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Host Plant Resistance and Yield Loss due to Anthracnose caused by *Colletotrichum lindemuthianum* in French Bean (*Phaseolus vulgaris*)

Nirmala Maibam[1] • Satish Chandra[1*] • Pankaj Baiswar[1] • D. Majumder[2] • Kanchan Saikia[1]

[1]*ICAR Research Complex for NEH Region, Umiam-793103, Meghalaya*

[2]*College of Post Graduate Studies, Central Agricultural University, Umiam-793103, Meghalaya*

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ABSTRACT

Screening against anthracnose (*Colletotrichum lindemuthianum*) was conducted using 20 genotypes of French bean (*Phaseolus vulgaris*) for identifying the resistant genotypes. Three genotypes *viz*., Rajma Gold, ML-D and ML-F were found moderately resistant, whereas ten and seven genotypes were categorized as moderately susceptible and susceptible, respectively. None of the genotypes was found highly resistant or highly susceptible. Estimation of yield loss due to anthracnose under protected and non-protected conditions using a susceptible variety Manipuri local -J revealed that reduction in pod wt. varied from 9.1 to 11.2%, pod length from 4.3 to 6.6%, breadth 4.5 to 8.8%, and thickness 16.6 to 30.5% according to disease severity rating. This study provided conclusive evidence that pod length, breadth and thickness are also affected according to various infection categories.

1. Introduction

French bean (*Phaseolus vulgaris* L.) is a leguminous vegetable also known as Rajmash or Rajma (Hindi) or haricot bean or kidney bean or common bean or snap bean. It is rich in protein content (23%) and it also contains calcium, phosphorus and iron. It is used as pulse as well as green vegetable (tender pods). In India, the green bean is cultivated in an area of 218352 ha with a production of 617869 MT and yield of 28297 hectogram/ha (FAOSTAT 2011). It is largely grown in Himachal Pradesh, Jammu and Kashmir, Uttar Pradesh, North Eastern Hills, Darjeeling, South plateau Hills (Nilgiri and Palni hills) Mahabaleshwar, Ratnagiri (Maharastra) and Chickmanglore (Karnataka) having mild climate with humid environmental conditions.

Anthracnose of French bean caused by fungus *Colletotrichum lindemuthianum* (Sacc. & Magnus) Briosi & Cavara is a major problem throughout the world but it is present in more severe form in the temperate regions than in the tropics. In north India, the disease appears in the second or the third week of June and reaches the maximum damaging stage from the beginning of August to mid-September. Since this pathogen overwinters inside bean seeds hence the losses can be 100% when badly contaminated seed is planted under conditions favourable for disease development (cool and wet weather) (Sharma et al. 1994).

Plants at all growth stages are susceptible and susceptibility increases with age Infection of a susceptible cultivar under favourable conditions leading to an epidemic may result in 100% yield loss (Fernandez et al. 2000). Symptoms can be seen on the stems, leaves and fruits of the French bean (Perfect et al. 1999). Purple to red, elongated angular lesions are more prominent on lower side of the leaves and veins, becoming dark red as the disease progresses. Elongated, sunken and reddish brown lesions are present on the pods. The fungus can invade the pod surface and infect the seed coat and cotyledon of the developing seeds. Under favourable conditions during the growing season, infected seeds become discoloured, shrivelled and dark acervuli are prominent on the lesions (Gonzalez et al. 1998). Under very humid conditions pink spore mass can also be seen oozing out from the lesions. Bean production is considerably reduced due to bean anthracnose because of poor seed germination and seedling vigor, more plant death and low yields. Marketing losses are attributed to seed spots and blemishes, which lower their quality rating and salability (Dillard 1988). In Himachal Pradesh, India, the incidence of this disease has been reported to range from 5.0 to 65.0 per cent in different localities leading to considerable yield losses in certain years (Sharma et al. 1994).

Corresponding author: satishbarapani@rediffmail.com

This disease is also common in the French bean fields of North-Eastern Hill (NEH) states. Although the disease is endemic in the NEH region, no systematic investigation with respect to varietal reaction (resistant genotypes) and yield loss has been done on the anthracnose-French bean pathosystem. These kind of investigations are needed since agro climatic conditions in NEH region differ from rest of the country and profitable French bean cultivation for green pod has potential to improve the economic conditions of tribal farmers in this region. Therefore, the present investigation was done for identification of different resistant genotypes of French bean and estimation of yield loss due to anthracnose.

2. Materials and methods

Host Plant Resistance

Screening of 20 French bean genotypes including popular local land races and released varieties was done in the experimental field of Plant Pathology, ICAR Research Complex for NEH Region, Umiam, Meghalaya. The sowing was done on 18th March 2013 in randomized complete block design (RCBD) with two replications. Each test genotype was planted in 3 m row with spacing of 30 cm between the row and 15 cm within the row. Fertilizer dose of 40-60-40 (NPK) was given as basal application. No disease protection measures were adopted. Three weeks old plants were inoculated with spore suspension (10^6conidia/ml) of the pathogen *C. lindemuthianum* by using pin prick method to check for resistance or susceptibility against *C. lindemuthianum*

Ten pods from each genotype were randomly selected from each replication for assessing disease severity. The severity of the disease was recorded on the basis of 1 to 9 scales (CIAT 1987). The description of the scale is given below in Table 1. Per cent Disease Index (PDI) was calculated on the basis of rating scale using the following formula,

$$\text{PDI} = \frac{\text{Sum of all numerical rating}}{\text{Number of pods x maximum score in scale}} \text{ x } 100$$

On the basis of PDI, genotypes were classified into different categories (Table 2).

Yield loss assessment

A susceptible variety Manipuri local- J was used for estimating yield loss due to French bean anthracnose. The experiment was laid out in Replicated Measurement's' Test (paired plot). Experimental setting consisted of two treatments i.e. fungicide protected and a control i.e. nonprotected with 12 replicates and a spacing of 40x30 cm with plot size 3x2 m². In protected plots, carbendazim @ 2 g/kg seeds was used for seed treatment before sowing to control seed borne infection, if any. The disease severity (PDI) was recorded at maturity stage (R8) (CIAT 1987).

Ten pods from protected and unprotected plots were randomly selected, harvested separately and data were recorded separately for different infection grades based on (1-9 scale) for yield loss assessment. Per cent reduction in pod weight, length, breadth and thickness due to different severity grade of infection was also calculated. The data pertaining to yield loss was calculated by employing the formula,

$$\text{Per cent yield loss} = \frac{\text{YCP}-\text{YDP}}{\text{YCP}} \text{ x } 100$$

where, YCP is the yield of 10 pods randomly selected from control (protected) plots and YDP is the yield of 10 pods randomly selected from diseased (non-protected) plots

3. Results and Discussion

Host Plant Resistance

French bean genotypes were screened during 2012, for identifying the degree of resistance against the anthracnose under mid hill conditions of Meghalaya. Out of 20 different genotypes tested, three genotypes *viz.,* Rajma Gold, ML-D and ML-F were moderately resistant with PDI of 24.44, 25.55 and 31.11, respectively. Ten genotypes exhibited moderate susceptibility against the anthracnose disease *viz.,* ML-A, Rajma Purple, ML-C, ML-B, ML-H, ML-G, ML-I, Arka Anoop, Naga local-A and ML-K. Seven genotypes *viz.,* Annapurna, ML-J, Selection 9, Darjeeling White, Anupama, Naga local-B and selection-3 showed susceptible disease reaction. Resistant reaction was not recorded in any of the tested genotypes. Reactions recorded against anthracnose are presented in Table 3.

Screening is one of the important processes involved in breeding programmes and it ensures that cultivars chosen exhibits increased resistance to a wide range of diseases and insects, better tolerance to environmental stress, better seed quality and improved efficiency in the utilization of limited soil nutrients. Many workers have conducted screening and reported varying degree of resistance to anthracnose in local land races and exotic French bean genotypes (Pathania et al. 2006, Kour et al. 2012). More than 10 different anthracnose resistance genes have been identified in a number of bean varieties (Kelly and Vallejo 2004). According to Mahuku and Riascos (2004), the best strategy to manage this disease is planting resistant cultivars, which is most effective, least expensive and easiest for farmers to adopt.

Yield loss assessment

The yield loss experiment in the present study was conducted based on per cent reduction in pod weight, length, breadth and thickness. Pods from protected and non-protected plots exhibited various categories of infection grades. Hence infected pods were collected from protected and non-protected plots and sorted into various infection grades (1-9). The ten pod wt. of healthy pods (score-1) varied from 66.00 to 65.58 g (Table 4).

The pods showing infection grade- 9 and 7 recorded significant reduction in pod length. The reduction in pod breadth (mm) was found highest (8.84%) with disease score-9 and the difference between protected and non-protected was significant (Table 4). The mean pod breadth for healthy pods varied from 10.73-11.43. There was no significant difference between healthy and diseased pod breadth with disease score-3, 5 and 7 (Table 4). The pod thickness was significantly reduced with disease score-3, 5, 7 and 9. The reduction was found highest in disease score-7 (Table 4, Figure 1). The differences between protected and non-protected at all four disease scores were significant (Table. 4). Variation in percent reduction in respect of pod thickness was highest ranging from 16.57 to 30.47% (Table 5, Figure 1). Least variation in percent reduction was in pod weight ranging from 9.08 to 11.18%.

The data pertaining to effect of pod infection in terms of number of seeds/pods and seed weight/pods was earlier recorded by Sharma et al. (2008). They found reduction of 57.76 per cent in number of seed/pod and in pods graded 9 followed by 52.59 per cent in pods grade 7. In the present study the highest reduction in pod weight was found in grade 7 (11.18%) followed by grade 9 (11.02%). The reduction in pod length, breadth and thickness was not studied by other workers. This study provides first conclusive evidence that pod length, breadth and thickness are also affected according to various infection categories.

Table 1. Description scale for rating against anthracnose

Rating Scale	Per cent Infection
1	no infection
3	up to 1% of pod surface area
5	up to 5% of surface area
7	Up to 10% of surface area
9	more than 25% pod surface area

Table 2. Reaction of different genotypes of French bean against *Colletotrichum lindemuthianum*

PDI	Categories
0	Absolutely resistant (AR)
0.01	Highly resistant (HR)
12.22-33.33	Moderately resistant (MR)
34.44-55.55	Moderately susceptible (MS)
56.66-77.77	Susceptible (S)
78-88-100.00	Highly susceptible (HS)

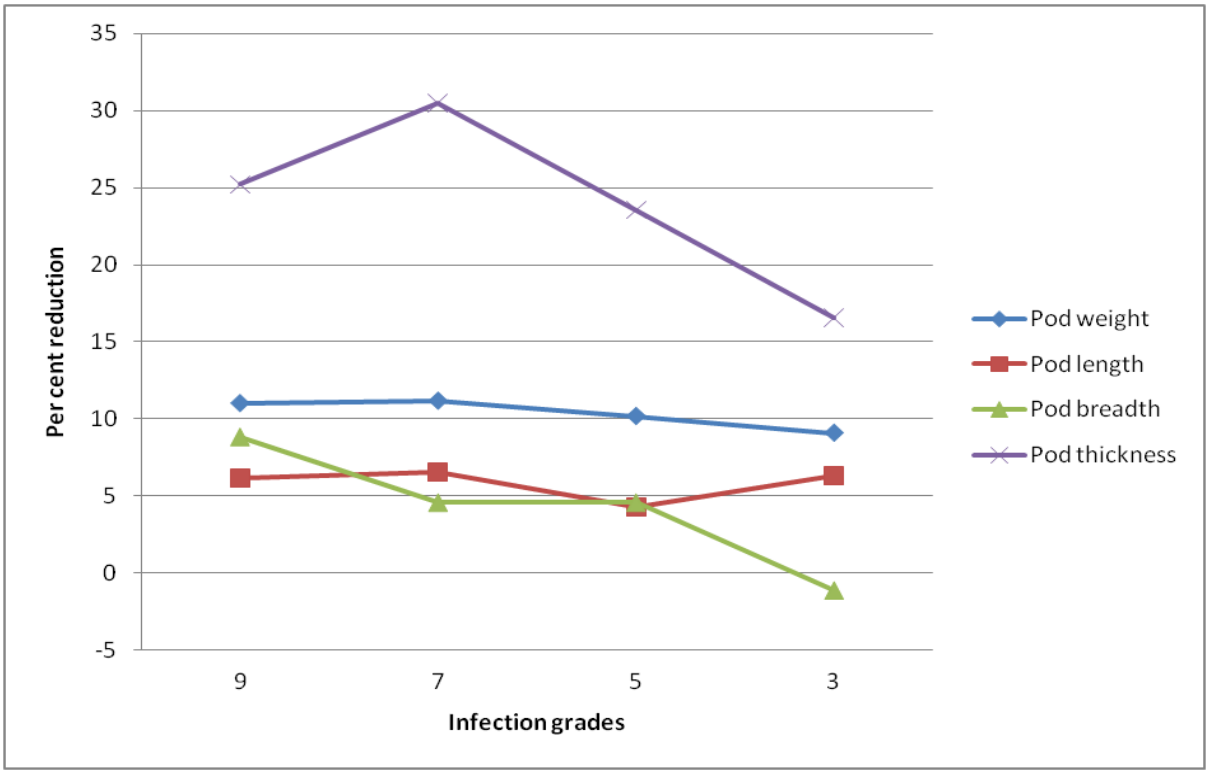

Figure 1. Percent reduction in various parameters related to pod for four infection grades

Table 3. Reaction of different genotypes of French bean against anthracnose

French bean genotypes	Percent Disease index	Category
Rajma Gold	24.44	MR
ML-D	25.55	MR
ML-F	31.11	MR
ML-A	34.44	MS
Rajma Purple	34.44	MS
ML-C	36.11	MS
ML-B	37.77	MS
ML-H	39.99	MS
ML-G	43.33	MS
ML-G	47.77	MS
Arka Anoop	47.77	MS
Naga local-A	49.44	MS
ML-K	53.33	MS
Annapurna	57.22	S
ML-J	59.99	S
Selection 9	61.10	S
Darjeeling white	67.21	S
Anupama	68.88	S
Naga local-B	69.99	S
Selection 3	74.44	S

Table 4. Different pod parameters as affected by disease severity scores under protected and non-protected conditions

Disease score	Pod weight (g)			Pod length (cm)			Pod breadth (mm)			Pod thickness (mm)		
	P	NP	D	P	NP	D	P	NP	D	P	NP	D
9	64.25	57.17	7.08*	5.84	14.86	0.98*	11.43	10.42	1.01*	8.57	6.41	2.16*
7	65.58	58.25	7.33*	15.99	14.94	1.05*	10.92	10.42	0.50ns	9.22	6.41	2.81*
5	66	58.75	7.25*	6.06	15.37	0.69ns	10.94	10.44	0.50ns	9.47	7.24	2.23*
3	66.17	60.16	6.01*	15.98	14.97	1.01ns	10.73	10.85	0.12ns	8.93	7.45	1.48*

*significant (p = 0.05), ns- non significant; P-Protected; NP – non-protected; D-Difference

4. Conclusion

Out of 20 genotypes screened, three genotypes viz., Rajma Gold, ML-D and ML-F were found moderately resistant, whereas other ten and seven genotypes were categorized as moderately susceptible and susceptible, respectively. None of the genotypes was found highly resistant or highly susceptible. Estimation of yield loss due to anthracnose disease under field experiment revealed reduction in pod weight, length, breadth and thickness according to disease severity rating. These moderately resistant varieties can be used by tribal farmers for maximizing profit.

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