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WHITE RUST [*Albugo candida* (PERS.) Kuntze] OF MUSTARD [*Brassica juncea* (L.) Czern. & Coss.]: A REVIEW

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Introduction

Among the major oilseed crops grown in the country, rapeseed-mustard occupy a prestigious position and ranks 2nd after groundnut both in area and production, sharing 27.8% in the India`s oilseed economy (Tyagi and Upadhyay, 2017; Akanksha *et al.* 2017; Sapakal *et al.* 2017). Indian mustard [*Brassica juncea* (L.) Czern. &Coss.] is an important *rabi* major edible oilseed crop, widely grown in northern belt of India (Yadav, 2007**)**,which plays a significant role in Indian Economy (Kumar *et al*., 2014). In India it is cultivated over area of 6.45 million ha with production and productivity of 7.28 million tons and 1128 kg/ha, respectively (Bawaskar *et al.* 2017*)*. India contributes 28.3% and 19.8% in world acreage and production. India produced around 7.4mt of rapeseed-mustard next to China (11-12) and EU (European Union) (10–13 mt) with significant contribution in world rapeseed-mustard industry (Singh *et al.*, 2014).

Mustard is attacked by a number of diseases such as White rust,*Alternaria* blight, Downey mildew and Powdery mildew. Among these diseases white rust caused by *Albugo candida* (Pers.) Kuntze, is wide spread and causing substantial losses in yield up to 23-60% (Saharan, 1993). White rust, more appropriately known as white blisters due to production of white sori formed on various parts of the host plant, appears in different proportion on rapeseed-mustard crop at several location throughout the world particularly in India and Canada (Kolte, 1985). The white sori, blisters or pustules, are the result of sub-epidermal growth, proliferation and expansion of zoosporangiophores leading to ruptures in the epidermis of host tissue (Meekes *et al.*, 2004). Affected plant parts include roots, leaves, stems, inflorescence, fruits, and seeds.

Symptomatology of white rust:

The disease is manifested by two types of infection: local and syetemic. In the case of local infection, symptoms of the disease appears on the leaves and are characterized by the appearance of white or creamy yellow raised pustules (1 to 2 mm in diameter) which later coalesce to form patches. The pustules are found scattered on the under surface of the leaves. The upper surface, corresponding to the pustules on the lower surface, become yellow and the prevalence of the disease is easily recognized from the upper surface of the affected leaves.

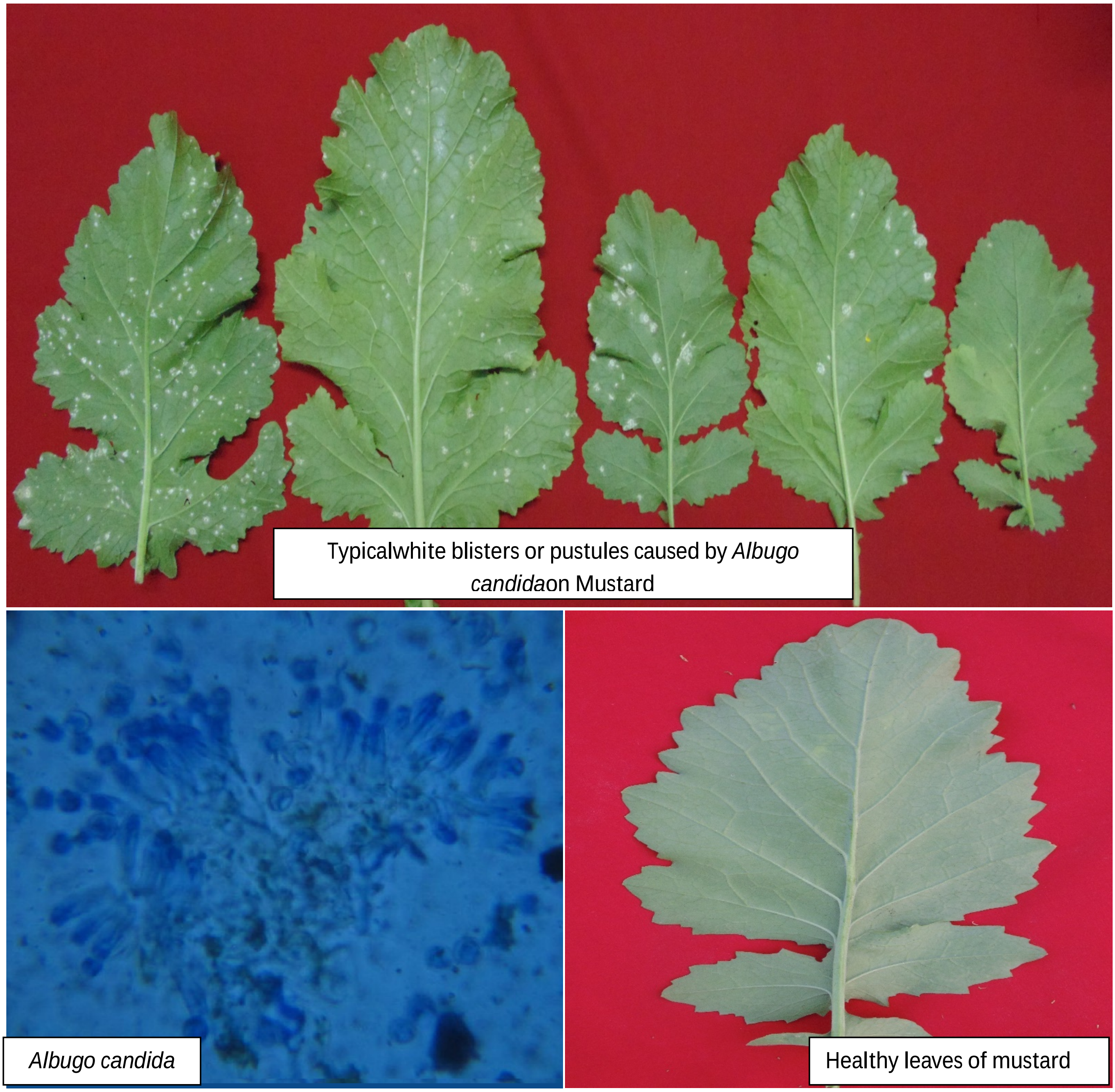

Plate 1: **White rust infected, healthy leaves of mustard and picture of *Albugo candida***

After the complete development of the pustules, the surface ruptures and releases a chalky dust of spores. The symptoms of systemic infection are distortion, hypertrophy, hyperplasia and sterility of the inflorescence. This phase of infection has been referred to as the staghead. The affected flowers show malformation, petals become green sepal-like and stamens may be transformed into a leaf-like or carpelloid structure. The petals and stamens persist in the flower instead of falling early, as in the case of normal flowers (Sandhu *et al.* 2015). *Albugo candida* (Pers.) Kuntze, an obligate parasite, is a diploid biotroph belonging to the family Albuginacae of the order Peronosporales in the class Oomycetes causing white rust disease in oilseed Brassica. White rust occurrence on oilseed Brassica have been reported in India with yield losses up to 17 to 37% (Kolte, 1985) and from 12 countries in the world (Saharan, 1992).

Weather Parameters for disease development

White rust of Indian mustard as influenced by weather parameters like temperature, relative humidity and rainfall play an important role in the development of white rust. Thus, Efficient, economical and environment friendly control of the rust may be obtained through knowledge of its timing of attack in relation to weather factors. Khunti *et al.,* (2004) studied under field condition in Gujarat, India, during 1989-90 and 1990-91. The maximum (between 22 and 27°C) and minimum (between 8 and 11°C) temperature and the maximum relative humidity (70% or more than 80%) favored disease development.Bal *et al.,* (2014) reported development of white rust favored by a mean temperature ranging between 12.2-14.8^{0}C, along with an average relative humidity of more than 80 per cent.

Induced Resistance

Induced resistance has been investigated extensively for the control of many plant diseases (Gorlach, *et al.* 1996). A wide range of compounds such as benzothiadiazoles (Narusaka, *et al.* 1999), salicylic acid (Yalpani, and Raskin, 1993), harpin protein (De *et al.* 2001), fatty acids and oligosaccharides (Kobayashi, *et al.* 1993) are known to be effective inducers of plant resistance to disease. In addition, many microorganisms applied to the leaves or roots of plants may induce systemic or local resistance (Liu, *et al.* 1995). Such resistance is active against many types of organisms such as bacteria, fungi and even parasitic plants (Matheron and and Porchas, 2002).

Plant Defence Activators

In nature plants can be induced systemically to become more resistant to diseases through some biotic or abiotic inducers. Resistance to disease can be induced systematically in a number of plant species by biological and chemical means (Ryals, *et al*. 1994., Spletzer and Enyedi, 1999).

A. Induction of resistance with abiotic activators

In recent years, a new group of chemicals that activate host defense mechanism and protect the plant against pathogens has been developed to manage crop diseases. These chemicals are called “plant defense activators” or “plant activators” (Romero *et al*., 2001). Salicylic acid mimic compound (acibenzolar-s-methyl, Bion), phosphorous salts (Foli-R-Fos 400, Nutri-Phite-P) and micronutrient potassium salts have been developed as commercial plant activators (Graham and Leite, 2004).Sood and Sohal, (2012) reported that foliar spray with arachidonic acid at 10 ppm concentration significantly elicited peroxidase and superoxide dismutase activity, whereas 50 ppm was effective in increasing the phenylalanine ammonia lyase activity. Phenolics*viz.*, total phenols, o-dihydroxyphenol and flavanols showed similar trend to that of defense related enzymes as they are involved in their synthesis.

B. Induction of resistance with biotic activators

Some biological plant defense inducers such as *Trichoderma, Pseudomonas, Bacillus, Serratia,* non-pathogenic strains of *Fusarium* and yeast have been developed as commercial product to manage various diseases (Droly *et al.,* 2002; Varhagen *et al.,* 2004). *Trichoderma viride*is one of the most important biocontrol agents that have been used in agriculture across the globe. They provide systemic resistance to plants infested by various fungal phyto pathogens. Biocontrol activity of *Trichoderma* based biocontrol agents inheres in their ability to orchestrate various biochemical pathways in plants parasitized by fungi (Surekha *et al.* 2014).

Host Plant Resistance

Host resistance can be induced by the application of non-pathogenic microorganisms (Vishwanath *et al.,* 1999) and certain chemicals such as salicylic acid (Spletzer and Enyedi, 1999) and amino butyric acid (Kaur and Kolte, 2001). Host resistance is considered to be the most effective and economical method in disease management. Kumar *et al.,* (2009) reported HC 9605, TKG 16, EC 339000, GSL 1, EC 399301, ORT (M) 6-2 and TKG 24 varieties of mustard resistant against white rust. Sandhu *et al.,* (2015) suggested that genotypes like PBC 9221, EC 414299 and GSL-1 exhibited resistant reaction to white rust pathogen

Biochemical analysis

Sapna*et al.,* (2009) reported activities of antioxidant pathway enzymes in leaves of white rust resistant (RH 781) and susceptible (Varuna) genotypes of Indian mustard (*Brassica juncea* L.) were estimated in un-inoculated and inoculated leaves. The activities of peroxidase and superoxide dismutase were higher in healthy leaves of susceptible genotype than resistant genotype, while the activities of catalase, ascorbate peroxidase and glutathione reductase were higher in resistant genotype in comparison to susceptible one. Inoculation with *Albugocandida* pathogen on leaves resulted in significant enhanced activities of, catalase, ascorbate peroxidase and glutathione reductase in leaves of resistant genotype as compared to the susceptible genotype. Inoculation of leaves showed enhanced activity of peroxidase, superoxide dismutase in susceptible genotype, whereas, its activity declined in resistant genotype.

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