Variability analysis and impact of weather parameters on productivity of green gram in Jalgaon district of Maharashtra

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ABSTRACT

The secondary data on productivity of green gram in Jalgaon district, Maharashtra from the year 1991 to 2018 (28 years) were collected from Epitome of Maharashtra. Looking to the adverse climatic situation and persistent changes in productivity of green gram in Jalgaon district, the present investigations were undertaken in order to study the impact of weather parameters on productivity of green gram. The study revealed that annual average number of rainy days was 39.5 with a standard deviation of 8.9 days during the season period of green gram during last 28 years. Thus among the weather parameters high variability was observed in case of wind velocity (58.4%) followed by bright sunshine hours (43.9%) while the area and production of green gram in Jalgaon district showed wide variation depicting that the number of rainy days was the most important factor for achieving higher yield in the district. The productivity of green gram was mostly influenced by rainfall and number of rainy days. The wind velocity and relative humidity in the evening indirectly influenced the productivity of green gram during the study period. In the present study the highest contribution of wind velocity (22.09%) in productivity of green gram was observed.

Keywords: Green gram; rainfall; variability; weather parameters; productivity

INTRODUCTION

Climate change and variability will directly and significantly affect the current and future agriculture (Gregory et al 2010). Changes in farm operational schedules also lead to changes in productivity and therefore contribute to inter-annual changes in crop yield (Adejuwon 2005). Crop growth and development are affected by solar radiation, relative humidity, rainfall, temperature and cloud cover which combine to produce the observed impacts of climate on crop yield (Daubenmire 1974). Ayinde et al (2011) observed the effect of climate change on agricultural productivity in Nigeria. Kumar and Sharma (2014) carried out the study for the understanding of relationship between climatic factors and sugarcane productivity. Mali et al (2014) analyzed the impact of weather changes on sugarcane production and to quantify the interrelationship between different weather parameters and yield of sugarcane. Dhuppar et al (2013) conducted micro-level location specific study to understand the impact of weather changes on lentil crop production at Agra. Many studies gave the clear evidence that due to climate change agricultural productivity in different regions of India and other countries of the world was decreasing.

Green gram is one of the most important pulse crops. It is grown in almost all parts of the country. In India green gram is grown on an area of about 3 million hectares with the production of about 1 million tonne. The major green gram growing states are Orissa, Maharashtra, Andhra Pradesh, Telangana, Rajasthan, Madhya Pradesh, Bihar, Karnataka and Uttar Pradesh. Green gram is best suited to areas having an annual rainfall of 60 to 75 cm. It requires a hot and warm climate. Green gram is considered to be hardiest among all pulse crops and can tolerate drought to a great extent.

Hence it is successfully grown in all adverse conditions and particularly in drought prone areas during kharif season. However water logging and cloudy weather are harmful for the crop. Yield is mainly determined by ecological factors including climate, soil, pests and diseases. Due to the large variability in weather parameters, presently farmers are facing many problems in getting production of crop in all regions of Maharashtra. Looking to the adverse climatic situation and persistent changes in productivity of green gram in Jalgaon district the present investigations were undertaken in order to study the impact of weather parameters on productivity of green gram.

METHODOLOGY

The secondary data on productivity of green gram in Jalgaon district from 1991 to 2018 (28 years) were collected from Epitome of Maharashtra. The data on weather parameters considering the crop period were collected from Oilseeds Research Station, Jalgaon, Maharashtra. The data were utilized for correlation and path analysis.

Correlation

The mean of one random variable is linearly dependent upon the random component of the other. A correlation coefficient (-1 to +1) indicates a pair of variables that vary together precisely, one variable being related to the other by means of a positive (negative) scaling factor (Panse and Sukhatme (1985):

$$r = \frac{\sum XY - \frac{\sum x \sum y}{n}}{\sqrt{\sum X^2 - \frac{(\sum x)^2}{n}} \sqrt{\sum Y^2 - \frac{(\sum Y)^2}{n}}}$$

where X: Weather parameters (T_{max},T_{min}, RH_I, RH_{II}, wind velocity, evaporation, BSS, rainfall and number of rainy days), Y: Productivity of crop

Path analysis

Path analysis extends the idea of regression modeling and gives flexibility of quantifying indirect and total causal effects in addition to the direct effect (Wright 1923). The relationship can be expressed in the form of a partial regression equation and is given by:

$$Y = \mu + \beta_1 X_1 + \beta_2 X_2 + \cdots\cdots + \beta_9 X_9 + R$$

here $\beta_1, \beta_2 \cdots \cdots, \beta_9$: Regression coefficients, β_1: Partial regression coefficient of Y on X_1 means the amount of change that can be brought about in Y due to one unit change in X_1 and $X_2 \cdots \cdots, X_9$ held constant, $\beta_2 \cdots \cdots, \beta_9$ have similar meanings, R is the residual component

For estimating the contribution of each weather parameter on productivity of green gram a set of nine simultaneous equations was then formulated from path diagram as:

$$rY_{X_1} = a + br_{X_1X_2} + cr_{X_1X_3} + \cdots\cdots + ir_{X_1X_9}$$

$$rY_{X_2} = ar_{X_2X_1} + b + cr_{X_2X_3} + \cdots\cdots + ir_{X_2X_9}$$

$$\vdots$$

$$\vdots$$

$$rY_{X_9} = ar_{X_9X_1} + br_{X_9X_2} + cr_{X_9X_3} + \cdots\cdots + i$$

where $Y_{X_1} \ldots \ldots Y_{X_9}$: Estimated values of correlation coefficients between dependent variable Y and the component variables viz X1, X2 .....X9, $r_{X_1X_2}$: Estimates of simple correlation coefficient between X1 and X2 variables, $r_{X_1X_3}$: Estimates of simple correlation coefficient between X1 and X3 variables

Similarly for $r_{X_2X_1}, r_{X_2X_3} \ldots\ldots\ldots r_{X_9X_8}$

a, b, c, d, e, f, g, h, i: Direct effects of variables X1, X2 ,..... X9

RESULTS and DISCUSSION

The results of variability in productivity of green gram and weather parameters in Jalgaon district are presented in Table 1. The data reveal that annual average area under green gram in Jalgaon district was 3,68,300 ha with 14.4 per cent variability during the study period of 28 years while annual average production of green gram was 1,93,200 tonnes with 31.8 per cent of variation and average productivity was 520.9 kg/ha with a variability of 24.8 per cent. The mean maximum and minimum temperature of monsoon season in Jalgaon district is 33.4 and 23.8°C respectively. Kaur et al (2006) analyzed the annual and seasonal variabilities in maximum and minimum temperature and rainfall from historical daily meteorological data for Ludhiana (1970-2004).

The coefficient of variation for minimum temperature (5.1%) was found higher than the

Table 1. Variability in area, production and productivity of green gram and weather parameters in Jalgaon district (1991-2018)

Component	Mean	SD	CV (%)
Area ('00 ha)	368.3	53.2	14.4
Production ('00 tonnes)	193.2	61.4	31.8
Productivity (kg/ha)	520.9	129.4	24.8
Maximum temperature (°C)	33.4	0.8	2.5
Minimum temperature (°C)	23.8	1.2	5.1
Relative humidity-I (%)	80.9	5.0	6.2
Relative humidity-II (%)	60.8	6.2	10.3
Bright sunshine (h)	6.6	2.9	43.9
Evaporation (mm)	5.6	1.4	25.0
Wind velocity (kmph)	7.7	4.5	58.4
Rainfall (mm)	676.3	205.3	30.4
Number of rainy days	39.5	8.9	22.5

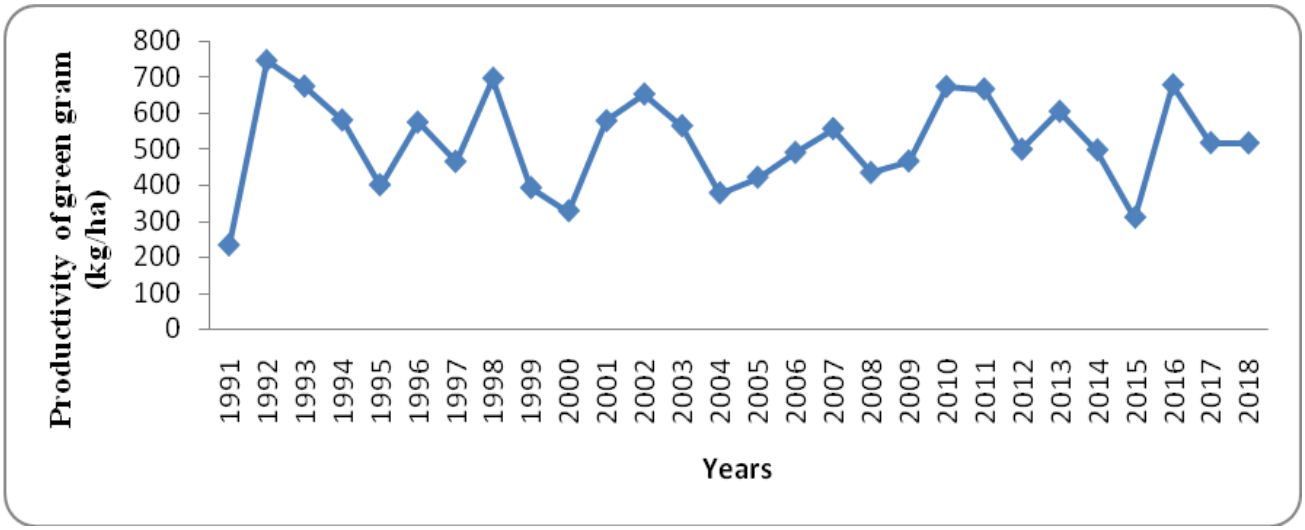

Fig 1. Trend of productivity of green gram in Jalgaon district (1991-2018)

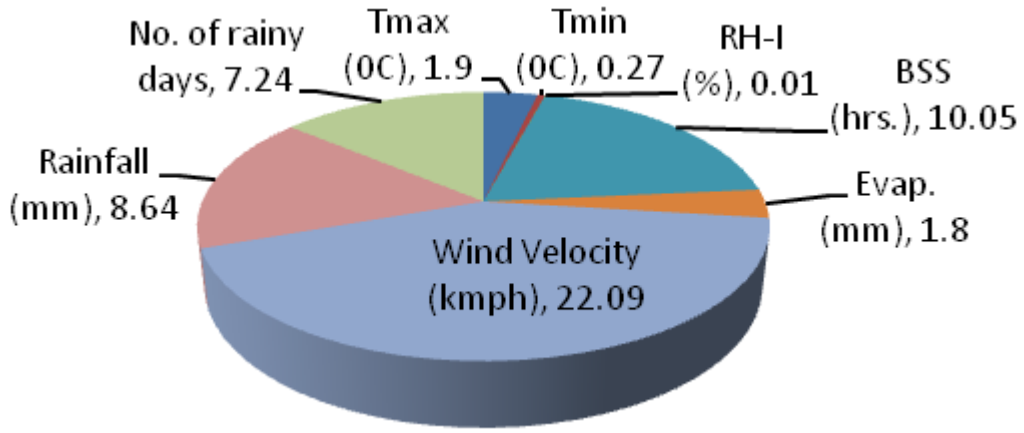

Fig 2. Contribution of weather parameters in productivity of green gram

Table 2. Interrelationship between productivity of green gram and weather parameters (1991-2018)

Component	Y	T_{max}	T_{min}	RH-I	RH-II	BSS	Evaporation	Wind velocity	Rainfall	Rainy days
Y	1.00	-	-	-	-	-	-	-	-	-
T_{max}	-0.22	1.00	-	-	-	-	-	-	-	-
T_{min}	-0.09	0.41*	1.00	-	-	-	-	-	-	-
RH-I	-0.01	-0.28	-0.41*	1.00	-	-	-	-	-	-
RH-II	0.15	-0.69**	-0.39*	0.59**	1.00	-	-	-	-	-
BSS	-0.15	0.17	0.08	-0.30	0.06	1.00	-	-	-	-
Evaporation	-0.25	0.27	0.23	-0.32	-0.22	0.52**	1.00	-	-	-
Wind velocity	-0.22	0.09	0.03	0.24	-0.28	-0.40*	0.39*	1.00	-	-
Rainfall	0.36	-0.57**	-0.46*	0.28	0.40*	-0.16	-0.17	0.07	1.00	-
Rainy days	0.38*	-0.56**	-0.20	0.14	0.25	-0.28	-0.14	0.12	0.64**	1.00

**Significant at 1% level of significance, *Significant at 5% level of significance, Y: Productivity, T_{max}: Maximum temperature, T_{min}: Minimum temperature, RH-I: Relative humidity-I, RH-II: Relative humidity-II, BSS: Bright sunshine

Table 3. Decomposition of correlation coefficients between productivity under green gram and weather parameters

Component	T_{max}	T_{min}	RH-I	RH-II	BSS	Evaporation	Wind velocity	Rainfall	Number of rainy days
T_{max}	**0.138**[3]	0.021	0.002	0.060	-0.053	0.037	-0.044	-0.168	-0.151
T_{min}	0.056	**0.052**[7]	0.004	0.030	-0.026	0.030	-0.016	-0.136	-0.053
RH-I	-0.039	-0.022	**-0.009**[6]	0.050	0.095	-0.043	-0.112	0.083	0.038
RH-II	-0.095	-0.020	-0.005	**-0.001**[5]	-0.017	-0.029	0.130	0.117	0.066
BSS	0.023	0.004	0.003	0.042	**-0.317**[8]	0.069	0.190	-0.047	-0.076
Evaporation	0.038	0.012	0.003	0.039	-0.164	**0.134**[4]	-0.184	-0.049	-0.038
Wind velocity	0.013	0.002	-0.002	0.041	0.128	0.052	**-0.470**[9]	0.021	0.032
Rainfall	-0.079	-0.024	-0.002	0.138	0.050	-0.022	-0.033	**0.294**[1]	0.173
Number of rainy days	-0.078	-0.010	-0.001	0.089	0.089	-0.019	-0.055	0.189	**0.269**[2]

Diagonal (direct) and off-diagonal (indirect) effects, Residual effect= 71%, R^2= 29%, T_{max}: Maximum temperature, T_{min}: Minimum temperature, RH-I: Relative humidity-I, RH-II: Relative humidity-II, BSS: Bright sunshine

maximum temperature (2.5%) during the season of green gram. The wind velocity in Jalgaon district was 7.7 kmph with coefficient of variation of 58.4 per cent and bright sunshine hours were 6.6 with a variability of 43.9 per cent.

The average evaporation was observed 5.6 mm with 25.00 per cent variation. The annual average rainfall in Jalgaon district was 676.3 mm with a 30.4 per cent variability and 205.3 mm standard deviation during the crop season of green gram. The annual average number of rainy days was 39.5 with a standard deviation of 8.9 days during the season period of green gram during last 28 years. Thus among the weather parameters high variability was observed in case of wind velocity followed by bright sunshine hours while the area and production of green gram had shown wide variation. Similar results were reported by Kumar et al (2014).

The correlation coefficients for different pairs of variables were assessed and are presented in Table 2. The productivity of green gram was positive and significantly correlated with number of rainy days (0.38) and remaining all weather parameters were non-significantly correlated with productivity. Therefore it can be inferred from the results that the number of rainy days are the most important for achieving higher yield in Jalgaon district as the productivity of green gram was largely influenced by number of rainy days. With productivity of green gram, only relative humidity at evening, rainfall and number of rainy days had shown positive correlation.

The results of path analysis between productivity of green gram and weather parameters are depicted in Table 3. The results indicate that the rainfall had high positive direct effect (0.294) on

Table 4. Contribution of weather parameters in productivity of green gram

Component	Productivity (%)
Maximum temperature (°C)	1.90
Minimum temperature (°C)	0.27
Relative humidity-I (%)	0.01
Relative humidity-II (%)	0.00
Bright sunshine (h)	10.05
Evaporation (mm)	1.80
Wind velocity (kmph)	22.09
Rainfall (mm)	8.64

productivity of green gram and it was followed by number of rainy days (0.269), maximum temperature (0.138) and evaporation (0.134). The highest total indirect contribution of wind velocity on productivity of green gram was found positive (0.287) and it was followed by bright sunshine hours (0.208), number of rainy days (0.204), rainfall (0.201) and relative humidity at evening (0.147).

Kumar et al (2014) reported that climatic factors had a statistically significant impact on productivity of most of food grain crops but this effect varied across crops. The highest total direct and indirect contribution of rainfall on the productivity of green gram was (0.495) and it was followed by number of rainy days (0.473) and relative humidity at evening (0.146). The residual value was 0.71 and it indicated that 71 per cent of variation in respect of the green gram productivity was accounted by other factors and 29 per cent of variation in productivity under green gram was accounted by nine selected weather parameters. Similar results were reported by Laxmi (2014). The contribution of wind velocity was higher (22.09%) for productivity of green gram (Fig 2) and it was followed by bright sunshine hours (10.05%), rainfall (8.64%) and number of rainy days (7.24). Laxmi (2014) reported similar results.

CONCLUSION

The productivity of green gram was mostly influenced by rainfall and number of rainy days. The wind velocity and relative humidity at evening indirectly influenced the productivity of green gram during the study period. The per cent contribution of wind velocity recorded higher contribution in productivity and it was followed by bright sunshine hours (10.05%), rainfall (8.64%) and number of rainy days (7.24 %) during the study period .

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