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Designing agromet advisories for selected weather windows under automated weather based advisory system in Tamil Nadu – A case study

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ABSTRACT

Research work was undertaken at Agro Climate Research Centre, Tamil Nadu Agricultural University Coimbatore, with the objective of developing agromet advisories for rice crop for 54 independent selected weather windows (SWW) covering eight rice growing seasons/systems of Tamil Nadu. This was done to provide weather-based agromet advisory to the farming community. Weather sensitive rice agromet advisories were developed for its nine stages through group discussions based on rice crop sensitiveness to SWW. The available literature on interaction between rice crop and weather elements at their different threshold levels was also properly considered during this exercise. Proto-type were run for one block of Tamil Nadu and thus problems identified for seeking solutions.

Key words: Developing, rice agromet advisories, selected weather window, automated weather advisory, proto-type.

Many studies on rice and weather interaction in the past (Oldeman *et al.,* (1986), Venkataraman and Krishnan (1992), Yin *et al*. (1996), Thakur *et al.* (2010)) reveals that (i) minimum temperature prevailed during pre-flowering stage of the cool dry season would extend the rice vegetative period, (ii) extremely heavy wet-season rainfall caused crop lodging with flooding, especially during flowering and harvest stages, (iii) high humidity during the wet season and relatively high temperature prevailing during both dry and wet seasons were favoured for heavy infestation of insect-pests and diseases, (iv) lower night temperature during post-flowering stage had positive correlation with the grain yield and (v) high diurnal differences led to more efficient energy conversion. Thereby suggesting, that the observed weather during crop growing season, would affect rice grain yield both through direct and indirect processes. These impacts or risks could be reduced to a level of minimum, though not fully, with suitable intervention from introduction of weather based agromet advisories, which will guide / help the farmers to take weather based farm decisions / interventions under response farming concept.

Considering this, an attempt was made to develop rice agromet advisories for 54 selected weather windows (SWW) that prevailed in Tamil Nadu covering both spatial and temporal dimensions in the ambit of automated weather based agromet advisory system being operated at ACRC, TNAU, under National Agricultural Development Programme of Government of Tamil Nadu.

MATERIALS AND METHODS

The development and fine-tuning of agromet advisories for rice crop for 54 selected weather windows (SWW) based on six days weather forecast was undertaken at ACRC of Tamil Nadu Agricultural University, Coimbatore between 2013 and 2014. Already identified 54 SWW, covering both spatial and temporal dimensions of Tamil Nadu weather (Balasubramanian *et al.,* 2014) were the base for defining the agromet advisories for rice in the present study and selected 18 are given in Table 1. The sequential steps to provide automated weather based rice agromet advisories to farmers through Short Message Service (SMS) to their mobiles are given below:

The already developed and validated 54 SWW, which contain ranges of each weather element (means values of six day maximum and minimum temperature; relative humidity and mean wind speed along with six day cumulative rainfall) were uploaded in the database of the server maintained at ACRC.

- The developed agromet advisories for each stage of rice for 54 SWW were also uploaded on the server . To

Table 1: Selected weather windows (SWW) (absolute range values)

SWW. No	Absolute range values of weather elements					Name of the selected weather windows (SWW)
	RF (mm)	Tmax (°C)	Tmin (°C)	Mean RH (%)	Wind speed (kmph)	
1	0	<20	<15	> 40	<5	Dry cool humid weather
2	0	30.1-35	15.1-20	> 40	<5	Dry warm humid weather
3	0	>35.1	15.1-20	> 40	<5	Dry hot humid weather
4	0.1-30	<20	<15	> 40	<5	Moist cool humid weather
5	0.1-30	30.1-35	15.1-20	> 40	<5	Moist warm humid weather
6	0.1-30	>35.1	15.1-20	> 40	<5	Moist hot humid weather
7	>30	<20	<15	> 40	<5	Wet cool humid weather
8	>30	30.1-35	15.1-20	> 40	<5	Wet warm humid weather
9	>30	>35.1	15.1-20	> 40	<5	Wet hot humid weather
10	0	<20	<15	> 40	>5	Windy dry cool humid weather
11	0	30.1- 35	15.1-20	> 40	>5	Windy dry warm humid weather
12	0	>35.1	15.1-20	> 40	>5	Windy dry hot humid weather
13	0.1-30	<20	<15	> 40	>5	Windy moist cool humid weather
14	0.1-30	30.1-35	15.1-20	> 40	>5	Windy moist warm humid weather
15	0.1-30	>35.1	15.1-20	> 40	>5	Windy moist hot humid weather
16	>30	20-30	<15	> 40	>5	Windy wet cool humid weather
17	>30	30.1-35	15.1-20	> 40	>5	Windy wet warm humid weather
18	>30	>35.1	15.1-20	> 40	>5	Windy wet hot humid weather

develop appropriate agromet advisories for rice crop for the selected 54 SWW, initially four group discussions were organized with subject experts from agronomy, plant pathology, agricultural entomology, crop physiology, agro-meteorology, agricultural extension and farmers from rice growing tracts. Thereafter, based on the literature, current available research information and group consensus, the weather based crop agromet advisories were fine tuned for nine crop stages of rice (Table 2). These nine stages of rice crop were chosen after a thorough group discussion with the farmers and extension workers in the State.

- The Automatic Weather Stations (AWS) installed in each block (385 blocks) were directly uplinked with the server maintained at ACRC, TNAU to have daily weather profile of the concerned block parameters including maximum and minimum temperature, relative humidity, wind speed and rainfall.

- Using the regional climate model (Weather Research Forecast), weather forecast were developed with lead-time of six days by utilizing Global Forecasting System outputs of National Centre for Environment Prediction, USA and the AWS observed weather over past six days.

- The information on observed weather over past six days and the forecast developed for the next six days, will then get automatically compressed to mean values for maximum and minimum temperature, relative humidity, wind speed and cumulative six days rainfall to arrive a SWW in respect of forecasted and observed weather.

- Based on the information on growth stage of the rice as fed by the extension officials via World Wide Web to the ACRC server on every Monday at block level, the relevant agromet advisory for rice to the SWW as above will be picked up by the programme automatically and get communicated to the farmers as SMS to their mobile phones. For this purpose 100 mobile numbers of farmers from each block were included in the database of the server. These agromet advisory were thus sent on every Monday with lead time of six days (from Tuesday to Sunday) to guide / help farmers to take weather based farm decisions.

RESULTS AND DISCUSSION

The agromet advisories(for18 only as an example) on rice developed for 54 SWW for nine growth stages are given in Table 2 (a-e). In response to each SWW the relevant agromet advisory was prepared taking into account expected grain loss with the SWW and percentage of risk reduction with the application of agromet advisory. The agromet advisory included forecast for daily means of maximum and minimum temperature, relative humidity, wind speed and cumulative rainfall.

Table 2 : Agromet advisories of rice for 18 selected weather windows (SWW) of Tamil Nadu (a) for cropstages R_1,R_2 and R_3

Crop Stages	Past observed 6 days weather data	Weather forecast for 6 days	Agromet advisory
R1: Nursery Preparation	Rainfall from 0.1 to >30mm and other weather elements not considered (SWW: 4,5,6, 13,14 and 15)	-	**AA 1.**Rainfall received in past six days may be used to puddle the soil for nursery bed preparation to save irrigation water and achieve higher rainfall use efficiency
	-	Rainfall from 0.1 to >30mm and other weather elements not considered (SWW: 4,5,6, 13,14 and 15)	**AA 1.**The anticipated rainfall may be used for preparing rice nursery **AA 2.**For the sown rice nursery, anticipating rainfall, impound water over the seeds sown in the nursery during evening and drain it by next day morning so as to prevent somersaulting of sown seeds with rainfall against poor germination
	Rainfall from 0.1 to 30mm and other weather elements not considered (SWW: 4,5,6, 13,14 and 15)	Rainfall from 0.1 to >30mm and other weather elements not considered (SWW: 4,5,6, 13,14 and 15)	**AA 1.**Continuous rainfall situation may affect nursery preparation and hence impound the rainwater in the field where ever possible. **AA 2.**For the sown rice nursery, anticipating rainfall, impound water over the seeds sown in the nursery during evening and drain it by next day morning so as to prevent somersaulting of sown seeds against poor germination
R2: Two leaf stage seedlings	Rainfall >30 mm and other weather elements not considered (SWW: 7,8, 9,16,17 and 18)	Rainfall >30 mm and other weather elements not considered (SWW: 7,8, 9,16,17 and 18))	Considering the receipt of heavy rainfall and also with anticipating heavy rainfall, provide drainage to rice nursery against rotting of seedlings with water stagnation. Close all water entry points in the field against flooding.
R3: Three to four leaf stage seedlings	Maximum temperature >35.1°C with RH >40% and other weather elements not considered (SWW: 3,12 and 18)	Maximum temperature >35.1°C with RH > 40 % and other weather elements not considered(SWW: 3,12 and 18)	The prevailing and anticipated weather with high temperature and high relative humidity may result in thrips and jassid attack in young rice seedlings. Monitor the pest population and adopt plant protection measures in consultation with extension specialist.
	Minimum temperature <15 °C with RH >40 % and other weather elements not considered (SWW:1,4,7,10, 13 and 16)	Minimum temperature <15 °C with RH >40 % and other weather elements not considered (SWW:1,4,7,10,13 and 16)	The prevailing and anticipated weather with low temperature and high relative humidity may affect rice seedlings with fungal diseases. Monitor the disease intensity and take plant protection in consultation with Agricultural Specialist.

The ACRC, TNAU has developed a proto-type software to disseminate agromet advisory through SMS to the farmers of a block. Trial runs of software were made to identify the problems before its finalization for all 385 blocks. Ex-ante analysis through partial budgeting was done for three selected agromet advisories from Table 2 (a,b & c) to examine the benefits likely to be accrued with the adoption of agromet advisories for SWW.

Agromet advisory during nursery establishment (R1)

The stage of the rice crop is one day nursery sown

Table 2(b) : Agromet advisories for Crop stages R_4 and R_5

Crop Stages	Past observed 6 days weather data	Weather forecast for 6 days	Agromet advisory
R4: Preparation of the main field and transplanting	Rainfall from 0.1 to >30 mm and other weather elements Not considered (SWW: 4,5,6, 13,14 and 15)	-	Prepare the main field for transplanting rice with the amount of rainfall received so as to save both ground and surface water sources.
	-	Rainfall from 0.1 to >30 mm and other weather elements not considered (SWW: 4,5,6, 13,14 and 15)	**AA1**Anticipating heavy rainfall prepare the main field for transplanting rice so as to save both ground and surface water sources. **AA2**Make provision of drainage in the freshly transplanted rice field to drain out excess water from anticipated rainfall otherwise the planted seedlings will get uprooted and get floated. **AA3**If not planted, postpone the transplanting by 2 to 3 days.
	Rainfall >30 mm and other weather elements not considered (SWW: 7,8, 9,16,17 and 18)	Rainfall >30 mm and other weather elements not considered (SWW: 7,8, 9,16,17 and 18)	**AA1** If green leaf manure has already been applied in the puddled field, considering the rainfall already received and to be received, plug all water outlets in the field since it may drain out the nutrients from the field. **AA2**If green leaf manure has not been applied, arrange proper drainage before its application. **AA3**In case of prediction of likely wet spell, stop transplanting and also don't apply basal application of NPK fertilizer.
R5: Established seedlings and tillering stages	Rainfall >30 mm and other weather elements not considered (SWW: 7,8, 9,16,17 and 18)	Rainfall >30 mm and other weather elements not considered (SWW: 7,8, 9,16,17 and 18)	Under the situation of continuous wet spell of heavy rain, provide drainage.
	Maximum temperature >35.1 °C with RH >40 % and other weather elements not considered (SWW:3,12 and 18)	Maximum temperature >35.1 °C with RH >40 % and other weather elements not considered (SWW:3,12 and 18)	The prevailing and anticipated weather with high temperature and high relative humidity may result in thrip and jassid attack on rice seedlings. Monitor the pest population and take plant protection in consultation with extension specialist.

with pre-germinated seeds. The sensitiveness of the crop stage to rainy weather is anticipated to be 60 per cent in terms of failure of nursery establishment due to somersaulting of sown seeds under impact of raindrops. The proposed agromet advisory is to irrigate the nursery during evening hours of a day anticipating rainfall and drain it on next day morning and this be continued for two days till the rice plumule comes-up. Farmers do not practice any contingency measure for this type of weather situation since nursery area is too small for them and would not lead to any substantial economical loss. But in reality, this may not be so. Though, this may be small at individual farm level, but when considered over blocks in the State, the area would be quite significant.

Agromet advisory during peak vegetative growth (R5)

The sensitiveness of the crop stage to rainy weather is that the number of tiller production would be less by 15 per cent with additional rainwater stagnation in case proper drainage is not provided. The proposed agromet advisory is to provide drainage to drain excess rainwater so as to create water free environment for proper tiller development. Farmers generally do not adopt any management practice for this

Table 2(C) : Agromet advisories for Crop stages R_6

Crop Stages	Past observed 6 days weather data	Weather forecast for 6 days	Agromet advisory
R6: Maximum tillering and panicle initiation stage	Wind speed > 5kmph and other weather parameters not Considered (SWW: 10 to 18)	Wind speed > 5kmph and other weather parameters not considered (SWW: 10 to 18)	Since the wind speed is more than 5 kmph do not top dress the crop with nutrients through broadcasting. May go for foliar application of Nitrogen and Potash if need arises.
	Wind speed <5kmph and RH >40 % + no rain+ maximum temperature >20 °C(SWW:2 and 3)	Wind speed <5kmph and RH >40 % + no rain+ maximum temperature >20 °C(SWW:2 and 3)	Since the weather is calm and dry, may top dress the Nitrogen and Potassium fertilizers
	-	Rainfall >30mm and other weather elements not considered (SWW: 7,8, 9,16,17 and 18)	**AA1**In view of anticipating heavy rainfall provide drainage as the rice is in maximum tillering stage and flooding may result in poor tillering . **AA2**May postpone top dressing of N and K fertilizers in view of the anticipating heavyrainfall.
	Maximum temperature >35.1 °C with RH >40 % and other weather elements not considered (SWW: 3,12 and 18)	Maximum temperature >35.1°C with RH >40 % and other weather elements not considered (SWW: 3,12 and 18)	The prevailing and anticipated weather with high temperature and high relative humidity may favour attack of worms in rice. Monitor the pest population and take plant protection in consultation with extension specialist.
	Rainfall from 0.1 to 30mm with RH >40 % and other weather elements not considered (SWW:4,5,6,13,14 and 15)	Rainfall from 0.1 to 30mm with RH >40 % and other weather elements not considered (SWW:4,5,6,13,14 and 15)	The cloudy weather with rainfall may favour infestation by leaf folder and brown plant hopper in rice. Take plant protection measures under expert advice.
	Temperature <15 °C + Rainfall >30mm + RH >40 % (SWW: 7 and 16)	Temperature <15 °C + Rainfall >30mm + RH >40 % (SWW: 7 and 16)	The weather with rainfall, high relative humidity and low minimum temperature may cause blast and *Helminthosporium* leaf diseases in rice. Consult extension specialist for undertaking the plant protection measures.
	Rainfall >30 mm and other weather elements not considered (SWW: 7,8, 9,16,17 and 18)	Rainfall >30 mm and other weather elements not considered (SWW: 7,8, 9,16,17 and 18)	The prevailing weather situation may result in flooding under low land. Consult extension specialist for expert advice for expert advice on management strategies for such situations.

weather situation.

Agromet advisory for blast and Helminthosporium leaf disease management (R6)

The sensitiveness of these crop stages to the weather situation mentioned above are a yield loss of up to 30 per cent as a result disease infestation if it is not controlled by taking appropriate plant protection measures in consultation with plant pathologist when the disease load crossed threshold level. The proposed agromet advisory is to adopt timely plant protection measures. The present practice generally prevalent with farmers is to go for plant protection measures as per advice of agricultural input dealer rather

Table 2(d) : Agromet advisories for Crop stages R_7 and R_8

Crop Stages	Past observed 6 days weather data	Weather forecast for 6 days	Agromet advisory
R7: Flowering stage	Minimum temperature <15 °C and other weather elements not considered (SWW:1,4,7,10,13 and 16)	Minimum temperature <15 °C and other weather elements not considered (SWW:1,4,7,10,13 and 16)	**AA1**As the prevailing night temperature are low, to enhance the growth of rice spray 120 ppm Salicylic acid (120 mg in 1 litre of water) **AA2**The prevailing low night temperature is likely to favour blast disease and sheath rot disease of rice. Take expert advice from extension specialist for plant protection measures to be adopted.
	Maximum temperature >35.1 °C with RH >40 % and other weather elements not considered (SWW: 3,12 and 18)	Maximum temperature >35.1°C with RH >40 % and other weather elements not considered (SWW: 3,12 and 18)	The weather with high temperature and high relative humidity may favour stem borer and brown plant hopper attack. Consult Extension specialist for appropriate control measures.
	-	Rainfall >30 mm and other weather elements not considered (SWW: 7,8, 9,16,17 and 18)	In view of the anticipated heavy rainfall don't go for top dressing of nutrients in rice.
R8: Milking and grain development stage	Maximum temperature >35.1 °C with RH >40 % and other weather elements not considered(SWW: 3,12 and 18)	Maximum temperature >35.1°C with RH >40 % and other weather elements not considered (SWW: 3,12 and 18)	The weather with high temperature and high relative humidity may invite earhead bug. Consult extension specialist and take necessary plant protection measures as per advice.
	Minimum temperature <15 °C + RH >40 % and weather elements are not considered (SWW:1,4,7,10,13 and 16)	Minimum temperature <15 °C + RH >40 % and other weather elements are not considered (SWW:1,4,7,10,13 and 16)	The prevailing and anticipated weather with low temperature and high relative humidity may favour blast and bacterial blight diseases. Monitor the disease intensity and take plant protection in consultation with extension specialist.

than to contact extension specialist for proper advice on choice of chemical, its dose and dilution.

The study hypothesis envisaged that whenever weather based agromet advisory is adopted by the farmers, there would be profound reduction in rice crop production risks. The examination of the results of proto-type testing for single block revealed positive signal. However, the benefits of these agromet advisories have to be monitored closely over seasons with the farmers and accordingly they have to be redefined in terms of technical feasibility and socio-cultural acceptability for better mass adoption among stakeholders.

Venkataraman and Krishnan (1992), have reported that many crops are highly sensitive to weather elements throughout their growth, while many others were sensitive to weather elements during certain stages only. Considering the philosophy and science, nine stages have been considered for providing agromet advisories to rice crop.

Parvinder Maini and Rathore (2011) from their study made in India reported that farmers who adopted medium range weather based agromet advisories did accrue a net physical benefit of 10 to 15 per cent higher yield for the agricultural crops tested and also there was reduction in the cost of cultivation by 2 to 5 per cent as compared to the non-adoption. Based on the experiences gained from these results greater scope exists across globe to use this research strategy to reduce the weather related rice crop production risks. Further plans have to be done to develop self-learning

Table 2(e) : Agromet advisories for Crop stages R_9

Crop Stages	Past observed 6 days weather data	Weather forecast for 6 days	Agromet advisory
R9: Maturity and harvesting stage	-	Rainfall >30 mm and other weather elements not considered (SWW: 7,8, 9,16,17 and 18)	**AA1**In view of anticipated heavy rainfall, may postpone the harvest and provide drainage.
	-	Rainfall > 30mm + wind speed > 5kmph (SWW: 16,17 and 18)	Anticipating heavy rainfall with heavy wind, press the matured plants inward to centre of the field along the border to avoid lodging and also provide field drainage.
	Minimum temperature <15 °C + RH >40 % and other weather elements are not considered (SWW:1,4,7,10,13 and 16)	Minimum temperature <15 °C + RH >40 % and other weather elements are not considered (SWW:1,4,7,10,13 and 16)	The prevailing low temperature with high relative humidity may lead to discoloration of the matured rice grains. Monitor the grain colour and if required adopt plant protection measures in consultation with extension specialist.
	No rainfall + Maximum temperature > 20 °C (SWW:1,4,7,10,13 and 16)	No rainfall + Maximum temperature > 20 °C (SWW:1,4,7,10,13 and 16)	The prevailing weather is conducive for rice harvesting and hence may undertake harvesting, winnowing and drying operations as the case may be.

(AA - Agromet Advisory)

heuristic models and simulate the required results for fine-tuning of the developed agromet advisories.

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