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Satyendra Vikaram Singh
Department of Plant Pathology, Acharya Narendra Deva University Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Krishna Kumar
Department of Plant Pathology, Acharya Narendra Deva University Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Satya Prakash Vishwakarma
Department of Plant Pathology, Acharya Narendra Deva University Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Anand Singh
Department of Genetics and Plant Breeding, Acharya Narendra Deva University Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

JP Srivastava
Department of Plant Pathology, Acharya Narendra Deva University Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Corresponding Author:
Satyendra Vikaram Singh
Department of Plant Pathology, Acharya Narendra Deva University Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Effect of environmental factors on development of diseases powdery and downy mildew of Pea

Satyendra Vikaram Singh, Krishna Kumar, Satya Prakash Vishwakarma, Anand Singh and JP Srivastava

Abstract
Pea (*Pisum sativum* L.) is the third most widely grown grain legume worldwide, commonly called as matar in Hindi and belongs to family leguminaceae. The values of Correlation coefficients among disease intensity and minimum temperature, maximum temperature, relative humidity and sunshine hours and wind velocity were -0.51, -0.60, -0.35, -0.30, 0.92 and -0.50, -0.60, -0.37, -0.30, 0.90 in protected and unprotected environments respectively. The trend of correlation was almost similar in all cultivar of pea only wind velocity showed positive correlation with all tested cultivars. The values of Correlation coefficients among disease intensity and minimum temperature, maximum temperature, relative humidity and sunshine hours and wind velocity were 0.35, 0.49, -0.57, 0.10, -0.83 and -0.24, 0.75, -0.67, 0.47, -0.17 in protected and unprotected environments respectively. The trend of correlation was almost different in all cultivars of pea except maximum temperature which showed positive correlation with all tested cultivars.

Keywords: Pea, germplasms, powdery mildew, Downey mildew

Introduction
Pea (*Pisum sativum* L.) is the third most widely grown grain legume worldwide, commonly called as matar in Hindi and belongs to family leguminaceae and cultivated as an important vegetable as well as pulse crop throughout the world. Among various grain legumes is one of the ancient domesticated popular pulse crops of India and has versatile uses in both food and feed. The dry seed contains 22.5g proteins and 62.5g carbohydrates 100g and having relatively less is anti- nutritional substances. In India, the maximum cultivation of pea in Uttar Pradesh followed by Bihar and Madhya Pradesh. At national level the total area under pea cultivation is about 0.96 million ha with a production of 0.92 million tonnes and productivity is 960 kg/ha. In U.P., total area under pea is about 357000 ha with production of 354000 tonnes and a productivity is 992 kg/ha. (Anonymous, 2014-15) [1]. Powdery mildew caused by the pathogen *Erysiphe pisi* is a serious disease of pea. The pathogen is obligate parasite act as biotroph. Linnaeus (1753) [5] was the first to name a powdery mildew as an organism by using the binomial *Mucor erysiphe* to a white fungus on the leaves. Powdery mildew first appears on the upper surface of the lower most (oldest) leaves as small (4-5mm diameter), scattered, white, almost circular colonies which eventually coalesce as the colonies grow further covering the entire leaf surface under favourable environmental conditions. Colony colour changes from white to greyish brown, plants become stunted. Mildew appears as fine talcum powder like appearance. Leaf, stem, floral parts and pods get affected. Improper seed setting reduced number and size of seeds. The conidia of *E. pisi.* can germinate on living/ non- living substrates at wide range RH and limited of temperature. The involvement of phenolic compounds in induced resistance against powdery mildew pathogen was demonstrated by Maranon (1924) [7]. No conidiophores and conidial formation on highly resistant cultivar is reported (Singh and Singh, 1983) [10]. Up to 50% are more yield reduction in late planted or late maturing pea cultivar is reported (Mahmood *et al.*, 1983) [6]. A drastic reduction in the number of pickings from sever in healthy to one in diseased crop has also been reported Powdery mildew (Dixon, 1987) [3].

Materials and Methods
First appearance and severity of both downy mildew as well as powdery mildew was recorded at different appropriate intervals (weekly) to draw a disease progress curve correlating with weather parameters like min- max temp RH, Rainfall, Wind velocity etc. Besides the conidial

germination of powdery mildew at different temperatures, RH and light regime was also studied. The field experiment was conducted at the pea G.P.B. field, A.N.D.U.A.T, Kumarganj, during the *Rabi* seasons of 2016-2017. Field pea variety Rachna was shown on 29 November, 2016 in a randomized block design with three replication and plot size was of 4 x 5 meter. The observation on appearance of powdery mildew and downy mildew was carefully recorded. Thereafter, progress of the disease was recorded at seven days interval and continued until disease severity reaches maximum up to physiological maturity of the crop. Observations of powdery mildew and downy mildew were recorded in the term of percent disease severity. The effects of climatic factors *viz.* temperature, humidity, wind velocity and sunshine on disease severity were also studied. The meteorological data were collected from meteorology department, Narendra Dev University of Agriculture and technology Kumarganj Ayodhya (U.P.). Correlation co-efficient between disease severity and meteorological parameters were determined by Karl Pearson's formula and tested individually for their significance at 5% probability level by using following formula.

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

Where,
t = test of significance
r = correlation coefficient
n = number of observations

The rate of disease development/ unit / day was estimated according to the method given by Vanderplank (1963) [11]. The apparent infection rate (r) for total period was:

$$r = \frac{1}{t_2 - t_1} \log_e \left[\frac{x_2(1-x_1)}{x_1(1-x_2)} \right]$$

Where
r = rate of disease development
t_1 = date of first observation
t_2 = date of second observation
X_1 = disease severity on first observation
X_2 = disease severity on second observation

Results and Discussion

Downy mildew

It is evident from the data (Table no. 1) correlation study between downy mildew disease intensity and weather parameter in different cultivars of pea was made and it was noted that cultivar V1 showed negative correlation with minimum temperature, maximum temperature, relative humidity and sunshine hours and positive correlation with wind velocity in both protected and unprotected environment. The values of Correlation coefficients among disease intensity and minimum temperature, maximum temperature, relative humidity and sunshine hours and wind velocity were -0.51, -0.60, -0.35, -0.30, 0.92 and -0.50, -0.60, -0.37, -0.30, 0.90 in protected and unprotected environments respectively. The trend of correlation was almost similar in all cultivar of pea only wind velocity showed positive correlation with all tested cultivars. The magnitudes of correlation for varieties V_2, V_3, V_4, V_5, V_6, V_7, V_8, V_9, V_{10} and V_{11}. Were (-0.72, -0.33, -0.61, -0.01, 0.77), (-0.51, -0.60, -0.40, -0.30, 0.91), (-0.66, -0.42, -0.54, -0.10, 0.82), (-0.50, -0.60, -0.36, -0.29, 0.90), (-0.62, -0.48, -0.48, -0.15, 0.86), (-0.48, -0.62, -0.30, -0.31, 0.93), (-0.72, -0.34, -0.60, -0.01, 0.77), (-0.59, -0.51, -0.45, -0.19, 0.87), (-0.65, -0.43, -0.52, -0.10, 0.83), (-0.55, -0.54, -0.41, -0.23, 0.89), (-0.69, -0.39, -0.56, -0.05, 0.81), (-0.53, -0.57, -0.38, -0.26, 0.90), (-0.65, -0.43, -0.52, -0.10, 0.83), (-0.52, -0.58, -0.37, -0.27, 0.91), (-0.64, -0.45, -0.50, -0.12, 0.85), (-0.58, -0.52, -0.43, -0.20, 0.88), (-0.64, -0.45, -0.50, -0.13, 0.85), (-0.58, -0.51, -0.45, -0.19, 0.87), (-0.67, -0.42, -0.54, -0.08, 0.82) and (-0.40, -0.67, -0.26, -0.39, 0.92) in protected and unprotected respectively. The similar result found by Singh *et al*., (1998) [9] reported that temperature had a marked effect on the penetration of pea leaflets by conidial germ tube of *Peronospora pisi*. The pathogen penetrate the leaf tissue at 12-14 ^{0}C in 8.0 - 8.5 hours, whereas, more time (9.5-16.5 hours) was required for penetration at higher temperature (15-18 ^{0}C). Maximum spore discharge in *P. pisi* was observed from 9.00-15 hours. However, presence of light, high temperature, lack of moisture on leaf surface and wind velocity affected discharge. Gaag *et al*., (1996) [4] studied the oospores production at 5, 10, 15 and 20 ^{0}C in systemically colonized shoots and in local lesions on leaflets, stem parts and pods of the pea. Most oospores were produced at 20 ^{0}C. At 10 ^{0}C, few oospores were found in stem parts and none in leaflet lesions. At 5 ^{0}C no to spore were formed at all. In pods more oospores were produced at 15and 20 ^{0}C than at 10 ^{0}C, but the effect of temperature, on the number of oospores was smaller than in the other plant parts. Oospores formed at lower temperature, were larger than those farmed at higher temperature. Singh (1998) **[9]** reported that infection take place with only 4 hours of leaf wetting provided the temperature for spore germination is favourable. The disease is common in areas where night temperatures are low and there is heavy fog and dew. Infection can occur at almost freezing temperature to 22 ^{0}C with optimum at 16 ^{0}C.

Powdery mildew

It is evident from the data (Table no. 2) correlation study between powdery mildew disease intensity and weather parameters in different cultivars of pea was made and it was noted that cultivar V_1 showed positive correlation with minimum temperature, maximum temperature and sunshine hours and negative correlation with relative humidity and wind velocity in protected environment and unprotected environment V_1 cultivar showed positive correlation with maximum temperature and sunshine hours and negative correlation with minimum temperature, relative humidity and wind velocity. The values of Correlation coefficients among disease intensity and minimum temperature, maximum temperature, relative humidity and sunshine hours and wind velocity were 0.35, 0.49, -0.57, 0.10, -0.83 and -0.24, 0.75, -0.67, 0.47, -0.17 in protected and unprotected environments respectively. The trend of correlation was almost different in all cultivars of pea except maximum temperature which showed positive correlation with all tested cultivars. The magnitudes of correlation for varieties V_2, V_3, V_4, V_5, V_6, V_7, V_8, V_9, V_{10}, V_{11}. Were (0.41, 0.39, -0.49, 0.03, - 0.86), (-0.31, 0.81, -0.73, 0.55, -0.23), (0.38, 0.32, -0.44, 0.03, -0.89), (-0.18, 0.76, -0.69, 0.44, -0.25), (0.41, 0.39, -0.49, 0.03, -0.86), (-0.24, 0.75, -0.67, 0.47, -0.17), (0.51, 0.33, -0.42, -0.06, -0.78), (-0.19, 0.70, -0.62, 0.41, -0.13), (0.53, 0.29, -0.39, -0.80, -0.78), (-0.12, 0.58, -0.48, 0.29, 0.01), (0.30, 0.37, -0.49,

0.11,-0.93), (-0.42, 0.73, -0.63, 0.55, -0.02), (0.48, 0.34, -0.43, -0.03, -0.82), (-0.24, 0.75, -0.67, 0.47, -0.17), (0.46, 0.22, -0.34, -0.06, -0.85), (-0.53, 0.80, -0.71, 0.66, -0.09), (0.59, 0.15, -0.26, -0.18, -0.77), (-0.45, 0.74, -0.63, 0.57, -0.02) and (0.30, 0.37,-0.49, 0.11, -0.93), (-0.41, 0.79, -0.70, 0.59, -0.13) in protected and unprotected respectively. Banyal and Tyagi (1997) [2] studied the role of climatic factors, such as temperature and relative humidity, on the development of powdery mildew (*Erysiphe pisi*) of pea (*Pisum sativa*) using simple correlation analysis. The result shows that temperature plays a significance role in determining the course of powdery mildew epidemics of pea in and around Palampur. Highly significant and positive correlation between temperature and severity were obtained during 1991-92 and 1992-93. The disease developed rapidly when the average of maximum and minimum exceeded 20 ^{0}C, high relative humidity was not pre requisite for the development the powdery mildew. A highly significant correlation observed between temperature and disease severity. It is suggested that the negative effect of relative humidity on disease development is associated with rainfall. Yarwood (1936) [12] reported that *in vitro* germination of conidia was maximum, when collected in the afternoon. Paulech (1969) [8] reported the minimum, optimum and maximum temperature for the germination of conidia were 7^{0}C, 25^{0}C and 35^{0}C, respectively.

Table 1: Correlation coefficient between downy mildew intensity and meteorological factors

S. No.	Varieties	Treatments	Correlation coefficient between disease severity and weather parameter				
			Min. Temp.	Max. Temp.	Average R.H.	Sunshine hours	Wind velocity
1.	V_1 FP-16-21	P	-o.51	-0.60	-0.35	-0.30	0.92
		UP	-0.50	-0.60	-0.37	-0.30	0.90
2.	V_2 FP-16-19	P	-0.72	-0.33	-0.61	-0.01	0.77
		UP	-0.51	-0.60	-0.40	-0.30	0.91
3.	V_3 FP-16-48	P	-0.66	-0.42	-0.54	-0.10	0.82
		UP	-0.50	-0.60	-0.36	-0.29	0.90
4.	V_4 FP-16-30	P	-0.62	-0.48	-0.48	-0.15	0.86
		UP	-0.48	-0.62	-0.32	-0.31	0.93
5.	V_5 FP-16-42	P	-0.72	-0.34	-0.60	-0.01	0.77
		UP	-0.59	-0.51	-0.45	-0.19	0.87
6.	V_6 FP-16-27	P	-0.65	-0.43	-0.52	-0.10	0.83
		UP	-0.55	-0.54	-0.41	-0.23	0.89
7.	V_7 FP-16-4	P	-0.69	-0.39	-0.56	-0.05	0.81
		UP	-0.53	-0.57	-0.38	-0.26	0.90
8.	V_8 FP-16-11	P	-0.65	-0.43	-0.52	-0.10	0.83
		UP	-0.52	-0.58	-0.37	-0.27	0.91
9.	V_9 FP-16-31	P	-0.64	-0.45	-0.50	-0.12	0.85
		UP	-0.58	-0.52	-0.43	-0.20	0.88
10.	V_{10} FP-16-2	P	-0.64	-0.45	-0.50	-0.13	85
		UP	-0.58	-0.51	-0.45	-0.19	0.87
11.	Rachna	P	-0.67	-0.42	-0.54	-0.08	0.82
		UP	-0.40	-0.67	-0.26	-0.39	0.92

Table 2: Correlation coefficient between powdery mildew intensity and meteorological factors

S. No.	Varieties	Treatments	Correlation coefficient between disease severity and weather parameter				
			Min. Temp.	Max. Temp.	Average R. H.	Sunshine hours	Wind velocity
1.	V_1 FP-16-21	P	0.35	0.49	-0.57	0.10	-0.83
		UP	-0.24	0.75	-0.67	0.47	-0.17
2.	V_2 FP-16-19	P	0.41	0.39	-0.49	0.03	-0.86
		UP	-0.31	0.81	-0.73	0.55	-0.23
3.	V_3 FP-16-48	P	0.38	0.32	-0.44	0.03	-0.89
		UP	-0.18	0.76	-0.69	0.44	-0.25
4.	V_4 FP-16-30	P	0.41	0.39	-0.49	0.03	-0.86
		UP	-0.24	0.75	-0.67	0.47	-0.17
5.	V_5 FP-16-42	P	0.51	0.33	-0.42	-0.06	-0.78
		UP	-0.19	0.70	-0.62	0.41	-0.13
6.	V_6 FP-16-27	P	0.53	0.29	-0.39	-0..8	-0.78
		UP	-0.12	0.58	-0.48	0.29	0.01
7.	V_7 FP-16-4	P	0.30	0.37	-0.49	0.11	-0.93
		UP	-0.42	0.73	-0.63	0.55	-0.02
8.	V_8 FP-16-11	P	0.48	0.34	-0.43	-0.03	-0.82
		UP	-0.24	0.75	-0.67	0.47	-0.17
9.	V_9 FP-16-31	P	0.46	0.22	-0.34	-0.06	-0.85
		UP	-0.53	0.80	-0.71	0.66	-0.09
10.	V_{10} FP-16-2	P	0.59	0.15	-0.26	-0.18	-0.77
		UP	-0.45	0.74	-0.63	0.57	-0.02
11.	Rachna	P	0.30	0.37	-0.49	0.11	-0.93
		UP	-0.41	0.79	-0.70	0.59	-0.13

Conclusion

The downy mildew disease intensity and weather parameter in different cultivars of pea was made and it was noted that cultivar V1 showed negative correlation with minimum temperature, maximum temperature, relative humidity and sunshine hours and positive correlation with wind velocity in both protected and unprotected environment. The values of Correlation coefficients among disease intensity and minimum temperature, maximum temperature, relative humidity and sunshine hours and wind velocity were -0.51, -0.60, -0.35, -0.30, 0.92 and -0.50, -0.60, -0.37, -0.30, 0.90 in protected and unprotected environments respectively. The powdery mildew disease intensity and weather parameters in different cultivars of pea was made and it was noted that cultivar V_1 showed positive correlation with minimum temperature, maximum temperature and sunshine hours and negative correlation with relative humidity and wind velocity in protected environment and unprotected environment V_1 cultivar showed positive correlation with maximum temperature and sunshine hours and negative correlation with minimum temperature, relative humidity and wind velocity. The values of Correlation coefficients among disease intensity and minimum temperature, maximum temperature, relative humidity and sunshine hours and wind velocity were 0.35, 0.49, -0.57, 0.10, -0.83 and -0.24, 0.75, -0.67, 0.47, -0.17 in protected and unprotected environments respectively. The trend of correlation was almost different in all cultivars of pea except maximum temperature which showed positive correlation with all tested cultivars.

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