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Symptomology, biology and management of Alternaria leaf spot of mustard (*Brassica* spp.)

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Abstract
Oilseed *Brassica spp.* is one of the most important diseases of oilseed crop in the world. Rapeseed mustard are susceptible to a number of diseases which is caused by the living (biotic) pathogen. It is also known as *Alternaria* black spot diseases surrounded with yellow colours on the leaves which is known to be the most destructive diseases in the world. This disease is generally characterised by the different names which are as follows, *Alternaria brassica*, *Alternaria brassicola* and *Alternaria raphani. Alternaria* leaf spot pathogen produces lesion around the leaves, stem, and the Silique which cause reduction in defoliation. These pathogens are seed borne, soil borne, and airborne diseases. *Alternaria* leaf spot diseases caused by the heavy rainfall and the weather with the highest diseases incidence. The Conidia, age of the host plant is also responsible for severity of the diseases. This disease is more prominent during the summer seasons where the temperature falls 27- 28 ^{0}C. This paper also determines the development of *Alternaria* leaf blightin Mustard crop in relation to the pathogen such as taxonomy, biology, epidemiology and their management through biological, chemical, cultural and botanical approaches. It represents the future outlook and their strategy for *Alternaria* leaf blight of rapeseed mustard plant.

Keywords: *Alternaria blight*, rapeseed mustard, symptoms, variability, pathogen

Introduction
Juncea L. Czern. et Cosson (oriental, leaf, or Indian mustard). Family: *Brassicaceae.* Scientific Name(s): *Sinapis alba* L. Koch (white or yellow mustard), *Brassica nigra* (black or true mustard), and *Brassica*

Indian mustard [*Brassica juncea* (L.) Czern&Coss.] is one of the most important oilseed crops which contribute around 80 per cent of total rapeseed-mustard produced in India. Mustard crop is considered to be the second largest produced oilseed crop in the world having an area of 37.0m tonnes productivity of 63.09 m tonnes and productivity of 18.50q/hac. (Singh *et al.* 2014) [30]. In world acreage and production and the productivity and production having the area of 6.3 m hac and production of 76m tonnes with the productivity of 11.90q/hac in India. In Punjab, the area there were 27 thousand hectares and 33 thousand tonnes of production area were found during 2008-09. Indian mustard is cultivated in the various states namely of Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Madhya Pradesh, Orissa, Punjab, Rajasthan, Uttar Pradesh and West Bengal as a *Rabi* crop.

Alternaria leaf blight Diseases are generally caused by The *Alternaria brassicae* (Berk) Sacc. is considered to be one of the most important diseases of oilseed brassica which cause heavy losses in terms of both quantity and quality of the products in many parts of the world. In India the yield losses due to *Alternaria brassicae* (Berk) Sacc. to the extent of 70 percent and cause 47 percent reduction in the seed yield in India. (Chahal 1986, Kolte 1985, Saharan 1991) [5, 15, 24]. *Alternaria brassicae* is found to be the more severe one (Verma and Saharan, 1994) [32]. Out of the four species of *Alternaria* is known to be occur in this crop. The former reports from Holland on the variability in *Alternaria species* were made by (Van Schreven, 1953) [33] and UK (Mridha 1983) [22].

General characteristics of *Alternaria brassicae*
The mycelium of *Alternaria. brassicae* is septate and it becomes brown to brownish grey in colour. The conidiophores are dark septate, measuring 14-74-*4-8um. The structure of Conidia is brownish black, singly borne or sparingly in chains with 2-4, Muriform along with beak. This species Generally represents the slow and rudimentary growth in media and it forms

Chlamydospores in less frequency given by the scientist (Kolte, 1985) [15]. Sporulation occurs between the temp 21-28°c.When the temperature decreases the time period than it takes for germination increases (Degenhardt *et al.*, 1982) [14] and (Sharma *et al.*, 2013) Found that the 32 Indian isolates of *Alternaria. brassicae* and colony of the isolates on PDA varied between olivaceous black to light olive grey whereas mycelia colour varied between brown to golden colour.

Most of the Conidia were long and it is pyriform in shape with long beak and colour was found golden or brown with mostly smooth surface. Sporulation of each isolates on the different media was found almost similar ones. All isolates studied by (Sharma *et al.*, 2013) [28] were found to be pathogenic in nature but it is not directly related to the cultural and morphological characteristics. A temperature ranges for mycelial growth and the sporulation of *Alternaria brassicae* is 25-30°c and 15-35°c was found respectively. Mycelial growth was favoured by the 100 percent relative humidity.

The pathogen

The genus of *Alternaria brassica* belongs to the phylum *Ascomycota* which consist of both saprophytic and pathogenic species. Alternaria belongs to the class *Dothideomycetes, order Pleosporales* and the family *Pleosporaceae.* The *Alternaria spp* is generally characterized by the formation of transverse septa with long and short beaks and having a polymorphous type of conidia in the form of single or the short long chains. Taxonomy of *Alternaria* leaf blight is acted upon the morphology and development of Conidia and Conidiophore with a lesser degree on the host plant and along with the Colony morphology given by the scientist (Elliot 1917 [6], Wiltshire 1933 [25], Simmons 1967 [17]).

Survival of pathogen

In India it has been observed that the survival of this pathogen in the tropical and the subtropical is on the diseased seed or in the infected plant debris given by the scientist (Mehta *et al.*, 2002) [21]. Looking to the situation in the temperate conditions (Humpherson jones and Maude, 1982) [12]. In India, the sowing time of oilseed *Brassicas* is from late August to November, depending on the crop and their variety. Oilseed *Brassica* totally favours the availability of soil moisture, temperature and the weather condition for seed germination. Harvest occurs from Feb to May. Off seasons crops are grown in non-traditional areas from May to Sep. And this, grouped with the fungal pathogen by vegetable *Brassica* crops and the alternatives hosts such as (*Anagllis arvensis*) are the reason to carry over the *A. brassicae* from one crop season to the next seasons (Mehta *et al.*, 2002) [21] thus, the primary source of inoculum of these polycyclic diseases are known to be the air borne spores given by the scientist.

Variability in pathogen

The Isolates variation of *Alternaria brassicae* is indicated (Mridha 1983, Vishwanath *et al.*, 1999 [22, 27]). Development of pathogenic variability of pre breeding population is considered to be the most strategic defence mechanism. Three distinct *A. brassicae* isolates, which are prevalent in India are as follows A (highly virulent), C (moderately virulent) and D (avirulent) given by (Kolte *et al.*, 1991) [24]. *Alternaria alternata* shows three distinct types on Crambe abyssincia, Strain A that was moderately pathogenic (as associated with leaves, stem and silique), strain B that was the most pathogenic (associated with silique), and strain C that was least pathogenic (associated with leaves), (Czyzewska, 1971) [10]. Due to Ageing *Alternaria raphani* found to be the Cottony whitish to greenish grey and dark olive in nature. The temp requires for Conidial germination of *Alternaria raphani* 7 to 31^{0}C.The optimum temp for the *A. raphani* is 23°c or greater, whereas 98% of the spores germinate after 6-hrs of incubation. The lowest temperature whereas the 98% of the spores germinate at a temperature of 13°c, which requires 10-hrs of incubation for germination (Degenhardt *et al.*, 1982) [14]. It has been observed that *A. Brassicae* germinates more quickly at temperature range of 21-28°c. Conidia takes only 3-hrs for germination at a temperature range of 31°c and Congenial factor for germination needs 15°c after 10-hrs of incubation.

Symptoms and causal organism

Symptoms are first visible with appearance of black spots; later these spots enlarge and develop into prominent round spots with concentric rings showing target board characteristics of the spots. Many spots coalesce to form large patches and causing blighting and defoliation of leaves. In some *Brassica* species, of Rapeseed mustard the formation of concentric rings in the lesion and the zone of yellow halo around the lesions are well known.

This type of diseases is generally found to be the more severe and they are more closely related to the soil and it is infected as the wind blow and the rain splash spores, Symptoms Of these diseases is generally found on the older leaves. Deep lesions on the Siliqua causes infection in the seeds. *Alternaria leaf blight* adversely affect the oil content in seed and quality of the seeds (Meena *et al.*, 2008) [10]. He has mentioned that foliar diseases are one of the most important limiting factors for cultivation of oilseed *brassica* in tropical and sub-tropical areas in India. *Alternaria brassicae* (Berk) sacc. Causes severe losses to oilseed brassica in terms of seed yield and the quality of the crop.

In India the *Alternaria blight* diseases is considered to be the most severe diseases and is generally caused by the *Alternaria brassicae* and *Alternaria brassicola* is found to be the major route in rapeseed mustard production in India. *Alternaria blight* diseases this experiment was conducted in order to study the effect of nutrients and their lower leaf removal in Indian mustard plants (*Brassica juncea*) (2009-10) and (2010-11). Due to *Alternaria* blight diseases 32-57% var yield loss occur. The *Alternaria* morphologically produces a series of concentric rings at the initial site attack of host plant. It has destructive effect on *Cucurbitaceae, Brassicae*, and *Solanaceae*. (Anju *et al.*, 2013) [2].

The *Alternaria* generally produces a series of concentric rings at the initial site attack of the host plant. The production of the mustard crop is greatly influenced by the fungal pathogen and it is considered to be second largest oilseed *Brassica* in the world. This pseudo fungus by causing foliar damage to the crop leads to yields reduction and then severely deteriorates the oil quality. It is observed that the best time for the diseased sample collection was January to April. Infected leaf sample were collected in cellophane bag. And the Samples were collected from the different sites and brought to the laboratory for the further studies (Chauhan, 2009) [6].

The seed borne diseases of mustard is caused by the Alternaria leaf blight diseases which is caused due to *Alternaria brassicae* and *Alternaria brassicola* is found to be the most prominent one. The pathogen generally infects

initially the leaves. From the infected leaves it spreads to stem and silique (Fakir, 2008) [11]. The causal agent of Blackspot disease of rapeseed mustard is *A. brassicae*. It is an economically important pathogen in western Canada, in several countries of Europe and South East Asia (Conn, 1990) [5]. He also demonstrates that the modes of survival and existence of *A. brassica* attacking rapeseed and mustard were examined. The pathogen remains viable in the infected plant debris and seeds of infected plants which distribute as a primary source of inoculum. The pathogen was internally seed borne diseases (Ansari, 1989) [3]. And demonstrates that the modes of survival and their existence of *Alternaria brassicae* attacking rapeseed and mustard were found to be greatly examined.

He conducted an experiment in Canada and observed that *A. brassicola* requires high temperature for germination and infection than *A. brassicae* and *A. Raphani* The relative humidity for Conidial germination of *Alternaria spp* requires above more than 95%. A. *brassicola* germinates very poorly with a dew periods of 6-8 hrs at temperature below 15°c (Degenhardt *et al.,* 1982) [14]. The *A. brassicae* is a necrotrophic pathogen produce lesion on leaves, stem, and Silique which affect seed quality and quantity by reducing oil content, seed size and seed colour. This disease may significant losses in both temperate and tropical *Brassica crops* (Mathpal *et al.,* 2011) [17].

Sources of inoculum

Seed

Due to the *Alternaria leaf blight* diseases the Siliquae a part of the mustard crop plant gets infected at late stage of plant growth. The main transport of these pathogens is the infected seed with their spores on their seed coat or seed coat under their mycelium given by (Shrestha *et al.,* 2000) [16]. Seed borne inoculum plays a role in disease cycle in temperate climate whereas it fails to survive in tropical region (Awasthi and Kolte, 1994) [4]. *Alternaria. brassicae* is found to be prevalent in the seed coat and occasionally in the embryos of rapeseed mustard and which causes lesion development in cotyledonary leaves and then it appears in the first true leaves (any leaves of a seed plant other than cotyledons) by (Shrestha *et al.,* 2000) [16]. (Shrestha *et al.,* 2003) [12] reported that the importance of survival of the fungus in the seeds is generally in the low temperature and found that infected seeds act as a primary source of inoculum in Nepal. (Shrestha *et al.*, 2003) [12] clearly mentioned that the survival of *Alternaria brassicae* in seed is generally stored in the room temperature having (11-25°c) for 10 and 6 months at 30°c.

Management

He has reported that in the absence of resistant cultivars, fungicides provide the most reliable means of disease control. Multiple application of fungicides is required to achieve economic yield and acceptable quality in infected seeds (VYAS, 1993) [35].

For the control of *Alternaria leaf blight* diseases the sprayed of three systemic fungicides like Thiophanate methyl, Ridomil MZ, (Mancozeb, 64percent+Metalaxy l, 8 percent) and the Carbendazim alone and in combination with the four non systemic fungicides namely as Captan, Mancozeb, Zineb and Thiram in the field condition of 0.2 percent per litre was very much effective for *Alternaria* leaf blight diseases. Ridomil MZ is considered to be the most effective treatment followed by the combination of Carbendazim + Captan (Khan *et al.,* 2007) [13].

He also reported that the three-succeeding spray of Mancozeb founds the maximum control of *Alternaria leaf blight* intensity followed by the schedule with two consecutive spray of Mancozeb (0.2percent) and the third of Ridomil MZ (0.25 percent). Foliar spray of Mancozeb have been found to be the most effective in the disease management of *Alternaria leaf blight* diseases given by (Singh and Singh, 2006) [22].

He demonstrated that the spray of *Eucalyptus* leaf extract is significantly reduced the no of leaf spots, minimum size of spots, minimum disease index and the highest yield followed by the *Calotropis*. Foliar sprays of aqueous bulb extract of *Allium sativum* (garlic) and the *Eucalyptus globulus* (Eucalyptus) plant have been found to be effectively control the *Alternaria blight* on leaves and pods are considered to be eco-friendly substitute for the chemical fungicides that is Mancozeb in the management of mustard diseases by (Meena *et al.,* 2008, 2011 [10] and Yadav, 2009 [28]).

He also suggested that some research finding indicate the possibility of Biological management of *Alternaria blight of brassicas.* The foliar application of the soil inhabitants isolates of *T. harzianum* the, *fluorescens* were found to be effective in the management of *Alternaria leaf blight* diseases. (Meena *et al.,* 2004, 2008) [10].

The Resistance in susceptible variety of the mustard CV.PR-15 against the highly and moderately virulent isolates of *A. brassicae* was induced using an avirulent *A. Brassicae* isolate. The induction of resistance due to the avirulent isolate against the highly virulent and the moderately virulent isolate of *A. brassicae* resulted in the significant reduction in the disease severity (Vishwanath *et al.,* 1995) [35].

The application of potash at 40gm and the soil application of minerals namely as sulphur, borax, potash, and zinc were found to be the most effective for the management of *Alternaria leaf blight* disease. These minerals were generally found to increase the resistance in plants. (Godiva *et al.,* 2001) [18]. He found that the minimum disease severity at 45 cm row spacing in comparisons with broadcast method of sowing and found less disease severity in early sown, weeded crops.

Maximum Severity of *Alternaria blight* on leaves by (Meena *et al.,* 1985) and the pods given by (Sindhu *et al.,* 1985) were found to be much higher in the late sown crops. He also suggested that the severity of *Alternaria* leaf blight disease on leaves was followed by the maximum temperature of 18°c - 27°c in the preceding week,> 70°c mean relative humidity, > 9 sunshine and >10 h of leaf wetness. Minimum temperature of 8-12°c, mean temperature > 90°c morning relative humidity,

Under the field condition diseases severity on pods was greatly influenced by the maximum temperature 20-30°c. He also tested seven fungicides for their efficacy against *Alternaria* leaf blight disease under the field condition. And they found that the foliar spray with Iprodione twice at 45 days 60 days after sowing was very effective in controlling *Alternaria leaf blight* disease followed by Mancozeb. However, **(**Singh and Singh, 2007) mentioned very clearly that foliar spray with Mancozeb was found effective in reducing the disease severity followed by Baiting and Blitox-50. Cuman Lasa found to be the least effective in reducing the disease intensity. The two foliar sprays of Ridomil MZ at 60and 80 days after sowing reduced the chances of *Alternaria leaf blight* disease severity from 57.3-41.4 percent, and increases the yield from1052to 1842kg/hac (Yadav, 2003) [31].

Other methods of *Alternaria* blight management

In order to manage the diseases, timely weeding and the maintenance of optimum plant population, early sowing, and well stored diseases free seeds, avoid irrigation at flowering and pod formation stage, clean cultivation is quite helpful for the reduction of *Alternaria leaf blight diseases* (Meena *et al.*, 2002) [18]. Spraying of Iprodione (Rovral) has been found effective in checking the silique infection which is caused due to *Alternaria. Brassicae* (Cox *et al.*, 1983) [7], In order to check to check *Alternaria blight* disease in mustard soil application of potassium at the basal stage has been used.

Conclusion

While writing the review Article we came to know that the *Alternaria* leaf blight is the most destructive disease of oilseed brassica across the world. *Alternaria* blight causes considerable reduction in the quantity and quality of harvested product of *Oilseeds brassica*. In conclusion, it is having been revealed that the foliar spray with the Mancozeb at 45 days followed by Hexaconazole at 60 days was found to be very effective in controlling *Alternaria* leaf blight and the severity of pod blight and it increases the seed yield over untreated control. It may be tested as preventive sprays at farmers' fields in mustard crop, so that the recommendation can be made very clear for the control of this pathogen.

One of the most commonly used methods is the use of fungicides. In spite of tremendous use of fungicides against pathogens, these fungicides cause serious health hazard to human beings and also, they cause the environmental pollution. Hence, nowadays more importance is made on the other methods for disease management like growing of somewhat resistant varieties, use of the plant and natural product, use of biocontrol agents and alternation in the agronomic practices because they are found to be more economical, eco-friendly and safe.

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