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Study on Crop-weather Calendar of Rice for the District of Faizabad of Eastern Plain Zone of UP

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ABSTRACT: An investigation entitled "Study on crop-weather calendar of Rice for the district of Faizabad of eastern plain zone of UP" was carried out at the Department of Agricultural Meteorology, ANDUA&T, Kumarganj, Ayodhya. A Crop weather calendar for rice crop has been prepared for district Faizabad through the collection of historical weather data of last 20 years (2000- 2020). The Crop weather calendar for rice was formulated by combining the weekly climatic averages and phenological calendar for the crop along with the optimum weather criteria needed at different phenological stages of the crop. The Climatic normal for rice crop has been taken formthe25th Standard meteorological week to the 43rd Standard meteorological week (from sowing to harvesting). According to the crop weather calendar rice crop, the maximum temperature for rice crop during emergence was 32.7°C and the minimum temperature was 26.8°C, respectively. During these edling phase to transplanting, maximum temperature and minimum temperature were observed 31-34°C and 25-26°C, respectively, while morning humidity and evening humidity were found at 87-88% and 69-76% respectively. Rainfall during transplanting till heading has been found 22.5 mm to 80mm, while during flowering it was found to be 29 mm. During the grain filling stage maximum temperature 34-32°C and minimum temperature 21-22°C, while at the phase of physiological maturity, maximum temperature 34°C and minimum temperature 19-17.5°C were found conducive. For gall midge, maximum temperature 32-35°C, minimum temperature 23-26°C, rainfall of 66-39 mm during 26th to 39th Standard meteorological week with morning humidity 82-88% were found to be conducive for the infestation. Maximum temperature 30-32°C, minimum temperature 14-27°C, morning humidity >90% and rainfall of 23-51mm were found conducive weather requirements for infestation of yellow stem borer. These conditions were found to be prevail during the 28th-29th meteorological week i.e., seedling and transplanting stage of rice crop to 37th to 38th meteorology. week i.e., flowering stage of the crop. Maximum temperature 32-35°C and minimum temperature 24-26°C with morning humidity 96-99% and evening humidity 75-81% were found to be conducive to the incidence of rice hispa insect in paddy.

Keywords: Crop-weather calendar, Rice, climatic normal.

INTRODUCTION

Rice (*Oryza sativa* L.) belongs to family Poaceae. It's a kharif season crop. It's a self-pollinated, short -day and C3 plant. In India its cultivation is confined between 8°N to 34° N latitudes. Rice is the major crop in Uttar Pradesh and is grown in about 5.90 mha, which comprises of 13.5% of total rice in India. Uttar Pradesh has favourable and suitable climate, vast areas of fertile soils, sunshine and adequate water resources. The cropping intensity is 153%. The state ranks 3rd in the country in production of rice. The major area under lowland and flood prone is located in eastern part of Uttar Pradesh covering 15 districts which constitute about 30% of the total rice cultivated area in the state.

In 2020, rice production for Uttar Pradesh was 15.52 million tonnes. Though Uttar Pradesh rice production fluctuated substantially in recent years, it tended to increase through 2017-2020 period ending at 15.52 million tonnes in 2020. Rice requires a warm and humid climate and 100-150 cm average annual rainfall. In India, the area under irrigated rice is 58.7% of total rice area.

The growth and development stages of rice are divided into four main phases. The duration of its vegetative phase is 50-60 days, which is subdivided into seedling and nursery stages (4-6 leaves), transplanting stage and tillering (35-40 DAT). Reproductive phase splits as Panicle initiation (PI), which starts at 50-60 DAT,

internode elongation & booting phases, heading stage and flowering stage. Rice ripening takes 25-35 days, with milking taking 7-12 days after anthesis and dough stage taking 2-3 weeks. Joint effect of weather variables (individual and interaction effects) in rice and found the particular significant impacts of rainfall and wind velocity. Besides these weather variables sun shine (hrs.) has also been found to have an individual and interaction impact. The individual effects of wind velocity, sunshine (hrs.) and rainfall and the interaction effects of wind velocity and rainfall is relatively more important for rice yield (Pandey *et al.,* 2015). At maturity, grains turn hard andare free from greenish flecks. Anaverage temperature of 21-37°C is required during the period of growth of the crop. Blooming in rice requires 26.5-29.5°C while PI and ripening require 20-25°C, respectively. High night temperature (>30 °C) reduces crop yield in rice crop and it causes rise in respiratory rate, subsequently, decreases photosynthesis rate, amount of dry matter (DM), and leaf area and high daytime temperature (>40 °C) affects negatively the rice cultivation, as high day time temperature generates an increase in respiratory rate, and therefore, a reduction in photosynthesis rate by non-stomatal limitations (Alvarado *et al.,* 2017; Sanchez *et al.,* 2014). The rice crop transplanted on 25th June can take maximum days, growing degree days, heliothermal units and photothermal units, to attain various phenological stages untill physiological maturity which reduced significantly with the latter delay in transplanting date (Abhilash *et al*., 2017).

The Crop weather calendar is a comprehensive guide with information of whole crop phenology and their optimum weather requirements which helps the forecaster determine average weather for every week, planting, sowing and harvesting periods of locally adopted crops in a specific agro-ecological zone. It also provides information on the sowing rates of seed and planting material and the so the most agricultural practices. This tool supports farmers and agriculture extensionists in taking appropriate decisions on crops and their sowing period, respecting the agro-ecological dimension. It also provides a strong base for emergency/contingency planning for the rehabilitation of farming systems after disasters (Rao *et al*., 2015). IMD (India Meteorological Department) is doing commendable work in the direction of crop weather calendar for farming community in such a way that every single issue gets addressed appropriately in a time bound manner. IMD collects information from the scientists of different agriculture departments and presents it in a pictorial form, often called as Crop Weather Calendar (Kaur *et al.,* 2013).

MATERIALS AND METHODS

Geographical Location of Study Area. Uttar Pradesh situated between 23°52` N and 31°28'N latitudes and 77°3' and 84°39'E longitudes, this is the fourth largest state in country in terms of area, first in the terms of population. Uttar Pradesh falls under three agro-climatic zones viz. Agro-Climatic Zone-IV: Middle Gangatic Plains region, Agro-climatic region zone-V: Upper Gangatic Plains region and Agro Climatic Zone - VIII: Central Plateau and hills region.

This Agro-Climatic zone IV is further divided into three sub-zone:

1) North Eastern Plains Zone (NEPZ) of Uttar Pradesh,
2) Eastern Plains Zone (EPZ) of Uttar Pradesh and
3) Vindhyan Zone of Uttar Pradesh.

Eastern Plain Zone UP covers the 10 districts namely Barabanki, Faizabad, Sultanpur, Jaunpur, Azamgarh, Mau, Ballia, Ghazipur, Varanasi and Sant Ravidas Nagar. Rainfall is adequate with a normal of 1,025 mm. The climate is dry sub-humid to moist sub-humid. Over 70% of the land is cultivated and more than 80% of the cultivated area is irrigated.

Weather Data. Weather data for thelast twenty years (2000-2020) were collected fromthe Department of Agricultural Meteorology, ANDUAT, Kuamrganj Ayodhya and IMD. Weekly climatic normals for standard meteorological weeks (1st-52nd) for Faizabad district were computed.

The collected weather data of Faizabad district were arranged and calculated to find the average, summation, maximum and minimum values which was used for further analysis.

The Crop weather calendar for the rice crop for district Faizabad was formulated by combining the weekly climatic averages and phenological calendar for the crop along with the optimum weather criteria needed at different phenological stages of the crop. The processing of data was done on the basis of the standard date of sowing recommended for given crops and the standard average duration of the crop. The collected weather data was tabulated to find out average value of weather parameters *viz.* minimum temperature (Tmin), maximum temperature (Tmax), rainfall, morning relative humidity (RHm), evening relative humidity (RHe) and evaporation for further analysis. The range of different meteorological parameters for the higher production of wheat crop at district Faizabad was worked out from the actual meteorological data of the high productivity crop year, which was collected from the ATIC of ANDUA&T, Kumarganj Ayodhya.

The range of the different meteorological parameters for the high productivity of the major crops at eastern plain zone of UP was worked out from the actual meteorological data of high productivity crop year.

Table 1: Climatic Normal for Weather Parameters (2000-2020).

Week/ Weather Parameter	Tmin (°C)	T max (°C)	RHm (%)	RHe (%)	Rainfall (mm)	Evp (mm/day)	Bss(hrs.)
1	6.7	19.1	89.8	63.8	4.7	12.0	4.49
2	6.1	19.3	85.9	61.1	1.1	13.5	4.72
3	7.2	20.8	86.6	57.6	5.2	14.1	5.71
4	7.0	21.3	88.2	56.3	5.3	15.4	7.28
5	7.7	22.8	87.7	53.2	1.3	18.2	6.73
6	8.6	24.5	90.0	52.7	5.7	20.6	7.18
7	9.6	23.5	86.1	51.1	3.5	21.4	8.7
8	10.8	27.0	86.2	46.2	5.5	25.1	8.49
9	11.9	27.8	83.6	43.8	3.6	26.4	8.32
10	12.2	29.5	79.9	42.1	4.2	27.2	8.56
11	13.5	30.6	78.6	40.4	2.5	30.3	8.39
12	14.9	33.2	74.1	34.9	0.4	34.5	8.38
13	16.1	34.0	71.7	30.6	0.4	36.6	8.7
14	17.0	36.3	68.8	31.1	0.7	40.8	8.81
15	19.2	36.3	62.5	28.8	0.8	48.3	8.81
16	21.1	37.9	66.6	32.1	1.4	47.0	9
17	21.7	40.1	62.9	31.4	3.5	50.5	9.15
18	23.0	37.4	69.2	32.8	5.1	48.7	9.34
19	23.8	39.0	67.0	33.5	5.1	52.6	9.3
20	24.0	39.1	69.4	34.7	3.7	54.0	9.18
21	25.6	38.6	70.6	36.7	5.5	52.4	8.41
22	25.4	38.7	69.2	40.2	10.9	51.7	8.6
23	25.9	38.5	73.2	43.8	25.1	51.4	8.13
24	26.5	37.7	72.8	48.1	22.7	47.5	7.24
25	26.7	35.7	80.3	57.7	38.3	41.9	5.69
26	26.7	35.4	82.2	59.6	66.2	37.0	4.57
27	26.5	33.5	85.0	70.2	68.4	32.4	4.89
28	25.8	33.1	87.8	71.3	57.7	36.0	4.11
29	26.0	32.9	87.9	72.5	71.0	31.1	4.85
30	26.3	32.8	88.6	72.4	45.1	29.3	5.68
31	26.2	32.0	87.9	71.7	44.4	29.3	4.92
32	26.4	33.3	85.7	70.6	40.8	32.6	4.95
33	26.1	33.1	90.4	74.7	67.0	27.4	4.38
34	26.2	32.4	89.6	73.4	51.7	31.0	4.45
35	26.0	29.5	89.2	70.1	30.8	33.6	5.42
36	25.8	32.9	86.9	70.2	37.4	31.6	4.59
37	25.6	32.9	89.4	70.1	36.5	32.5	5.06
38	25.0	32.7	89.1	69.7	35.9	31.8	6.07
39	23.8	32.6	88.3	69.1	39.7	30.5	6.52
40	22.9	32.6	86.2	64.7	11.3	32.8	7.17
41	21.0	32.9	85.3	59.8	6.7	32.2	7.5
42	19.2	32.1	86.8	52.6	5.2	31.1	8.19
43	16.9	31.3	87.1	50.9	0.5	28.3	7.69
44	15.4	30.4	87.5	48.3	0.0	27.0	8.26
45	13.9	29.9	89.0	49.6	0.3	25.8	7.89
46	13.2	28.9	88.8	49.2	0.6	25.3	7.37
47	11.6	27.5	85.0	46.5	0.0	23.0	7.14
48	10.5	27.2	87.2	46.7	0.0	21.3	6.8
49	8.9	25.4	87.9	47.9	0.0	30.9	6.85
50	8.7	24.0	88.5	53.4	2.0	19.7	6.59
51	7.3	22.2	89.9	56.7	0.0	22.2	5.88
52	6.6	22.2	91.2	58.3	1.4	30.2	5.77

Table 2: Highest Productivity Year for Rice at Faizabad.

Year	2015	2016	2018	2020
Productivity of Rice qha^{-1}	253.58	242.56	249.67	74.64

The data on weather conditions favourable for the incidence of pests and nature of the weather warnings were collected. The investigation is based on data collection from pest investigations on rice and weather averaged over the last 5 years.

Structure of crop-weather calendar. The structure of the crop weather calendar consists of three main parts *viz*., upper part, which contains location specific weather data for the crop growing season, middle part, which shows the typical life history of the crop in the form of a diagram. Important "growth phases" related to the crop like sowing, germination/emergence, transplanting (in the case of rice), vegetative growth, flowering, grain formation and maturity period etc. are indicated. In addition, suited to the above acquaintance, the middle part of the calendars revealed the compatible meteorological condition for the crop (stage-wise or whole crop growth period) which will lead towards high yield of the crop. In the bottom part, favourable weather conditions for the incidence of pests and diseases are reported (Fig. 1).

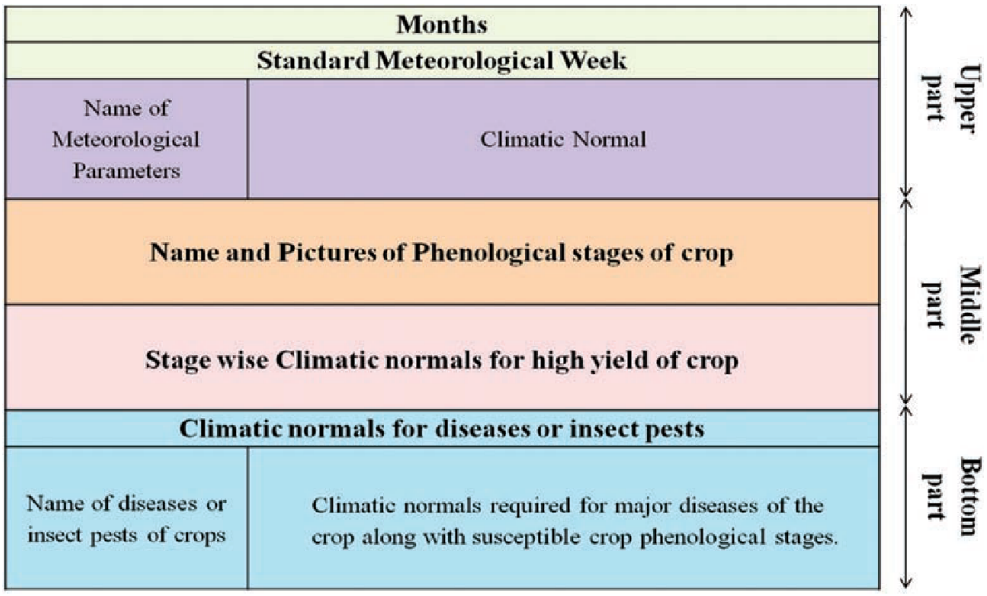

Fig. 1. Structure of crop weather calendar**.**

RESULTS AND DISCUSSION

Crop Weather Calendar for Rice (District Faizabad)

Climatic normal for rice at Faizabad. The climatic normal for the rice crop, has been taken from the 25th meteorological week to the 43rd meteorological week (from sowing to harvesting) at the upper part of the crop weather calendar for rice. The highest weekly normal rainfall (71mm) was found in 29th week, whereas the highest normal maximum temperature 35.7°C was found in the 25th week followed by 35.4°C during 26th met. Week and highest normal T min 26.7°C were found during the 25th and 26th week. The highest morning humidity (90.4%) was found in the 33th week and evening humidity (50%) was found in the43th week. Under low temperatures, delayed germination and seedling growth may result in non-uniform seedling growth and weak seedlings, which may affect the final grain yield. Similar results are reported by Cruz *et al*. (2006) (Fig. 2).

Phenophase-wise weather for better yield for rice:

Rice took 120-125 days to complete its life cycle in Faizabad. The data in the crop weather calendar represents that seed took 2-5 days to emerge. During the phase of emergence, the maximum temperature was 32.7°C and minimum temperature was 26.8°C. During transplanting, maximum temperature and minimum temperature were found 31-34°C and 25-26°C, respectively, while morning humidity and evening humidity were found to be 87-88% and 69-76%, respectively. Rainfall (22.5mm to 80mm) during transplanting till heading, followed by 29 mm during the flowering phenophase was found congenial for better yield. During the grain filling stage, maximum temperature was found 34-32°C and minimum temperature was found 21-22°C while at physiological maturity, maximum temperature and minimum temperature were found 34°C and 19-17.5°C, respectively. During the grain filling and maturity phases, BSS >6.5 and >7.5 hrs./day, respectively, were found conducive to a better yield of the crop. The temperature regime determines the growth. Low temperatures inhibit tillering. High rainfall during the vegetative phase found to be ideal. There is a negative impact of rainfall on rice production at the milking stage during the ripening phase. Similar results were reported by Abbas and Mayo (2020).

Congenial weather requirements for infestation of insect and diseases of Rice at District Faizabad

Rice hispa. *Dicaladipa armigera* (Oliver) is a series pest of rice. The adult of this insect scraps the upper

surface of leaf blade, leaving only upper epidermis. Damaged areas show white streaks parallel to the midrib. The pest is reported to be active in hot and humid conditions. Maximum temperature 32-35°C and minimum temperature 24-26°C with morning humidity 96-99% and evening humidity 75-81% were found to be congenial for the incidence rice hispa insect in paddy. These weather conditions were found to be prevail from the 28th meteorological week to the 32nd meteorological week, highly optimum for insect occurrence (Table 3).

Yellow stem borer. It bores and feeds inside the stem. They cut the growing parts of the plants from the base, causing the plant to die. The drying of the growing parts of the plant is known as 'dead heart'. Maximum temperature 30-32°C, minimum temperature 14-27°C, morning humidity >90% and rainfall of 23-51mm were conducive weather requirements for infestation of yellow stem borer. These conditions were found to be prevail during the 28th-29th meteorological week, i.e., seedling and transplanting stages of the rice crop to the 37th to 38th meteorological week, i.e., flowering stage of the crop, (Table 3) & (Fig. 2).

Gall midge. The damage to the crop is done by the larvae, which form galls commonly known as "silver shoots" or "onion shoots". The rice plant is stunted and the seed heads fail to develop. Insect abundance is directly affected by environmental temperature and due to its poikilothermic nature, their response to temperature fluctuations is quick.

Maximum temperature 32-35°C, minimum temperature 23-26°C, rainfall of 66-39mm during 26th to 39th Standard meteorological week with morning humidity 82-88% were found conducive conditions for the infestation of gall midge (Table 4). Maximum population density was found during 38th and 39th weeks due to higher humidity condition with rainfall and a slight lower temperature providing leaf wetness, which was found to be favourable for insect multiplication.

Table 3: Weather parameters for Yellow Stem Borer and Rice Hispa. (Averaged over 5 years)

Std. Met. Week No.	T max (°C)	T min (°C)	RHm %	RHe %	RF (mm)	Yellow stem borer DH (%)	Rice Hispa Damaged leaf (%)
33	32.1	26.6	90.7	75.8	46.0	0.8	1.6
34	33.7	26.4	90.0	73.6	51.2	2.5	2.4
35	33.0	26.2	87.6	73.3	31.3	4.2	1.3
36	32.7	26.1	88.1	67.4	21.0	5.5	1.0
37	33.5	26.1	89.8	69.3	23.4	6.0	0.5
38	34.1	25.3	90.2	69.7	34.7	6.3	0.3
39	33.9	23.4	88.9	68.8	58.7	5.3	0.0
40	33.0	21.8	87.7	59.8	4	4.7	0.0
41	32.0	20.6	86.5	56.0	4	4.5	0.0
42	33.0	19.1	87.4	50.1	0	4.1	0.0

Table 4: Population of gall midge with relation to weather parameters. (Averaged over 5 years)

Std. Met. Week No.	T min (°C)	T max (°C)	RHm %	RHe %	RF (mm)	Population of gall midge
26	26.7	35.4	82.2	59.6	66.2	30
27	26.5	33.5	85.0	70.2	68.4	30
28	25.8	33.1	87.8	71.3	57.7	30
29	26.0	32.9	87.9	72.5	71.0	32
30	26.3	32.8	88.6	72.4	45.1	33
31	26.2	32.0	87.9	71.7	44.4	33
32	26.4	33.3	85.7	70.6	40.8	34
33	26.1	33.1	90.4	74.7	67.0	34
34	26.2	32.4	89.6	73.4	51.7	35
35	26.0	29.5	89.2	70.1	30.8	35
36	25.8	32.9	86.9	70.2	37.4	35
37	25.6	32.9	89.4	70.1	36.5	35
38	25.0	32.7	89.1	69.7	35.9	38
39	23.8	32.6	88.3	69.1	39.7	38

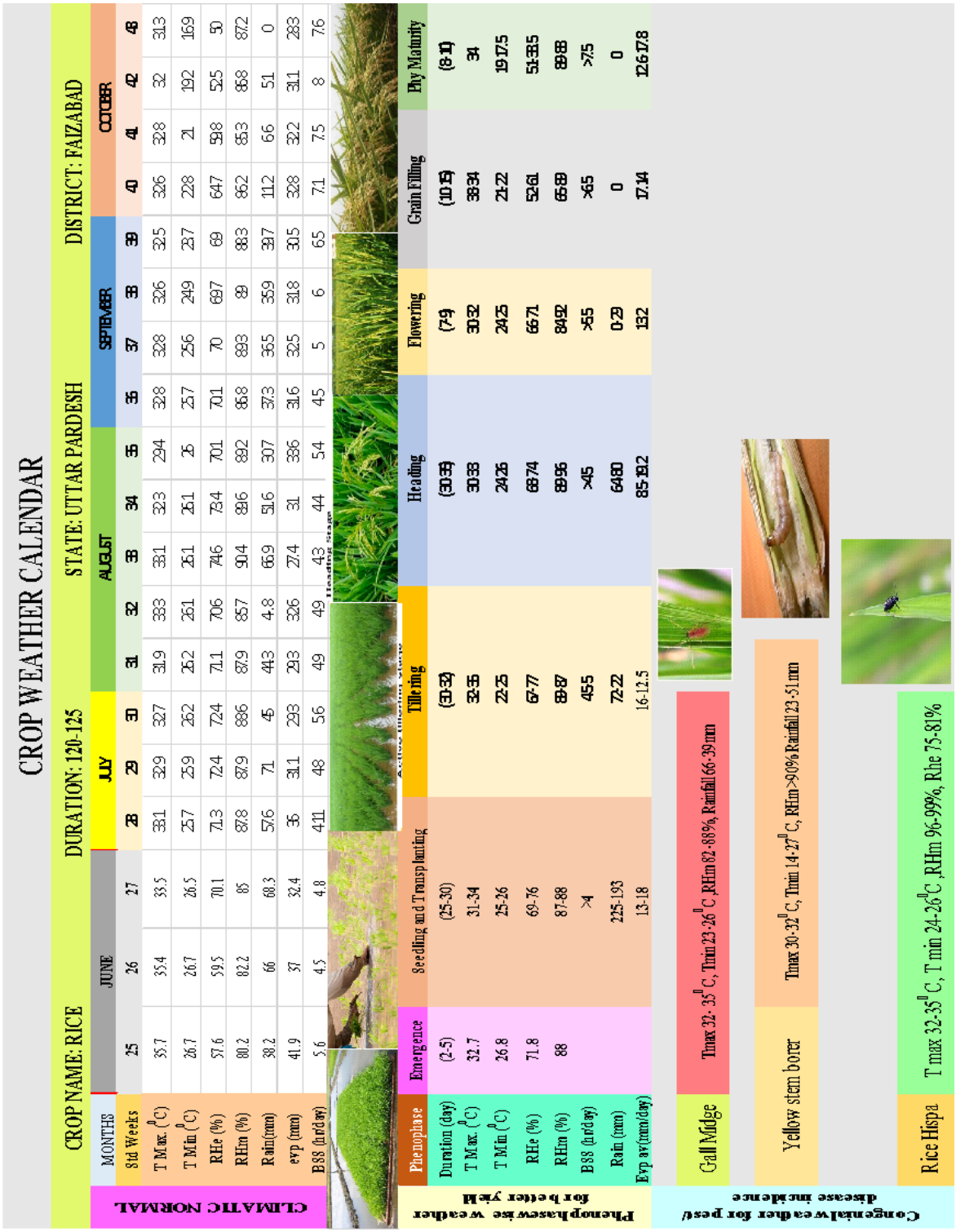

Fig. 2. Crop Weather Calendar for Rice.

CONCLUSIONS

The highest normal rainfall in 29th week 71mm, the highest maximum temperature 35.7°C in the 25th week and the minimum temperature 26.7°C during 25th and 26th week, morning relative humidity was 90.4% in the 33rdweek and evening relative humidity was 50% in the 43rdweek, were suitable climatic normal for rice in the district of Faizabad. During the phase of seedling to transplanting maximum temperature and minimum temperature 31-34°C and 25-26°C, respectively, were found optimum for the better yield of rice in the district of Faizabad. Rainfall during transplanting till heading has been found in the range of 22.5 mm to 80mm. Maximum temperature 32-35°C, minimum temperature 23-26°C, and humidity of 88% were found to be congenial weather requirements for the infestation of gall midge**,** yellow stem borer and rice hispa Tmax 30-35°C, T Min 14-27°C, RHm> 90% and rainfall 23-51 mm and for Tmax 32-35°C, Tmin 24-26°C, RHm >96% and RHe 75-81%, were found conducive. The crop weather calendar is a comprehensive guide of the weather requirements of the crop that provides

information the researcher as well as to the forecaster that will be utilised for the making decisions about the timing of sowing\transplanting, agronomic practices, water management and pest-disease management. The information of congenial weather requirement at every growth stage will help researchers, forecasters and farmers in the management the crop in adverse weather conditions and precautions can be taken to avoid losses.

FUTURE SCOPE

To increase utilization of the crop weather calendars, they can be prepared at the village panchayat level through research and development activities taken up for the major crops and varieties. They can be prepared according to different times of sowing of the same crop, i.e., timely, mid, and late conditions, as well as for the crop taken in rainfed and irrigated conditions, which will make crop weather calendars more dynamic. This will help in improving the quality of agro advisory services for the particular location and making the contingency plan, which may be sent directly to the stockholders, including farmers, on a weekly or fortnightly basis. This also helps identify extreme weather conditions at sensitive stages of the crop and facilitates planning ahead of the event(s) to save the crop.

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Conflict of Interest. None.

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