Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2020; 9(2): 1185-1189
Received: 03-01-2020
Accepted: 07-02-2020

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Correlation studies in weather parameters and yield of green gram varieties under changing weather conditions

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Abstract
An experiment was carried out at experimental farm of Department of Agricultural Meteorology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, during *Kharif* season 2015 entitled "Influence of dates of sowing on *kharif* green gram [*Vigna radiate* (L.) Wilczek] varieties under varied weather conditions" to find out most suitable week for sowing of Green gram in *kharif* season and to work out the correlation between yield of green gram and weather parameters. The experiment was conducted in Spilt plot design with three replications. Treatments comprised of three sowing dates in main plot D_1(25MW), D_2 (26MW) & D_3 (27MW) with four varieties in sub plot *viz*. BM-4, BPMR-145, BM-2003-2 and BM-2002-1.The crop was sown with spacing 30×10 cm. Gross and net plot size *viz*. 4.5 m x 4.0 m and 3.9 m x 3.6 m respectively. The result obtained from experiment revealed that all biometric observations (Plant height(cm), number of functional leaves, dry matter (gm), number of pods per plant) and yield of *kharif* green gram were significantly highest in first date D_1 25 MW (18 to 24 June) as compared to other date of sowing. The green gram variety BM-2003-2(510 kg ha^{-1}) was found to be highly productive as compared to BM-2002-1(467 kg ha^{-1}), BM-4 (402 kg ha^{-1}) and BPMR-145 (346 kg ha^{-1}). The correlation study was carried out between weather variables prevailed during (P_1) to (P_5) growth stages of different varieties under different sowing dates. The correlation coefficient showing degree of association between seed yield and weather variables prevailed during growth stages of green gram crop. Rainfall and rainy days were found significantly negative correlated at P_2 (-0.663*), (-0.597*) and P_3 (-0.665*), (-0.661*) respectively.
T_{max} and T_{min} were found significantly positive correlation at P_2 (0.698*), P_3 (0.624*) while T_{max}were found significantly negative correlation at P_4 (-0.727*) and T_{min} at P_1 (-0.605*). RH-I was found significantly positive correlation at P_4 (0.685*) and found significantly negative correlated at P_2 (-0.712*), P_3 (-0.692*), and (-0.685*). RH-II was found significantly negatively correlated at P_2 (-0.762*). Evaporation was found significantly negatively correlated at P_1 (-0.691*) and at P_4 (-0.743**) while it found significantly positive correlation at P_2 (0.663*) and at P_3 (0.769**). BSS was found significantly negatively correlated at P_3 (-0.035*) and at P_4 (-0.738**) while it found significantly positive correlation at P_5 (0.676*) Wind velocity was found significantly positive correlation at P_3 (0.640*) and at P_4 (0.698*).

Keywords: Green gram yield, weather parameters, correlation

Introduction
Green gram locally called as mung [*Vigna radiata* (L.) Wilczek] belong to the family Leguminoceae, it fixes atmospheric nitrogen and improves soil fertility by adding 20-25 kg N ha^{-1}. The green gram foliage left over afterpicking of mature pods can either be feed to livestock or it may ploughed as green tomanure enrich the soil with organic matter. Mung bean is a short duration crop so it can be grown as catch crop. Due to covering of stand with foliage it is also grown as cover crop, as it checks the erosion by smothering the soil.
Mungbean [*Vigna radiata* (L.) Wilczek] is an important pulse crop of *kharif* season in India. The crop is highly sensitive to environment. Time of sowing is a non-monetery input which influences seed yield extent. (Singh and Sekhon 2003). The optimum time of sowing ensures the complete harmony between the vegetative and reproductive phases on one hand and the climatic rhythm on the other and helps in realizing the potential yield. (Singh and Dhingra 1993) [13]. Therefore time of sowing show remarkable influence on the growth and productivity of Mungbean in *kharif* due to rainy season. (Brar *et al*. 1988) [2]. Temperature is the prime weather variable which affects plant life. Heat unit concept is the agronomic application of temperature effect on plant, which has been employed to correlate phonological development in crops and to predict maturity dates. (Nuttonson 1955) [7]. Crop phenology is an essential component of the crop-weather models, which can be used to specify the most appropriate rate and time of specific plant growth and development process.

The different phases of this crop are subjected to the variation in wind speed throughout its lifecycle. Agronomically, the optimum date of sowing for this crop has been demarcated (Rahman *et al*., 2009, Bhowmick *et al.*, 2006) [10, 1]. However, the impact of weather parameter on this important crop is not well studied. As the crop has to pass its lifecycle within a particular atmospheric specification, it is important to study the impact of weather parameter on the crop to demarcate its growing season properly

Material and Methods

A one year field trial was conducted during *kharif* season 2015 at PGI, VNMKV, Parbhani (Maharashtra) situated at the $19^0$16' North latitude and $76^0$47' Eastlongitude. The experimental site had soil is well drainedand depth of the soil varied from 2 to 3 meter. The treatmentcomprised of four varieties *viz.* BPMR-145, BM-2002-1, BM-2003-2 and BM-4 and three different sowing times *viz*. June, 23, 30 and first week of July,07. In all twelve treatment combinations were tested in split plot design with three replications. Individual plot size was 4.5 m x 4.0 m. A seed rate of 10-12 kg ha^{-1} was used depending upon seed size. The trial was conducted meticulously with recommended package of practices. Observations were taken on plant height,(cm), number of functional leaves, dry matter at 20,40,60 days after sowing (DAS) and at harvest, seed yield (kg ha-1) and its attributes.

Correlation between Green gram yield and weather parameters

Simple correlation between weather parameters i.e. Rainfall, Rainy days, Maximum temperature, Minimum temperature, Relative humidity, Evaporation, Bright sun shine hours and Wing velocity on the development of green gram was estimated to know the correlation between these weather parameters and green gram yield**.**

Theprocedure and formula described were significant was tested.

$$r = \frac{\sum xy}{\sqrt{[\sum x]\,[\sum y]}}$$

Where

r = Correlation coefficient

x = Independent variables (attributes)

y = Dependent variables (yield)

Results and Discussion

Growth studies

Plant Height

Data on periodical mean plant height (cm) recorded at various stages of crop growth is presented in Table 1. Data presented in Table 1.Revealed that the mean plant height progressively increased and reached to maximum (36.99cm) at harvest. The plant height was observed significantly highest in first date of sowing i.e. D_1 (25 MW) 40.98 cm at harvest than other date of sowing at all stages of crop growth, the plant height was significantly highest at 40 DAS. Lowest plant height was recorded in D_3 during all growth stages of crop.

The variety BM-2003-2 was found significantly superior over other varieties in producing taller plant up to harvest. The mean plant height of BM-2002-1 is significantly superior at 20, 40, 60 DAS and at harvest i.e. 11.31, 26.47, 35.84 and 40.67 respectively, over varieties BM-2002-1, BM-4 and BPMR-145 during all the growth stages. It might be due to genetic character of BM-2003-2. Similar results were reported by Choudhary *et al*. (1994) [3], Shrivastava & Verma (1986) [12].

Mean number of functional leaves per plant

Data regarding mean number of functional leaves at 20, 40, 60 DAS and at harvest was found to be 3.61, 7.06, 9.31 and 4.91 respectively. It was observed that number of functional leaves per plant was increased continuously up to 60 DAS (days after sowing), thereafter it was decreased due to crop senescence. The crop sown on D_1 (23rd June) produced significantly higher number of functional leaves per plant at 60 DAS i.e. 11.39 and at harvestreduced number of functional leaves i.e. 5.80 over rest of all other sowing dates.

The variety BM-2003-2 (V_3) was found significantly superior in producing maximum number of leaves per plant over varieties BM-2002-1, BM-4 and BPMR-145. Similarresults was obtained by Singh *et al.* (2010) [14].

Mean total dry matter production plant^{-1} (g)

Mean of dry matter per plant at 20, 40, 60 DAS and at harvest was 0.45, 4.91, 8.88 and 9.56 gm $plant^{-1}$ respectively. At initial stages it was very slow between Emergence to 20 DAS. At 20 DAS of crop, it was only 0.45(g) $plant^{-1}$. However, the rate of increase of dry matter was highest between 40 DAS to 60 DAS. The treatment D_1 (23rd June) was produced significantly higher dry matter per plant at 20, 40, 60 DAS and at harvest i.e.0.47, 6.31, 9.86 and 10.54 respectively over D_2 (30th June) and lowest dry matter per plant produced in sowing date D_3 (07th July) at 20, 40, 60 DAS and at harvest. The variety BM-2003-2 (V_3) was found significantly superior at 20, 40, 60 DAS and at harvest i.e. 0.51, 5.52, 10.51 and 11.18 over variety BM-2002-1, BM-4 and BPMR-145 and produced maximum dry matter per plant at all stages of crop.

Post harvest studies

Number of pods per plant

The maximum number of pods per plant were observed with the crop sown on D_1 (25 MW) was found significantly superior it produced 11.40 pods per plant over D_2 (26 MW) and D_3 (27 MW) sowing dates. Higher number of pods per plant was produced by variety BM-2003-2 (V_3) i.e. 14.38 and was significantly superior over variety BM-2002-1 (V_2) i.e.12.56, BM-4 (V_1) i.e.7.06 and variety BPMR-145 (V_4) i.e. 6.46. Similar result was reported by Faroda *et al*. (1983), Rana *et al.* (2006) [8] and Fraz *et al.* (2006) [5].

Number of seeds per pod

The crop sown on D_1 25 MW (23rd June) has recorded maximum number of seeds per pod i.e.7.54 followed by D_2 (26 MW) i.e. 6.04 and D_3 (27 MW) i.e. 5.41. The variety BM-2003-2 (V_3) has recorded the higher number of seeds per pod (8.07) was significantly superior over rest of varieties. Same results were reported by Reddy *et al.* (1991) [9].

Pod weight per plant

The crop sowing at D_1 (23rd June) has produced highest pod weight per plant i.e. 8.85 (gm) and significantly superior over rest of the sowing dates. The lowest pod weight per plant recorded by crop sown on D3 (07th July) i.e. 6.94 (gm). The variety BM-2003-2 (V_3) produced maximum pod weight per plant (8.58 gm) and found significantly superior as compared to varieties BM-2002-1 (V_2) i.e.8.39 (gm), BM-4 (V_1) i.e.

7.54 (gm) and BPMR-145 (V_4) i.e.7.39 (gm). Similar results were obtained by Sharma *et al.* (1989) [11].

Seed yield per plant

The crop sown i.e. 23rd June (D_1) produced maximum seed yield per plant (2.54 gm) was significantly influenced as compared to the rest of sowing dates. Lowest seed yield per plant produced sowing date D_3 (27 MW) i.e.1.86 (gm). Similar results were reported by Singh *et al.* (2012). The variety BM-2003-2 (V_3) produced maximum seed yield per plant i.e. (2.51gm) was significantly superior over BM-2002-1 (2.37gm), BM-4 (2.08gm) and BPMR-145 (1.92gm). Similar results were reported by Monem *et al.* (2012) [6].

Test weight

Test weight (1000 seed weight) was not influenced by different sowing dates, varieties and their interactions. The effect of different sowing dates on test weight (1000 seeds)was found to be non significant. But the highest test weight was observed at D_1 23rd June (41.3 gm) followed by sowing date D_2 30th June (40.3 gm) and D_3 30th June (37.6 gm) and variety BM-2003-2 produced maximum test weight (46.1 gm) was significantly superior over BM-2002-1 (42.6 gm), BM-4 (36.4gm) and BPMR-145 (33.8 gm) as shown in table 2. Similar results were reported by Rana *et al.* (2006) [8].

Yield

The crop sown on D_1 (23rd June) produced maximum seed yield, Straw yield and biological yield was 524 kg ha^{-1}, 1248 kg ha^{-1}, 1772kg ha^{-1} respectively which was significantly superior over rest of sowing dates and variety BM-2003-2 (V_3) produced maximum seed yield, straw yield and biological yield was 510 kg ha^{-1}, 1254 kg ha^{-1}, and 1763 kg ha^{-1} respectively which was significantly superior over other varieties. Similarly close results were reported by Yadahalli and Palled (2004)[15].

Correlation studies growth and yield attributing characters

The result given in table 3. The rainfall has been significantly negative correlated with growth & yield attributing characters of Green gram varieties at harvest stage of BM-2003-2, BM-2002-1, BM-4 and BPMR-145 varieties.

Data revealed that during sowing to germination stage (P_1), minimum temperature and rate of evaporation showed negative association. During germination to bud emergence stage (P_2), maximum temperature, mean temperature and evaporation showed significant positive association whereas rainfall, RH-I, RH-II and RH mean showed negative association. During bud emergence to flower emergence stage (P_3), maximum temperature, mean temperature and wind speed showed significant positive association and evaporation rate showed highly positive significance. Whereas rainfall, rainy day, morning relative humidity and mean relative humidity showed negative association. During flower emergence to pod emergence stage (P_4), morning relative humidity and mean relative humidity showed positive association whereas maximum temperature showed negative association and evaporation rate and bright sun shine hours showed highly negative association. During pod emergence to harvest stage (P_5), evaporation rate, bright sun shine hours and wind speed showed significant positive association.

Table 1: Mean Plant Height (cm), Number of Functional leaves $plant^{-1}$, Dry matter production (gm) $plant^{-1}$as influenced by various treatments.

Treatments	Plant height (cm)	Number of functional leaves $plant^{-1}$	Dry matter production (gm) $plant^{-1}$
Sowing dates (D)			
D1: 25 MW (23rd June)	40.98	5.80	10.54
D2: 26 MW (30th June)	37.07	4.75	9.47
D3: 27 MW (07th July)	32.92	4.18	8.67
SE ±	1.52	0.17	0.18
CD at 5%	4.52	0.53	0.54
Varieties (V)			
V1: BM-4	36.10	4.80	8.83
V2: BM-2002-1	37.45	5.09	9.94
V3: BM-2003-2	40.67	5.52	11.18
V4: BPMR-145	33.74	4.24	8.29
SE ±	1.04	0.15	0.30
CD at 5%	3.09	0.46	0.90
Interaction (D×V)			
SE ±	1.80	0.27	0.52
CD at 5%	NS	NS	NS
General Mean	36.99	4.91	9.56

Table 2: Mean number of pods $plant^{-1}$, number of seed pod^{-1}, pod weight $plant^{-1}$, seed yield $plant^{-1}$ and test weight as influenced by various treatments.

Treatments	Number of pods $plant^{-1}$	Number of seed pod^{-1}	Pod weight $plant^{-1}$	Seed yield (gm) $plant^{-1}$	Test weight
Sowing dates (D)					
D1: 25 MW (23rd June)	11.40	7.54	8.85	2.54	41.3
D2: 26 MW (30th June)	10.88	6.04	8.13	2.26	40.3
D3: 27 MW (07th July)	8.07	5.41	6.94	1.86	37.6
SE ±	0.57	0.24	0.13	0.02	0.61
CD at 5%	1.70	0.73	0.39	0.07	2.05
Varieties (V)					
V1: BM-4	7.06	5.01	7.54	2.08	36.4
V2: BM-2002-1	12.56	7.56	8.39	2.37	42.6
V3: BM-2003-2	14.38	8.07	8.58	2.51	46.1
V4: BPMR-145	6.46	4.68	7.39	1.92	33.8

SE ±	0.53	0.25	0.15	0.04	0.63
CD at 5%	1.59	0.74	0.45	0.12	2.11
Interaction (D×V)					
SE ±	0.92	0.43	0.26	0.07	1.39
CD at 5%	NS	NS	NS	NS	NS
General Mean	10.11	6.33	7.97	2.22	39.7

Table 3: Mean seed yield, straw yield, biological yield (kg ha^{-1}) and harvest index as influenced by various treatments.

Treatments	Seed yield(kg ha^{-1})	Straw yield(kg ha^{-1})	Biological yield(kg ha^{-1})	Harvest index (%)
Sowing dates (D)				
D1: 25 MW (23rd June)	524	1248	1772	29.46
D2: 26 MW (30th June)	437	1132	1570	27.76
D3: 27 MW (07th July)	331	954	1285	25.53
SE ±	5.05	21.59	26.20	0.13
CD at 5%	19.84	84.77	102.88	0.52
Varieties (V)				
V1: BM-4	402	1028	1429	27.78
V2: BM-2002-1	467	1205	1672	27.72
V3: BM-2003-2	510	1254	1763	28.75
V4: BPMR-145	346	959	1304	26.09
SE ±	10.28	27.88	36.98	0.27
CD at 5%	30.54	82.84	109.88	0.82
Interaction (D×V)				
SE ±	17.80	48.29	64.05	0.47
CD at 5%	NS	NS	NS	NS
General Mean	431	1111	1543	27.59

Table 4: Correlation between weather parameters and different phenophages of Green gram with seed yield of different varieties.

Weather Parameters	P1	P2	P3	P4	P5
Rainfall (mm)	-0.102	-0.663*	-0.665*	-0.271	-0.420
Rainy days	-0.221	-0.597	-0.661*	0.211	-0.272
T max (^{0}C)	-0.325	0.698*	0.624*	-0.727*	0.386
T min (^{0}C)	-0.605*	0.500	0.373	0.450	0.433
T mean	-0.511	0.630*	0.672*	-0.123	0.486
R.H.-I. (%)	0.536	-0.712*	-0.692*	0.685*	-0.443
R.H.-II (%)	0.071	-0.762**	-0.499	0.585	-0.345
R.H. Mean (%)	0.276	-0.757**	-0.608*	0.636*	-0.394
EVP (mm)	-0.691*	0.663*	0.769**	-0.743**	0.651*
B.S.S. (hrs day^{-1})	0.039	0.601	-0.035	-0.738**	0.676*
W.V. (kmph)	-0.320	0.500	0.640*	0.293	0.698*

* Significant at 5% ** Significant at 1%
P_1: Sowing to Germination P_2: Germination to Bud emergence
P_3: Bud emergence to Flower emergence P_4: Flower emergence to Pod emergence
P_5: Pod emergence to Harvest

Conclusion

Significant positive correlation was found with seed yield of BM-2003-2, BM-2002-1, BPMR-145 and BM-4 during the phenophases P_2 (T max., T min., Evaporation), P_3 (T max., T min., Evaporation and Wind speed), P_4 (RH-I, RH-II) and P_5 (B.S.S. Evaporation and Wind speed).

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