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Status and symptomatology of early blight (*Alternaria solani*) of potato (*Solanum tuberosum* L.) in Kashmir valley

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Alternaria leaf blight is one of the most important diseases of potato (*Solanum tuberosum* L.) worldwide. The disease was prevalent in all the potato growing areas of Kashmir valley surveyed during 2009 and 2010. The overall mean disease incidence and intensity ranged from 24.54 to 28.23% and 13.84 to 15.98%, respectively. The highest disease incidence (39.09%) and intensity (22.54%) was recorded in district Budgam. The lowest level of disease was in district Shopian (14.89 and 8.05%, respectively). The pathogen associated with the disease was identified as *Alternaria solani* (Ellis and Martin) Jones and Grout. In early stages of disease development, small irregular to circular dark brown spots on lower leaves appear, measuring 0.5 mm in size. Upto fourth week of June concentric rings form as a result of irregular growth patterns by the organism in the leaf tissue giving the lesion a characteristic 'target spot' or 'bulls eye' appearance. The maximum lesion size 7.4 mm was recorded in the second week of August.

Key words: Potato, *Alternaria solani*, survey, disease incidence, symtomatology.

INTRODUCTION

Potato, also known as white or Irish potato, is the most important and useful member of the family Solanaceae and is grown in tropics as well as sub-tropics during the cool as well as dry seasons .The cultivated potato (*Solanum tuberosum* L.) originated in the Andean highlands of South America and was disseminated to other continents by Europeans. It is believed to have been introduced in India towards the beginning of 17th century most probably by the Portuguese traders or by British missionaries (Pushkarnath, 1976). Today, India ranks fourth in the area and fifth in the production of potato in the world (Shailbala and Pathak, 2008). In 1998-99 India produced 22.50 million tones of potato from an area of 1.28 million hectares. The year 2008 was celebrated for "International Potato Year" by United States organization dated 18th October, 200 7 (Shailbala

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and Pathak, 2008). Potato is considered 'The King' in food staples and hardly any domestic kitchen is available which does not use it one or the other form as it possesses all the attributes to be a potential food crop. Potato is the only non cereal food crop to commend such a high position in the world since being nutritious it can solve the problem of malnutrition and under nutrition if adopted as a major food crop. It has been recognized as a wholesome food and richest source of energy in most countries of the world where it forms important part of the human diet. Potato contains significant levels of phenolic compounds and vitamin C as potent antioxidants (Brown, 2005).

Potato is highly remunerative and nutritive crop in Jammu and Kashmir particularly in high altitude cold and cold arid areas of J&K. where it serves as a staple food. An overall production scenario of potato in Jammu and Kashmir depicts that area, production and productivity have sharply increased in past decade. Its cultivation is carried both in the large tracts as well as in the home gardens. The climatic conditions under which potatoes are grown in Kashmir are similar to those in Europe and North America, but due to lack of suitable high yielding varieties the productivity is far below that of some of the leading potato growing states in the country. Further the climatic conditions/topography of the valley is congenial for true potato seed (TPS) production and potato seed tuber production. Although it is being grown in Kashmir for many years, only few varieties are in cultivation which are either poor yielders, low in quality/and or susceptible to various pests and diseases. The intensive and extensive cultivation under the most favourable environmental conditions for potato crop production in the state failed to provide significant strides in potato yields, because of a number of production constraints, of which frequent occurrence of may fungal diseases viz., Early blight (*Alternaria solani*), Late blight (Phytophthora infestans), Powdery scab (Spongospora subterranean), Wart (Synchytrium endobioticum), Leaf black (Cercospora concors), Fusarium Wilt (Fusarium solani f.sp. radicicola), Black scurf (Rhizoctonia solani) and Charcoal rot (Macrophomina phaseolina) are note worthy and have been taking heavy toll of the produce. Amongst all these diseases early blight of potato is one of the most important foliar diseases of potato worldwide (Christ, 1990; Pelletier and Fry, 1990; Shtienberg et al., 1990; Vander-Walls et al., 2001). In recent years, increase in *A. solani* disease on potato foliage has been reported in various potato growing areas (Vloutoglou and Kalogerakis, 2000). In India *A. solani* (Ellis and Martin) Jones and Grout on leaves of potato (*Solanum tuberosum* L.) was reported from Farukhabad (U.P) by Butler in 1903 (Butler and Bisby, 1931). It was first reported from Srinagar (Kashmir) in 1957 (Koul, 1957).

Primary damage by early blight is attributed to premature defoliation of the potato plants, resulting in tuber yield reduction. Yield loss estimates resulting from foliar damage incited by early blight on potato vary by location, cropping season, cultivar, and the stage of potato maturity. In general, yield reductions of 5 to 40% have been reported in Israel (Rotem and Feldman, 1965) and 20 to 30% in the USA (Christ and Maczuga, 1989; Shtienberg et al., 1990). Early blight may also cause dry rot of tubers, reducing both the quantity and quality of marketable tubers (Nnodu et al., 1982). Environmental factors such as temperature, wetness duration and relative humidity (moisture) affect the development of early blight on potatoes (Adams and Stevenson, 1990; Harrison et al., 1965; Vloutoglou and Kalogerakis, 2000). Temperature increases *A. solani* infection and sporulation (Vloutoglou and Kalogerakis, 2000). Water in the form of high relative humidity, rainfall or dew accumulation can increase conidia germination and pathogen infection (Rotem, 2004). Alternating low and high humidity conditions have also been shown to favour disease development (Van der Walls et al., 2001). Early blight is also enhanced through continuous potato production (Olanya et al., 2009). The young plants of potato show high resistance to early blight due to *A. solani* as compared to older ones (Bambawale, 1978). Within the same plant, the lower leaves which are physiologically different from middle and top ones (Dowley et al., 1975) are more susceptible to certain pathogens with resistance increasing in an aeropetal direction. Potato early blight symptoms first occur on the lower senescing leaves, which become chloratic and abscise prematurely. The present study was undertaken to study the current status and symptomatology of early blight of potato in Kashmir valley.

MATERIALS AND METHODS

Survey for assessment of potato early blight disease (Plate 1) was conducted in the major potato growing areas of the valley viz., Baramulla, Budgam, Srinagar and Shopian districts during the month of June-July 2009 and 2010. Each district was represented by three locations and each location by three sites. Five plants were randomly selected from four corners and centre of the plot representing each site. All the leaves were examined for recording incidence and intensity of disease.

Disease incidence

Percent disease incidence was worked out as per the following formula given by James (1974):

$$\text{Percent disease incidence} = \frac{\text{No. of diseased leaves}}{\text{Total No. of leaves examined}} \times 100$$

Disease intensity

For assessment of disease intensity, diseased leaves were categorized as per the scale (Plate 2) given by Pandey and Pandey (2002) with a little modification as shown in Table 1.Percent disease intensity (PDI) was calculated as per the following formulae given by FAO (Anonymous, 1967):

Plate 1. *Alternaria* leaf spot on potato leaf.

Plate 2. Scale (0-5) for assessment of *Alternaria* leaf spot intensity.

Table 1. Assessment scale of disease intensity of early blight of potato.

Category	Grade/Numerical value	Leaf area infected (%)
I	0	Disease free
II	1	1-10
III	2	11-25
IV	3	26-50
V	4	51-75
VI	5	>76

$$PDI = \frac{\sum(n \times v)}{N \times S} \times 100$$

Where, ∑ = Summation; N = No. of leaves in each category; V = Numerical value of leaves observed, and S = Maximum numerical value/grade.

Symptomatology and disease development

The symptomatology of the disease was studied on five randomly selected plants of susceptible cultivars “Kufri Jyoti”. The selected plants were marked for continuous monitoring of disease development. Plants were kept unsprayed throughout the growing seasons (2009 and 2010) to study the symptoms of early blight leaf spot under natural epiphytotic conditions. First observation was taken as soon as the disease appeared. Periodic observations were recorded besides size, shape, coalescing and colour of the lesion on leaves. Size of the lesions was recorded in terms of average lesion size in mm.

Isolation of the pathogen

Potato leaves showing typical disease symptoms, collected from susceptible cultivar Kufri Jyoti, during the course of survey, were repeatedly used for isolation of the pathogen.

The diseased leaves were first examined for associated fungus by teasing the diseased portion with the help of a teasing needle and observed under microscope at the margins of the diseased spots (10x X 10x). For the isolation of fungus, small segments of diseased tissue along with some healthy leaf portion (5 × 5 mm^2) were cut with a sterilized razor blade at the margins of the diseased spots on the leaves and surface sterilized in 0.1% mercuric chloride solution for 30 s (Johnston and Booth, 1983). The leaf segments were then rinsed thrice in distilled sterilized water to remove the last trace of mercuric chloride solution, blotted dry and placed on acidified potato dextrose agar medium (PDA) in sterilized Petri plates. Three pieces of sterilized specimen were placed in each Petri plate and incubated for 7 days at 22±2°C. One set of PDA plates was seeded with bits without mercuric chloride treatment. The composition of potato dextrose agar medium used was:

Peeled potato: 200 g
Dextrose: 20 g
Agar: 20 g
Nacl: 1 g
Distilled water was included to make the volume 1000 ml

Purification and maintenance of pathogen

The culture was purified by hyphal tip method (Pathak, 1972) and single spore technique (Johnston and Booth, 1983). As soon as the mycelial growth was observed in Petri plates, advancing hyphal tips growing out of tissue segments were cut off with sterilized inoculation needle and transferred to potato dextrose agar slants for further growth.

In case of single spore technique 2 to 3 drops from spore suspension prepared from 10 days old culture and teased leaf tissue smear in autoclaved distilled water were used to spread on the surface of plain agar medium in Petri plates and incubated at 22±2°C for 24 h. The plates were observed for germinating spores under stereoscopic microscopic and finally germinating spores were lifted by inoculation needle and transferred aseptically to potato dextrose agar slants for further growth. The pure cultures thus obtained, were maintained by repeated sub-culturing at an interval of 30 days for further studies. The stock culture in PDA slants was stored at 4°C in refrigerator. To retain the vigour of the fungus, it was isolated repeatedly from naturally infected leaves and purified by the method described above.

Identification of the pathogen

The pathogen was identified on the basis of colony characters, viz., colour, growth, pigmentation etc. and morphological characters of its mycelium and conidia produced on host and in culture.

Pathogenicity test

The pathogenicity of the isolated fungal pathogen was conducted on detached leaves of “Kufri Jyoti” variety. Apparently healthy leaves were removed from plants, washed with sterilized distilled water and placed in sterilized Petri plates, with their petiole inserted in moist cotton. Spore suspension was made from 15 days old culture with sterilized distilled water and diluted to get a concentration of 2 × 10^4 conidia/ml. The spore suspension was inoculated at different places on the upper leaf surface. Control was maintained spraying only sterilized distilled water on the leaf surface. The leaves were then placed in humic chambers, where humidity was maintained by keeping moist cotton in chambers. The chambers where placed in diffused sunlight on laboratory benches at room temperature (19 to 20°C) till appearance of typical disease symptoms compared to those of in nature. Re-isolations of pathogen from artificially inoculated leaves where carried out and resultant cultures compared with the original culture to satisfy Koch’s postulates.

Morphological and cultural characters

The morphological characteristics of the causal organism were studied on culture in the laboratory *(in-vitro)*. The important characters studied were as follows:

Colony: Colour, shape, margins and pigmentation; Mycelium:

Colour, shape, septation, branching; Conidia: Colour, shape, size and septation.

RESULTS AND DISCUSSION

To find out the status of early blight disease of potato in Kashmir valley, various potato growing areas in district Budgam, Baramulla, Srinagar and Shopian were surveyed during two consecutive years of 2009 and 2010 in the month of June. The data on disease incidence and intensity recorded during the year 2009 and 2010 are presented in Tables 2 and 3.

Disease incidence

The data presented in Table 2 revealed that mean disease incidence at the locations surveyed varied from 13.06 to 44.95% with overall mean incidence of 25.96%. Maximum disease incidence was noticed at Mazhama (44.95%) followed by Khansahib (39.32%), Sopore (35.67%), Chadoora (32.99%) and Pattan (30.45%).

Comparison of year-wise data revealed that higher disease incidence (28.23%) was recorded during 2010 as compared to 2009 (24.54%). During the year 2009 maximum disease incidence was recorded at site Kawoosa (44.17%) followed by Mazhama (43.47%), Tarzoo (41.27%), Kuthipora (40.54%), Haigam (40.18%) and Wagar (39.02%). Minimum disease incidence (10.22%) was recorded at site Warpora while as maximum disease incidence was recorded during the year 2010 at Kawoosa (49.20%) followed by Wagar (49.01%), Mazhama (47.40%), Tarzoo (45.49%), Kuthipora (44.92%) and Haigam (43.66%). Minimum disease incidence (12.68%) was recorded at site Warpora.

District-wise mean disease incidence was maximum in Budgam (39.09%) followed by Baramulla (27.36%), Srinagar (22.53%) and Shopian (14.89%).

On an overall comparison amongst different localities surveyed, the highest disease incidence of 44.95% was recorded at Mazhama which was statistically at par with that of Khansahib (39.32%). The least disease incidence of 13.06% was recorded at Herpur (Shopian).

Disease intensity

The data presented in Table 3 revealed that mean disease intensity at the locations surveyed varied from 6.93 to 26.19% with overall mean intensity of 14.84%. Among sites maximum disease intensity was recorded at Kawoosa (27.33%) followed by Mazhama (26.33%), Tarzoo (25.37%), Kuthipora (24.91%), Haigam (24.39%) and Wagar (24.00%). While among locations maximum disease intensity was recorded at Mazhama (26.19%) followed by Khansahib (23.25%), Sopore (22.62%), Chadoora (18.19%), Pattan (17.10%) and HMT (14.66%).

Comparison of year-wise data revealed more disease intensity (14.98%) during 2010 as compared to 2009 (13.84%). District-wise mean disease intensity was maximum in Budgam (22.54%) followed by Baramulla (16.25%), Srinagar (12.53%) and Shopian (8.05%).

On an overall comparison amongst different localities surveyed, the highest disease intensity of 26.19% was recorded at Mazhama which was statistically at par with that of Khansahib (23.25%). The least disease intensity of 6.93% was recorded at Herpur (Shopian).

The present investigations indicated variable disease incidence as well as disease intensity at different places. It may be associated with prevalent environmental and/or pathogen factors. Changes in weather variables and amount of initial inoculum of *A. solani* may be responsible for varying disease intensities at different locations (Vander-Walls et al., 2003). The variation in environmental factors such as temperature, wetness duration and relative humidity (moisture) has also been reported to affect the development of early blight in potatoes (Harrison et al., 1965; Adams and Stevenson, 1990; Vloutoglou and Kalogerakis, 2000). Water in the form of high relative humidity, rainfall or dew accumulation can increase conidial germination and pathogen infection (Rotem, 2004). Alternating low and high humidity conditions have also been shown to favour disease development (Van der-Walls et al., 2001). These observations are also supported by the findings of Duhan and Suhag (1989), Hilal and Kamal (1990), Fazal et al. (1994), Rotem (1994), Anastasia et al. (1998), Dillard et al. (1998) and Ghosh et al. (2009). Lower disease at some locations could be attributed to balanced dose of fertilizers, wide spacing besides rapid disposal of debris of gerbera crop. These observations are in accordance with the findings of Humpherson (1983) and Duhan and Suhag (1990).

Symptoms of the early blight disease of potato under natural conditions of infection in field were studied on leaves of unsprayed susceptible potato cultivar ‘Kufri Jyoti’ during the year 2009 and 2010.The periodic (weekly) observations were recorded from first week of May. The initial disease symptoms with first appearance of the disease were recorded in the second week of May till second week of August. The first symptoms appeared as small irregular to circular dark brown spots on the lower leaves (Plate 3) measuring 0.5 mm in size. Apparently the leaves looked healthy but the lesions were visible only if the leaves were kept against the source of light. Periodic changes in size, shape and colour of the lesions were observed and the results are summarized in Table 3 and Figure 1.

The lesion progression was initially slow upto first week of June (0.5-0.6 mm/week) after which it showed a curvilinear behavior upto third week of July beyond which the lesion enlargement declined sharply. The maximum

Table 2. Incidence of early blight of potato (*Alternaria solani*) (Ellis and Martin) Jones and Grout in various districts of Kashmir valley during 2009 and 2010.

District	Location	Site	2009	2010	Pooled mean
Budgam	Khansahib	Kremshore	37.24	42.33	**39.78**
		Wager	39.02	49.01	**41.51**
		Khansahib	37.26	42.13	**36.69**
		Mean	**37.84**	**44.49**	**39.32**
	Chadoora	Nowbough	27.52	28.08	**27.03**
		Bugam	30.77	35.06	**32.91**
		Kaisarmulla	37.28	40.08	**39.04**
		Mean	**31.85**	**34.40**	**32.99**
	Mazhama	Mazhama	43.47	47.40	**45.44**
		Kuthipora	40.54	44.92	**42.73**
		Kawoosa	44.17	49.20	**46.68**
		Mean	**42.72**	**47.17**	**44.95**
		District mean	**37.47**	**42.02**	**39.09**
Baramulla	Pattan	Pattan	24.19	27.27	**25.72**
		Ganiepora	31.65	34.29	**32.97**
		Ganjipora	31.56	33.79	**32.67**
		Mean	**29.13**	**31.78**	**30.45**
	Sopore	Haigam	40.18	43.66	**33.41**
		Tarzoo	41.27	45.49	**43.35**
		Krankshavan	28.66	31.88	**30.26**
		Mean	**36.70**	**40.34**	**35.67**
	Tangmarg	Yarikhah	19.01	20.76	**19.88**
		Zeeran	15.50	17.77	**16.63**
		Warpora	10.22	12.68	**11.36**
		Mean	**14.91**	**17.07**	**15.95**
		District mean	**26.91**	**29.73**	**27.36**
Srinagar	Noorbagh	Noorbagh	15.55	20.63	**18.09**
		Palpora	17.23	23.71	**20.47**
		Waganpora	19.55	24.16	**21.85**
		Mean	**17.44**	**22.83**	**20.13**
	HMT	Maloora	21.67	24.26	**22.97**
		Mujgund	23.57	26.67	**25.12**
		Zainkot	25.53	30.39	**27.76**
		Mean	**23.59**	**27.10**	**25.28**
	Harwan	Theed	25.19	28.15	**26.67**
		Darbagh	18.73	20.17	**19.45**
		Saidapora	19.59	21.30	**20.87**
		Mean	**21.17**	**23.20**	**22.33**
		District mean	**20.73**	**24.38**	**22.53**
Shopian	Sedew	Sedew	14.77	18.18	**16.47**
		Chetipora	13.35	17.03	**14.86**
		Check	14.28	18.09	**16.18**
		Mean	**14.13**	**17.76**	**15.83**
	Herpur	Bohir hela	11.02	14.03	**12.52**
		Padapawan	12.04	15.38	**13.71**
		Herpur	11.41	14.54	**12.97**
		Mean	**11.49**	**14.65**	**13.06**

Table 2. Contd.

		Chogam	13.02	18.35	**15.68**
		Kanipora	15.68	19.28	**17.48**
	Chogam	Khudpora	12.08	16.27	**14.17**
		Mean	**13.59**	**17.96**	**15.77**
		District mean	**13.07**	**16.79**	**14.89**
		Overall mean	**24.54**	**28.23**	**25.96**

Table 3. Intensity of early blight of potato (*Alternaria solani*) (Ellis and Martin) Jones and Grout in various districts of Kashmir valley during 2009 and 2010.

District	Location	Site	2009	2010	Pooled mean
		Kremshore	21.35	24.82	**23.08**
	Khansahib	Wager	22.43	25.58	**24.00**
		Khansahib	21.02	24.33	**22.67**
		Mean	**21.60**	**24.91**	**23.25**
		Nowbough	19.80	16.08	**15.44**
	Chadoora	Bugam	16.29	18.96	**17.62**
Budgam		Kaisarmulla	20.58	22.48	**21.53**
		Mean	**18.89**	**19.17**	**18.19**
		Mazhama	25.37	27.28	**26.33**
		Kuthipora	23.76	26.06	**24.91**
	Mazhama	Kawoosa	26.04	28.61	**27.33**
		Mean	**25.05**	**27.31**	**26.19**
		District Mean	**21.84**	**23.80**	**22.54**
		Pattan	13.47	15.51	**14.49**
	Pattan	Ganiepora	18.03	20.02	**19.03**
		Ganjipora	16.41	19.17	**17.79**
		Mean	**15.97**	**18.23**	**17.10**
		Haigam	23.39	25.40	**24.39**
	Sopore	Tarzoo	23.80	26.95	**25.37**
Baramulla		Krankshavan	16.56	19.45	**18.10**
		Mean	**21.25**	**23.93**	**22.62**
		Yarikhah	10.05	12.86	**11.45**
		Zeeran	8.31	10.91	**9.61**
	Tangmarg	Warpora	5.63	6.52	**6.07**
		Mean	**7.99**	**10.09**	**9.04**
		District Mean	**15.07**	**17.42**	**16.25**
		Noorbagh	7.83	10.63	**9.23**
	Noorbagh	Palpora	8.89	11.66	**10.27**
		Waganpora	10.55	12.95	**11.75**
		Mean	**9.09**	**11.74**	**10.41**
		Maloora	12.75	14.05	**13.40**
	HMT	Mujgund	13.64	15.24	**14.44**
Srinagar		Zainkot	14.35	17.94	**16.14**
		Mean	**13.58**	**15.74**	**14.66**
		Theed	13.88	15.77	**14.82**
	Harwan	Darbagh	10.00	11.59	**10.80**
		Saidapora	11.04	12.87	**11.95**
		Mean	**11.64**	**13.41**	**12.52**

Table 3. Contd.

		District Mean	**11.43**	**13.63**	**12.53**
Shopian	Sedew	Sedew	7.83	10.46	**9.14**
		Chetipora	7.11	10.18	**8.64**
		Check	7.50	9.42	**8.46**
		Mean	**7.48**	**10.02**	**8.74**
	Herpur	Bohir hela	5.68	7.64	**6.66**
		Padapawan	6.77	8.47	**7.62**
		Herpur	5.57	7.49	**6.53**
		Mean	**6.00**	**7.86**	**6.93**
	Chogam	Chogam	**6.94**	**9.88**	**8.41**
		Kanipora	8.59	10.48	**9.54**
		Khudpora	7.21	7.82	**7.51**
		Mean	**7.58**	**9.39**	**8.48**
		District Mean	**7.02**	**9.09**	**8.05**
		Overall Mean	**13.84**	**15.98**	**14.84**

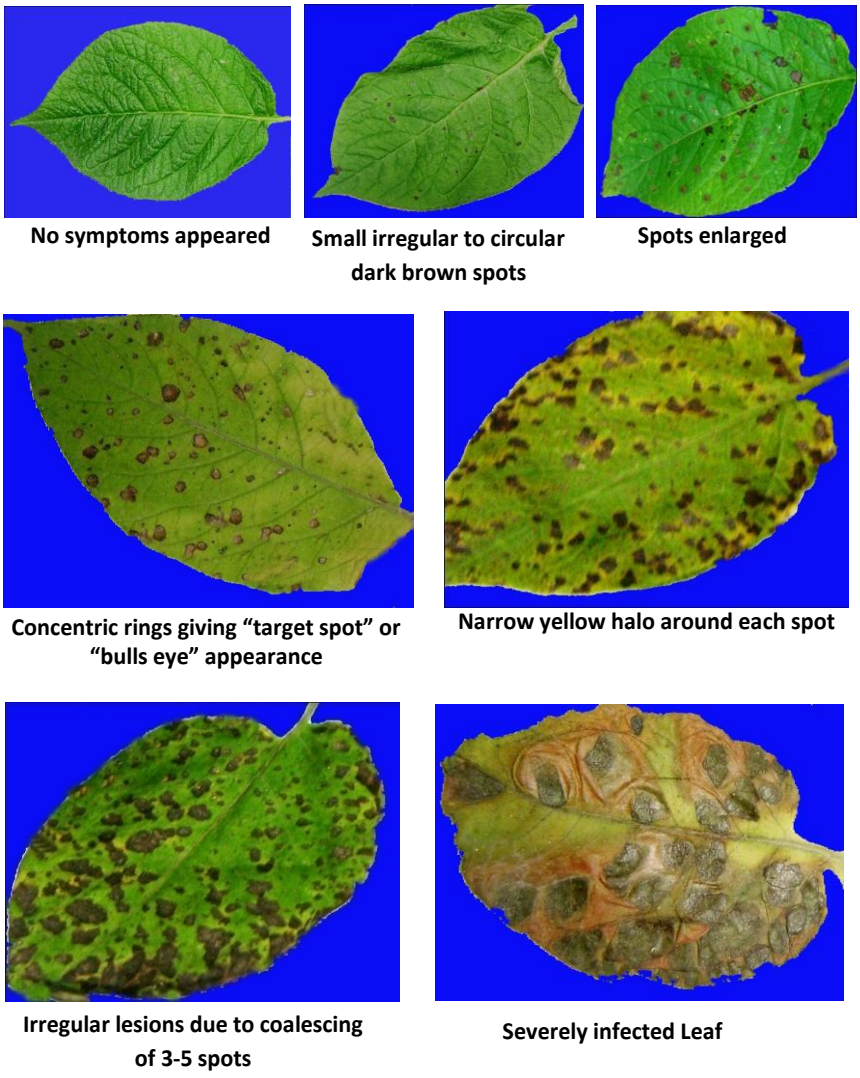

Plate 3. Symptomatological development of *Alternaria* leaf spot in field.

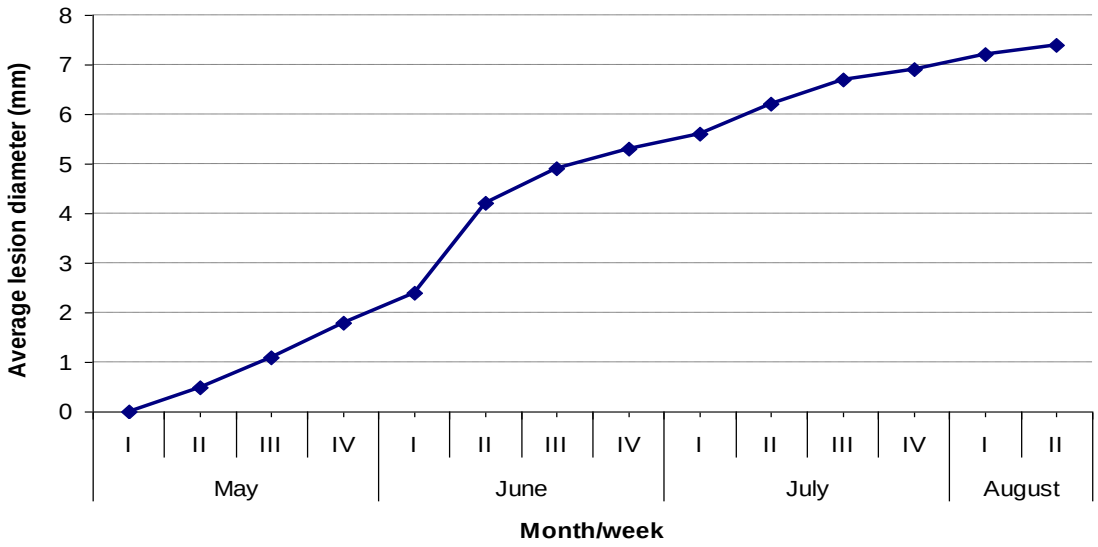

Figure 1. Periodical lesion progression of potato early blight caused by *A. solani* on cultivar 'Kufri Jyoti'.

Table 4. Symptomatology of potato early blight caused by *A. solani* on cultivar 'Kufri Jyoti' during the year 2009 and 2010.

Time of observation		Symptoms	Lesion size (mm)
Month	Week		
May	I	No symptoms appeared	-
	II	Small irregular to circular dark brown spots on the lower leaves	0.5
	III	-do-	1.1
	IV	Spots enlarge and are surrounded by a border of yellow host tissue	1.8
June	I	-do-	2.4
	II	-do-	4.2
	III	Concentric rings giving "target spot" or "bulls eye" appearance	4.9
	IV	-do-	5.3
July	I	Narrow yellow halo around each spot	5.6
	II	Irregular lesions due to coalescing of 3-5 spots	6.2
	III	Irregular patches due to coalescing of spots	6.7
	IV	Irregular blighted patches	6.9
August	I	Severely infected leaves eventually wither and die	7.2
	II	-do-	7.4

lesion size of 7.4 mm was recorded in the second week of August (Table 4). Upto fourth week of June concentric rings form as a result of irregular growth patterns by the organism in the leaf tissue giving the lesion a characteristic 'target spot' or 'bulls eye' appearance. There was often a narrow, yellow halo around each spot and lesions were usually bordered by veins. Beyond second week of July due to coalescing of 3 to 5 spots small irregular patches were formed. The spots covered large area of the leaf in the last week of July. Severely infected leaves eventually wither and die but usually remain attached to the plant. Observations on periodical disease development are more or less identical to those described by Mirkova and Konstantinova (2003).

Isolation, purification and maintenance of pure culture

Isolations were made from diseased leaf tissues of potato cultivar 'Kufri Jyoti'. After 72 h of incubation at 25±2°C, dark ranging from grey to black with tints of olive or brown mycelial growth started emerging from the diseased leaf tissues, inoculated on potato dextrose agar

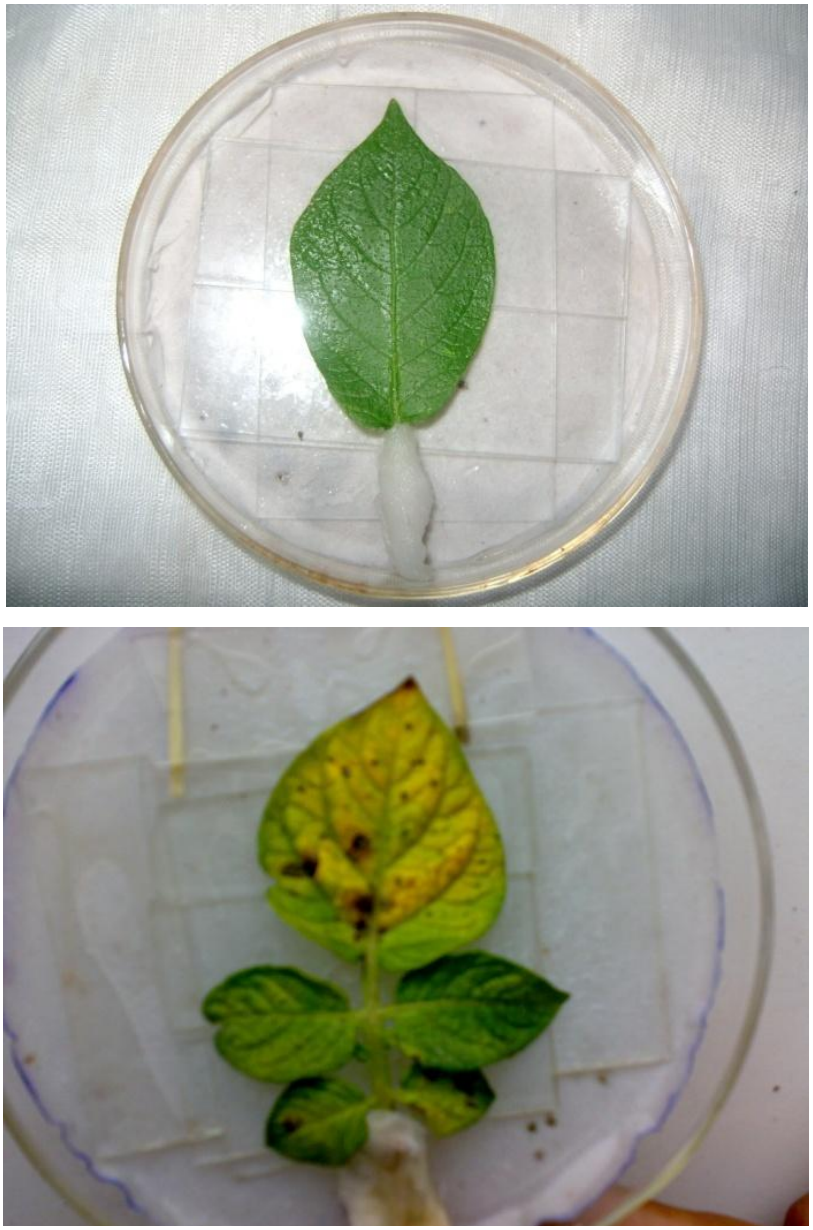

Plate 4. Pathogenicity of *A. solani* on potato leaf.

medium. The culture so obtained was purified by the hyphal tip and single spore isolation methods. The pure culture was maintained by subculturing at monthly intervals and stored in a refrigerator for further studies.

Pathogencity test

Observations regarding the pathogencity of the test fungus revealed the initiation of typical symptoms of the disease appeared after 10 days of inoculation on injured detached leaves of potato (Plate 4). However, in field plantation, symptoms appeared on injured leaves 14 days after inoculation. In case of uninjured leaves the disease symptoms does not appear. Reisolations from infected leaves yielded typical cultures of the fungus thus satisfied the Koch's postulates. Similar observations were also recorded by Foolad et al. (2000) on detached leaves of tomato.

Morphology of the fungus

The morphological characters of the pathogen were studied in culture (*in vitro*) are presented in Table 5. The morphological characters of fungus isolated from potato leaves, were studied on potato dextrose agar medium. The various morphological characters of the pathogen

Table 5. Morphological characters of *A. solani* causing early blight disease of potato.

Structure	Characters	Size
Colony	Spreading, hairy and gray-brown to black in colour	-
Mycelium	Branched, septate, dark coloured with tints of olive brown	-
Conidiophores	Septate, short, simple, straight or flexuous dark coloured	50-90 × 9 µm (Av. 67 × 7 µm)
Conidia	Long beaked, muriform, dark coloured, borne singly, both longitudinal and transverse septa in mature conidia	15-19 x 150-300 µm (Av. 17 x 163 µm)

observed in culture as the following.

Macroscopic characters

The fungus at first produces a mycelium which is dark, ranging from grey to black with tints of olive or brown. Colonies are spreading hairy and grey brown to black, possessing a texture similar to cotton, felt or velvet.

Microscopic characters

The pathogen in culture produced septate, dark coloured, ranging from grey to black with tints of olive or brown mycelium. The conidiophores were septate, short, simple, erect, flexuous pale to olive brown in colour. They measured 50-90 × 9 µm with an average size of 60 × 7 µm. The conidia are dark coloured and muriform, with 9 to 11 transverse septa and 2 to 3 longitudinal septa. They are ellipsoid to oblong with a long beak which is occasionally branched. They measured 15-19 × 150-300 µm with an average size of 17 × 163 µm. The beak is flexuous pale and 2.0-5.0 µm wide.

Identification of the pathogen

On the basis of morphological characters, pathogencity and comparison with the authentic description, the fungus was identified as *A. solani* (Ellis and Mart) Jones and Grout. Further its identity was confirmed by Dr. P.N. Chudhary, Principal Mycologist, National Centre of Fungal Taxonomy, New Delhi, under NCFT No. 4372.11. The morphological descriptions of the pathogen almost corroborate with descriptions giving by Neergard (1945). According to M.B. Ellis (1971), the solitary and beaked conidia have 9 to 11 transverse septa and a few or no longitudinal or oblique septa. Virender Kumar et al. (2008) reported that pigmentation varied from yellow, brown, black, brownish to green black in isolates of *A. solani* on potato dextrose agar medium.

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