.9	23.6	374.8	2.7
July 20th-2020	2625.0	29.8	23.0	792.2	2.4	30.8	23.4	54.9	3.2	30.8	23.4	54.9	3.2
August 5th-2021	2625.0	30.1	23.4	383.7	2.4	29.7	23.6	151.9	1.7	31.1	23.9	139.8	4.9
June 20th-2020	2350.0	30.6	23.3	420.8	2.2	30.7	23.4	86.7	3.0	29.6	23.0	809.9	1.9
June 5th-2022	2340.0	31.1	23.6	373.6	4.1	27.7	22.8	327.3	0.1	29.7	23.7	301.5	2.3
August 5th-2019	2269.0	29.2	21.7	992.1	1.0	30.2	21.7	286.2	1.7	31.8	22.1	96.4	4.1
July 20th-2019	2250.0	29.3	22.2	1014.5	1.7	29.9	21.6	166.5	1.4	30.1	21.7	403.5	1.5
August 5th-2018	2142.3	29.3	22.2	897.1	2.3	31.7	22.0	0.5	9.6	32.8	22.5	60.6	6.5
July 20th-2018	1657.0	29.3	22.8	488.9	0.8	28.3	21.9	615.4	1.9	31.1	22.3	33.1	6.8
June 20th-2022	1465.0	29.0	23.2	703.0	1.4	29.4	23.8	91.3	2.1	29.8	23.6	431.1	3.4
Average	4084.7	30.0	23.1	513.9	2.6	29.9	22.9	187.5	2.8	30.3	23.0	306.7	3.6
Standard deviation	1402.3	0.8	0.6	213.4	1.1	1.1	0.7	151.4	2.1	0.9	0.6	205.4	1.8

P1- Transplanting to active tillering, P2- Active tillering to panicle initiation, P3- Panicle initiation to booting
Tmax- Maximum temperature, Tmin- Minimum temperature, RF- Rainfall and BSS- Bright sunshine hours

Table 2. Phenophase wise weather for obtaining assured yield for rice (contd.)

Planting date/ year	Yield (kg ha^{-1})	Tmax-P4 (°C)	Tmin-P4 (°C)	RF-P4 (mm)	BSS-P4 (hrs)	Tmax-P5 (°C)	Tmin-P5 (°C)	RF-P5 (mm)	BSS-P5 (hrs)	Tmax-P6 (°C)	Tmin-P6 (°C)	RF-P6 (mm)	BSS-P6 (hrs)
Planting date/year	6712.5	28.3	22.6	580.1	0.7	30.0	23.4	22.2	4.2	30.1	22.5	298.4	4.3
June 5th-2013	6520.0	28.7	22.3	236.3	1.3	30.5	22.1	26.8	5.4	30.6	22.5	373.9	5.2
July 20th-2013	6440.0	27.8	23.1	288.6	0.0	28.8	22.5	62.2	0.5	30.1	23.4	452.5	4.1
June 5th-2014	6430.0	32.8	23.1	77.0	4.3	30.3	22.4	222.4	3.4	31.4	22.6	178.2	4.3
July 20th-2017	6405.0	29.4	22.2	118.6	2.7	28.9	22.6	192.9	2.2	30.8	22.2	274.7	5.6
July 5th-2013	5807.5	30.9	23.6	31.4	4.6	30.7	23.7	55.6	3.8	31.4	23.7	352.8	5.6
June 5th-2015	5782.5	30.3	23.6	52.5	6.0	31.1	23.7	18.2	4.6	30.3	23.5	98.4	6.1
June 20th-2016	5750.0	30.8	23.7	87.1	4.4	29.6	23.9	72.1	2.7	30.9	23.3	463.8	3.4
June 5th-2017	5700.0	30.1	23.0	52.7	4.0	30.5	22.8	39.7	3.8	30.4	23.4	116.6	5.6
June 5th-2016	5622.5	29.9	22.7	35.5	5.3	31.5	23.1	0.0	6.4	30.0	22.1	344.3	3.8
June 20th-2013	5590.0	30.2	23.1	125.5	2.5	30.5	22.7	56.0	3.2	31.1	23.0	525.3	4.0
June 20th-2017	5430.0	30.8	22.9	38.5	3.7	31.0	22.5	60.2	2.9	31.9	22.3	149.5	5.3
August 5th-2017	5320.0	31.5	23.4	26.5	4.2	33.0	22.8	72.2	3.6	31.3	22.7	326.2	4.4
July 5th-2017	5225.0	30.8	23.5	70.7	3.4	28.9	24.0	38.1	0.8	31.6	23.6	82.5	6.2
July 5th-2022	4835.0	30.8	21.8	24.6	5.3	30.9	21.8	12.3	6.2	31.4	23.5	359.4	5.6
August 5th-2013	4775.0	32.0	24.0	37.4	5.8	30.2	23.5	92.8	3.8	30.9	23.3	284.6	5.1
June 20th-2014	4700.0	30.9	23.3	3.0	6.5	31.6	22.9	0.0	9.3	32.3	23.8	294.7	4.8
July 20th-2014	4475.0	30.6	23.0	0.6	4.8	30.8	24.2	9.4	6.6	31.0	23.3	75.6	5.5
July 5th-2016	4380.0	32.0	23.6	114.0	6.3	31.2	23.3	7.0	6.0	31.8	23.8	228.8	5.9
June 20th-2015	4376.8	27.8	21.8	605.6	1.5	30.8	22.1	1.5	6.7	32.1	22.3	150.4	6.3
June 20th-2018	4195.0	30.4	23.1	31.5	6.5	30.8	23.5	20.6	6.2	32.2	23.7	244.9	5.3
July 5th-2014	4142.5	31.2	23.7	30.4	3.9	30.8	23.2	18.8	1.7	32.5	24.1	271.2	6.1
July 20th-2015	4092.5	30.7	23.7	25.6	3.9	30.7	23.5	25.4	5.2	31.1	23.0	37.5	5.7
July 20th-2016	4070.0	32.5	24.0	80.4	5.0	31.9	23.5	72.3	3.9	31.9	23.5	237.6	4.7
August 5th-2014	3950.0	30.4	23.3	128.7	2.5	30.4	23.5	33.1	3.3	30.0	23.4	405.5	2.3
June 5th-2021	3950.0	31.2	21.9	64.2	6.7	30.0	21.3	122.8	2.3	32.2	22.0	161.1	5.8
August 5th-2020	3805.0	32.0	23.6	68.6	5.6	30.4	23.5	97.8	4.5	32.4	24.0	195.1	4.9

P4- Booting to heading, P5- Heading to 50% flowering and P6- 50% flowering to physiological maturity
Tmax- Maximum temperature, Tmin- Minimum temperature, RF- Rainfall and BSS- Bright sunshine hours

Table 2. Phenophase wise weather for obtaining assured yield for rice (contd.)

Planting date/ year	Yield (kg ha^{-1})	Tmax-P4 (°C)	Tmin-P4 (°C)	RF-P4 (mm)	BSS-P4 (hrs)	Tmax-P5 (°C)	Tmin-P5 (°C)	RF-P5 (mm)	BSS-P5 (hrs)	Tmax-P6 (°C)	Tmin-P6 (°C)	RF-P6 (mm)	BSS-P6 (hrs)
July 5th-2015	3792.5	31.3	23.2	109.8	4.1	31.8	23.6	6.6	8.0	32.0	23.9	291.4	5.5
June 5th-2020	3775.0	28.7	22.8	360.8	0.2	27.3	21.8	102.4	0.1	30.8	23.0	376.0	3.8
August 5th-2016	3717.5	30.6	23.5	0.0	6.4	31.5	22.4	0.0	3.5	31.8	22.4	40.2	5.1
June 5th-2019	3655.0	29.7	23.0	552.2	1.8	26.7	20.5	417.9	0.5	30.2	21.9	768.6	1.8
June 20th-2019	3609.0	30.1	22.5	53.7	1.3	30.1	22.0	72.4	1.8	31.2	21.8	615.7	3.5
July 20th-2022	3475.0	31.5	23.5	19.5	7.1	32.6	23.9	0.4	8.9	32.1	23.6	69.6	6.2
July 5th-2021	3450.0	30.3	23.9	135.6	3.4	31.9	24.4	8.2	4.3	30.9	23.6	508.8	4.1
August 5th-2022	3400.0	31.4	24.0	9.1	4.6	31.8	22.9	14.7	5.3	32.8	23.6	73.7	6.5
July 5th-2018	3174.3	31.9	22.6	0.7	7.3	32.6	22.3	0.2	8.1	32.9	23.0	420.6	5.4
June 20th-2021	3075.0	30.3	23.5	81.6	2.0	30.1	23.4	59.2	4.2	30.5	23.8	365.9	3.8
June 5th-2018	2808.3	29.8	22.8	204.9	1.6	28.5	22.2	60.8	0.1	30.3	22.2	648.5	5.5
July 5th-2019	2775.0	31.4	22.4	75.6	3.5	31.2	22.2	31.8	3.0	32.5	21.6	445.6	5.7
July 5th-2020	2675.0	30.1	22.3	115.2	0.9	29.1	22.0	83.2	0.8	29.9	22.0	584.0	3.3
July 20th-2021	2650.0	32.3	24.3	8.2	5.4	31.1	23.7	14.1	7.1	31.2	23.5	615.4	3.5
July 20th-2020	2625.0	27.7	21.8	124.0	0.0	30.7	21.9	3.7	5.1	30.6	21.7	329.8	4.5
August 5th-2021	2625.0	32.2	24.0	113.9	4.3	29.6	23.3	229.5	2.4	31.3	23.5	550.9	2.9
June 20th-2020	2350.0	30.8	23.2	27.8	4.0	32.6	24.0	0.5	7.4	30.2	22.5	571.0	3.1
June 5th-2022	2340.0	28.1	23.1	378.5	1.3	30.0	23.7	45.8	4.6	30.5	23.8	285.4	4.2
August 5th-2019	2269.0	33.5	21.8	22.2	7.2	33.2	22.4	12.9	7.3	32.3	20.9	599.7	5.5
July 20th-2019	2250.0	32.0	22.7	16.3	4.8	30.2	21.6	34.5	0.8	32.5	21.5	437.7	5.7
August 5th-2018	2142.3	32.9	22.6	161.0	4.3	32.4	24.3	14.9	5.0	32.9	23.1	190.1	6.6
July 20th-2018	1657.0	31.7	23.0	0.9	5.8	33.0	22.0	1.5	8.9	32.9	22.9	419.1	5.5
June 20th-2022	1465.0	31.9	24.2	24.4	8.1	28.4	23.1	82.6	1.7	31.0	23.7	199.9	5.1
Average	4084.7	30.7	23.1	112.6	4.0	30.6	22.9	55.0	4.2	31.3	23.0	327.8	4.9
Standard deviation	1402.3	1.4	0.7	146.5	2.1	1.4	0.9	74.9	2.5	0.9	0.8	180.5	1.1

P4- Booting to heading, P5- Heading to 50% flowering and P6- 50% flowering to physiological maturity
Tmax- Maximum temperature, Tmin- Minimum temperature, RF- Rainfall and BSS- Bright sunshine hours

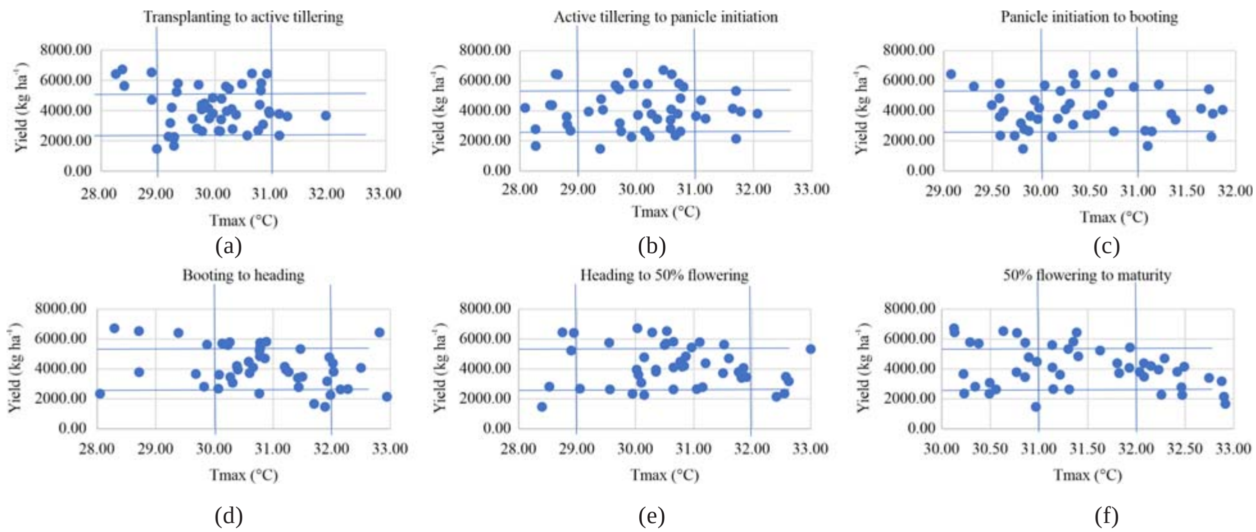


Fig. 2. Influence of optimum maximum temperature during each phenophase i.e. transplanting to active tillering (a), active tillering to panicle initiation (b), panicle initiation to booting (c), booting to heading (d), heading to 50% flowering (e), 50% flowering to maturity (f)

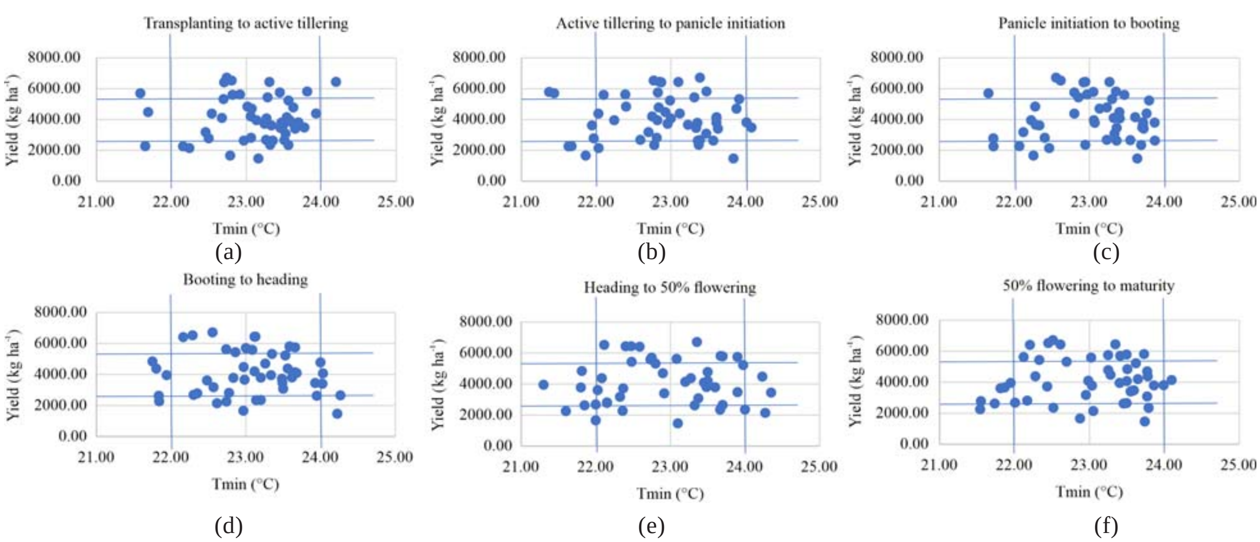


Fig. 3. Influence of optimum minimum temperature during each phenophase i.e. transplanting to active tillering (a), active tillering to panicle initiation (b), panicle initiation to booting (c), booting to heading (d), heading to 50% flowering (e), 50% flowering to maturity (f)

24°C for minimum temperature, with bright sunshine hours ranging between 2.2 to 5.5 hours and rainfall range between 135 - 425 mm. Throughout the heading stage, the maximum temperature ranged from 30 to 32°C, with a minimum of 22 to 24°C, bright sunshine ranging from 2.2 to 6.3 hours, and range of rainfall between 50 - 140 mm. Similarly, during the 50% flowering stage, there was a range of maximum temperatures from 29 to 32°C, minimum temperatures from 22 to 24°C, bright sunshine lasting from 2.0 to 6.9 hours, and range of rainfall between 32 - 79 mm. The physiological maturity stage encountered temperatures between 31-32°C for maximum and 22-24°C for minimum temperature. Bright sunshine (BSS) of 3.7 - 6.0 hours and rainfall range between 170 - 485 mm during physiological maturity phases significantly contributed to improved crop yield.

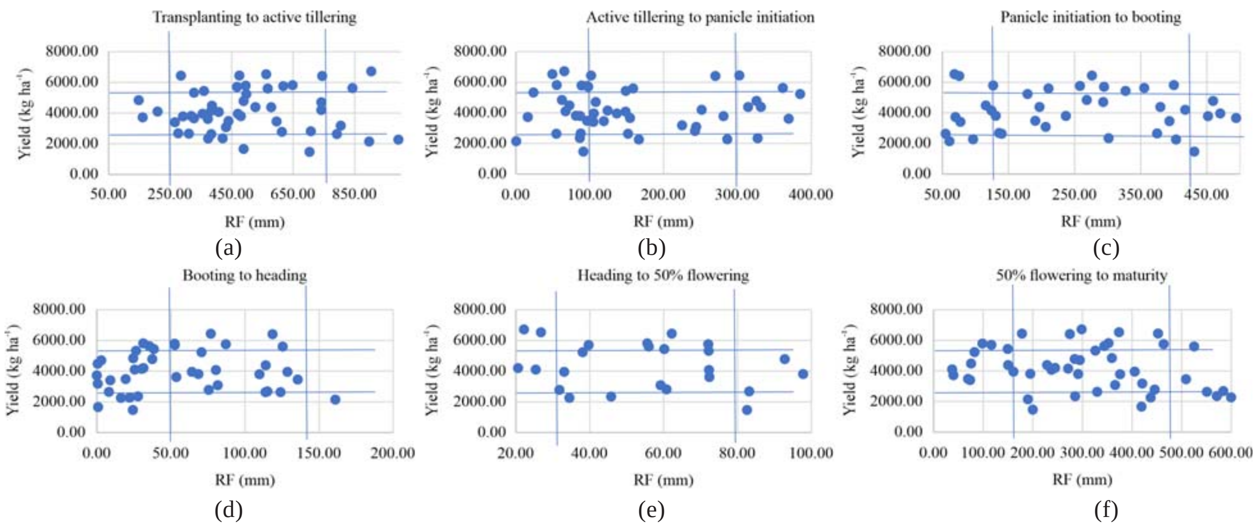


Fig. 4. Influence of optimum rainfall during each phenophase i.e. transplanting to active tillering (a), active tillering to panicle initiation (b), panicle initiation to booting (c), booting to heading (d), heading to 50% flowering (e), 50% flowering to maturity (f)

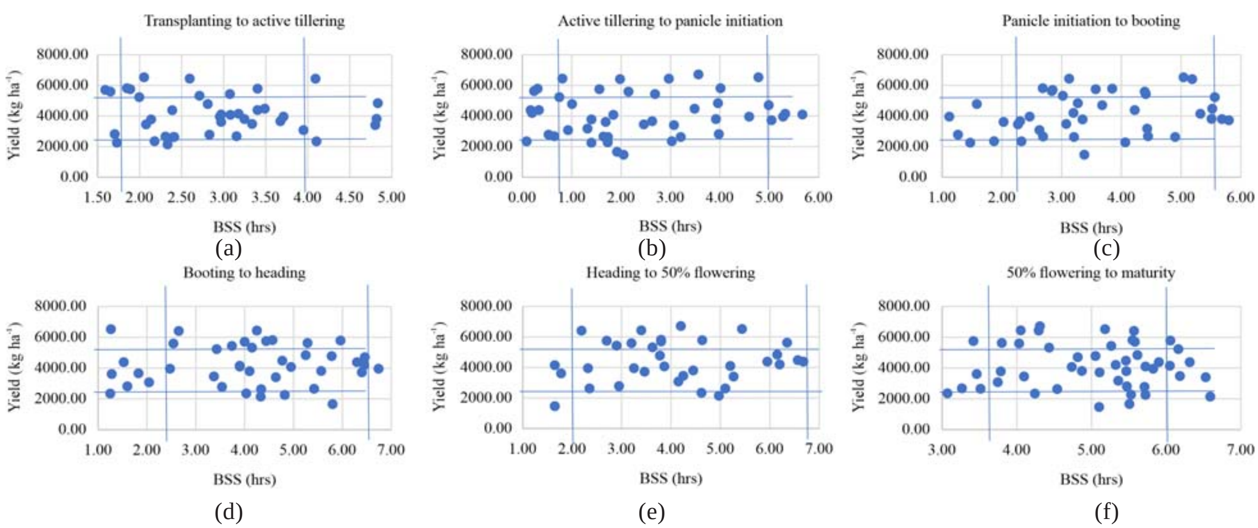


Fig. 5. Influence of optimum bright sunshine hours during each phenophase i.e. transplanting to active tillering (a), active tillering to panicle initiation (b), panicle initiation to booting (c), booting to heading (d), heading to 50% flowering (e), 50% flowering to maturity (f)

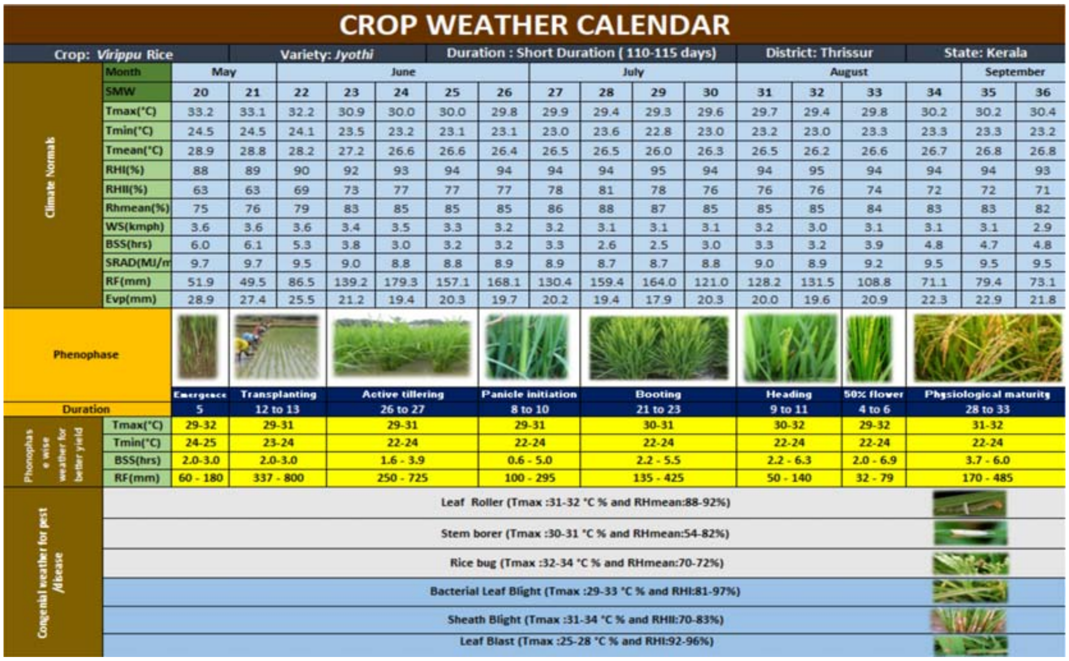
Congenial weather for pest and diseases of rice

Congenial weather for pests and diseases of rice was collected from different literatures:

Stem borer: Certain weather conditions favor the stem borer incidence, including maximum temperatures (Tmax) ranging between 30-31°C and an average relative humidity (RHmean) ranging from 54 - 82% (Adiroubane *et al.*, 2010).

Rice bug: The rice bug tends to experience increased infection rates under specific favorable weather conditions. These include maximum temperature (Tmax) ranges of 32-34°C and an average relative humidity ranging between 70-72% (Gupta *et al.*, 2018).

Bacterial leaf blight: The bacterial leaf blight disease demonstrates high susceptibility to thrive under varied weather conditions. These conditions



CROP WEATHER CALENDAR

Crop: *Virippu* Rice | Variety: *Jyothi* | Duration : Short Duration (110-115 days) | District: Thrissur | State: Kerala

	Month	May		June					July				August				September	
Climate Normals	SMW	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	Tmax(°C)	33.2	33.1	32.2	30.9	30.0	30.0	29.8	29.9	29.4	29.3	29.6	29.7	29.4	29.8	30.2	30.2	30.4
	Tmin(°C)	24.5	24.5	24.1	23.5	23.2	23.1	23.1	23.0	23.6	22.8	23.0	23.2	23.0	23.3	23.3	23.3	23.2
	Tmean(°C)	28.9	28.8	28.2	27.2	26.6	26.6	26.4	26.5	26.5	26.0	26.3	26.5	26.2	26.6	26.7	26.8	26.8
	RHI(%)	88	89	90	92	93	94	94	94	94	95	94	94	95	94	94	94	93
	RHII(%)	63	63	69	73	77	77	77	78	81	78	76	76	76	74	72	72	71
	Rhmean(%)	75	76	79	83	85	85	85	86	88	87	85	85	85	84	83	83	82
	WS(kmph)	3.6	3.6	3.6	3.4	3.5	3.3	3.2	3.2	3.1	3.1	3.1	3.2	3.0	3.1	3.1	3.1	2.9
	BSS(hrs)	6.0	6.1	5.3	3.8	3.0	3.2	3.2	3.3	2.6	2.5	3.0	3.3	3.2	3.9	4.8	4.7	4.8
	SRAD(MJ/m	9.7	9.7	9.5	9.0	8.8	8.8	8.9	8.9	8.7	8.7	8.8	9.0	8.9	9.2	9.5	9.5	9.5
	RF(mm)	51.9	49.5	86.5	139.2	179.3	157.1	168.1	130.4	159.4	164.0	121.0	128.2	131.5	108.8	71.1	79.4	73.1
	Evp(mm)	28.9	27.4	25.5	21.2	19.4	20.3	19.7	20.2	19.4	17.9	20.3	20.0	19.6	20.9	22.3	22.9	21.8
Phenophase		Emergence	Transplanting		Active tillering			Panicle initiation		Booting			Heading		50% flower	Physiological maturity		
Duration		5	12 to 13		26 to 27			8 to 10		21 to 23			9 to 11		4 to 6	28 to 33		
Phonophase wise weather for better yield	Tmax(°C)	29-32	29-31		29-31			29-31		30-31			30-32		29-32	31-32		
	Tmin(°C)	24-25	23-24		22-24			22-24		22-24			22-24		22-24	22-24		
	BSS(hrs)	2.0-3.0	2.0-3.0		1.6 - 3.9			0.6 - 5.0		2.2 - 5.5			2.2 - 6.3		2.0 - 6.9	3.7 - 6.0		
	RF(mm)	60 - 180	337 - 800		250 - 725			100 - 295		135 - 425			50 - 140		32 - 79	170 - 485		

Congenial weather for pest /disease

Leaf Roller (Tmax :31-32 °C % and RHmean:88-92%)

Stem borer (Tmax :30-31 °C % and RHmean:54-82%)

Rice bug (Tmax :32-34 °C % and RHmean:70-72%)

Bacterial Leaf Blight (Tmax :29-33 °C % and RHI:81-97%)

Sheath Blight (Tmax :31-34 °C % and RHII:70-83%)

Leaf Blast (Tmax :25-28 °C % and RHI:92-96%)

Fig. 6. Crop weather calendar for rice

encompass maximum temperatures (Tmax) varying from 29 to 33°C and a forenoon relative humidity (RH-I) spanning between 81 and 97% (Reddy *et al.*, 2015).

Leaf roller: There are certain favorable weather conditions for leaf roller insect which increase its infection rate such as maximum temperature (Tmax) ranges of 31-32°C and mean relative humidity (RHmean) from 88-92% (Plantix. (n.d.)

Sheath blight: Sheath blight disease shows more susceptibility under particular favorable weather circumstances. These conditions involve maximum temperatures (Tmax) between 31-34°C and afternoon relative humidity (RH-II) ranging from 70-83% (Pal *et al.*, 2017).

Leaf blast: The susceptibility of leaf blast disease is amplified under specific favorable weather conditions. These conditions include maximum temperatures (Tmax) ranging from 25-28°C and forenoon relative humidity (RH-I) levels spanning between 92-96% (Padmanabhan, 1962).

Conclusion

Crop weather calendar (CWC) serves as a comprehensive guide detailing the entire life cycle of a crop, spanning from sowing to maturity. It encompasses critical stages such as vegetative growth, flowering, grain development, and maturity. These calendars offer insights into expected weather patterns during each growth phase, warning based on prevailing weather conditionsat different stages, and weather conditions conducive to crop pest and diseases. Their significance lies in aiding crop planning, irrigation scheduling, and implementing effective plant protection measures. This resource plays a crucial role in optimizing and ensuring food security.

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