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Bean Anthracnose (*Colletotrichum lindemuthianum*) in Kashmir: Epidemiology and Yield Loss Assessment

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ABSTRACT

Background: The present study is region specific carried out to see the relation of bean anthracnose with weather in Kashmir and also to assess the yield loss in bean vis-à-vis anthracnose. Such studies form basis for deciding disease suppressive crop geometry and also sowing date alterations besides helping in disease predictions. The yield loss study in particular reveals the importance of a disease before any management strategies are worked out.

Methods: Epidemiology was conducted under natural epiphytotic conditions using a susceptible bean cv. Shalimar Rajmash-1 for recording disease development at weekly intervals. Yield loss assessment was also recorded on Shalimar Rajmash-1 where different disease levels were created by inoculating at different phonological stages after maturity the crop stand disease free.

Conclusion: During cropping season, the incidence and intensity of bean anthracnose developed to the extent of 77.06 and 54.51 per cent, when average temperature, average RH and weekly rain fall ranged from 16.6-23.8°C, 62.2-76.5 per cent and 1.7-48.2 mm, respectively. However, the highest periodic increase in disease incidence (12.62%) was recorded during 24th standard metrological week which coincided with highest rain fall and the increase in periodic disease intensity was higher (> 10%) when RH was above 70 per cent. The yield loss in bean vis-a-vis variable levels of disease as created by inoculating different unit population of bean plants at different phenological stages revealed significant and positive correlation of bean anthracnose and yield loss. Highest yield loss (68.42%) was recorded in populations where the disease started at 1st trifoliate stage which then reached maximum intensity of 81.09 per cent at physiological maturity. The terminal disease intensity in population where disease started at pod filling was significantly low (18.59%) and caused least yield loss of 10.95 per cent. The study reveals that bean anthracnose caused significant yield loss when it appeared at any stage upto flowering.

Key words: Bean anthracnose, *Colletotrichum lindemuthianum*, Epidemiology, Yield loss.

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is an annual legume crop of Fabaceae. It has originated in South Mexico and Central America (Vavilov, 1951) and has gained increasing popularity due to its quality proteins and nutritional balance besides certain medicinal properties (Adikshta and Sharma, 2017). This crop has become third most important food legume after soybean and peanut in production and is also the most utilized crop for direct consumption in the world (Broughton *et al*., 2003). According to Food and Agriculture Organization, global production and productivity of dry bean and green bean in 2019 cropping season was about 31.40 million tonnes and 24.22 million tonnes, respectively. In India dry bean and green bean are cultivated on an area of 15.42 and 0.24 million hectare, respectively. India alone produced 6.39 million tones of dry bean with a productivity of 4.14 quintals ha^{-1} (Anonymous, 2019). Jammu and Kashmir is one of the most important pulse growing regions where different pulses are grown over an area of about 26.57 thousand hectares with an annual production of 8.41 thousand tonnes and productivity of 0.317 tonnes ha^{-1} (Anonymous, 2015). Bean crop suffers due to a number of fungal and bacterial diseases. Among these bean anthracnose caused by *Colletotrichum lindemuthianum* is considered an important disease for causing huge yield loss year after year (Junaid *et al*., 2014). The yield losses due to this disease can reach 100 per cent when badly contaminated seeds are sown and environmental conditions remain favorable for disease development for long periods (Sharma *et al*., 1994). The mean incidence and intensity of this disease in Kashmir during 2011 cropping season varied from 28.47-40.18 per cent and 10.69-16.42 per cent, respectively (Junaid *et al*., 2014). However, it may vary from season to season depending upon the weather. Therefore, region specific epidemiology that can provide base line data for deciding any disease suppressive changes in crop geometry and sowing date besides helping in predicting

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disease in a given season has a scope. Moreover, the extent of yield loss vis-à-vis this disease has to be determined through a systematic approach. In view of importance of this crop in Kashmir, both these aspects of bean anthracnose were studied as follows.

MATERIALS AND METHODS

The present investigations on bean anthracnose (*Colletotrichum lindemuthianum*) in Kashmir vis-a-vis epidemiology and yield loss assessment were conducted in experimental farm of the Division of Plant Pathology, Sher-e-Kashmir University of Agricultural Sciences and Technology, FoA, Wadura Sopore, located at 34°-20′ north latitude and 74°-24′ east longitude at an elevation of 1610 meters above mean sea level.

Temporal dynamics of bean anthracnose

Bean crop (Cv. Shalimar Rajmash-1) was raised over an area of 100 m^2 with 30 cm and 10 cm row to row and plant to plant spacing, respectively. To ensure the presence of inoculums, The boarder rows inoculated with *Colletotrichum lindmuthianum* spore suspension (10^7 conidia ml^{-1}) in the evening hours at 1st trifoliate stage and the entire crop was then maintained unsprayed under natural epiphytotic conditions. The crop was examined periodically for disease scores until it reached physiological maturity. The observations on disease incidence was worked out as follows:

$$\text{Disease incidence (\%)} = \frac{\text{Number of diseased units}}{\text{Total number of units observed}} \times 100$$

For disease intensity, the sampled units were categorized using 0-9 severity scale of Mayee and Dattar (1986). Where 0 = No symptoms 1= Small, round brown spots covering < 1 per cent area, 3= spots covering 1-10 per cent area, 5 = spots covering 11-25 per cent area, 7 = spots covering 26-50 per cent area, 9 = spots covering > 50 per cent area. It was then worked out by using the following formula:

$$\text{Disease intensity} = \frac{\sum (n \times v)}{N \times G} \times 100$$

Where,

n = Number of units in each category, v = Numerical value of category, N = Number of units examined and G = Maximum numerical value *i.e.* 9.

In order to see the role of temperature RH and rainfall in disease development the weather data for the period was obtained from Indian metrological department Srinagar through Division of Agronomy FoA, SKUAST-K.

Disease simulation and yield loss assessment

The experiment comprised of five treatments with four replications in randomized block design. Variable levels of disease were created by inoculating different unit populations of bean at different phenological stages *viz.*, 1st trifoliate, 3rd trifoliate, flowering and pod filling representing five treatments. Until inoculation, the plants were maintained disease free by regular chemical intervention, using combo formation of Carbendazim and Mancozeb @ 0.25%.

The observation on terminal disease were recorded on a random sample of 10 plants per replication. Disease incidence and intensity were worked out as given above. However, the seed yield was calculated from net yield of four 3 meter rows in each plot.

RESULTS AND DISCUSSION

First symptoms of bean anthracnose were recorded in the 22nd standard metrological week (SMW) and it reached maximum of 77.06 per cent incidence and 54.51 per cent intensity towards the end of growing season by 29th SMW. Weekly average temperature, RH and total precipitation recorded during the corresponding period ranged from 16.6 to 23.4°C, 62.2 to 76.5 per cent and 1.7 to 48.2 mm, respectively. Periodic increase in disease incidence was higher (>10%) during 24th, 26th and 29th SMWs. Average temperature, RH and total precipitation recorded during the corresponding period were ≥ 17.5 ≥ 67.5 ≥ 15.4, respectively. Comparatively, the periodic increase in disease intensity was higher (>10%) during 26th and 29th SMWs. The prevailing average temperature, RH and total precipitation recorded during the corresponding period were ≥ 18.9°C, > 70 per cent ≥ 15.4 mm (Table 1 and Fig 1).

These observations confirmed prior findings of Rathava (2017) who in Gujrat recorded first symptoms of bean anthracnose after 26 days of sowing. Further, he found the disease was continuously increasing upto 16th October reaching 35.20 per cent from 6.80 per cent recorded on July 24th and reported quick jump of the anthracnose intensity during 30th to 34th standard weeks which he considered a window period for the anthracnose. Our findings are further supported by Patial (2004) who reported (79.48%) terminal disease intensity in the highly susceptible bean cultivar, Jawala.

The present findings indicated significant and positive correlation of temperature with disease intensity. However, the correlation of RH with disease incidence and intensity was non-significant but positive. Moreover, rain showed significant and positive correlation with disease incidence although its impact on disease intensity was found non-significant (Table 2). Significant and positive correlation of RH with bean anthracnose was also reported by Rathava (2017). However, he found rainfall and minimum temperature to be more important in the disease development as compared to other weather parameters. Earlier, Hall (1994) reported that bean anthracnose is favoured by 13-26°C temperature. During the course of present investigation there was not much variation in average temperature due to which its impact on overall disease development was not worked out. The effect of rain being significant in the present investigation is in corroboration of the findings of Tu (1981), who have also reported that periods of heavy rainfall are responsible for the spread of *C. lindemuthianum* in the field. The underlying reason could be the appearance of conidia

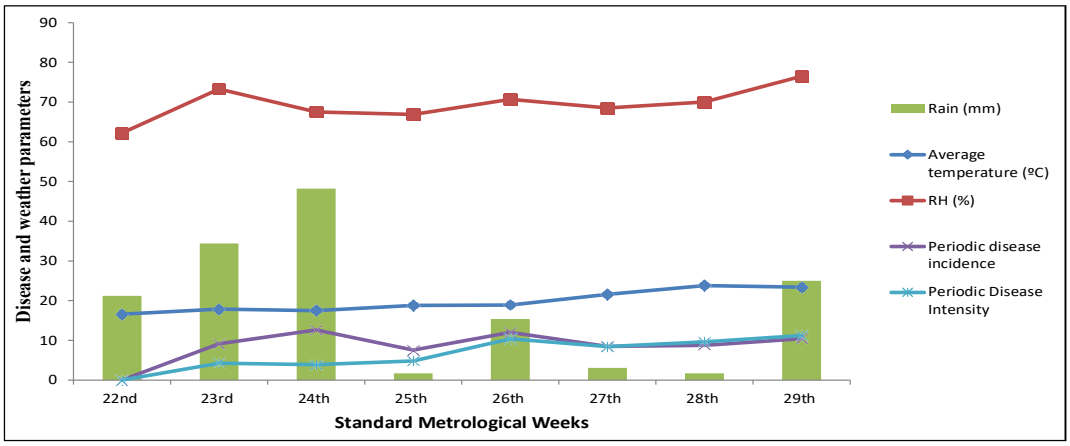

Fig 1: Bean anthracnose vis-à-vis metrological factors during *Kharif* 2019.

Table 1: Relationship of bean anthracnose with metrological factors during *Kharif* 2019.

Standard week	Disease incidence (%)		Disease Intensity (%)		Weather factors		
	Cumulative	Periodic	Cumulative	Periodic	Av. temperature (°C)	Av. RH (%)	Total rain (mm)
22nd	6.50	-	1.85	-	16.6	62.2	21.2
23rd	15.63	9.13	6.12	4.27	17.9	73.3	34.4
24th	24.76	12.62	10.01	3.89	17.5	67.5	48.2
25th	37.38	7.56	14.84	4.83	18.8	66.9	1.7
26th	49.40	12.02	25.22	10.38	18.9	70.7	15.4
27th	57.89	8.49	33.65	8.43	21.6	68.5	3.1
28th	66.65	8.76	43.29	9.64	23.8	70	1.7
29th	77.06	10.41	54.51	11.22	23.4	76.5	25

*Av. of 30 observations.

Table 2: Coefficients of simple correlation between metrological factors and bean anthracnose.

Variable	Metrological factors			Disease incidence	Disease intensity
	Temperature	Relative humidity	Precipitation		
Temperature	1.00				
Relative humidity	0.390	1.00			
Precipitation	-0.524	0.250	1.00		
Disease incidence	-0.317	0.128	0.703*	1.00	
Disease intensity	0.776*	0.491	-0.437	0.089	1.00

*Significant at 5%.

in a gelatinous mass which can be more efficiently displaced by rain splashes.

Regression analysis was also worked out to know the extent of correlation which is presented in (Table 3). It indicated that for every unit increase in RH and precipitation there was an increase of 0.071 and 0.073 units in disease incidence, respectively. Likewise for every unit increase in temperature and RH, there was an increase of 0.920 and 0.447 units in disease intensity, respectively.

Table 3: Simple regression equations of bean anthracnose and weather.

Dependable variable	Equation	R^2
Disease incidence (Y)	-0.029 + 14.50 X_1	0.101
-do-	0.071 + 4.849 X_2	0.016
-do-	0.073 + 8.502 X_3	0.495
Disease intensity (Y)	0.920 - 11.13 X_1	0.687
-do-	0.047 - 24.02 X_2	0.241
-do-	-0.074 + 8.906 X_3	0.191

Whereas, X_1, X_2 and X_3 represent temperature, relative humidity and precipitation, respectively.

Disease simulation and yield loss assessment

The data generated on disease simulation and consequent yield loss (Table 4 and Fig 2) revealed that the terminal

Table 4: Bean anthracnose levels and associated yield loss assessment under field conditions during *Kharif* 2019.

Disease initiation stage	Terminal disease (%)						Seed Yield (g/3m^2)	Yield loss (%)
	Incidence			Intensity				
	Leaves	Pods	Mean	Leaves	Pods	Mean		
1st trifoliate	88.25	90.25	89.25(70.91)	84.69	77.50	81.09(64.21)	130	64.382
3rd trifoliate	77.78	72.49	75.13(60.13)	63.84	61.38	62.61(52.28)	186	49.04
Flowering	64.03	50.49	57.21(49.12)	40.68	28.74	34.50(35.95)	290	20.54
Pod filling	41.77	27.66	34.71(36.05)	23.08	14.11	18.59(25.44)	325	10.95
Check	16.47	11.13	13.80(21.73)	3.94	3.71	3.82(11.21)	365	-
C.D (P≤0.05)			3.66			2.53	26.76	

*Figures in parenthesis are arc sine transformed values.

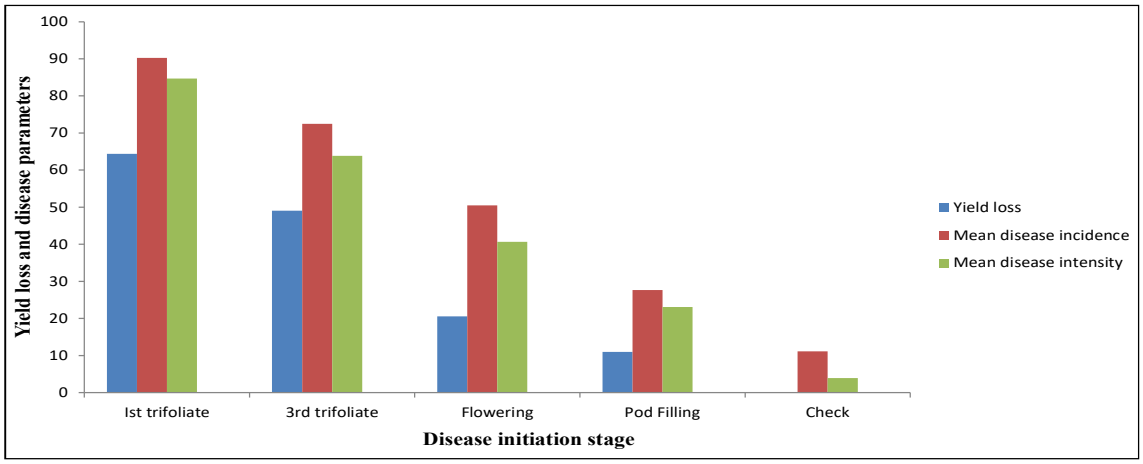

Fig 2: Bean anthracnose levels and associated yield loss.

disease incidence and intensity were significantly higher when disease initiated at first trifoliate stage and thus caused maximum yield loss. The yield potential as affected by bean anthracnose was 64.38, 49.04, 20.54 and 10.95 per cent when the disease started at first trifoliate, third trifoliate, flowering and pod development stages, respectively. Yield loss was proportionately least (10.95%) when disease started late in the season at pod filling stage. Bean anthracnose is a polycyclic disease and can also start as early in the season as on seedling stage. Moreover, there were well distributed rains during 2019 growing season which helped disease development to this extent. The proportionate yield losses as revealed by correlation studies are due to the fact that bean anthracnose caused reduction in photosynthetic area of affected plant populations. Earlier, Patial (2004) also reported highest yield reduction of 44.59 per cent in cotyledonary leaf stage infection, which is the most susceptible stage of plant with respect to anthracnose infection followed by 35.52 per cent reduction in pod development stage infection and least reduction of 9.61 per cent in second trifoliate leaf stage infection. The findings of Sharma and Sharma (1994) are in close proximity with our finding who found reduction in number of grains per pod, grain weight per pod and reduction in plant height of anthracnose affected bean plants when compared with the healthy plants. The present finding is further in relevance with that of Guzman *et al.* (1979), who reported yield losses of 95 per cent in the highlands of Colombia when a susceptible bean cultivar was inoculated one week after plant emergence and 38 per cent when inoculated six weeks after emergence with (10^7 conidia ml^{-1}). Similarly, Mukunya and Keya (1979) has also recorded losses up to the tune of 100 per cent in kidney bean due to seed borne infection of bean anthracnose in Kenya.

The analysis matrix indicated significant and positive correlation of disease incidence and disease intensity with yield loss (Table 5). The findings are supported by Amin and Ullase (1981), who reported positive and significant correlation between disease indices and infected fruits and total yield in bean crop. Highest correlations were found between yield loss and disease indices during flowering to

Table 5: Coefficients of simple correlation between anthracnose and bean yield parameters.

Variables	Yield loss	Mean disease incidence	Mean disease intensity
Yield loss	1.00		
Mean disease incidence	0.983*	1.00	
Mean disease intensity	0.988*	0.997*	1.00

*Significant at 5%.

fruit formation. Similarly, Ali *et al*. (1987) reported highly significant positive correlation between loss in grain yield and disease severity in sorghum crop.

CONCLUSION

Although the prevailing temperature during *Kharif* 2019 was less variable its effect on disease intensity was found significantly positive. The correlation of RH with disease incidence and the disease intensity was also positive but non-significant. Further, rain showed significant and positive correlation with disease incidence. The study thus revealed that a weather set comprising of high relative humidity (>75%), moderate rainfall and moderate temperature 16-24°C with an optimum of 17°C leads to rapid development of anthracnose disease in bean. The yield potential of bean was significantly affected by bean anthracnose causing >10 per cent yield loss even after appearing at pod development stage. Given these facts the bean anthracnose be considered among the major diseases of bean in Kashmir. It can start any time in the vegetative and reproductive stages of the crop and is more importantly favored by frequent rain, thus highlights the significance of wider spacing in minimizing the yield losses in bean.

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