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Assessment of correlation and forewarning models between weather parameters and population of *Melanagromyza obtuse* in pigeonpea varieties under different sowing windows

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Abstract
Since, Pod fly, *Melanagromyza obtusa* is one of the major pests causing grain damage ranging from 10-80% in pigeonpea, hence it is necessity to establish relationship with pest and weather parameters, and forecasting of pest. For that correlation was carried out between weather parameter and population of *M. obtuse* on different pigeonpea varieties at different sowing windows and forewarning models for prediction of pest, during 2017-18 and 2018-19. An experiment was laid out in split-plot design with three replications. The treatment comprised of four varieties *viz.*, Vipula, Rajeshwari (Phule T 0012), BDN 711 and ICPH 2740 as main plot and four sowing windows *viz.*, 24th MW, 26th MW, 28th MW and 30th MW as sub plot treatments. The overall correlation of weather parameters with seasonal incidence of *M. obtuse* found that positively correlation with morning relative humidity, bright sunshine hours and wind speed whereas, maximum and minimum temperature, evening relative humidity and rainfall showed negative correlation during *Kharif* seasons of 2017-18 and 2018-19. The forecasting of population of *M. obtuse* with multiple linear regression equations were recorded the highest R^2 value as 0.841 in treatment combination of 24th MW and ICPH 2740.

Keywords: Correlation, forewarning models, weather, varieties, population and m. obtuse

Introduction

Pigeonpea (*Cajanus cajan* (L.) Millspaugh) is one of the major pulse crops of the tropics and subtropics. It is the second most important pulse crop of India, after chickpea (Nene *et al.*, 1990) [6]. Pigeonpea is grown on an area of 4.43 m ha and production of 4.25 m tonnes the productivity is 960 kg ha^{-1} in India (Anonymous, 2019) [3]. Pigeonpea is grown throughout the country, except the hilly regions where winter temperature is very low. In India, Maharashtra, Andhra Pradesh and Gujarat account for a major pigeonpea growing states. The production and productivity of this crop has remained stagnant over the past three decades due to its vulnerability to *biotic* and *abiotic* stresses. A large number of insect pests (more than 300 species) attack pigeonpea (Prasad and Singh, 2004) [7]. Insects that attack the reproductive structures of plant cause the maximum yield losses (Rangaiah and Sehgal, 1984) [8]. The most important pests those attack at flowering and podding stage of the crop are pigeonpea pod borer, spotted pod borer, blue butterflies, and pod fly, *Melanagromyza obtuse* Malloch (Reed *et al.*, 1989). Pod borers caused 60 to 90% loss in the grain yield under favourable conditions, damage of seed by pod fly ranged from 14.3 to 46.6% (Lal *et al.*, 1992) [5] and loss of yield was recorded 60 to 80% due to the pod fly (Durairaj, 2006) [2]. There are no obvious external symptoms of pod fly attack till the fully grown larvae chew holes in the pod walls leaving a "window" through which the flies emerge after pupation in the pod. Damaged seeds are of no value. All the immature stages remain within the developing pod and it is very difficult to monitor the pest without damaging the pod. The sowing window is one of the crop habitat desertification that is to be looked into, to minimize the incidence of insect pests on pigeonpea crop so that its yield can be enhanced. The sowing window takes the advantage of the absence of the pest or avoids susceptible stage of the crop. It prevents carryover of pests from early sown crop to late sown crop and prevents buildup of damaging populations. The pest forewarning model was able to predict the percent population of pod borer for different pigeonpea varieties and sowing windows with good r^2 values.

Keeping these facts in view, the correlation between weather parameter and population of pod fly (*M. obtuse*) maggots per five plants on different pigeonpea varieties at different sowing windows and development of forewarning models for prediction of population pod fly (*M. obtuse*) larvae per five plants was studied during, 2017-18 and 2018-19.

Material and Methods

An experiment was laid out in split-plot design with three replications and sixteen treatment combinations formed considering different varieties and sowing windows. The gross and net plot size was 4.0 × 4.5 m^2 and 3.6 × 4.0 m^2, respectively for two consecutive years at Department of Agricultural Meteorology farm, College of Agriculture, Pune during 2017-18 and 2018-19. The geographical location of the site (Pune) was 18° 32'N, latitude; 73°51E, longitude and 559 m above mean sea level (MSL). The soil is medium black having depth of about 1m. Pune is situated in the sub-tropical region (Plain Zone). The average annual rainfall of Pune is 675 mm, which is distributed from second fortnight of June to second fortnight of October. Out of total rainfall, about 75 per cent is received from June to September during south-west monsoon, while remaining is received from north-east monsoon (October and November). The maximum temperature during the month of April and May is ranged between 34^0C to 40^0C. But on the onset of monsoon, it drops down to 27^0C. In the month of July and August, it is ranged from 26 to 30 ^{0}C. The minimum temperature varied from 6 to 10 ^{0}C in winter season from November to middle of February. Humidity of monsoon period *i.e.* from June to September is quite high during morning (about 85 to 93%). The evening humidity is generally ranged between 43 to 83 per cent. Urea and DAP were used as source of N and P and applied as per recommended dose i.e., 25 kg N and 50 kg. Seeds were treated with Thiram @ 4 g per kg of seed followed by *Rhizobium* and PSB @ 10 g per kg of seed.

Correlation of weather parameters with pests

The observation on the incidence of pod fly maggot was recorded at weekly interval from five randomly selected and tagged plants from net plot. The effect of weather parameters *viz.*, maximum and minimum temperatures (^{0}C), relative humidity (%) (morning and evening), bright sunshine hours, rainfall (mm) and rainy days, wind speed, evaporation rate on *Melanagromyza obtuse* were recorded from meteorological weeks 24^{th} to 2^{nd} during 2017-18 and 2018-19. The correlation studies were carried out between pest population, various above weather parameters of different sowing windows and varieties during 2017-18 and 2018-19. The multiple regression analysis was also worked out between pod fly pest population and weather parameters.

The influence of weather parameters on pest population was estimated by using prediction equation as,

Y = a + b1x1+b2x2+b3x3+______+bnxn.

Where,

Y= Pest population, ‘a’ as constant and ‘b’ as

Regression coefficients of independent variable ‘x’.

The simple correlations (Snedecor and Cochron, 1968) [10] and forewarning models for different sowing windows and varieties of pigeonpea were worked out by statistical analysis using SPSS8.0 software with multiple linear regression method.

Results and Discussion

During the course of study the incidence of *M. obtuse* were recorded on different pigeonpea varieties at different sowing windows. The incidences of M. obtuse were recorded on all varieties during the year 2017-18 and 2018-19, across all sowing windows. The influence of different weather parameters *viz.*, maximum and minimum temperature, morning and evening relative humidity, wind speed evaporation and rainfall on the seasonal population of *M. obtuse* maggots per five plants was quantified by working out correlation coefficient (r) and presented in table 1 and 2. The overall linear multiple regression analysis was worked out between pest population of W0 week with weather parameters of one week prior (W-1) for all different treatment combinations and forewarning models were developed are given in Table 3.

Table 1: Correlation between weather parameters and population of pod fly, *M. obtusa* maggots per five plants during 2017-18

Treatment		r' values							
Sowing window	Variety	T_{max}	T_{min}	RH-I	RH-II	Wind speed	Rainfall	Epan	BSS
D_1- 24th MW	V_1- Vipula	-0.301	-0.244	0.286	-0.013	0.335	-0.245	-0.094	0.056
D_2- 26th MW	V_1- Vipula	-0.360	-0.306	0.025	-0.008	0.494	-0.331	-0.054	0.133
D_3- 28th MW	V_1- Vipula	-0.558*	-0.490	0.052	-0.131	0.537*	-0.475	-0.205	0.196
D_4- 30th MW	V_1- Vipula	-0.651*	-0.567*	0.068	-0.130	0.457	-0.462	-0.325	0.151
D_1- 24th MW	V_2 - Rajeshwari	-0.047	-0.097	0.276	-0.080	0.178	-0.132	0.095	0.117
D_2- 26th MW	V_2 - Rajeshwari	-0.382	-0.336	0.235	-0.055	0.409	-0.335	-0.091	0.114
D_3- 28th MW	V_2 - Rajeshwari	-0.459	-0.334	0.061	-0.083	0.512	-0.426	-0.131	0.085
D_4- 30th MW	V_2 - Rajeshwari	-0.407	-0.264	0.167	0.064	0.369	-0.326	-0.264	0.001
D_1- 24th MW	V_3 - BDN 711	-0.305	-0.462	0.379	-0.306	0.160	-0.380	-0.173	0.291
D_2- 26th MW	V_3 - BDN 711	-0.347	-0.278	0.029	0.004	0.487	-0.334	-0.088	0.124
D_3- 28th MW	V_3 - BDN 711	-0.500	-0.389	0.067	-0.048	0.584*	-0.415	-0.126	0.135
D_4- 30th MW	V_3 - BDN 711	-0.627*	-0.526	0.034	-0.098	0.498	-0.447	-0.309	0.140
D_1- 24th MW	V_4 - ICPH 2740	-0.120	-0.123	0.012	-0.025	0.437	-0.234	0.147	0.160
D_2- 26th MW	V_4 - ICPH 2740	-0.377	-0.332	0.045	-0.160	0.582*	-0.338	-0.058	0.160
D_3- 28th MW	V_4 - ICPH 2740	-0.551*	-0.548*	0.058	-0.237	0.522*	-0.457	-0.203	0.239
D_4- 30th MW	V_4 - ICPH 2740	-0.566*	-0.582*	0.045	-0.256	0.534*	-0.460	-0.204	0.257

Where,

T_{max}: Maximum temperature RH-II: Evening relative humidity WS: Wind speed Epan: Pan evaporation * Significant at 0.05% level

T_{min}: Minimum temperature RH-I: Morning relative humidity RF: Rainfall BSS: Bright sunshine hours ** Significant at 0.01% level

Table 2: Correlation between weather parameters and population of pod fly, *M. obtusa* maggots per five plants during 2018-19 (cont)

Treatment		r' values							
Sowing window	Variety	T_{max}	T_{min}	RH-I	RH-II	Wind speed	Rainfall	Epan	BSS
D_1- 24th MW	V_1- Vipula	0.328	0.061	0.341	-0.249	-0.076	-0.320	0.431	0.262
D_2- 26th MW	V_1- Vipula	-0.066	-0.088	0.142	-0.039	-0.013	-0.443	0.185	0.151
D_3- 28th MW	V_1- Vipula	-0.278	-0.269	0.054	0.036	-0.126	-0.483	-0.085	0.083
D_4- 30th MW	V_1- Vipula	-0.344	-0.387	0.053	-0.013	-0.217	-0.510	-0.203	0.092
D_1- 24th MW	V_2 - Rajeshwari	0.366	0.105	0.318	-0.253	-0.124	-0.349	0.404	0.175
D_2- 26th MW	V_2 - Rajeshwari	-0.054	-0.249	0.072	-0.168	-0.226	-0.457	0.042	0.135
D_3- 28th MW	V_2 - Rajeshwari	-0.242	-0.351	0.052	-0.022	-0.352	-0.456	-0.200	0.003
D_4- 30th MW	V_2 - Rajeshwari	-0.411	-0.474	0.164	0.030	-0.338	-0.471	-0.365	-0.045
D_1- 24th MW	V_3 - BDN 711	0.108	-0.214	0.356	-0.360	-0.046	-0.534	0.190	0.392
D_2- 26th MW	V_3 - BDN 711	-0.031	-0.038	0.200	-0.024	0.032	-0.421	0.216	0.096
D_3- 28th MW	V_3 - BDN 711	-0.476	-0.358	0.056	0.112	-0.116	-0.480	-0.226	0.042
D_4- 30th MW	V_3 - BDN 711	-0.527	-0.470	0.143	0.047	-0.217	-0.525	-0.347	0.036
D_1- 24th MW	V_4 - ICPH 2740	0.286	0.247	0.420	-0.023	0.191	-0.279	0.526	0.151
D_2- 26th MW	V_4 - ICPH 2740	-0.123	-0.077	0.192	0.006	0.069	-0.438	0.175	0.153
D_3- 28th MW	V_4 - ICPH 2740	-0.445	-0.285	0.003	0.125	-0.044	-0.452	-0.175	0.029
D_4- 30th MW	V_4 - ICPH 2740	-0.463	-0.322	0.098	0.117	-0.111	-0.453	-0.223	0.008

Where,
T_{max}: Maximum temperature RH-II: Evening relative humidity WS: Wind speed Epan: Pan evaporation * Significant at 0.05% level
T_{min}: Minimum temperature RH-I: Morning relative humidity RF: Rainfall BSS: Bright sunshine hours ** Significant at 0.01% level

Table 3: Forewarning models for one prior (W-1) for prediction of pod fly, *M. obtusa* maggots on pigeonpea during 2017-18 and 2018-19.

Treatment		Forewarning model	R^2 Value
Sowing window	Variety		
D_1- 24th MW	Vipula	Y= –26.545+ 2.408(T_{max}) – 1.065(T_{min}) – 0.556(RH I) + 0.434(RH II) – 0.086(Rainfall) –1.1159(BSS)	0.552
D_2- 26th MW	Vipula	Y= –16.226+ 1.286 (T_{max}) – 1.089(T_{min}) – 0.448(RH I)+ 0.654 (RH II) – 0.115(Rainfall) – 2.152(BSS)	0.636
D_3- 28th MW	Vipula	Y= 14.924 – 0.080(T_{max}) – 0.599 (T_{min}) – 0.244 (RH I) + 0.458(RH II) – 0.139(Rainfall) + 1.128(BSS)	0.524
D_4- 30th MW	Vipula	Y= 11.250 + 0.802(T_{max}) – 1.273(T_{min}) – 0.344(RH I) + 0.477(RH II) – 0.104(Rainfall) + 0.299(BSS)	0.632
D_1- 24th MW	Rajeshwari	Y= -15.521 + 2.463 (T_{max}) – 1.089 (T_{min}) – 0.316 (RH I) -0.005 (RH II) – 0.040(Rainfall) –1.553(BSS)	0.605
D_2- 26th MW	Rajeshwari	Y= -28.003+ 2.124(T_{max}) – 1.208(T_{min}) – 0.119(RH I) + 0.146(RH II) – 0.066(Rainfall) – 1.289(BSS)	0.784
D_3- 28th MW	Rajeshwari	Y= -5.215 + 1.099(T_{max}) – 0.743(T_{min}) -0.077 (RH I) -0.097(RH II) – 0.089(Rainfall) –1.324(BSS)	0.822
D_4- 30th MW	Rajeshwari	Y= – 17.329 +1.677(T_{max}) – 1.136(T_{min}) – 0.103(RH I) + 0.169(RH II) – 0.069(Rainfall) –1.503(BSS)	0.529
D_1- 24th MW	BDN 711	Y= – 30.274+ 4.480(T_{max}) – 2.108(T_{min}) – 0.689(RH I) +0.228(RH II) – 0.098(Rainfall) –1.824(BSS)	0.785
D_2- 26th MW	BDN 711	Y= – 30.424+ 2.789 (T_{max}) – 1.832(T_{min}) – 0.029(RH I) +0.162(RH II) – 0.160(Rainfall) –2.760(BSS)	0.683
D_3- 28th MW	BDN 711	Y= 14.061+0.986(T_{max}) – 1.597(T_{min}) – 0.103(RH I) + 0.314(RH II) – 0.159(Rainfall) –1.782(BSS)	0.686
D_4- 30th MW	BDN 711	Y= 11.387+1.138 (T_{max}) – 1.858 (T_{min}) – 0.130 (RH I) + 0.288(RH II) – 0.128(Rainfall) – 2.289(BSS)	0.750
D_1- 24th MW	ICPH 2740	Y= –30.424 + 2.789(T_{max}) – 1.832(T_{min}) – 0.029(RH I) + 0.162(RH II) – 0.160(Rainfall) – 2.760(BSS)	0.841
D_2- 26th MW	ICPH 2740	Y= 80.311 – 2.036(T_{max}) + 0.708(T_{min}) - 0.354(RH I) + 0.0.089(RH II) – 0.141(Rainfall) + 1.244(BSS)	0.600
D_3- 28th MW	ICPH 2740	Y= 86.341 – 2.695(T_{max}) + 0.558(T_{min}) – 0.177 (RH I) + 0.149(RH II) – 0.138(Rainfall) + 0.842(BSS)	0.519
D_4- 30th MW	ICPH 2740	Y= 59.177 – 1.531(T_{max}) + 0.005 (T_{min}) – 0.210(RH I) + 0.218(RH II) – 0.107(Rainfall) +0.632(BSS)	0.615

Correlation between weather parameters and population of (*M. obtuse*) maggots on pigeonpea var. Vipula at different sowing windows and forewarning models for incidence of *M. obtuse*

During first sowing window 24th MW with var. Vipula the population of *M. obtuse* maggots per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.286 and 0.341) and bright sunshine hours (0.056 and 0.262) whereas, it was negative correlated with evening relative humidity (-0.013 and -0.249) and rainfall (-0.245 and -0.320) during *Kharif* seasons of 2017-18 and 2018-19, respectively. The forewarning model for var. Vipula and 24th MW sowing window obtained as an increase of one unit of maximum temperature and evening relative humidity increased the population of *M. obtuse* by 2.408 and 0.434 units, respectively. These weather parameters collectively increased the population of *M. obtuse* to an extent of 55.2% (R^2=0.552). During second sowing window 26th MW with var. Vipula the population of *M. obtuse* maggots per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.025 and 0.142), bright sunshine hours (0.133 and 0.151), whereas, it was negative correlated with maximum temperature (-0.360 and -0.066), minimum temperature (-0.306 and -0.088), evening relative humidity (-0.008 and -0.039) and rainfall (-0.331 and -0.443) during *Kharif* seasons of 2017-18 and 2018-19, respectively.

The forewarning model for var. Vipula and 26th MW sowing window obtained as an increase of one unit of maximum temperature and evening relative humidity increased the population of *M. obtuse* by 1.286 and 0.654 units, respectively. These weather parameters collectively increased the population of *M. obtuse* to an extent of 63.6% (R^2=0.636). During third sowing window 28th MW with var. Vipula the population of population of *M. obtuse* maggots per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.052 and 0.054), bright sunshine hours (0.196 and 0.151), whereas, it was significant negatively correlated with maximum temperature (-0.058 and -0.278) minimum temperature (-0.490 and -0.269), and rainfall (-0.475 and -0.483) during *Kharif* seasons of 2017-18 and 2018-19, respectively. The forewarning model for var. Vipula and 28th MW sowing window as an increase of one unit of evening relative humidity and bright sunshine hours increased the population of *M. obtuse* by 0.458 and 1.128

units, respectively. These weather parameters collectively increased the population of *M. obtuse* to an extent of 52.4% (R^2=0.524). During fourth sowing window 30th MW with var. Vipula the population of population of *M. obtuse* maggots per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.068 and 0.053) and bright sunshine (0.151 and 0.092), whereas, it was significant negatively correlated with maximum temperature (-0.651 and -0.344), minimum temperature (-0.567 and -0.387), evening relative humidity (-0.130 and -0.013), rainfall (-0.462 and -0.510) during *Kharif* seasons of 2017-18 and 2018-19, respectively. The forewarning model for var. Vipula and 30th MW sowing window as an increase of one unit of maximum temperature, evening relative humidity and bright sunshine hours increased the population of *M. obtuse* by 0.802, 0.477 and 0.299 units, respectively. These weather parameters collectively increased the population of *M. obtuse* to an extent of 63.2% (R^2=0.632).

Correlation between weather parameters and population of *M. obtuse* maggots on pigeonpea var. Rajeshwari at different sowing windows and forewarning models for incidence of *M. obtuse*

During first sowing window 24th MW with var. Rajeshwari the population of *M. obtuse* maggots per five plants for one week prior (W-1) was significant positively correlated with morning relative humidity (0.276 and 0.318), bright sunshine hours (0.117 and 0.175), whereas, it was negative correlated with evening relative humidity (-0.080 and -0.253) and rainfall (-0.132 and -0.349) during *Kharif* seasons of 2017-18 and 2018-19, respectively. The forewarning model for var. Rajeshwari and 24th MW sowing window as an increase of one unit of maximum temperature increased the population of *M. obtuse* by 0.928 units to an extent of 60.5% (R^2=0.605). During second sowing window 26th MW with var. Rajeshwari the population of *M. obtuse* maggots per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.235 and 0.072) and bright sunshine hours (0.114 and 0.135), whereas, it was negative correlated with maximum temperature (-0.382 and -0.054) and minimum temperature (-0.336 and -0.249), evening relative humidity (-0.055 and -0.168) and rainfall (-0.335 and -0.042) during *Kharif* seasons of 2017-18 and 2018-19, respectively. The forewarning model for var. Rajeshwari and 26th MW sowing window as an increase of one unit of maximum temperature and evening relative humidity increased the population of *M. obtuse* by 2.124 and 0.146 units. These weather parameters collectively increased the population of *M. obtuse* to an extent of 78.4% (R^2=0.784). During third sowing window 28th MW (D_3) with var. Rajeshwari the population of *M. obtuse* maggots per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.061 and 0.052) and bright sunshine hours (0.085 and 0.003), whereas, it was negative correlated with maximum temperature (-0.459 and -0.242), minimum temperature (-0.334 and -0.351) and rainfall (-0.426 and -0.456) during *Kharif* seasons of 2017-18 and 2018-19, respectively. The forewarning model for var. Rajeshwari and 28th MW sowing window as an increase of one unit of maximum temperature increased the population of *M. obtuse* by 1.099 units to an extent of 82.2% (R^2=0.822). During fourth sowing window 30th MW with var. Rajeshwari the population of *M. obtuse* maggots per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.167 and 0.164) and evening relative humidity (0.064 and 0.030), whereas, it was negative correlated maximum temperature (-0.407 and -0.411) and minimum temperature (-0.264 and -0.474) and rainfall (-0.326 and -0.471) during *Kharif* seasons of 2017-18 and 2018-19, respectively. The forewarning model for var. Rajeshwari and 30th MW sowing window as an increase of one unit of maximum temperature and evening relative humidity increased the population of *M. obtuse* by 1.677 and 0.169 units, respectively. These weather parameters collectively increased the population of *M. vitrata* to an extent of 52.9% (R^2=0.529).

Correlation between weather parameters and population of *M. obtuse* maggots on pigeonpea var. BDN 711 at different sowing windows and forewarning models for incidence of *M. obtuse*

During first sowing window 24th MW with var. BDN 711 the population of *M. obtuse* maggots per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.379 and 0.356) and bright sunshine hours (0.291 and 0.392) whereas, it was negative correlated with maximum temperature (-0.305 and -0.108), minimum temperature (-0.462 and -0.214) and evening relative humidity (-0.306 and -0.360) during *Kharif* seasons of 2017-18 and 2018-19, respectively. The forewarning model for var. BDN 711 and 24th MW sowing window as an increase of one unit of maximum temperature and evening relative humidity increased the population of *M. obtuse* by 4.480 and 0.228 units, respectively. These weather parameters collectively increased the population of *M. obtuse* to an extent of 78.5% (R^2=0.78.5). During second sowing window 26th MW (D_2) with var. BDN 711 the population of population of *M. obtuse* maggots per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.029 and 0.200) and bright sunshine hours (0.124 and 0.096), whereas, it was negative correlated with maximum temperature (-0.347 and -0.031), minimum temperature (-0.278 and -0.038) and rainfall (-0.334 and -0.421) during *Kharif* seasons of 2017-18 and 2018-19, respectively. The forewarning model for var. BDN 711 and 26th MW sowing window as an increase of one unit of maximum temperature and evening relative humidity increased the population of *M. obtuse* by 4.480 and 0.228 units, respectively. These weather parameters collectively increased the population of *M. obtuse* to an extent of 68.3% (R^2=0.683). During third sowing window 28th MW with var. BDN 711 the population of population of *M. obtuse* maggots per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.067 and 0.056) and bright sunshine hours (0.135 and 0.042), whereas, it was negative correlated with maximum temperature (-0.500 and -0.476), minimum temperature (-0.389 and -0.358) and rainfall (-0.415 and -0.480) during *Kharif* seasons of 2017-18 and 2018-19, respectively. The forewarning model for var. BDN 711 and 28th MW sowing window as an increase of one unit of maximum temperature and evening relative humidity increased the population of *M. obtuse* by 0.986 and 0.314 units, respectively. These weather parameters collectively increased the population of *M. vitrata* to an extent of 68.6% (R^2=0.686). During fourth sowing window 30th MW with var. BDN 711 the population of population of *M. obtuse* maggots per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.034 and 0.143) and bright sunshine hours (0.140 and 0.036), whereas, it was significant negative correlated with maximum temperature (-0.627 and -0.527), minimum temperature (-0.526 and -0.470) and rainfall (-0.447 and -0.525) during *Kharif* seasons of 2017-18 and 2018-19, respectively. The forewarning model for var. BDN 711 and 30th MW sowing window as an increase of one unit of maximum temperature and evening relative humidity increased the population of *M. obtuse* by 1.138 and 0.288 units, respectively. These weather parameters collectively increased the population of *M. obtuse* to an extent of 75.0% (R^2=0.750).

Correlation between weather parameters and population of *M. obtuse* maggots on pigeonpea var. ICPH 2740 at different sowing windows and forewarning models for population of *M. obtuse*

During first sowing window 24th MW with var. ICPH 2740 the population of *M. obtuse* maggots per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.012 and 0.420), bright sunshine hours (0.160 and 0.151), whereas, it was negative correlated with maximum temperature (-0.120 and -0.286), evening relative humidity (-0.025 and -0.023) and rainfall (-0.234 and -0.279) during *Kharif* seasons of 2017-18 and 2018-19, respectively. The forewarning model for var. ICPH 2740 and 24th MW sowing window as an increase of one unit of maximum temperature and evening relative humidity increased the population of *M. obtuse* by 2.789 and 0.162 units, respectively. These weather parameters collectively increased the population of *M. obtuse* to an extent of 84.1% (R^2=0.841). During second sowing window 26th MW with var. ICPH 2740 the population of population of *M. obtuse* maggots per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.045 and 0.192), bright sunshine hours (0.160 and 0.153), whereas, it was negative correlated with maximum temperature (-0.377 and -0.123), minimum temperature (-0.332 and -0.077) and rainfall (-0.338 and -0.175) during *Kharif* seasons of 2017-18 and 2018-19, respectively. The forewarning model for var. ICPH 2740 and 26th MW sowing window as an increase of one unit of minimum temperature, evening relative humidity and bright sunshine hours increased the population of *M. obtuse* by 0.708, 0.089 and 1.244 units, respectively. These weather parameters collectively increased the population of *M. obtuse* to an extent of 60.0% (R^2=0.600). During third sowing window 28th MW with var. ICPH 2740 the population of population of *M. obtuse* maggots per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.058 and 0.003), bright sunshine hours (0.239 and 0.029), whereas, it was significant negative correlated with maximum temperature (-0.551 and -0.445), minimum temperature (-0.548 and -0.285) and rainfall (-0.457 and -0.452) during *Kharif* seasons of 2017-18 and 2018-19, respectively. The forewarning model for var. ICPH 2740 and 28th MW sowing window as an increase of one unit of minimum temperature, evening relative humidity and bright sunshine hours increased the population of *M. obtuse* by 0.558, 0.149 and 0.842 units, respectively. These weather parameters collectively increased the population of *M. obtuse* to an extent of 51.9% (R^2=0.519). During fourth sowing window 30th MW with var. ICPH 2740 the population of population of *M. obtuse* maggots per five plants for one week prior (W-1) was positively correlated with morning relative humidity (0.045 and 0.098), bright sunshine hours (0.257 and 0.008), whereas, it was significant negative correlated with maximum temperature (-0.566 and -0.463), minimum temperature (-0.582 and -0.322) and rainfall (-0.460 and -0.453) during *Kharif* seasons of 2017-18 and 2018-19, respectively. The forewarning model for var. ICPH 2740 and 30th MW sowing window as an increase of one unit of minimum temperature, evening relative humidity and bright sunshine hrs increased the population of *M. obtuse* by 0.005, 0.218 and 0.632 units, respectively. These weather parameters collectively increased the population of *M. obtuse* to an extent of 61.5% (R^2=0.615). Shinde *et al.* (2017) [9] found that correlations of *M. obtuse* population with maximum temperature were negatively significant and minimum temperature, and evening relative humidity were negatively non-significant. The coefficient of multiple regressions was non-significant in all weather parameters except maximum temperature. The selected weather parameter indicated 62.4 per cent variation in the infestation of *M. obtuse*. The similar results were reported by Akhauri *et al.* (1996) [1], Yadav *et al*. (2011) [11] and Keval *et al.* (2018) [4].

Conclusion

Results of the cumulative correlation showed that the population of pod fly was found to have positively correlation with morning relative humidity, wind speed and bright sunshine hours. It was negative correlated with maximum temperature, minimum temperature, evening relative humidity, rainfall and evaporation.

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