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Sowing environments effect on rust (*P. arachidis*) disease in groundnut (*Arachis hypogea* L.)

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ABSTRACT

An experiment was laid out in Randomized Block Design with five sowing dates *viz.*, S_1 -22nd June, S_2 -29th June, S_3 -6th July, S_4 -13th July and S_5 -20th July and four replications. The observations on initiation of rust diseases and per cent disease intensity were recorded periodically at an interval of one week after the occurrence of these diseases. In rust disease maximum temperature (0.59), morning relative humidity (0.33), evaporation (0.33) and bright sunshine hours (0.55) showed positive correlation with disease intensity. Whereas, minimum temperature (-0.44), evening relative humidity (-0.58) and wind speed (-0.63), showed negatively significant correlation with disease intensity in *Kharif* season. Other climatic factors *i.e.* rainfall showed no significant correlation with disease intensity. The morning relative humidity and bright sunshine hours were correlated for rust disease incidence. The result from all the relevant observations indicated that the morning relative humidity (2.87) and bright sunshine hours (5.65) during the crop growing period was found to be highly significant weather conditions for rust disease development among the all other weather parameters. The multiple regression equation developed from the data in this regard is as :

Y= -257.591 +2.879RH-I(W-1) +5.651BSS(W-1)

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INTRODUCTION

Groundnut is essentially a tropical plant and requires a long and warm growing season. The favorable climate for groundnut is a well distributed rainfall of at least 500 mm during the crop growing season, with abundance of sunshine and relatively warm temperature. Temperature in the range of 25 to 30ºC is optimum for plant development (Weiss, 2000).

The rust of groundnut caused by *Puccinia arachidis* Speg. was reported from Punjab in 1969 (Chahal and Chohan, 1969) and now it is common in occurrence in most groundnut growing states in India (Mayee *et al*., 1977; Subrahmanyam *et al*., 1979). *Uredospores* are the main source of inoculums of rust disease of groundnut of which the dispersal is brought about on large scale.

Based on disease progress curves, bioclimatic guidelines have been formulated for forewarning farmers for the likely epidemic of rust. A stepwise multiple regression computer programme was used to identify one biological and seven meteorological variables to predict rust severities as holistic approach similar analysis for predicting the incubation period has been found extremely useful. The validity of all predicting

systems is also determined so that the most realistic model shall be put to operation. The sowing time of groundnut also play important role in occurrence and development of rust diseases of groundnut during *Kharif* season.

It is necessary to work out the relation between all these weather parameters and occurrence and growth of rust diseases of groundnut; which are the major diseases of groundnut that cause heavy yield losses. However, very meager research work is carried out to quantify the correlation between these weather parameters and occurrences and development of rust diseases.

MATERIAL AND METHODS

The experiment was laid out in Randomized Block Design with five treatments: five sowing dates *viz*., S_1 -22nd June, S_2 -29th June, S_3 -6th July, S_4 -13th July and S_5 -20th July and four replications. The observations of rust (*Puccinia arachidis*) disease incidence pattern on groundnut crop was studied in *Kharif* seasons by observing periodically the intensity of lesions and pustules from bottom, middle and top leaves of five randomly selected plants. Observations were recorded early in the morning before 8.00 O'clock with an interval of seven days throughout the season. The average number of lesions and pustules plant^{-1} was worked out.

The incidence pattern of the rust diseases, number of infected plants at seven days interval from 30 days after sowing were recorded and percentage of infected plants was worked out. Per cent disease incidence was calculated using following formula :

$$\text{PDI} = \frac{\text{Number of diseased plants}}{\text{Total number of plants observed}}$$

Disease intensity is calculated by following formula :

$$\text{Disease intensity (\%)} = \frac{0(X_0) + 1(X_1) + 2(X_2) + ...}{X_0 + X_1 + X_2 + ... \times \text{max. grade used}} \times 100$$

where, X represents the number of diseased entities within a sampling unit in the respective class or grade such as 0, 1, 2, …. 9.

The effect of climatic factors *viz*., temperature, humidity, rainfall and bright sun shine hours on tikka and rust disease intensity due to various sowing dates were also studied. The correlation and regression equations are also worked out by the following formulae between different sowing dates and per cent disease intensity :

$$Y = a + b_1x_1+b_2x_2+b_3x_3+.....+b_nx_n.$$

where, Y= PDI, 'a' as constant and 'b' as regression co-efficients of independent variable 'x'.

The influence of factors on rust disease incidence was estimated by using prediction equation as :

$$Y = a + b_1x_1+b_2x_2+b_3x_3+.....+b_nx_n.$$

where, Y= PDI, 'a' as constant and 'b' as regression co-efficients of independent variable 'x'.

The influence of factors on rust disease intensity was estimated by using prediction equation as,

$$Y = a + b_1x_1+b_2x_2+b_3x_3+.....+b_nx_n.$$

where, Y= PDI, 'a' as constant and 'b' as regression co-efficients of independent variable 'x'.

The scale explained by Mayee and Datar (1986) was used to record field observations on rust diseases of groundnut.

RESULTS AND DISCUSSION

The present investigation was carried out on the farm of the Department of Agricultural Meteorology, Pune-5, during the *Kharif* season. The results obtained are presented hereunder.

Disease observations :

The symptomatology of rust diseases of groundnut was studied under field conditions during *Kharif*. Symptomatology was studied by recording observations on growing plants sown on five different dates in *Kharif* season. The first symptom of tikka and rust disease normally appeared on groundnut in *Kharif* and it was observed 25-30 days after sowing in all sowing dates. The sequence of development of symptoms in all sowing dates was similar however differed in conspicuousness and the severity.

Per cent disease intensity of rust of groundnut in sowing dates :

The data on rust disease intensity of five sowing dates are depicted in Table 1 and 2. The data indicated that the occurrence of the rust of groundnut was observed throughout the *Kharif* season, normally 30 days after sowing and then up to the harvesting. The disease intensity was higher mostly in

Table 1 : Development of rust disease in different sowing dates

Sr. No.	Sowing dates	Disease intensity (%) days after sowing												
		30	37	42	49	56	63	70	77	82	89	96	105	Har
1.	S_1 (22nd June)	0.87	3.45	6.34	19.37	22.69	30.22	34.86	38.96	45.52	64.48	66.38	75.45	85.46
2.	S_2 (29th June)	1.19	3.33	8.11	9.12	14.59	19.38	28.34	45.96	65.45	76.13	89.12	91.42	95.56
3.	S_3 (6th July)	0	0.2	0.4	0.93	1.59	1.63	1.67	3.9	4.68	7.91	10.39	19.78	22.42
4.	S_4 (13th July)	0	0	0.54	1.23	3.06	3.66	8.42	15.6	33.54	42.12	49.69	52.99	55.25
5.	S_5(20th July)	0	0	0	0.52	0.93	3.57	3.95	8.64	10.52	19.32	20.96	22.46	24.79

PDI-Per cent disease intensity; MW-Meteorological week

the month of September. Among all sowing dates studied, the average rust intensity level were higher in second date of sowing that is 95 .56 per cent rust in *Kharif* season, respectively. The first incidence In case of rust it was observed 30 DAS in S_1, S_2 and 45 DAS in S_3, S_4 and S_5 treatments. the maximum intensity in all the five dates of sowing in *Kharif* season was observed between 65 to 79 days after sowing.

Rust (*Puccinia arachidis*) :

The data on rust disease intensity depicted in Table 2 indicated that in *Kharif* season the rust disease intensity exponentially increased during 31 MW to 41 MW from 6.34 per cent to 85.46 per cent, during 32 MW to 42 MW from 8.11 per cent to 95.56 per cent ,during 38 MW to 43 MW from 3.9 per cent to 22.42 per cent, during 37 MW to 44 MW from 3.66 per cent to 55.25 per cent, from 39 MW to 45 MW from 3.95 per cent to 24.79 per cent in S_1, S_2, S_3, S_4, S_5 sowing date treatments, respectively. It is revealed that the favourable climatic conditions for disease development were temperature ranged between 26^0C to 32^0C and relative humidity ranged between 61-79 per cent. It was evident from the Table 2 that the disease intensity increased with variation in climatic conditions. Normally disease appearance was started from 30 DAS and thereby increased up to the harvesting time. The similar results were observed by following scientist in groundnut crop, they revealed that the rust disease was

Table 2 : Developement of tikka and rust diseases in sowing

Sr. No.	Particulars		Per cent disease intensity (PDI)				
			S_1 (22nd June)	S_2 (29th June)	S_3 (6th July)	S_4 (13th July)	S_5 (20th July)
	Obse. dates	MW	Rust	Rust	Rust	Rust	Rust
1.	22-Jul.	29	0.87	0.41	0	0	0
2.	29-Jul.	30	3.45	1.19	0	0	0
3.	05-Aug.	31	6.34	3.33	0	0	0
4.	12-Aug.	32	19.37	8.11	0.2	0	0
5.	19-Aug.	33	22.69	9.12	0.4	0	0
6.	26-Aug.	34	30.22	14.59	0.93	0.54	0
7.	02-Sep.	35	34.86	19.38	1.59	1.23	0
8.	09-Sep.	36	38.96	28.34	1.63	3.06	0.52
9.	16-Sep.	37	45.52	45.96	1.67	3.66	0.93
10.	23-Sep.	38	64.48	65.45	3.9	8.42	3.57
11.	30-Sep.	39	66.38	76.13	4.68	15.6	3.95
12.	07-Oct.	40	75.45	89.12	7.91	33.54	8.64
13.	10-Oct.	41	85.46	91.42	10.39	42.12	10.52
14.	18-Oct.	42	-	95.56	19.78	49.69	19.32
15.	28-Oct.	43	-	-	22.42	52.99	20.96
16.	04 Nov.	44	-	-	-	55.25	22.46
17.	11-Nov.	45	-	-	-	-	24.79

Table 3 : Correlation co-efficient between bio-meteorological factors and rust disease intensity in groundnut in five different sowing dates

Weather parameters		'r' values for groundnut Rust diseases				
Sr. No.	Particulars					
	Climatic factors	S_1 (22nd June)	S_2 (29th June)	S_3 (6th July)	S_4 (13th July)	S_5 (20th July)
1.	Temperature (Max.) °C	0.788**	0.861**	0.775**	0.897**	0.872**
2.	Temperature (Min.) °C	-0.836**	-0.778**	-0.905**	-0.827**	-0.881**
3.	Relative humidity am (%)	0.474	0.460	0.279	0.315	0.238
4.	Relative humidity pm (%)	-0.833**	-0.885**	-0.906**	-0.921**	-0.945**
5.	Wind speed (km/hr)	-0.846**	-0.900**	-0.848**	-0.948**	-0.912**
6.	Rainfall (mm)	0.125	0.018	-0.021	-0.097	-0.197
7.	Rainy days	-0.155	-0.223	-0.141	-0.310	-0.376
8.	Evaporation (mm/day)	0.339	0.419	0.380	0.565*	0.518*
9.	Bright sunshine hours/day	0.756**	0.822**	0.786**	0.853**	0.836**

* and ** indicates significance of values at P = 0.05 and P = 0.01, respectively

mainly associated with actual date of sowing and varying climatic conditions.

Kolte (1986) reported that the severity of white rust development was found to be highly significant among the dates of sowing, in mustard cultivars and observation intervals. Gupta *et al.* (1990) observed that rust is the most important foliar disease of pea in India which regularly appears mild to severe form in timely sown crops at poding stage.

Effect of biometerological factors on disease intensity and pathogenesis of rust of groundnut :

The effect of bio-meteorological factors *viz.*, PDI, maximum and minimum temperatures, morning and evening humidity, rainfall, rainy days, evaporation rate wind speed and bright sunshine hours on PDI groundnut was studied in same week (0-week), one week prior (W^{-1}) and two weeks prior (W^{-2}). The data on PDI on each plant considered from the earlier observations for calculating the correlation co-efficients. The correlation co-efficients worked out for PDI and different climatic factors are depicted in Table 3.

Among studied factors in *Kharif* season on rust the multiple regression analysis by step down method was worked out and PDI of W^0 taken as a dependent variable and W^{-1} (one week prior) PDI, W^{-2} (two weeks prior) PDI as well as weather parameters of (W^0), (W^{-1}), (W^{-2}) weeks as a independent variables. Multiple regression analysis was carried out and regression equation worked out.

In case of rust disease in first date of sowing (W^{-1}: PDI of one week prior (0.98), (W^{-2}: two week prior PDI (0.98) and maximum temperature (0.78) and bright sun shine hours (0.75,0.74) of (W^0) week, (W^{-1}) week and bright sunshine hours (0.66) of (W^{-2}) weeks were found to be highly significant and positively correlated. The minimum temperature (-0.83, -0.66, -0.56), evening relative humidity (-0.83, -0.80, -0.61) and wind speed (-0.72) of (W^0), (W^{-1}), (W^{-2}) week were found to be highly significant but negatively correlated.

Table 3(a): Correlation coefficient between bio factors rust disease intensity (One Week Prior) meteorological in groundnut in five different sowing dates

Bio-meteorological parameters		'r' values for groundnut diseases				
Sr. No.	Particulars	Rust				
	One week prior	S_1 (22nd June)	S_2 (29th June)	S_3 (6th July)	S_4 (13th July)	S_5 (20th July)
1.	Temperature (Max.) ^{0}C	0.732**	0.811**	0.860**	0.872**	0.883**
2.	Temperature (Min.) ^{0}C	-0.666**	-0.786**	-0.827**	-0.777**	-0.824**
3.	Relative humidity am (%)	0.419	0.521*	0.447	0.326	0.344
4.	Relative humidity pm (%)	-0.807**	-0.880**	-0.900**	-0.905**	-0.920**
5.	Wind speed (km/hr)	-0.851**	-0.883**	-0.893**	-0.914**	-0.921**
6.	Rainfall (mm)	0.115	0.190	0.022	-0.037	0.004
7.	Rainy days	-0.212	-0.166	-0.190	-0.352	-0.275
8.	Evaporation (mm/day)	0.474	0.408	0.392	0.542*	0.485*
9.	Bright sunshine hours/day	0.740**	0.792**	0.764**	0.856**	0.819**
10.	Disease intensity (%)	0.988**	0.993**	0.980**	0.988**	0.981**

* and ** indicate significance of values at P = 0.05 and P = 0.01, respectively

Table 3(b): Correlation co-efficient between bio meteorological factors and rust disease intensity (two week prior) in groundnut in five different sowing dates

Bio-meteorological parameters		'r' values for groundnut rust diseases				
Sr. No.	Particulars					
	Two weeks prior	S_1 (22nd June)	S_2 (29th June)	S_3 (6th July)	S_4 (13th July)	S_5 (20th July)
1.	Temperature (max.) °C	0.462	0.638*	0.809**	0.759**	0.819**
2.	Temperature (min.) °C	-0.565*	-0.728**	-0.746**	-0.711**	-0.756**
3.	Relative humidity am (%)	0.503	0.494	0.746**	0.462*	-0.442*
4.	Relative humidity pm (%)	-0.616*	-0.721**	-0.836**	-0.818**	-0.865**
5.	Wind speed (km/hr)	-0.727**	-0.809**	-0.916**	-0.872**	-0.914**
6.	Rainfall (mm)	0.015	0.243	0.478	0.093	0.137
7.	Rainy day	-0.354	-0.182	0.048	-0.293	-0.220
8.	Evaporation (mm/day)	0.390	0.419	0.229	0.419	0.378
9.	Bright sunshine hours/day	0.660*	0.709**	0.666**	0.802**	0.788**
10.	Disease intensity %	0.985**	0.983**	0.978**	0.962**	0.965**

* and ** indicate significance of values at P=0.05 and P = 0.01, respectively

In second and third date of sowing (W^{-1} : one week prior PDI (0.98, 0.99), (W^{-2} : two week prior PDI (0.98, 0.97) and maximum temperature (0.86, 0.81, 0.63) and bright sunshine hours (0.82, 0.79, 0.70) of (W^0), (W^{-1}), (W^{-2}) weeks were found to be highly significant and positively correlated. As well as minimum temperature (-0.77, -0.78, -0.72), evening relative humidity (-0.88, -0.88, -0.61) and wind speed (-0.90, -0.88, -0.80) of (W^0), (W^{-1}), (W^{-2}) week were found to be highly significant but negatively correlated.

In last two dates of sowing (W^{-1} : one week prior PDI (0.98), (W^{-2} : two week prior PDI (0.96) and maximum temperature (0.89, 0.87, 0.75), evaporation (0.56, 0.54, 0.41) and bright sun shine hours (0.85, 0.85, 0.80) of (W^0), (W^{-1}), (W^{-2}) weeks were found to be highly significant and positively correlated. As well as minimum temperature (-0.82, -0.77, -0.71), evening relative humidity (-0.92, -0.90, -0.81) and wind speed (-0.94, -0.91,-0.87) of (W^0), (W^{-1}), (W^{-2}) week were found to be highly significant but negatively correlated.

From Table 3 and 4 it is concluded here that, for development of rust disease in 22nd June sowing the bio-meteorological parameters that is PDI of one week prior, bright sun shine hours of same week and two week prior were found to be significantly superior and highly correlated among the all other parameters.

For 29th June sowing the bio-meteorological parameters that is PDI of one week prior, maximum temperature and wind speed of same week and maximum temperature and morning relative humidity of two week prior ware found to be significantly superior and highly correlated among the all other parameters.

For 6th August sowing the bio-meteorological parameters that is PDI of one week prior and maximum temperature of one week prior ware found to be significantly superior and highly correlated among the all other parameters.

For 13th August sowing the bio-meteorological parameters that is PDI of one week prior, bright sun shine hours and morning relative humidity of same week and minimum temperature of two weeks prior were found to be significantly superior and highly correlated among the all other parameters.

For 20th August sowing the bio-meteorological parameters that is PDI of one week prior, evening relative humidity, rain and wind speed of same week ware found to be significantly superior and highly correlated among the all other parameters.

Similar results was reported by, Singh *et al*. (1990) he was reported that maximum temperature (0.39), evaporation (0.30) and age of the crop (0.40) recorded significant and positive relationship with rust incidence while morning relative humidity (-0.33) was negatively associated with rust intensity.

Mayee (1986) and Mayee *et al*. (1977) concluded that, in India, a continuous dry period characterized by high temperature (>26° C) and low relative humidity (<70 %) is reported to delay rust occurrence and severity, whereas, intermittent rain, high relative humidity and 20 to 26° C temperature favor disease development.

Mayee and Kokate (1987) reported that, the leaf rust epidemic commonly occurs during prolonged dry spell after

Table 4 : Regression equations with for groundnut rust disease development over different sowing dates

Sr. No.	Sowing dates	Equations	R^2
1.	S_1	$PDI=11.148+1.229\ PDI^{(W-1)} -1.761BSS^{(W-2)} -1.718BSS^{(W0)}$	0.988
2.	S_2	$PDI=113.538+ 0.971\ PDI^{(W-1)} -3.635T(MAX)^{(W-2)} +2.444WS^{(W0)} -0.360RH\text{-}I^{(W-2)} + 0.481T(MAX)^{(WO)}$	0.998
3.	S_3	$PDI=-27.284+0.931PDI^{(W-1)} + 1.032T(MAX)^{(W-1)}$	0.981
4.	S_4	$PDI=-88.237+0.712\ PDI^{(W-1)} + 2.619BSS^{(W0)} +1.016RH\text{-}I^{(W0)} -.294T(MIN)^{(W-2)}$	0.992
5.	S_5	$PDI=28.903+0.503\ PDI^{(W-1)} -0.216RH\text{-}II^{(W0)} -1.556WS^{(W0)} -0.007RAIN^{(W0)}$	0.978

Table 5 : Correlation coefficients between disease intensity of five different sowing dates with climatic factors

Sr. No.	Particulars	'r' values for rust groundnut diseases
	Climatic factors	
1.	Temperature (max.)	0.591**
2.	Temperature (min.)	-0.445**
3.	Relative humidity am (%)	0.330**
4.	Relative humidity pm (%)	-0.586**
5.	Wind speed (km/hr)	-0.634**
6.	Rainfall (mm)	0.084
7.	Rainy days	-0.159
8.	Evaporation (mm/day)	0.337**
9.	Bright sunshine hours/day	0.550**

** indicate significance of values at P = 0.01, respectively

heavy showers. In their study on the influence of rainfall, temperature and relative humidity on groundnut leaf rust epidemiology. Incubation period of *Puccinia arachidis* causing groundnut rust was prolonged as the mean or maximum temperature increased while it is negatively correlated with relative humidity. Multiple regression analysis of different environmental factors combinations including rainfall, evaporation rates explained more than 96 per cent of the observed variation in incubation period.

While working with groundnut rust disease the similar results were observed by Lokhande *et al*. (1998). They reported that rainfall of about 200 mm, temperature between 23.5 to 29.5 ºC and relative humidity in the range 67 to 84 per cent are congenial weather conditions for initiation and development of rust disease in groundnut during *Kharif* season.

Effect of climatic factors on rust disease intensity :

The data on correlation coefficient between disease intensity and various climatic factors is given in Table 5.

In case of the rust disease maximum temperature (0.59), morning relative humidity (0.33), evaporation (0.33) and bright sun shine hours (0.55) showed positive correlation with disease development. Whereas, minimum temperature (-0.44), evening relative humidity (-0.58), wind speed (-0.63), showed negatively significant correlation with disease progress in *Kharif* season. Other climatic factors *i.e.* rainfall and rainy days showed no significant correlation with rust disease.

The overall step down multiple regression analysis was worked out between PDI of W0 week with weather parameters of one week prior for all sowing dates. The results obtained are given as follows.

The multiple regression equation is given below :

$$Y = -257.591 + 2.879RH\text{-}I^{(W-1)} + 5.651BSS^{(W-1)}$$

The result from experimentation indicated that the morning relative humidity (2.87) and bright sun shine hours (5.65) during the crop growing period was found to be highly significantly superior weather conditions for rust disease development among the all other weather parameters.

The similar results were quoted by Mayee and Datar (1986) that, the average temperature of 20-22º C, relative humidity above 85% and 3 rainy days in a week, if prevailed for 2 weeks, an outbreak of rust is likely in Maharashtra.

Patel and Vaishnav (1989) reported observations during the *kharif* season that severe rust (*Puccinia arachidis*) infection was associated with a temperature range of 25-29°C, relativity humidity 74-89%, bright sunshine 1-4.3 hours and 10-13 mm rainfall during the preceding week.

Sandhikar *et al*. (1989) studied that from the long-term observations of rust and weather conditions, prevail for a week, rust outbreak is likely to occur in next 15 days.

Summary :

The rust disease is caused by *Puccinia arachidis*. The first symptom of disease was the appearance of the orange coloured pustules on lower surface of the leaves and ruptured to expose masses of reddish brown urediniospores. They formed on all aerial plant parts apart from flowers and pegs. The rust affected leaves became necrotic but tend to remain attached to the plants.

Per cent disease intensity of rust of groundnut in relation to different sowing dates and effect of biometeorological factors on disease intensity and pathogenesis was studied and correlation and multiple regression equations were worked out.

Disease incidence and severity were found to be higher in early sown crop than in late sown crop. Disease intensity and weather parameters were found to be significantly correlated in all the sowing dates.

The climate plays important role in determining severity of disease. relative humidity (90-100%) and bright sunshine hours during the crop growing period were found to be highly significant in determining rust disease intensity followed by wind speed and rainy days.

The favourable climatic conditions for disease development were temperature ranged between 26^0C to 32^0C and relative humidity ranged between 61-79 per cent and bright sunshine hours of 4-6 hrs/day. The bio-meteorological studies showed that, earlier disease intensity also contribute in disease epidemic and development. The maximum temperature and bright sunshine hours were found to be significant and positively correlated with PDI. Minimum temperature, evening relative humidity and wind speed were found to be significant and negatively correlated.

The infection severity was found to be dependent on sowing dates and the stage of the crop. The quantitatively infection was highest in early sown crop as compared to late sown crop due to climatic conditions in growing period of crop. The average infection multiplication was higher from 65 to 79 days after sowing. The vulnerable stage of groundnut crop to rust disease incidence was active growth stage of 52-78 days after sowing.

Conclusion :

Based on the response of groundnut to different dates of sowing in respect of growth, yield and influence of weather parameters on rust disease development. The following conclusions are drawn.

From the observed values of the above weather parameters for rust diseases of groundnut the following step down regression equations are developed.

Rust:- $Y = -257.591 + 2.879RH\text{-}I^{(W-1)} + 5.651BSS^{(W-1)}$

From the above regression equations it is possible to predict the rust disease severity of the groundnut crop one

week prior.

From the above equations the rust diseases severity can be predicted one/two weeks prior by considering mean earlier one week weekly observations of weather parameters *viz.*, maximum and minimum temperatures (T max. and T min. °C), relative humidity in per cent (RH-I and RH-II), bright sunshine hours (BSS), rainfall (mm) and rainy days, wind speed (WS km/hr) and evaporation rate (mm/day).

It can be concluded from the existing study that, in the scenario of existing state of global warming and climate change, the appropriate sowing time of groundnut crop will be first week of July in Western Maharashtra and particularly in Pune region instead of earlier recommended sowing time of 15 June to 7 July which will help in obtaining comparatively higher pod yield and less occurrence of diseases like rust of groundnut in *Kharif* season. However, this is one year study and these results needs to be confirmed by conducting two to three more trials in subsequent years for giving concrete recommendations to the farmers and other stakeholders.

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