



## Prevalence of *Alternaria* Leaf Blight of Broad Bean in the Valley Districts of Manipur

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**ABSTRACT:** *Alternaria* leaf blight of broad bean is one of the significant fungal diseases of broad bean in Manipur. The disease initiates from the older plant parts, spreads to the younger parts and eventually the entire plants are affected. The affected plant becomes completely blighted. The disease is predominantly distributed in the valley districts of Manipur. The disease incidence and severity varied among all the selected locations of the districts in study. The disease incidence ranges between 29.67% to 59.67% during 2020-2021 and 49.00% to 84.00% during 2021-2022. The disease severity ranges between 19.11% and 51.78% during 2020-2021 and 26.15% and 62.96% during 2021-2022. The disease incidence and severity in all the surveyed areas were lowest in December and highest in February. All the fungal isolates collected from the surveyed areas produced a typical disease lesion in pathogenicity tests on broad bean plants and detached broad bean leaves. The extent of pathogenicity on both the plants and detached leaves varies for all the fungal isolates. The presence of concentric rings on the leave lesion is the most conspicuous symptom of this disease. As the disease progressed, the plant becomes blighted and dried.

**Keywords:** Broad bean, *Alternaria alternata*, blight, concentric rings, incidence, severity, pathogenicity.

### INTRODUCTION

Broad bean is one of the main leguminous crops cultivated in Manipur. In India, this legume is cultivated as cool season crop in plains while in hilly and mountain areas, it is cultivated as both cool and warm season crop successively (Singh and Bhatt, 2012). The crop thrives well in medium textured, clayey or loamy, moist soils with good water holding capacity, with pH range of 6.5 to 9.0 (Olson and Bowness 2016; Dhull *et al.*, 2022). The worldwide cultivation of broad bean in 2019 and 2020 reported an approximate area of 241611 ha and 255359 ha respectively, yield of 6322.4kg/ha and 6255.8kg/ha respectively, and production of 1527571 tonnes and 1597477 tonnes respectively (Anonymous, 2021).

Broad bean seed is an abundant source of antioxidant compounds namely, ferulic acid, p-coumaric acid, epicatechin, epicatechin gallate, epicatechin glucoside, procyanidin gallate, digallate procyanidin dimer, gallate procyanidin dimer and prodelfidin dimer (Amarowicz and Shahidi 2017). Mejri *et al.* (2018) delineated that broad bean pods are rich in protein, carbohydrates, dietary fiber, fatty acids (linoleic and  $\alpha$ -linolenic acids), flavonols (glycosides of kaempferol and quercetin),

flavones (derivatives of apigenin) and flavan-3-ols (epicatechin, catechin and their derivatives). Broad bean plants showed an abundance of L-3,4-dihydroxyphenylalanine (L-dopa) which is employed for Parkinson's disease and it also contains vicine and convicine which confers anti-inflammatory effects (Duan *et al.*, 2021).

Broad bean suffers from several fungal diseases. Leaf blight caused by *Alternaria alternata* is one of the economically important fungal diseases of broad bean in Manipur. This disease is also known as leaf spot. Gurha *et al.* (1981) first gave an account of this disease in India. The disease was also reported from Himachal Pradesh by Gupta *et al.* (1992), Kumar *et al.* (2005) reported this disease to be one of the most serious diseases of broad bean in Bihar and Jharkhand. The disease has also been reported from different geographical regions of the world including Tunisia, Syria, Japan, Korea, Russia, Bolivia, Egypt, Libya, Turkey and Iran (Kamel *et al.*, 1989; Akem and Bellar 1999; Honda *et al.*, 2001; Kwon and Park 2002; Kurkina, 2008; Coca-Morante and Mamami 2012; El-Mougy *et al.*, 2016; El-Ammari, 2017; Kayim *et al.*, 2018; Ghanbary *et al.*, 2020). The disease commenced

from the lower portion of the plant and progressed upwards. Formation of concentric rings on the blighted leaves is the conspicuous symptom of the disease. This fungal pathogen is seed borne, air borne, survives on plant debris in the soil and on other host plants as well (Dubey and Patel 2002; Grewling *et al.*, 2020; Newman and Derbyshire 2020). This disease not only reduces the production of this crop but also affects the economic value. The research study was conducted to study the occurrence and distribution of *Alternaria* leaf blight of broad bean in the valley districts of Manipur. The disease incidence and severity were recorded from 10 different locations of each district to study the degree of variation in regards to occurrence of this disease in the valley districts. Pathogenicity tests on detached leaves and broad bean plants were conducted to confirm the pathogenicity of the fungal isolates in question.

## MATERIAL AND METHODS

The research investigation was conducted at Department of Plant Pathology, College of Agriculture, Central Agricultural University, Imphal, Manipur.

**Survey for *Alternaria* leaf blight of broad bean in the valley districts of Manipur.** Surveys on leaf blight of broad bean were conducted in the valley districts namely, Imphal West, Imphal East, Bishnupur, Thoubal and Kakching. Surveys were conducted thrice during the cropping season in December, January and February 2020 to 2022. Observation of the disease severity will be recorded by (0-9) rating scale given by Ghosh *et al.* (2009) as follows:

Scale	Description
0	No infection
1	0-10% leaf area infected
2	10-20% leaf area infected
3	20-30% leaf area infected
4	30-40% leaf area infected
5	40-50% leaf area infected
6	50-60% leaf area infected
7	60-70% leaf area infected
8	70-80% leaf area infected
9	80-90% or more leaf area infected

Observations of the disease incidence and disease severity were taken by randomly selecting 100 plants from the farmer's field and were converted into per cent infection and per cent disease index as follows:

$$\text{Per cent Infection} = \frac{\text{Total no. of diseased plants}}{\text{Total no. of plants examined}} \times 100$$

$$\text{Per cent Disease Index} = \frac{\text{Sum of all individual disease rating} \times 100}{\text{Total no. of observation} \times \text{Maximum disease rating scale}}$$

Symptoms of the disease were observed from seedlings until maturity of the plants.

**Collection, identification and maintenance of the causal pathogen.** During survey, diseased leaves were collected from 10 different locations of each district.

*Konjengbam et al.*,

The samples were cut into small pieces and surface sterilized in 1% sodium hypochlorite solution followed by subsequent rinsing with sterile distilled water. The samples were blot dried and inoculated into petriplates containing sterilized and solidified potato dextrose agar. Pure culture of all the fungal isolates were obtained by hyphal tip cut method. All the isolates were subcultured and maintained on potato dextrose agar during the research period. The pathogen isolates were identified by comparison with relevant monographs. Symptoms of the disease were observed.

**Pathogenicity tests.** Pathogenicity test of all the isolates were conducted by following Koch's postulates on detached leaves and on the plants of local broad bean cultivar of Manipur (Rahman *et al.*, 2002). The fungal isolates were grown in 50 ml potato dextrose broth in 100 ml Erlenmeyer flask for 7 days at  $28 \pm 2^\circ\text{C}$ . The mycelial mats were collected and were blended with sterile distilled water and the spore suspension was diluted to  $10^6\text{CFU/ml}$ . Pathogenicity test was first conducted by detached leaf assay. Broad bean leaflets were surface sterilized with 1 % sodium hypochlorite solution and were subsequently washed with distilled water for three times. Blotter papers were placed on both the bottom container and upper lid of the sterilised petriplates and were subsequently moistened with sterile distilled water. Leaflets were placed on the moist blotter papers on the petriplates. The spore suspensions of the pathogen isolates were dropped on the leaflets. For control, only sterile distilled water was dropped on the leaflets. The petriplates were sealed with the lid and were incubated at  $28 \pm 2^\circ\text{C}$  for 7 days. Secondly, pathogenicity test was conducted on broad bean plant. Soil were sterilized in an autoclave at  $121^\circ\text{C}$  at 15lbs for 2 hours successively for 3 days. The plastic pots were filled up with the sterilized soil. Broad bean seeds were surfaced sterilised with 1% sodium hypochlorite solution and washed subsequently with distilled water for three times. Seed was sown at the depth of 5cm in each pot. After 8 weeks, the entire plants were sprayed with spore suspension and were covered with polyethylene sheets to maintain high moisture for 1 day. The control plants were sprayed with sterile distilled water only and were also covered with polyethylene sheets for 1 day. These plants were observed for development of lesions after 7 days. Three replications were maintained for both the pathogenicity tests. Disease lesions developed on the fungal isolates inoculated leaves were categorised into four grades *viz.*, – for no lesion, + for lesion on less than 50% of inoculated sites, ++ for lesion ranging from 50 to 75% of inoculated sites and +++ for lesion more than 75% of inoculated sites (Rahman *et al.*, 2002). The extent of pathogenicity were categorised into non pathogenic, slightly pathogenic, moderately pathogenic and highly pathogenic (Sendi *et al.*, 2019).

## RESULTS AND DISCUSSION

**Identification and maintenance of the pathogen.** The fungal isolates collected during survey from 10 different locations of 5 valley districts of Manipur are identified as *Alternaria alternata* on the basis of comparison with relevant monograph (Simmons and Roberts 1993). The hyphae and conidiophores are septed and pale brown to dark brown in colour. The conidia are multicelled, obpyriform, obclavate and muriform with both longitudinal and transverse septa. The conidia have a short apical beak. The conidia are produced in chains.

**Occurrence of *Alternaria* leaf blight of broad bean in the valley districts of Manipur.** *Alternaria* leaf blight of broad bean was widely distributed at different locations in the valley districts of Manipur. The disease incidence and severity of leaf blight for all the surveyed locations were minimum in December and maximum in February. Highest disease incidence and severity were observed in Thoubal while the lowest disease incidence and severity were recorded in Imphal West in both the cropping seasons. The maximum disease incidence of 33.00, 53.80 and 73.10% in 2020-2021 and 57.80, 77.30 and 93.20% in 2021-2022 were observed during December, January and February respectively in Thoubal. The minimum disease incidence of 22.60, 39.20 and 58.40% in 2020-2021 and 33.30, 52.70 and

72.90% were observed during December, January and February respectively in Imphal West. Similarly, the highest disease severity of 27.63, 41.30 and 62.63% in 2020-2021 and 38.59, 55.81 and 72.05% in 2021-2022 were recorded in December, January and February respectively in Thoubal. The lowest disease severity of 13.23, 22.72 and 36.16% in 2020-2021 and 16.83, 34.96 and 42.02% in 2021-2022 were recorded in December, January and February respectively in Imphal West. The highest disease incidence (59.67%) and severity (51.78%) during 2020-2021 was recorded in Haoreibi of Thoubal district. Similarly, the disease incidence (84.00%) and severity (62.96%) during cropping season 2021-2022 were also highest in Haoreibi. The lowest disease incidence (29.67%) and severity (19.11%) during 2020-2021 were observed in Lamjaotonba of Imphal West. Comparably, disease incidence (49.00%) and severity (26.15%) during 2021-2022 were also lowest in Lamjaotonba. Gupta and Choudhury (1986) gave first report of leaf blight of broad bean caused by *A. alternata* in Manipur. Later, Singh and Singh (1990) also gave an account of leaf spot of broad bean caused by *A. brassicicola* in Manipur. Kamei and Singh (2020) gave a brief description of occurrence of this disease in Senapati district of Manipur.

**Table 1: Survey for *Alternaria* leaf blight of broad bean in the valley districts of Manipur.**

District	Location	GPS coordinates		
		Latitude	Longitude	Altitude (m)
Imphal West	Iroisemba	24.812535°	93.890007°	730
	Moidangpok	24.768096°	93.816221°	735
	Langthabal lep	24.748888°	93.905965°	730
	Phayeng	24.850328°	93.815820°	736
	Taonthong apheiba	24.819169°	93.864881°	736
	Langjing	24.790519°	93.900357°	732
	Lairensajik	24.857506°	93.813014°	737
	Sairemkhul	24.817379°	93.807604°	736
	Meitram	24.719262°	93.867742°	737
Imphal East	Lamjaotonba	24.771939°	93.910460°	726
	Yumnam khunou	24.929058°	93.993014°	730
	Keibi khullen	24.910031°	94.038094°	735
	Khanarok	24.715627°	93.985518°	701
	Nongmada thongkhong	24.872088°	94.066046°	733
	Itam nungoi	24.870304°	94.032417°	733
	Napet palli	24.872761°	94.051978°	733
	Uyumpok	24.919016°	94.042051°	735
	Taretkhul	24.904321°	94.036626°	735
	Sagolmang	24.954083°	94.023522°	752
Bishnupur	Pukhao khabam	24.953553°	94.023299°	716
	Utlou	24.709118°	93.831890°	744
	Thiyam leikai	24.626381°	93.764302°	728
	Leimaram	24.720863°	93.778955°	730
	Keinou thongkha	24.672372°	93.783593°	729
	Laitongjam	24.719945°	93.844696°	731
	Oinam leikai	24.689764°	93.808618°	766
	Sabal leikai	24.712224°	93.827844°	729
	Thanga salam	24.501284°	93.777129°	723
	Moirangkhunou	24.474754°	93.780498°	720
Lilong	Toubul	24.626725°	93.764994°	720
	Lilong	24.697136°	93.949184°	737

Thoubal	Waithou tronglaobi	24.668489°	93.960495°	704
	Khangabok	24.668485°	93.960502°	720
	Haokha	24.654397°	93.986408°	680
	Wangjing	24.594817°	94.032242°	744
	Haoreibi	24.674321°	93.945586°	750
	Wangoi	24.673780°	93.898520°	726
	Khongjom	24.556010°	94.031952°	732
	Uchiwa	24.579882°	93.906137°	726
Katching	Kang samaram	24.556674°	94.031308°	735
	Sekmaijin	24.545829°	93.910322°	724
	Hiyanglam	24.524949°	93.928284°	803
	Langmeidong	24.463676°	93.936888°	721
	Sumak leikai	24.491368°	93.993238°	759
	Wabagai	24.562329°	93.902137°	713
	Ningthou leikai	24.495509°	93.978926°	707
	Sugnu	24.497104°	93.987480°	750
	Mayenglamjao	24.474235°	93.936546°	721
Makha lou	24.497059°	93.975611°	748	
Hayel hangoon	24.541073°	93.913115°	755	

**Table 2: Meteorological data for the cropping season 2020-2021.**

Month	Relative humidity (%)		Temperature(°C)		Rainfall (mm)
	700h	1300h	Maximum	Minimum	
October	93	67	37.1	20.9	165.8
November	94	50	26.3	12.7	104.9
December	96	48	23.1	6.5	0.0
January	96	41	23.3	6.6	6.6
February	91	32	26.1	8.4	7.5
March	79	33	28.8	12.8	55.6

\*Weather data from ICAR, Imphal, Manipur

**Table 3: Meteorological data for the cropping season 2021-2022.**

Month	Relative humidity (%)		Temperature(°C)		Rainfall (mm)
	700h	1300h	Maximum	Minimum	
October	89	62	29.4	20.0	77.7
November	85	48	26.6	13.4	2.0
December	91	54	22.5	10.0	70.9
January	92	58	21.0	7.9	20.9
February	87	37	22.2	7.3	25.3
March	80	37	29.4	13.7	32.7

\*Weather data from ICAR, Imphal, Manipur

**Table 4: Per cent disease incidence of *Alternaria* leaf blight of broad bean in Imphal West.**

Sr. No.	Locality	Disease incidence during 2020-2021 (%)			Mean	Disease incidence during 2021-2022 (%)			Mean	Pooled
		Dec.	Jan.	Feb.		Dec.	Jan.	Feb.		
1.	Iroisemba	25.00 (5.05)	41.00 (6.44)	60.00 (7.78)	42.00 (6.42)	32.00 (5.70)	50.00 (7.11)	72.00 (8.51)	51.33 (7.11)	51.33 (7.11)
2.	Moidangpok	20.00 (4.53)	35.00 (5.96)	54.00 (7.38)	36.33 (5.96)	25.00 (5.05)	50.00 (7.11)	78.00 (8.86)	51.00 (7.01)	51.00 (7.01)
3.	Langthabal lep	26.00 (5.15)	42.00 (6.52)	65.00 (8.09)	44.33 (6.59)	39.00 (6.28)	60.00 (7.78)	78.00 (8.86)	59.00 (7.64)	59.00 (7.64)
4.	Phayeng	26.00 (5.15)	44.00 (6.67)	62.00 (7.91)	44.00 (6.57)	38.00 (6.20)	54.00 (7.38)	75.00 (8.69)	55.67 (7.43)	55.67 (7.43)
5.	Taonthong apheiba	24.00 (4.95)	42.00 (6.52)	61.00 (7.84)	42.33 (6.44)	35.00 (5.96)	53.00 (7.31)	74.00 (8.63)	54.00 (7.30)	54.00 (7.30)
6.	Langjing	22.00 (4.74)	46.00 (6.82)	64.00 (8.03)	44.00 (6.53)	34.00 (5.87)	57.00 (7.58)	72.00 (8.51)	54.33 (7.32)	54.33 (7.32)
7.	Lairensajik	25.00 (5.05)	46.00 (6.82)	63.00 (7.97)	44.67 (6.61)	36.00 (6.04)	52.00 (7.25)	74.00 (8.63)	54.00 (7.30)	54.00 (7.30)
8.	Sairemkhul	21.00 (4.64)	32.00 (5.70)	60.00 (7.78)	37.67 (6.04)	32.00 (5.70)	51.00 (7.18)	72.00 (8.51)	51.67 (7.13)	51.67 (7.13)
9.	Meitram	20.00 (4.53)	34.00 (5.87)	53.00 (7.31)	35.67 (5.91)	32.00 (5.70)	48.00 (6.96)	69.00 (8.34)	49.67 (7.00)	49.67 (7.00)
10.	Lamjaotonba	17.00 (4.18)	30.00 (5.52)	42.00 (6.52)	29.67 (5.41)	30.00 (5.52)	52.00 (7.25)	65.00 (8.09)	49.00 (6.95)	49.00 (6.95)
	Mean	22.60 (4.80)	39.20 (6.28)	58.40 (7.66)	-	33.30 (5.80)	52.70 (7.29)	72.90 (8.56)	-	-
	SE(d) ±				0.16				0.18	0.18
	C.D. (5%)				0.33				0.38	0.41

Figures in the parenthesis are square root transformed

**Table 5: Per cent disease incidence of *Alternaria* leaf blight of broad bean in Imphal East.**

Sr. No.	Locality	Disease incidence during 2020-2021 (%)			Mean	Disease incidence during 2021-2022 (%)			Mean	Pooled
		Dec	Jan	Feb		Dec	Jan	Feb		
1.	Yumnam khunou	23.00 (4.85)	44.00 (6.67)	57.00 (7.58)	41.33 (6.37)	35.00 (5.96)	53.00 (7.31)	73.00 (8.57)	53.67 (7.28)	47.50 (6.82)
2.	Keibi khullen	25.00 (5.05)	47.00 (6.89)	60.00 (7.78)	44.00 (6.57)	37.00 (6.12)	54.00 (7.38)	77.00 (8.80)	56.00 (7.44)	50.00 (7.00)
3.	Khanarok	20.00 (4.53)	35.00 (5.96)	49.00 (7.04)	34.67 (5.84)	30.00 (5.52)	51.00 (7.18)	74.00 (8.63)	51.67 (7.11)	43.17 (6.48)
4.	Nongmada thongkhong	22.00 (4.74)	34.00 (5.87)	51.00 (7.18)	35.67 (5.93)	36.00 (6.04)	57.00 (7.58)	74.00 (8.63)	55.67 (7.42)	45.67 (6.67)
5.	Itam nungoi	26.00 (5.15)	49.00 (7.04)	61.00 (7.84)	45.33 (6.68)	40.00 (6.36)	62.00 (7.91)	77.00 (8.80)	59.67 (7.69)	52.50 (7.18)
6.	Napet palli	24.00 (4.95)	45.00 (7.45)	59.00 (7.71)	42.67 (6.47)	36.00 (6.04)	58.00 (7.65)	76.00 (8.75)	56.67 (7.48)	49.67 (6.97)
7.	Uyumpok	30.00 (5.52)	51.00 (7.18)	64.00 (8.03)	48.33 (6.91)	44.00 (6.67)	68.00 (8.28)	80.00 (8.97)	64.00 (7.97)	56.17 (7.44)
8.	Taretkhul	35.00 (5.96)	58.00 (7.65)	70.00 (8.40)	54.33 (7.33)	49.00 (7.04)	72.00 (8.51)	85.00 (9.25)	68.67 (8.27)	61.50 (7.80)
9.	Sagolmang	32.00 (5.70)	53.00 (7.31)	68.00 (8.28)	51.00 (7.10)	43.00 (6.60)	65.00 (8.09)	84.00 (9.19)	64.00 (7.96)	57.50 (7.53)
10.	Pukhao khabam	25.00 (5.05)	45.00 (6.75)	56.00 (7.52)	42.00 (6.44)	36.00 (6.04)	57.00 (7.58)	79.00 (8.92)	57.33 (7.51)	49.67 (6.98)
	<b>Mean</b>	26.20 (5.15)	46.10 (6.81)	59.50 (7.73)	-	38.60 (6.24)	59.70 (7.75)	77.90 (8.85)	-	
	<b>S.E(d) ±</b>				0.10				0.13	0.14
	<b>C.D. (5%)</b>				0.22				0.28	0.31

Figures in the parenthesis are square root transformed

**Table 6: Per cent disease incidence of *Alternaria* leaf blight of broad bean in Bishnupur**

Sr. No.	Locality	Disease incidence during 2020-2021 (%)			Mean	Disease incidence during 2021-2022 (%)			Mean	Pooled
		Dec	Jan	Feb		Dec	Jan	Feb		
1.	Utlou	27.00 (5.25)	50.00 (7.11)	72.00 (8.51)	49.67 (6.96)	40.00 (6.36)	59.00 (7.71)	82.00 (9.08)	60.33 (7.72)	55.00 (7.34)
2.	Thiyam leikai	30.00 (5.52)	54.00 (7.38)	77.00 (8.80)	53.67 (7.24)	45.00 (6.75)	66.00 (8.15)	85.00 (9.25)	65.33 (8.05)	59.50 (7.64)
3.	Leimaram	29.00 (5.43)	52.00 (7.25)	70.00 (8.40)	50.33 (7.02)	43.00 (6.60)	61.00 (7.84)	84.00 (9.19)	62.67 (7.88)	56.50 (7.45)
4.	Keinou thongkha	31.00 (5.61)	56.00 (7.52)	80.00 (8.97)	55.67 (7.37)	44.00 (6.67)	68.00 (8.28)	85.00 (9.25)	65.67 (8.06)	60.67 (7.72)
5.	Laitongjam	32.00 (5.70)	59.00 (7.71)	85.00 (9.25)	58.67 (7.55)	50.00 (7.11)	74.00 (8.63)	87.00 (9.35)	70.33 (8.36)	64.50 (7.96)
6.	Oinam leikai	26.00 (5.15)	48.00 (6.96)	69.00 (8.34)	47.67 (6.82)	37.00 (6.12)	58.00 (7.65)	80.00 (8.97)	58.33 (7.58)	53.00 (7.20)
7.	Sabal leikai	33.00 (5.79)	56.00 (7.52)	83.00 (9.14)	57.33 (7.48)	47.00 (6.89)	72.00 (8.51)	86.00 (9.30)	68.33 (8.24)	62.83 (7.86)
8.	Thanga salam	28.00 (5.34)	51.00 (7.18)	70.00 (8.40)	49.67 (6.97)	40.00 (6.36)	61.00 (7.84)	80.00 (8.97)	60.33 (7.73)	55.00 (7.35)
9.	Moirangkhunou	26.00 (5.15)	45.00 (6.75)	65.00 (8.09)	45.33 (6.66)	38.00 (6.20)	60.00 (7.78)	79.00 (8.92)	59.00 (7.63)	52.17 (7.15)
10.	Toubul	25.00 (5.05)	43.00 (6.60)	64.00 (8.03)	44.00 (6.56)	38.00 (6.20)	57.00 (7.58)	78.00 (8.86)	57.67 (7.55)	50.83 (7.05)
	<b>Mean</b>	28.70 (5.40)	51.4 (7.20)	73.50 (8.59)		42.20 (6.53)	63.60 (8.00)	82.60 (9.11)		
	<b>SE(d) ±</b>				0.09				0.10	0.07
	<b>C.D. (5%)</b>				0.20				0.22	0.15

Figures in the parenthesis are square root transformed

**Table 7: Per cent disease incidence of *Alternaria* leaf blight of broad bean in Thoubal.**

Sr. No.	Locality	Disease incidence during 2020-2021 (%)			Mean	Disease incidence during 2021-2022 (%)			Mean	Pooled
		Dec	Jan	Feb		Dec	Jan	Feb		
1.	Lilong	30.00 (5.52)	52.00 (7.25)	70.00 (8.40)	50.67 (7.05)	54.00 (7.38)	69.00 (8.34)	91.00 (9.57)	71.33 (8.43)	61.00 (7.74)
2.	Waithou tronglaobi	33.00 (5.79)	55.00 (7.45)	74.00 (8.63)	54.00 (7.29)	57.00 (7.58)	80.00 (8.97)	92.00 (9.62)	76.33 (8.72)	65.17 (8.01)
3.	Khangabok	31.00 (5.61)	48.00 (6.96)	67.00 (8.22)	48.67 (6.93)	54.00 (7.38)	67.00 (8.22)	90.00 (9.51)	70.33 (8.37)	60.67 (7.73)
4.	Haokha	34.00 (5.87)	55.00 (7.45)	76.00 (8.75)	55.00 (7.36)	59.00 (7.71)	83.00 (9.14)	94.00 (9.72)	78.67 (8.86)	66.83 (8.11)
5.	Wangjing	35.00 (5.96)	58.00 (7.65)	80.00 (8.97)	57.67 (7.53)	60.00 (7.78)	85.00 (9.25)	96.00 (9.82)	80.33 (8.95)	69.00 (8.24)
6.	Haoreibi	37.00 (6.12)	60.00 (7.78)	82.00 (9.08)	59.67 (7.66)	65.00 (8.09)	89.00 (9.46)	98.00 (9.92)	84.00 (9.16)	71.83 (8.41)
7.	Wangoi	31.00 (5.61)	50.00 (7.11)	70.00 (8.40)	50.33 (7.04)	56.00 (7.52)	69.00 (8.34)	91.00 (9.57)	72.00 (8.47)	61.17 (7.76)
8.	Khongjom	32.00 (5.70)	49.00 (7.04)	68.00 (8.28)	49.67 (7.00)	56.00 (7.52)	67.00 (8.22)	92.00 (9.62)	71.67 (8.45)	59.50 (7.65)
9.	Uchiwa	34.00 (5.87)	57.00 (7.58)	69.00 (8.34)	53.33 (7.26)	59.00 (7.71)	82.00 (9.08)	95.00 (9.77)	78.67 (8.86)	66.00 (8.06)
10.	Kang samaram	33.00 (5.79)	54.00 (7.38)	75.00 (8.69)	54.00 (7.29)	58.00 (7.65)	82.00 (9.08)	93.00 (9.67)	77.67 (8.80)	65.83 (8.04)
	<b>Mean</b>	33.00 (5.79)	53.80 (7.36)	73.10 (8.57)	-	57.80 (7.63)	77.30 (8.81)	93.20 (9.68)	-	
	<b>SE(d) ±</b>				0.10				0.16	0.04
	<b>C.D. (5%)</b>				0.20				0.34	0.10

Figures in the parenthesis are square root transformed

**Table 8: Per cent disease incidence of *Alternaria* leaf blight of broad bean in Kakching.**

Sr. No.	Locality	Disease incidence during 2020-2021 (%)			Mean	Disease incidence during 2021-2022 (%)			Mean	Pooled
		Dec	Jan	Feb		Dec	Jan	Feb		
1.	Sekmajjin	27.00 (5.24)	49.00 (7.04)	68.00 (8.28)	48.00 (6.85)	40.00 (6.36)	63.00 (7.97)	85.00 (9.25)	62.67 (7.86)	55.33 (7.36)
2.	Hiyanglam	35.00 (5.96)	58.00 (7.65)	78.00 (8.86)	57.00 (7.49)	54.00 (7.38)	72.00 (8.51)	96.00 (9.82)	74.00 (8.57)	65.50 (8.03)
3.	Langmeidong	25.00 (5.05)	46.00 (6.82)	68.00 (8.28)	46.33 (6.72)	37.00 (6.12)	60.00 (7.78)	82.00 (9.08)	59.67 (7.66)	53.00 (7.19)
4.	Sumak leikai	30.00 (5.52)	4.00 (7.04)	73.00 (8.57)	50.67 (7.04)	46.00 (6.82)	70.00 (8.40)	89.00 (9.46)	68.33 (8.23)	59.50 (7.63)
5.	Wabagai	30.00 (5.52)	52.00 (7.25)	71.00 (8.46)	51.00 (7.07)	45.00 (6.75)	68.00 (8.28)	90.00 (9.51)	67.67 (8.18)	59.33 (7.63)
6.	Ningthou leikai	32.00 (5.70)	55.00 (7.45)	74.00 (8.63)	53.67 (7.26)	48.00 (6.96)	72.00 (8.51)	93.00 (9.67)	71.00 (8.38)	62.33 (7.82)
7.	Sugnu	29.00 (5.43)	48.00 (6.96)	69.00 (8.34)	48.67 (6.91)	43.00 (6.60)	65.00 (8.09)	88.00 (9.41)	65.33 (8.03)	57.00 (7.47)
8.	Mayenglamjao	31.00 (5.61)	54.00 (7.38)	73.00 (8.57)	52.67 (7.19)	45.00 (6.75)	73.00 (8.57)	89.00 (9.46)	69.00 (8.26)	60.83 (7.72)
9.	Makha lou	23.00 (4.85)	44.00 (6.67)	67.00 (8.22)	44.67 (6.58)	35.00 (5.96)	57.00 (7.58)	80.00 (8.97)	57.33 (7.50)	51.00 (7.04)
10.	Hayel hangoon	33.00 (5.79)	56.00 (7.52)	75.00 (8.69)	54.67 (7.33)	50.00 (7.11)	75.00 (8.69)	91.00 (9.57)	72.00 (8.45)	63.33 (7.89)
	<b>Mean</b>	29.50 (5.47)	51.10 (7.18)	71.60 (8.49)	-	44.30 (6.68)	67.50 (8.24)	88.30 (9.42)	-	
	<b>SE(d) ±</b>				0.08				0.11	0.06
	<b>C.D. (5%)</b>				0.17				0.22	0.13

Figures in the parenthesis are square root transformed

**Table 9: Per cent disease severity of *Alternaria* leaf blight of broad bean in Imphal West.**

Sr. No.	Locality	Disease severity during 2020-2021 (%)			Mean	Disease severity during 2021-2022 (%)			Mean	Pooled
		Dec	Jan	Feb		Dec	Jan	Feb		
1.	Iroisemba	12.89 (3.66)	25.33 (5.08)	39.78 (6.35)	26.00 (5.03)	19.44 (4.47)	30.44 (5.56)	45.67 (6.79)	31.85 (5.61)	28.93 (5.32)
2.	Moidangpok	11.56 (3.47)	22.22 (4.77)	36.89 (6.11)	23.56 (4.78)	14.88 (3.92)	31.33 (5.64)	39.78 (6.35)	28.66 (5.30)	26.11 (5.04)
3.	Langthabal lep	16.11 (4.08)	25.11 (5.06)	37.89 (6.20)	26.37 (5.11)	20.89 (4.62)	34.56 (5.92)	50.67 (7.15)	35.37 (5.90)	30.87 (5.51)
4.	Phayeng	13.89 (3.79)	25.44 (5.09)	36.33 (6.07)	25.22 (4.99)	19.56 (4.48)	38.78 (6.27)	45.33 (6.77)	34.56 (5.84)	29.89 (5.41)
5.	Taothong apheiba	14.78 (3.91)	24.33 (4.98)	35.56 (6.00)	24.89 (4.97)	16.67 (4.14)	36.89 (6.11)	43.44 (6.63)	32.33 (5.63)	28.61 (5.30)
6.	Langjing	13.67 (3.76)	25.56 (5.10)	37.11 (6.13)	25.45 (5.00)	16.78 (4.16)	38.33 (6.23)	42.67 (6.57)	32.59 (5.65)	29.02 (5.33)
7.	Lairensajik	14.89 (3.92)	23.67 (4.92)	38.44 (6.24)	25.67 (5.03)	18.11 (4.31)	38.67 (6.26)	40.33 (6.39)	32.37 (5.65)	29.02 (5.34)
8.	Sairemkhul	12.44 (3.60)	20.11 (4.54)	35.56 (6.00)	22.70 (4.71)	14.56 (3.88)	35.33 (5.99)	38.89 (6.28)	29.59 (5.38)	26.15 (5.05)
9.	Meitram	11.67 (3.49)	18.89 (4.40)	33.67 (5.85)	21.41 (4.58)	15.44 (3.99)	34.67 (5.93)	37.56 (6.17)	29.22 (5.36)	25.32 (4.97)
10.	Lamjaotonba	10.44 (3.31)	16.56 (4.13)	30.33 (5.55)	19.11 (4.33)	12.00 (3.54)	30.56 (5.57)	35.89 (6.03)	26.15 (5.05)	22.63 (4.69)
	<b>Mean</b>	13.23 (3.70)	22.72 (4.81)	36.16 (6.05)		16.83 (4.15)	34.96 (5.95)	42.02 (6.51)		
	<b>SE(d) ±</b>				0.11				0.18	0.07
	<b>C.D. (5%)</b>				0.23				0.38	0.16

Figures in the parenthesis are square root transformed

**Table 10: Per cent disease severity of *Alternaria* leaf blight of broad bean in Imphal East.**

Sr. No.	Locality	Disease severity during 2020-2021 (%)			Mean	Disease severity during 2021-2022 (%)			Mean	Pooled
		Dec	Jan	Feb		Dec	Jan	Feb		
1.	Yumnam khunou	14.56 (3.88)	25.33 (5.08)	34.22 (5.89)	24.70 (4.95)	23.56 (4.91)	31.44 (5.65)	44.89 (6.74)	33.30 (5.76)	29.00 (5.36)
2.	Keibi khullen	16.44 (4.12)	28.00 (5.34)	37.33 (6.15)	27.26 (5.20)	24.00 (4.95)	33.67 (5.85)	45.67 (6.79)	34.45 (5.86)	30.85 (5.53)
3.	Khanarok	11.67 (3.49)	23.44 (4.89)	30.00 (5.52)	21.70 (4.63)	18.78 (4.39)	28.89 (5.42)	43.56 (6.64)	30.41 (5.48)	26.06 (5.06)
4.	Nongmada thongkhong	12.89 (3.66)	26.11 (5.16)	31.56 (5.66)	23.52 (4.83)	24.67 (5.02)	35.78 (6.02)	45.00 (6.75)	35.15 (5.93)	29.34 (5.38)
5.	Itam nungoi	17.33 (4.22)	30.56 (5.57)	39.22 (6.30)	29.04 (5.37)	27.00 (5.24)	37.11 (6.13)	50.44 (7.14)	38.18 (6.17)	33.61 (5.77)
6.	Napet palli	15.00 (3.94)	26.67 (5.21)	37.00 (6.12)	26.22 (5.09)	25.11 (5.06)	32.67 (5.76)	47.33 (6.92)	35.04 (5.91)	30.63 (5.50)
7.	Uyumpok	18.89 (4.40)	29.33 (5.46)	42.44 (6.55)	30.22 (5.47)	34.56 (5.92)	44.78 (6.73)	52.11 (7.25)	43.82 (6.63)	37.02 (6.05)
8.	Taretkhul	25.44 (5.09)	39.56 (6.33)	50.00 (7.11)	38.33 (6.18)	41.67 (6.49)	55.33 (7.47)	62.78 (7.95)	53.26 (7.31)	45.80 (6.74)
9.	Sagolmang	22.89 (4.84)	36.44 (6.08)	47.78 (6.95)	35.70 (5.95)	26.44 (5.19)	31.56 (5.66)	48.11 (6.97)	35.37 (5.94)	35.54 (5.95)
10.	Pukhao khabam	18.67 (4.38)	30.00 (5.52)	39.56 (6.33)	29.41 (5.41)	24.89 (5.04)	35.44 (5.99)	47.11 (6.90)	35.81 (5.98)	32.61 (5.69)
	<b>Mean</b>	17.38 (4.20)	29.54 (5.46)	38.91 (6.26)		27.07 (5.22)	36.67 (6.07)	48.70 (7.00)		
	<b>SE(d) ±</b>				0.07				0.14	0.24
	<b>C.D. (5%)</b>				0.15				0.29	0.55

Figures in the parenthesis are square root transformed

**Table 11: Per cent disease severity of *Alternaria* leaf blight of broad bean in Bishnupur.**

Sr. No.	Locality	Disease severity during 2020-2021 (%)			Mean	Disease severity during 2021-2022 (%)			Mean	Pooled
		Dec	Jan	Feb		Dec	Jan	Feb		
1	Utlou	19.56 (4.48)	32.89 (5.78)	54.67 (7.43)	35.71 (5.89)	22.67 (4.81)	43.44 (6.63)	66.78 (8.20)	44.30 (6.55)	40.00 (6.22)
2	Thiyam leikai	22.67 (4.81)	37.44 (6.16)	60.56 (7.81)	40.22 (6.26)	28.33 (5.37)	48.89 (7.03)	70.56 (8.43)	49.26 (6.94)	44.74 (6.60)
3	Leimaram	19.89 (4.52)	34.56 (5.92)	57.11 (7.59)	37.19 (6.01)	24.78 (5.03)	51.44 (7.21)	72.89 (8.57)	49.70 (6.93)	43.45 (6.47)
4	Keinou thongkha	24.33 (4.98)	38.89 (6.28)	62.44 (7.93)	41.89 (6.40)	29.56 (5.48)	50.00 (7.11)	72.67 (8.55)	50.74 (7.05)	46.32 (6.72)
5	Laitongjam	29.44 (5.47)	42.56 (6.56)	68.78 (8.32)	46.93 (6.79)	36.89 (6.11)	58.22 (7.66)	76.33 (8.77)	57.15 (7.51)	52.04 (7.15)
6	Oinam leikai	20.44 (4.58)	28.56 (5.39)	52.89 (7.31)	33.96 (5.76)	22.67 (4.81)	39.78 (6.35)	67.44 (8.24)	43.30 (6.47)	38.63 (6.11)
7	Sabal leikai	26.11 (5.16)	39.44 (6.32)	64.89 (8.09)	43.48 (6.52)	33.78 (5.85)	52.56 (7.28)	75.44 (8.71)	53.93 (7.28)	48.70 (6.90)
8	Thanga salam	22.56 (4.80)	34.22 (5.89)	58.78 (7.70)	38.52 (6.13)	25.56 (5.10)	44.67 (6.72)	69.89 (8.39)	46.71 (6.74)	42.61 (6.43)
9	Moirangkhnou	21.78 (4.72)	30.44 (5.56)	54.11 (7.39)	35.44 (5.89)	23.44 (4.89)	42.89 (6.59)	68.56 (8.31)	44.96 (6.60)	40.20 (6.24)
10	Toubul	17.00 (4.18)	30.44 (5.56)	53.11 (7.32)	33.52 (5.69)	20.33 (4.56)	42.11 (6.53)	64.89 (8.09)	42.44 (6.39)	37.98 (6.04)
	<b>Mean</b>	22.38 (4.77)	34.94 (5.94)	58.73 (7.69)		26.80 (5.20)	47.40 (6.91)	70.55 (8.43)		
	<b>SE(d) ±</b>				0.09				0.14	0.06
	<b>C.D. (5%)</b>				0.19				0.30	0.14

Figures in the parenthesis are square root transformed

**Table 12: Per cent disease severity of *Alternaria* leaf blight of broad bean in Thoubal.**

Sr. No.	Locality	Disease severity during 2020-2021 (%)			Mean	Disease severity during 2021-2022 (%)			Mean	Pooled
		Dec	Jan	Feb		Dec	Jan	Feb		
1.	Lilong	23.56 (4.91)	38.44 (6.24)	60.11 (7.79)	40.70 (6.31)	34.67 (5.93)	51.56 (7.22)	68.22 (8.29)	51.48 (7.15)	46.09 (6.73)
2.	Waithou tronglaobi	27.00 (5.24)	41.33 (6.47)	63.89 (8.02)	44.07 (6.58)	39.56 (6.33)	54.00 (7.38)	71.78 (8.50)	55.11 (7.40)	49.59 (6.99)
3.	Khangabok	21.00 (4.64)	34.56 (5.92)	52.56 (7.28)	36.04 (5.95)	33.78 (5.85)	49.00 (7.04)	65.89 (8.15)	49.56 (7.01)	46.69 (6.78)
4.	Haokha	29.44 (5.47)	42.56 (6.56)	65.89 (8.15)	45.96 (6.73)	37.44 (6.16)	58.11 (7.66)	72.56 (8.55)	56.04 (7.45)	51.00 (7.09)
5.	Wangjing	31.78 (5.68)	46.33 (6.84)	68.33 (8.30)	48.81 (6.94)	40.56 (6.41)	61.78 (7.89)	76.33 (8.77)	59.56 (7.69)	54.19 (7.31)
6.	Haoreibi	35.44 (5.99)	49.00 (7.04)	70.89 (8.45)	51.78 (7.16)	44.67 (6.72)	65.44 (8.12)	78.78 (8.90)	62.96 (7.92)	57.37 (7.54)
7.	Wangoi	24.56 (5.01)	35.89 (6.03)	55.67 (7.49)	38.71 (6.18)	35.78 (6.02)	51.89 (7.24)	69.89 (8.39)	52.52 (7.22)	45.61 (6.70)
8.	Khongjom	25.67 (5.12)	37.44 (6.16)	56.44 (7.55)	39.85 (6.27)	36.89 (6.11)	53.67 (7.36)	70.00 (8.40)	53.52 (7.29)	42.80 (6.48)
9.	Uchiwa	28.33 (5.37)	42.56 (6.56)	65.44 (8.12)	45.44 (6.68)	40.11 (6.37)	55.89 (7.51)	73.44 (8.60)	56.48 (7.49)	50.96 (7.09)
10.	Kang samaram	29.56 (5.48)	44.89 (6.74)	67.11 (8.22)	47.19 (6.81)	42.44 (6.55)	56.78 (7.57)	73.56 (8.61)	57.59 (7.58)	52.39 (7.19)
	<b>Mean</b>	27.63 (5.29)	41.30 (6.46)	62.63 (7.94)		38.59 (6.25)	55.81 (7.50)	72.05 (8.51)		
	<b>SE(d) ±</b>				0.07				0.08	0.09
	<b>C.D. (5%)</b>				0.14				0.16	0.21

Figures in the parenthesis are square root transformed



**Table 13: Per cent disease severity of *Alternaria* leaf blight of broad bean in Kakching.**

Sr. No.	Locality	Disease severity during 2020-2021 (%)			Mean	Disease severity during 2021-2022 (%)			Mean	Pooled
		Dec	Jan	Feb		Dec	Jan	Feb		
1.	Sekmaijin	23.56 (4.91)	34.67 (5.93)	57.89 (7.64)	38.71 (6.16)	26.67 (5.21)	47.00 (6.89)	66.56 (8.19)	46.74 (6.76)	42.73 (6.46)
2.	Hiyanglam	30.00 (5.52)	42.89 (6.59)	64.78 (8.08)	45.89 (6.73)	39.44 (6.32)	53.56 (7.35)	75.78 (8.73)	56.26 (7.47)	51.08 (7.10)
3.	Langmeidong	22.44 (4.79)	32.78 (5.77)	56.44 (7.55)	37.22 (6.03)	25.78 (5.13)	46.89 (6.88)	64.78 (8.08)	45.82 (6.70)	41.52 (6.37)
4.	Sumak leikai	26.55 (5.20)	34.89 (5.95)	63.78 (8.02)	41.74 (6.39)	29.11 (5.44)	50.89 (7.17)	69.89 (8.39)	49.96 (7.00)	39.30 (6.18)
5.	Wabagai	27.00 (5.24)	32.44 (5.74)	61.33 (7.86)	40.26 (6.28)	29.89 (5.51)	49.56 (7.08)	69.67 (8.38)	49.71 (6.99)	44.98 (6.64)
6.	Ningthou leikai	29.22 (5.45)	37.67 (6.18)	65.78 (8.14)	44.22 (6.59)	33.56 (5.84)	54.44 (7.41)	71.33 (8.48)	53.11 (7.24)	48.67 (6.92)
7.	Sugnu	25.78 (5.13)	33.56 (5.84)	57.22 (7.60)	38.85 (6.19)	27.89 (5.33)	49.67 (7.08)	68.22 (8.29)	48.59 (6.90)	43.72 (6.54)
8.	Mayenglamjao	27.89 (5.33)	36.33 (6.07)	63.56 (8.00)	42.59 (6.47)	29.89 (5.51)	52.56 (7.28)	70.67 (8.44)	51.04 (7.08)	46.82 (6.77)
9.	Makha lou	20.67 (4.60)	29.87 (5.51)	54.56 (7.42)	35.03 (5.84)	22.89 (4.84)	44.78 (6.73)	63.00 (7.97)	43.56 (6.51)	45.85 (6.69)
10.	Hayel hangoon	29.56 (5.48)	39.44 (6.32)	66.67 (8.20)	45.22 (6.67)	32.44 (5.74)	55.67 (7.49)	72.56 (8.55)	53.56 (7.26)	49.39 (6.96)
	<b>Mean</b>	26.27 (5.17)	35.45 (5.99)	61.20 (7.85)		29.76 (5.49)	50.50 (7.14)	69.25 (8.35)		
	<b>SE(d) ±</b>				0.09				0.11	0.04
	<b>C.D. (5%)</b>				0.19				0.23	0.08

Figures in the parenthesis are square root transformed

**Pathogenicity tests.** In both the tests, all the fungal isolates produced typical disease lesions in varying extent. However, in both the control broad bean plants and detached leaves, the typical disease lesions did not developed. The fungal isolates were reisolated and the same fungal isolates were consistently associated with the disease, thus, confirming the pathogenicity of the isolates. The fungal isolates are capable of producing typical disease lesions on both the broad bean plants and detached leaves (Honda *et al.*, 2001; Rahman *et al.*, 2002; Ahmed *et al.*, 2017). The size of the lesions varied in correspondence to each isolates (Rahman *et al.*, 2002; Kayim *et al.*, 2018). The isolates from

Taretkhul, Thiyam leikai, Laitongjam, Sabal leikai, Wangjing, Haoreibi, Hiayanglam, Ningthou leikai and Hayel hangoon were highly pathogenic in both the pathogenicity tests. The isolates from Lamjaotongba, Khanarok, Napet palli, Utlou and Oinam leikai were slightly pathogenic in both the pathogenicity tests. All the fungal isolates which were graded as highly pathogenic caused reduced growth, complete blighting, drying and death of the broad bean plants in due course of the disease. The pathogenicity of all the tested isolates as well as corresponding size of the lesions varied among both the pathogenicity tests (Rahman *et al.*, 2002).

**Table 14: Pathogenicity test of *Alternaria* isolates collected from Imphal West on broad bean.**

Sr. No.	Source of fungal isolates	Detached leaves		Broad bean plants	
		Lesion development	Pathogenicity degree	Lesion development	Pathogenicity degree
1.	Iroisemba	+++	Highly pathogenic	++	Moderately pathogenic
2.	Moidangpok	++	Moderately pathogenic	+	Slightly pathogenic
3.	Langthabal lep	+++	Highly pathogenic	++	Moderately pathogenic
4.	Phayeng	+++	Highly pathogenic	++	Moderately pathogenic
5.	Taonthong apheiba	+++	Highly pathogenic	++	Moderately pathogenic
6.	Langjing	+++	Highly pathogenic	++	Moderately pathogenic
7.	Lairensajik	++	Moderately pathogenic	++	Moderately pathogenic
8.	Sairemkhul	++	Moderately pathogenic	+	Slightly pathogenic
9.	Meitram	++	Moderately pathogenic	+	Slightly pathogenic
10.	Lamjaotonba	+	Slightly pathogenic	+	Slightly pathogenic
11.	Control	-	Non pathogenic	-	Non pathogenic

**Table 15: Pathogenicity test of *Alternaria* isolates collected from Imphal East on broad bean.**

Sr. No.	Source of fungal isolates	Detached leaves		Broad bean plants	
		Lesion development	Pathogenicity degree	Lesion development	Pathogenicity degree
1.	Yumnam khunou	++	Moderately pathogenic	+	Slightly pathogenic
2.	Keibi khullen	++	Moderately pathogenic	+	Slightly pathogenic
3.	Khanarok	+	Slightly pathogenic	+	Slightly pathogenic
4.	Nongmada thongkhong	++	Moderately pathogenic	++	Moderately pathogenic
5.	Itam nungoi	+++	Highly pathogenic	++	Moderately pathogenic
6.	Napet palli	+	Slightly pathogenic	+	Slightly pathogenic
7.	Uyumpok	+++	Highly pathogenic	++	Moderately pathogenic
8.	Taretkhul	+++	Highly pathogenic	+++	Highly pathogenic
9.	Sagolmang	+++	Highly pathogenic	++	Moderately pathogenic
10.	Pukhao khabam	+++	Highly pathogenic	++	Moderately pathogenic
11.	Control	-	Non pathogenic	-	Non pathogenic

**Table 16: Pathogenicity test of *Alternaria* isolates collected from Bishnupur on broad bean.**

Sr. No.	Source of fungal isolates	Detached leaves		Broad bean plants	
		Lesion development	Pathogenicity degree	Lesion development	Pathogenicity degree
1.	Utlou	+	Slightly pathogenic	+	Slightly pathogenic
2.	Thiyam leikai	+++	Highly pathogenic	+++	Highly pathogenic
3.	Leimaram	+++	Highly pathogenic	++	Moderately pathogenic
4.	Keinou thongkha	+++	Highly pathogenic	++	Moderately pathogenic
5.	Laitongjam	+++	Highly pathogenic	+++	Highly pathogenic
6.	Oinam leikai	+	Slightly pathogenic	+	Slightly pathogenic
7.	Sabal leikai	+++	Highly pathogenic	+++	Highly pathogenic
8.	Thanga salam	++	Moderately pathogenic	++	Moderately pathogenic
9.	Moirangkhumou	++	Moderately pathogenic	+	Slightly pathogenic
10.	Toubul	++	Moderately pathogenic	+	Slightly pathogenic
11.	Control	-	Non pathogenic	-	Non pathogenic

**Table 17: Pathogenicity test of *Alternaria* isolates collected from Thoubal on broad bean.**

Sr. No.	Source of fungal isolates	Detached leaves		Broad bean plants	
		Lesion development	Pathogenicity degree	Lesion development	Pathogenicity degree
1.	Lilong	++	Moderately pathogenic	+	Slightly pathogenic
2.	Waithou tronglaobi	++	Moderately pathogenic	++	Moderately pathogenic
3.	Khangabok	++	Moderately pathogenic	++	Moderately pathogenic
4.	Haokha	+++	Highly pathogenic	++	Moderately pathogenic
5.	Wangjing	+++	Highly pathogenic	+++	Highly pathogenic
6.	Haoreibi	+++	Highly pathogenic	+++	Highly pathogenic
7.	Wangoi	++	Moderately pathogenic	+	Slightly pathogenic
8.	Khongjom	++	Moderately pathogenic	+	Slightly pathogenic
9.	Uchiwa	+++	Highly pathogenic	++	Moderately pathogenic
10.	Kang samaram	+++	Highly pathogenic	++	Moderately pathogenic
11.	Control	-	Non pathogenic	-	Non pathogenic

**Table 18: Pathogenicity test of *Alternaria* isolates collected from Kakching on broad bean.**

Sr. No.	Source of fungal isolates	Detached leaves		Broad bean plants	
		Lesion development	Pathogenicity degree	Lesion development	Pathogenicity degree
1.	Sekmaijin	++	Moderately pathogenic	+	Slightly pathogenic
2.	Hiyanglam	+++	Highly pathogenic	+++	Highly pathogenic
3.	Langmeidong	++	Moderately pathogenic	+	Slightly pathogenic
4.	Sumak leikai	++	Moderately pathogenic	+	Slightly pathogenic
5.	Wabagai	++	Moderately pathogenic	++	Moderately pathogenic
6.	Ningthou leikai	+++	Highly pathogenic	+++	Highly pathogenic
7.	Sugnu	++	Moderately pathogenic	++	Moderately pathogenic
8.	Mayenglamjao	+++	Highly pathogenic	++	Moderately pathogenic
9.	Makha lou	+++	Highly pathogenic	++	Moderately pathogenic
10.	Hayel hangoon	+++	Highly pathogenic	+++	Highly pathogenic
11.	Control	-	Non pathogenic	-	Non pathogenic

**Observation of the symptoms.** The symptoms first appeared on the older leaves and subsequently the disease progressed upwards (El-Mougy *et al.*, 2016). The symptom starts as small brownish spots which eventually enlarged. In due course, brown irregular to circular shaped lesions starts appearing on the younger leaves. Sometimes, these spots are outlined by reddish to purplish margins. The spots eventually enlarged and developed concentric rings which is the striking symptom of this disease. The leaves area surrounding the blighted lesions becomes yellowish in colour (Rahman *et al.*, 2002). The part of blighted lesions gradually dried up and falls off giving a shot hole appearance. The enlarged blighted lesions coalesced and the entire leaves become blighted (Tiwari *et al.*, 2021). Blighting also starts from the tips or margins of the leaves which generally advanced towards the centre and then to the base of the leaves and eventually the entire leaves become blighted, dried and defoliate (Honda *et al.*, 2001; Rahman *et al.*, 2002). In the advanced stage of the disease, irregular to circular brown lesions starts appearing on the stem and pods (Honda *et al.*, 2001; Kwon *et al.*, 2002). The flower withered and becomes dried and falls off from the plant. The pods produced after the severe stage of the disease are smaller and underdeveloped. Lastly, the entire plants becomes blighted, dried and dies.



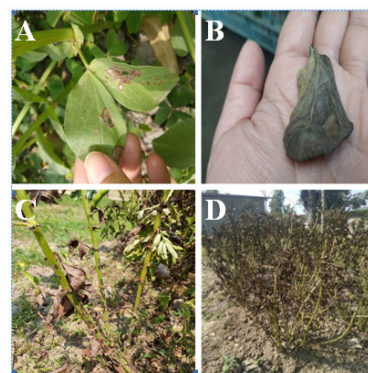
**Fig. 1.** Initial symptoms of *Alternaria* leaf blight of broad bean with spots surrounded by reddish to purplish border.



**Fig. 2.** Enlargement of spots and development of concentric rings on the leaf lesions.



**Fig. 3.** Initiation of blighting and chlorosis on the infected leaves.



**Fig. 4.** (A) Shot hole on leaf lesions, (B) Completely blighted leaf, (C) Lesions on stem, (D) Drying and death of the plant.

## CONCLUSIONS

*Alternaria* leaf blight of broad bean is widely distributed in the valley districts of Manipur. The disease exceptionally affects the eatable portions namely, broad bean pods, seeds and leaves. The disease remarkably reduces yield and quality of the produce thereby causing notable economic losses. The disease is distinguishable by the presence of characteristics target board or concentric rings on the leaf lesions. In the later stage the entire plants becomes wilted and completely dried up. The frequency of this disease varied among all the five valley districts of Manipur.

## FUTURE SCOPE

The incidence and severity of *Alternaria* leaf blight of broad bean were highest late in the season. In later stage, this disease commonly co-occurred with chocolate leaf spot and rusts. Rust pustules were found to be developed within the blighted lesions itself. This disease is also commonly confused with *Ascochyta* leaf blight which also has a characteristic zonate rings. Hence, isolation, observation and pathogenicity test of the pathogen are a must for determining the disease causal agents. Moreover, detailed study of the disease causing ability of the respective pathogen as well as co-infection of broad bean by multiple pathogens are crucial for understanding the impacts of disease in reducing productivity and aesthetic value of broad bean plants. Efficient management strategies should be developed to combat economic losses of broad bean production due to *Alternaria* leaf blight.

**Conflict of Interest.** None.

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