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HORTICULTURE

Current Health Status of Potato Crop in different Altitude Regions of Ladakh, Jammu and Kashmir, India

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ABSTRACT

Indian cold arid region of Ladakh is one of the highest elevated inhabited places in the world, due to harsh environmental situation leads to low yield potential of crops and high risk of pest and pathogens which does not allow crop diversity. Total 138 fields were surveyed for assessment of disease severity, and incidence of various diseases of potato in Ladakh during two cropping seasons of 2016-2017. On the basis of visual symptoms, early blight, late blight, bacterial wilting and ring rot were found the most common prevalent diseases and leaf roll virus was uncommon except Hanley during the survey. A lot of variations were found in the percentage of diseases incidence and severity in different villages of Ladakh at different levels of altitude and humidity. Potential plant fungal pathogens *Alternaria* spp., *Cochliobolus* spp., *Aspergillus* spp., *Fusarium* spp., *Curvularia* spp., and *Phytophthora* spp. were also identified on the basis of morphological characteristics. This study might be helpful for sound management strategies and evaluate the impact of climate changes on disease development in highly elevated regions of Ladakh.

Highlights

- Total 138 potato fields were surveyed in Ladakh region at different altitude and atmospheric humidity levels for diseases infestation, disease incidence and disease severity in which prevalence of early blight, late blight, chlorosis and wilting disease were encountered.
- It revealed that diseases infestation, diseases incidence and diseases severity were varied with place to place and our findings indicated that necessity of control measure against the potato diseases.

Keywords: Disease, severity, incidence, potato, Ladakh

Indian cold arid region comes under the trans-Himalayan zone and more than 90 percent cold desert of India is situated in Jammu & Kashmir state as Ladakh region. The full potential of agriculture is rarely achieved in this cold arid region due to the vagaries and harsh environmental conditions (Gupta *et al.* 2016). Emerging plant diseases also pose a continued threat to profitable agriculture in the Ladakh region and extent of this threat has drawn the attention in the last decade. Introduction of new diseases has not only caused yield losses but also lower the chances to maintain the regular supply of fresh vegetables to the local population. Therefore, to make available the vegetable needs to the local population in the inaccessible areas like Ladakh, it is necessary to identify different type diseases followed by their management.

Potato (*Solanum tuberosum* L.) is a versatile food crop and certainly the most valued non-cereal crop. It is a rich source of high-quality proteins, minerals and vitamins and superior dietary fibres (Singh and Ahmed, 2010). The basic recommended quantity, especially of vegetables, for an adult person in high altitude per head per day, is approximately 140 g potato, 170 g fresh vegetables (counting more than 20 types of vegetables) and 60 g onion (Singh and Ahmed, 2010). Among the vegetables provided, potato represents 38%, hence it needs more thoughtfulness regarding studying its different type of diseases and their management. Dickson (1926) also describes the disease in potato and tomato reported in the early 19th century. Early blight diseases are one of the major economic constraints for potato production worldwide. However, there have been large numbers of reports of disease incidence and crop damage caused by different microorganisms (Bekele *et al.* 2011; Choudhary *et al.*, 2018; Johnson *et al.* 2018; Kamuyu *et al.* 2017; Verma *et al.* 2016). For any management strategy to become a success, a field survey is very much essential as it provides the information about distribution and status of a disease. This work related to survey of various diseases of potato crops, their incidence, severity and identification of potential plant pathogens in field conditions. It is a first report on the disease incidence and severity of potato crop in the different altitude cold arid region in different locations of Ladakh.

MATERIALS AND METHODS

Geographical Characteristics of Surveyed locations

The altitude ranging from 9657 to 14329 feet above sea level were observed. Almost all the areas of Ladakh are dominated by hills and mountains. The atmospheric humidity reported which varies from 27 to 65% in the surveyed area. The pH values of soil in selected area are in the range of 7.0 - 9.0.

Survey locations

The research was conducted in Ladakh (Jammu and Kashmir) India during two cropping seasons of 2016-2017. Disease assessments were done in different farmer's field in potato crop from 23 locations of Ladakh (Fig. 1). The study areas were Saspol, Nimmo, Lamayuru, Drass, Chanigun, Kargil (Khumbtham), Leh, Rambirpur, Kerey, Hanley (Khaldo, Nagga, Rango), Nyoma, Koyul, Demchok (Lalkan), Tsaga, Chushul, Khaktat, Merak, Spangmik, Chumathang, Tangstey, Tharuk, Mulbug and Laga villages.

Disease Incidence and Severity

The questionnaires were answered by the farmers in the chosen field and using 1-5 disease rating scale method, calculated the percentage of disease incidence and disease severity occurred among the potato crop. In surveyed field's area, whole vegetative part of the plants of potato was evaluated in the farmer's fields.

The different diseases based on visual symptoms were noticed and evaluated. Percentage of disease severity and incidence were assessed and recorded on different diseases of potato crop. The selected sites were approximately equal distance from each other along the sampling pathway. The formulae in calculating percentage of disease severity and incidence are:

Disease incidence =

$$\frac{\text{Total Number of Infected plants}}{\text{Total Number of plant assessed}} \times 100$$

Disease severity =

$$\frac{\text{Sum of Individual Rating}}{\text{Number of plant assessed} \times \text{Maximum scale}} \times 100$$

The maximum rating scale (1-5) which is used for calculating the percentage of disease severity is: Rating Scale: Disease percentage 1 (1-5% infection), 2 (5-25% infection), 3 (25-50% infection), 4 (50-75% infection), 5 (75-100% infection). The data have been collected from six different fields from each village/location. Khosla (1977) described the method of conducting a survey to evolve appropriate technique for the evaluation of diseases in particular crop. The method of survey has also been suggested to establish the magnitude of loss caused by a disease and its dynamics (Nagarajan 1983). On the basis of visual symptoms of the particular disease, samples were collected from each field at random as per methods described by Yonghao Li (2013).

Sample collection

Symptomatic vegetative and tuber part collected in specific cultivation area of potato crop. The diseased parts were brought to the laboratory in zipped polyethylene bags (Fig. 4) and were preserved until used at low temperature (4º C).

Identification of plant pathogens

Infected plant tissues were surface sterilized with 1% sodium hypochlorite solution for 1 min and rinsed twice in water. Using a sterile scalpel, tissue pieces composed of spots, halo, and surrounding healthy tissue were placed onto potato dextrose

Table 1: Disease incidence and severity on potato at different locations of Ladakh

Sr. No	Location	Altitude (fts)	Humidity (%)	Disease incidence	Disease severity
1	Saspol	9799	56	74.28±3.758	70.00±2.092
2	Nimmo	10372	60	75.00±1.809	69.25±1.262
3	Lamayaru	10451	45	70.00±1.384	48.50±4.282
4	Drass	10044	45	60.00±1.009	38.57±4.112
5	Kargil	9657	65	84.20±1.235	78.00±6.286
6	Leh	11482	62	76.66±1.107	67.66±0.948
7	Rambirpur	11562	60	71.11±1.401	58.22±0.930
8	Chanigun	11320	61	75.55±0.321	62.00±4.500
9	Khaktat	14021	30	46.44±2.856	30.00±3.483
10	Merak	14049	31	42.66±4.496	25.00±2.578
11	Spangmik	14170	29	30.00±2.548	18.00±0.508
12	Chumathang	12959	36	48.66±1.956	28.00±3.390
13	Tharuk	13211	35	50.00±7.736	36.00±1.698
14	Mulbug	13511	30	47.69±4.991	32.00±0.509
15	Laga	12685	44	65.00±2.706	46.00±2.953
16	Kerey	12710	27	41.60±2.965	21.80±0.654
17	Hanley	14016	32	38.75±2.497	25.70±3.133
18	Nyoma	13862	31	15.50±3.131	09.60±0.666
19	Koyul	13917	33	27.50±4.553	17.30±2.371
20	Demchok	14019	35	59.62±4.038	30.80±0.401
21	Tsaga	14090	32	67.00±1.416	43.00±1.503
22	Chusul	14329	38	64.00±0.125	44.80±3.605
23	Tangstey	12944	39	56.41±3.371	33.30±1.731
C.D. at 5%				9.054	7.986
SE(m)				3.170	2.796

agar (PDA) amended with tetracycline at 12 µg/ml (Sigma) and incubated at 25°C. Mycelia from fungal colonies were transferred to new plates and left to grow for 5 to 7 days prior to macroscopic and microscopic identification (Narayanasamy, 2011).

RESULTS AND DISCUSSION

Geographical distribution of various potato diseases

Total 138 potato fields were surveyed for disease infestation, disease incidence, disease severity and prevalence of early blight, late blight, chlorosis and wilting disease (Fig. 2) were encountered in Ladakh during 2016-2017 (Table 1). Under field conditions, different diseases in potato crop were identified by observing the symptoms of a particular disease. Different types of symptoms on the different parts of plants like ring rot, leaf spot, common scab, leaf tip burner or scorch, chlorosis, wilt, tip dieback, blight, stunting were found on potato crop from 23 regions of Ladakh. Leaf roll virus was scarce in most of the region, but in Hanley (14016 feets altitude), potato crop was severely affected.

Effect of altitude on disease scoring

Infection observed in different altitude area (>12000 ft) with relatively low percentage of incidence and severity, and in low altitude area (<12000 ft) with high incidence and severity percentage were observed (Table 1, Fig. 3). The highest 84% disease incidence in potato was recorded in Kargil at 9657 fts altitude followed by 76.66% in Leh at 11482 fts, 75.55% in Chanigun at 11320 fts, 75% in Nimmo at 10372 fts and 74.28% in Saspol 9799 fts. Similarly, highest disease severity in potato 78% as recorded in Kargil at 9657 fts followed by 70% in Saspol at 9799 fts, 69.25% in Nimmo at 10372 fts and 67.66% in

Leh at 11482 fts. In Nyoma, lowest disease severity and incidence were recorded 9.6% and 15.5 %, respectively at 13862 fts.

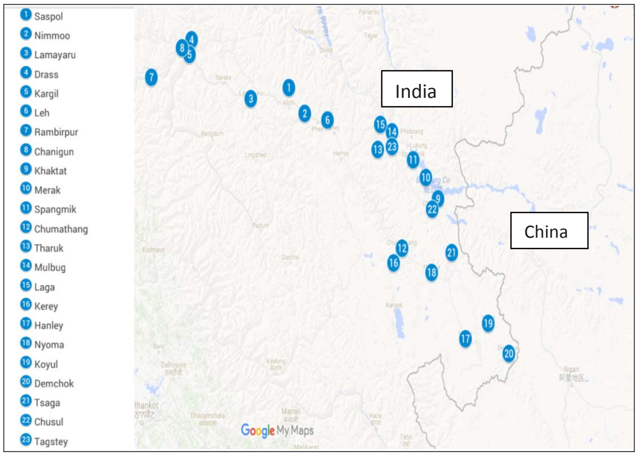

Fig. 1: Map showing survey locations of Ladakh, Jammu and Kashmir, India

Effect of atmospheric humidity on disease scoring

Relative atmospheric humidity directly affects the growth and sporulation in fungi as percentage of disease incidence and severity increased with an increase in atmospheric humidity in potato (Fig. 5). At 65% atmospheric humidity, highest 84% disease incidence was recorded in Kargil and followed by Leh 76.66% at 62% atmospheric humidity. Similarly, 75.55 % disease incidence was observed in Chanigun at 61% atmospheric humidity. At 60 % atmospheric humidity, 75% and 71.11% disease incidence were observed in Nimmo and Rambirpur, respectively. The lowest disease incidence 15.5 % was recorded at 31% atmospheric humidity. The highest 78% disease severity was recorded in Kargil at 65% atmospheric humidity and followed by Leh 67.66%

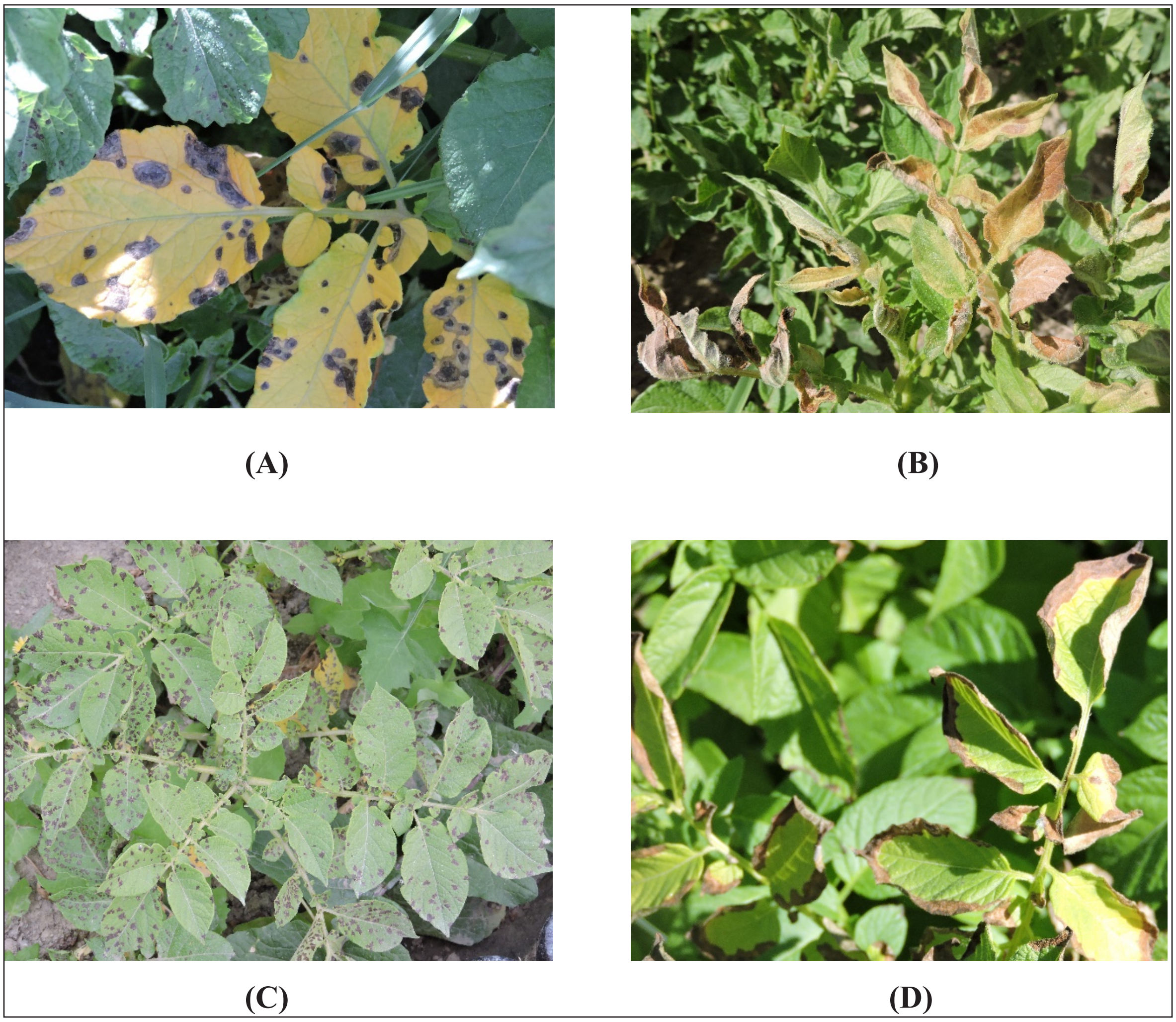

Fig. 2: Illustrating different type of disease symptoms on Potato in cold desert area of Ladakh (A) Early blight on potato leaves caused by *Alternaria solani* (B) Rolling of leaves by leaf roll virus (C) Brown spot appearance by *Alternaria alternata* (D) Above ground symptoms of ring rot by bacteria

at 62% atmospheric humidity. At 31% atmospheric humidity, lowest 9.6 and 25 % disease severity was recorded in Nyoma and Merak.

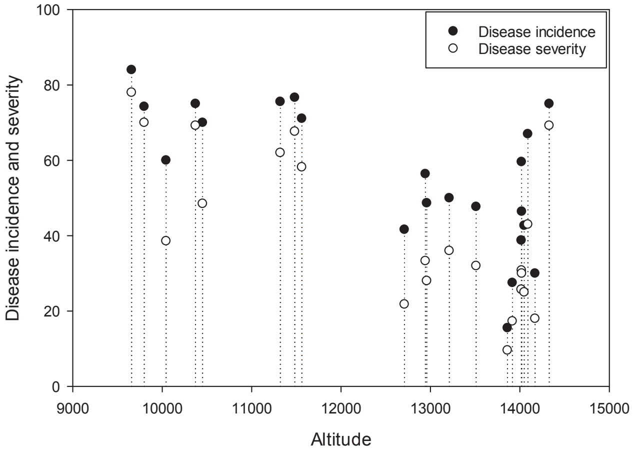

Fig. 3: Showing disease incidence and severity varies with different altitude and location range in potato crop

Fig. 4: Showing infected leaves of Potato in zipped polyethylene bags

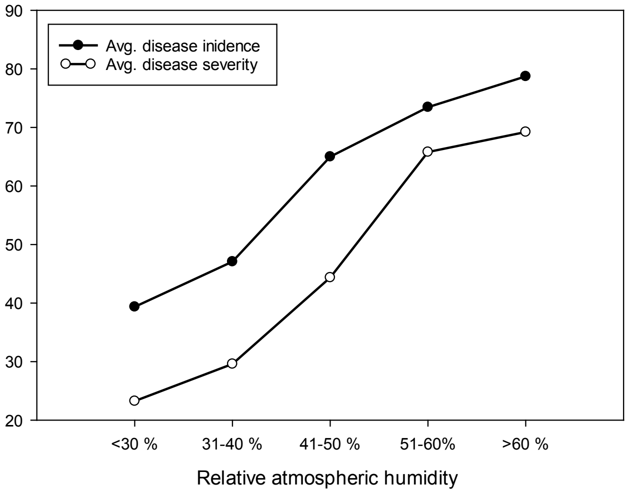

Fig. 5: Showing disease incidence and severity decreases with decrease in atmospheric humidity in potato

Disease identification

During survey, various potato diseases were identified by their typical visual symptoms under field conditions. Later, infected potato samples showing disease symptoms were collected for confirmation through morphological studies (Fig. 4, 6). The infected samples were inoculated in the potato dextrose agar (PDA) medium for the growth of causal pathogens. Under the bright field microscopy, potential pathogens *Alternaria* spp., *Cochliobolus* spp., *Aspergillus* spp., *Fusarium* spp., *Curvularia* spp., and *Phytophthora* spp. causing various diseases were identified (Fig. 6).

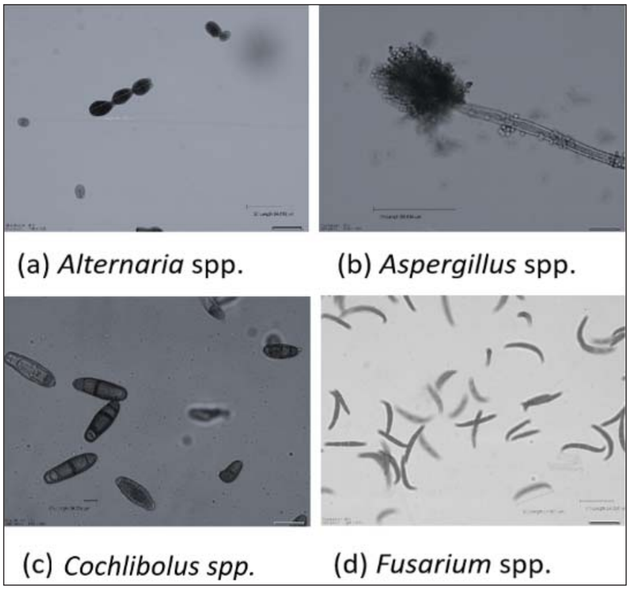

Fig. 6: Microscopic view of (a) *Alternaria* spp. (b) *Aspergillus* spp. (c) *Cochliobolus* spp. (d) *Fusarium* spp

Pathogen causing early blight diseases was identified as *Alternaria* species (Horsfield *et al*. 2010). Pathogens causing Fusarium dry rot and Fusarium wilt were identified as *Fusarium* species (Bokshi *et al*. 2003). Pathogen causing late blight disease was identified as *Phytophthora* spp. (Harrison, 1992) and various leaf spot and necrosis causing pathogen was identified as *Curvularia* spp. Pathogen causing foliar necrosis was identified as *Cochliobolus* spp. (Louis *et al*. 2013) and foliar and leaf blight causing pathogen was identified as *Aspergillus* spp. (Louis *et al*. 2003).

The other factor like the effect of seed quality, water quality on disease levels were difficult to analyse due to confounding influence of climate change, seed source and a large number of diseases.

Continuous changes in temperature also affect the atmospheric humidity which later affects the development and occurrence of diseases in Ladakh. Use of contaminated tubers, refusal of fungicides and high wind velocity which helps in the dispersion of spores to a large number of distances might be the most probable reason for the higher prevalence of blight diseases in Potato (Pacilly *et al.* 2016).On average, the blight disease, wilting and chlorosis were more prevalent in Ladakh, as favourable temperature and humidity required for the growth of pathogens were available during August and September. In last decade, it also observed that pathogen which is responsible for blight disease developed a shorter life cycle (Turkensteen and Mulder 1999) by 30%, and had the ability to cause more leaf spots in shorter infestation period (6 hours instead of 8 hours), tolerated higher temperature range (5 to 27° instead of 10 to 25°), later form stem lesions and causes sporulation on potato tubers. It might be one of the reasons that lower altitude areas like Kargil, Saspol, Nimmo, and Chanigun now had higher disease infestation. Few high altitude regions near the Nyoma were also unaffected by blight disease due to the presence of very harsh climatic conditions. The lesions were concentric having a small brownish black appearance. During the survey, some region of Ladakh, viral infection mainly leaf roll virus was also observed in potato crop. Earlier, Garg *et al.*(2003) also reported chlorosis, wavy leaf margins and rolling in potato due to combined infection of PVX, PVA, PVY and PLRV viruses in Leh and Ladakh. Similarly, Rajalakshmi *et al.* (2016) also carried out the field survey to assess the disease incidence and severity in Bhendi (*Abelmoschus esculentus*) and Pea (*Pisum sativum*) in five different districts of Tamilnadu and reported variation in disease incidence and severity. Tadesse *et al*. (2017) conducted a survey for pulse crop observed disease incidence ranging from 0 to 45.6%in Ethiopia during 2015-2016.

It has been also observed that survey locations or fields which were near to Indus River and near water streams coming from melted glaciers, had higher disease severity and incidence than the other field due to the presence of humid atmosphere. Earlier, Logan (1986) reported that disease causing fungus can grow and sporulate, and cause infection in a very dry as well as humid atmosphere but in our study, infection increased with an increase in atmospheric humidity. Heavy losses up to 84.2% in Kargil fields might be associated with bacterial wilting and scabbing of tubers resulting in a lower yield and productivity in potato crop. Heavy spoilage of tubers due to microbial infection, mainly by the blight diseases and scab, were the main reason for a lower yield of potato in Ladakh. Similarly, Guenthner *et al.* (1999) reported that late blight disease on potato was the most serious problem and cause severe yield losses in the United State. Frequently, higher yield losses due to bacterial and fungal diseases were observed than the viral diseases because extreme harsh environment does not allow survival and activities of vectors involved in transmittance of viruses which might be the reason of lower viral infection in potato crop in surveyed Ladakh. During the survey, it was observed that local plants like Langthang, Chikori, Rumax, wild rose etc. might be serving as a host for the pathogens which were responsible for the disease infestation in potato and other crops.

CONCLUSION

Types of symptoms and diseases were found in high altitude cold desert regions, and severity and incidence vary from field to field. Variations in disease incidence and severity were also observed at different altitude and atmospheric humidity levels. Thus, high altitude cold desert like region was also susceptible to common potato disease and our findings indicate the necessity of finding out control measure against the potato diseases.

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