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Identification of weather parameters affecting the yield of chickpea under different growing environments

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Abstract
A field experiment entitled "Identification of weather parameters affecting the yield of chickpea under different growing environments" was conducted at the Research and Instructional farm of I.G.K.V., Raipur during *rabi* 2019-20. The treatments consisting of three growing environments *viz*. 15th November, 30th November and 15th December and three varieties of chickpea *viz*. Vaibhav, JG-14 and JG-16 were laid out in Factorial RBD with three replications. Correlations studies between yield kg ha^{-1} with weather parameters were done. Significant negative correlation of Tmin (P-II) and RF (P-VI) stage for Vaibhav variety and significant positive correlation in the BSS (P-VI) was found. Significant negative correlation of Tmin in the (P-II and P-I), RF (P-VI), RH-I (P-VI), RH-II (P-IV and P-V) for JG-14 variety was found. Significant negative correlation in Tmin in the (P-II), RF (P-VI), RH-I (P-VI) and significant positive correlation for BSS in P-VI stage for JG-16 variety was found. Chickpea is sensitive to high (maximum daily temperature >35° C) as well as low (mean of maximum and minimum daily temperatures <15° C) temperature at reproductive stage. Both extreme of temperature lead to flower drop and reduced pod set. This resulted in significant reduction of seed yield due to untimely rain and lack of proper temperature as the crop started blooming.

Keywords: Chickpea, correlation, growing environments and weather parameters.

Introduction
Every crop/variety has own optimal requirements of climatic variables such as temperature, rainfall, relative humidity, sunshine hour etc. for potential yield. Weather and climate greatly influence the agricultural productivity in any region. Chickpea prefers cool weather. It requires fairly cold and dry climate. Severe cold and frost, especially during the flowering or pod initiation stages are injurious for developing flowers into seeds. The optimum daily temperature ranges from 18 to 29° C. Temperature is an important factor controlling crop growth and development (Zinn *et al*., 2010) [9]. Relative humidity of 21-41% is optimum for seed setting. The plants grow well in areas with annual rainfall between 600 - 1000 mm. The crop can be grown well in sandy loams soil to clay loam soils. Soil should be free from excessive salt and also neutral in the reaction with drainage facility, soils having >8.5 pH are best for the chickpea crop.

The major chickpea production states of India are M.P (45.95 Lt.), M.S. (17.61 Lt), Rajasthan (14.71 Lt.), Karnataka (8.25 Lt.), U.P. (6.84 Lt.), A.P. (6.76 Lt.), Gujarat (3.62 Lt.), Jharkhand (2.60 Lt.), C.G. (2.03 Lt.) and Telangana (1.50 Lt.). In India, it is cultivated in about 8.56 million hectare area with a production of 7.35 million tons and a productivity of 859 kg ha^{-1} (Tiwari and Meena, 2014) [7]. The per capita per day availability of pulses in 1951 was 60 g that dwindled down to a provisional level of 47.2 g in 2014. The per capita per year availability shows the same decreasing trend from 22.1 kg in 1951 to 17.2 kg in 2014 (Anonymous, 2017) [2]. In Chhattisgarh, the area of chickpea in the year 2017-18 is 349.81 thousand/ha and the productivity is 1116 kg ha^{-1} (Krishi diary, 2019) [3].

Materials and Methods
The field experiment was carried out at the Research and Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya; Raipur located in the south-eastern central part of Chhattisgarh at latitude, longitude and altitude of 21^{0}16 ' N, 81^{0}36 ' E and 289.5 meter above mean sea level respectively. The present study was conducted during the 2019-20 rabi season. Three chickpea cultivars, *viz*. Vaibhav (V_1), JG -14 (V_2) and JG -16 (V_3) were used and cultivated in a plot using factorial randomized block design with three sowing dates (growing environments). The crop was uniformly fertilized with 20:50:20 kg ha^{-1} N_2:P_2O:K_2O in the forms of urea, single super phosphate and muriate of potash respectively.

The occurrence of phenological events like emergence, branching, flower initiation, 50% flowering, 100% flowering, pod formation and maturity were recorded from each plots and average dates of these phases were calculated and used for analysis.

Multiple linear correlations using MS Excel computer programme

Often several quantitative variables are measured on each member of sample. If we consider a pair of such variables, it is frequently of interest to establish if there is a relationship between the two; i.e. to see if they are correlated.

We can categorize the type of correlation by considering as one variable increases what happens to the other variable:

- Positive correlation – the other variable also has a tendency to increase,
- Negative correlation – the other variable has a tendency to decrease,
- No correlation – the other variable does not tend to either increase or decrease.

Linear regression model: a multiple linear regression helps to assess the coefficients which best predicts the output of the dependent variable. The MS Excel output is shown here in which the following are used *viz*., maximum temperature (°C), minimum temperature (°C), rainfall (mm), relative humidity (%) and bright sun shine hours.

$$r = \frac{\sum xy}{(\sum x)(\sum y)}$$

Where,
r = Correlation coefficient
x = Independent variable (attributes)
y = Dependent variable (yield)

The coefficient of determination (R^2) ranges from 0 to 1, where 0 indicate no agreement and 1 indicate a perfect agreement between predicted and observed data (Willmott, 1984) [8]. Combination of different weather parameters will be worked out to find out the influence of weather parameters on yield contributing parameters and seed yield under different growing environments.

Regression equation

After analysis a simple equation has been developed, which may be a useful tool for yield prediction of chickpea crop in the region.

$$Y = a + (b_1)(x_1) + (b_2)(x_2) + (b_3)(x_3)$$

Where,
Y = Predicted yield
a = intercepted
b_1, b_2, b_3= Regression
X_1, X_2, X_3 = Dependent variables

3. Results and Discussion

Crop-weather relations studies were carried out the weather parameter Tmin was found to be significantly negatively correlated in the phase P-II (branching – flower initiation) with seeds per plant and also P-VI (Pod formation – maturity) stage for Vaibhav variety (Table 1). The weather parameters Tmin found to be highly significant negatively correlated in the P-II (branching – flower initiation) with seeds per plant and also P-VI (pod formation – maturity) stage for JG-14 Variety.

The weather parameter Tmin found to be highly significant negatively correlated in the P-II (branching – flower initiation) also P-VI (pod formation – maturity) stage but the weather parameter RH-I was having significantly positive correlation in the P-III (flower initiation – 50% flowering) stage for JG-16 variety.

Weather during P-II (branching – flower initiation) and P-VI (pod formation – maturity) stage of the crop played most important role by exercising its impact on seeds per plant.

Weather parameters RF and RH-I were significantly negatively correlated in the P-I (emergence – branching) stage affecting pods per plant for Vaibhav variety (Table 2). The weather parameter Tmin found to be having significantly negative correlation in the P-II (branching – flower initiation) and P-VI (pod formation – maturity) stage for JG-14 variety. Weather parameter RH-I found to be having significantly positive correlation in the P-III (flower initiation – 50% flowering) stage for JG-14 variety.

The weather parameter Tmin in P-II (branching – flower initiation) and P-VI (pod formation – maturity) stage and also relative humidity in P-VI (pod formation – maturity) stage found to be significantly negative correlated for JG -16 variety. These weather parameters in the crop played most important role by exercising its impact on pods per plant in different phases.

Correlations for seed yield are also done. The weather parameter Tmin is found to be having highly significant negative correlation in the P-II (branching – flower initiation) and BSS found to be having positive correlation in the P-VI (pod formation – maturity) but the weather parameter RF is having significantly negative correlation in the P-VI (pod formation – maturity) for Vaibhav variety (Table 3).

The weather parameter Tmin was having significantly negative correlation in the P-II (branching – flower initiation) and P-V (100% flowering - pod formation) and also the weather parameters *viz*., RF and RH-I found to be having significantly negative correlation in the P-VI (pod formation – maturity) and RH-II found to be having significantly negative correlation in P-IV (50% flowering - 100% flowering) stage and P-V (100% flowering - pod formation) stage for JG-14 variety.

The weather parameter Tmin found to be having highly significant negative correlated in the P-II but the BSS found to be having positive correlation in the P-VI (pod formation – maturity) and the RF and RH-I found to be significantly negative correlated in the P-VI (pod formation – maturity) stage for JG-16 variety.

These weather parameters are in the crop played most important role by exercising its impact on yield of chickpea in different phases.

Table 1: Significant weather parameters for seeds per plant in chickpea in different varieties (data base 2017-18, 2018-19 and 2019-20)

S.No.	Varieties	Weather parameter	Stage
1.	Vaibhav	Tmin	P-II (-0.699*) P-VI (-670*)
2.	JG-14	Tmin	P-II (-0.855**) P-VI (-795*)
3.	JG-16	Tmin	P-II (-0.839**) P-VI (-788*)
		RH-I	P-III (0.655*)

** Significant at 1% level, *Significant at 5% level

Table 2: Significant weather parameters for pods per plant in chickpea in different varieties (data base 2017-18, 2018-19 and 2019-20)

S.No.	Varieties	Weather parameter	Stage
1.	Vaibhav	RF	P-I (-0.667*)
		RH-I	P-I (-0.744*)
2.	JG-14	Tmin	P-II (-0.713*) P-VI (-0.776*)
		RH-I	P-III (0.665*)
3.	JG-16	Tmin	P-II (-0.734*) P-VI (-0.649*)
		RH-I	P-VI (-0.660*)

** Significant at 1% level, *Significant at 5% level

Table 3: Significant weather parameters for yield kg ha^{-1} plant in chickpea in different varieties (data base 2017-18, 2018-19 and 2019-20)

S.No.	Varieties	Weather parameter	Stage
1.	Vaibhav	Tmin	P-II (-0.906**)
		BSS	P-VI (0.779*)
		RF	P-VI(-0.697*)
2.	JG-14	Tmin	P-II (-0.767*) P-V (-0.668*)
		RF	P-VI (-0.663*)
		RH-I	P-VI (-0.740*)
		RH-II	P-IV(-0.655*) P-V (-0.768*)
3.	JG-16	Tmin	P-II (-0.866**)
		BSS	P-VI (0.843**)
		RF	P-VI (0.759*)
		RH-I	P-VI (-0.772*)

** Significant at 1% level, *Significant at 5% level

Conclusion

Weather parameters were found to be affecting the yield of chickpea under different growing environments. In general Tmin. Rainfall and RH-I in different phenophase of chickpea found to affect the chickpea yield and yield components. However these stages are different for different varieties. The weather parameter Tmin was found to be significantly negatively correlated in the phase P-II (branching – flower initiation) with seeds per plant and also P-VI (Pod formation – maturity) stage for Vaibhav, JG-14 and JG-16 variety. Negative correlation of Tmin leads to the point that if minimum temperature falls down seed yield will increase (within optimum limits). Weather parameters RF and RH-I significantly negative correlated in the P-I (emergence – branching) stage affecting pods per plant for Vaibhav variety. The weather parameter Tmin found to be having significantly negative correlation in the P-II (branching – flower initiation) and P-VI (pod formation – maturity) stage for JG-14 and JG-16 varieties. Correlations for seed yield are also done. The weather parameter Tmin is found to be having highly significant negative correlation in the P-II (branching – flower initiation) and the weather parameter RF is having significantly negative correlation in the P-VI (pod formation – maturity) for Vaibhav, JG-14 and JG-16 varieties. Positive correlation of BSS indicates that higher the sunshine values, more will be the seed yield.

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