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Role of micronutrients in defense to white rust and Alternaria blight infecting Indian mustard

A.S. Rathi[1]*, Dhiraj Singh[2], Ram Avtar[2] and Pawan Kumar[1]
[1]Department of Plant Pathology, CCS Haryana Agricultural University, Hisar-125 004, India
[2]Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar-125 004, India
*Corresponding Author E-mail: rathias1961@gmail.com

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Abstract

Field experiments were carried out at Oilseeds Research Area of CCS Haryana Agricultural University, Hisar during *rabi,* 2008-09 to 2011-12 to find out the possible role of soil application of different micronutrients alone and in combinations in defense to white rust and Alternaria blight diseases in Indian mustard [*Brassica juncea* (L.) Czern & Coss.]. Among the sole application of micronutrients, minimum disease severity of both white rust (35.0 %) and Alternaria blight (31.8 %) was observed when S @ 40 kg ha^{-1} in the form of Gypsum was applied as basal dose in the soil. When Gypsum was supplemented with Borax @ 10 kg ha^{-1} or with $ZnSO_4$ @ 15 kg ha^{-1} the level of tolerance seems to be improved for both the diseases as compared to the sole treatment of each nutrient i.e. $ZnSO_4$ @ 15kg/ha, Borax @ 10 kg ha^{-1} and Gypsum @ 250 kg ha^{-1}. Furthermore, minimum disease severity of both white rust (31.3 %) and Alternaria blight (26.3 %) was observed with soil application of $ZnSO_4$ @ 15 kg ha^{-1} + Borax @ 10 kg ha^{-1} + Gypsum @ 250 kg ha^{-1} as basal dose as compared to the severity of white rust (43.6%) and Alternaria blight (38.6%) in untreated check. Significant increase in seed yield (1612 kg ha^{-1}) was also recorded in above mentioned treatment as compared to the yield (1337 kg ha^{-1}) in untreated check. These findings will also be helpful in maintaining soil health and minimizing the losses due to both the fungal diseases for eco-friendly sustainability of Indian mustard.

Key words

Alternaria blight, Indian mustard, Micronutrients, White rust

Introduction

Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is one of the major oilseed crops cultivated in India and around the world. It is extensively grown traditionally as a pure crop as well as an intercrop (mixed crop) in marginal and sub-marginal soils in the eastern, northern and north western states of India. Cool and moist climate during winter months is the major factor for luxuriant growth and productivity of mustard in these states. Despite considerable increase in productivity and production, a wide gap exists between yield potential and yield realized at farmer's field, which is largely due to biotic and abiotic stresses. Among biotic stresses, white rust caused by *Albugo candida* (Pers. ex. Lev.) Kuntze and Alternaria blight caused by *Alternaria brassicae* (Berk.) Sacc. have been reported to be the most widespread and destructive fungal diseases of rapeseed-mustard throughout the world (Meena *et al.*, 2010). In India, Haryana state is the hot spot for both these diseases, where white rust usually appears early and becomes severe on lower leaves at the time of flowering, while Alternaria leaf blight, though appears early but remains severe at the time of pod initiation stage. Symptoms of both these diseases on same leaves are quite common, while combined infection of downy mildew and white rust on mustard have been observed rarely because of dry cool weather in this region. Alternaria blight can cause an yield loss of 10 to 71% (Chattopadhyay, 2008) and 32.57% (Shrestha *et al.*, 2005) while, the loss in seed yield was found to be 36.88% and the reduction in 1000 seed weight was 28.22% due to both the diseases (Bal and Kumar, 2014). Control of white rust and Alternaria blight in mustard by using various fungicides, with varying degree of success, has been extensively reported in literature worldwide (Mehta *et al.,* 1996; Bhargava *et al.,* 1997; Mehta *et al.*, 2005).

But, under real field situations in India, where most of the mustard is grown as rainfed, controlling diseases through scheduled fungicidal sprays seems to be impractical and uneconomical, as farmers notice the diseases late in the season and also have less economic resources to combat these diseases. Moreover, controlling of plant diseases using classical pesticides raises serious concerns about food and environmental safety and pesticide resistance, which have dictated the need for alternative disease management techniques.

In particular, soil application of nutrients can affect the disease tolerance or resistance of plants to pathogens. However, there are contradictory reports about the effect of nutrients on plant diseases and many factors that influence this response are not well understood. The composition of host plant with respect to macro and micro elements has great significance in resistance and susceptibility in various host pathogen combinations. There is a difference in the response of obligate parasites to nitrogen supply, when N level is high there is an increase in severity of infection (Celar, 2003). Phosphorus has been beneficial when applied to control seedlings and fungal diseases, where vigorous root development permits plants to escape from the disease (Huber and Graham, 1999). Potassium decreases the susceptibility of host plants up to optimal level for growth; beyond this point, there is no further increase in resistance (Huber and Graham, 1999). Decrease in Alternaria blight severity by applying K @ 40 kg ha^{-1}in soil increased seed yield over control plants (Sharma and Kolte, 1994 and Godika *et al*., 2001). However, the information regarding the role of micro nutrients such as sulfur, calcium, boron, zinc and others is lacking in plant diseases. Therefore, present field study was carried out on application of different micro nutrients, as basal dose, in the form of $ZnSO_4$, Borax [$Na_2B_4O_7.10H_2O$] and Gypsum [$CaSO_4.2H_2O$] alone and in different combinations to find out their possible role in defense against white rust and Alternaria blight severity in Indian mustard.

Materials and Methods

Highly susceptible Indian mustard variety, Varuna was grown in field plots of 5 x 3 m at 30 x 15 cm spacing, replicated thrice in randomized block design at Oilseeds Research Area of CCS Haryana Agricultural University, Hisar, Haryana during *rabi,* 2008-09 to 2011-12 to find out the role of different micronutrients in defense to white rust and Alternaria leaf blight diseases. Sowing was done during first week of November in each season in the same field. Soil of experimental plots was sandy loam in texture, low in organic carbon (0.28%) and available nitrogen (170 kg N ha^{-1}), medium in available phosphorus (20 kg P_2O_5 ha^{-1}), medium in boron content (0.8 ppm), medium in available sulphur (12.8 ppm) and zinc (1.1 ppm) contents having EC 0.30 dS m^{-1} and with slightly saline nature (pH 8.1). All the experimental plots received recommended dose of fertilizers (80 kg N and 30 kg P_2O_5 ha^{-1}). Ten different treatments including untreated and fungicidal check (Dithane M-45 @ 0.2% after 50 days of sowing) along with different micronutrient treatments in the form of chemical fertilizers were given. Micronutrient treatments involved zinc sulphate ($ZnSO_4$) @ 15 kg ha^{-1}, Borax ($Na_2B_4O_7.10H_2O$) @ 10 kg ha^{-1} and the recommended dose of sulphur @ 40 kg ha^{-1} in the form of Gypsum ($CaSO_4.2H_2O$) as single and combined doses. In addition, one treatment as spray with slaked lime ($Ca(OH)_2$) @ 1% at 50-55 days after sowing, was also given. Observations on white rust severity was recorded at 60-70 DAS, while observations on Alternaria leaf blight severity were recorded at 90-100 DAS by the method suggested by Conn *et al.* (1990) during all the four crop seasons; seed yield was also recorded in these treatments. The data for intensity of both the diseases were averaged and angularly transformed for carrying out statistical analysis using SPSS 10.0 software.

Results and Discussion

Among single doses of micronutrients, soil application of S, in the form of Gypsum as basal dose when applied @ 40 kg ha^{-1}, resulted into less white rust and Alternaria blight with (35.0 and 31.8 %) severity in comparison to white rust and Alternaria blight with 43.6 and 38.6 % severity, respectively in untreated check (Tables 1, 2). Calcium is also important for stability and function of plant membranes and during Ca deficiency there is membrane leakage of low-molecular-weight compounds like sugars and amino acids, from cytoplasm to apoplast, which stimulates infection by pathogens (Marschner, 1995). Secondly, Ca an important component of cell wall structure as calcium polygalacturonates is required in the middle lamella for cell wall stability. Adequate soil Ca is needed to protect peanut pods from *Rhizoctonia* and *Pythium* infection and application of Ca to soil eliminates the occurrence of the disease and there are reports that Ca confers resistance against *Pythium*, *Sclerotinia*, *Botrytis* and *Fusarium* (Dordas, 2008). Although, in the present study, Ca spray in the form of slaked lime @ 1% at 50 DAS could not satisfactorily reduce both white rust and Alternaria leaf blight and therefore, no significant increase in seed yield was observed (Tables 1, 2 and 3).

Sulphur deficiency in crop plants plays a greater role and results in reduction of leaf area, seed number, seed weight, delayed floral initiation and anthesis (Jackson, 2000) besides resulting in reduction of disease tolerance level caused by reduction of dependent phytoanticipin (Dubuis *et al*., 2005). Sulphur is one of the essential elements required for the normal growth of plants and concentrations of S in plants are lower than that of N and similar to P. Sulphur plays an important role in plant metabolism as a constituent of many plant processes and deficiency of S causes basic metabolic impairment, which not only reduces crop yield but also the quality of produce (Dordas, 2008). The perusal of data in Tables 1 and 2 reveals that the combination of two chemical fertilizers *i.e.* $ZnSO_4$ @ 15 kg ha^{-1} + Gypsum @ 250 kg ha^{-1} (S @ 40 kg ha^{-1}) and also Borax @ 10 kg ha^{-1} + Gypsum @ 250 kg ha^{-1}, as basal dose, were found to

Table 1 : Effect of different micronutrients alone and in combinations on white rust severity in Indian mustard

Treatments	White rust severity* (%)				
	2008-09	2009-10	2010-11	2011-12	Mean
$ZnSO_4$ @ 15kg ha^{-1} (Zn)	30.0 (33.2)	34.7 (36.1)	42.0 (40.4)	41.9 (39.8)	37.2 (37.6)
Borax @ 10 kg ha^{-1} (B)	32.2 (34.6)	38.3 (38.2)	42.5 (40.7)	43.7 (41.4)	39.2 (38.8)
Gypsum @ 250 kg ha^{-1} (S)	28.9 (32.5)	33.3 (35.2)	37.2 (37.6)	40.7 (39.6)	35.0 (36.3)
$ZnSO_4$ + Borax	27.2 (31.4)	35.5 (36.5)	40.9 (39.7)	40.8 (39.7)	36.1 (36.9)
$ZnSO_4$ + Gypsum	26.7 (31.3)	32.8 (34.9)	37.4 (37.7)	38.5 (38.4)	33.9 (35.6)
Borax + Gypsum	25.0 (30.0)	32.2 (34.6)	36.8 (37.3)	40.0 (39.2)	33.5 (35.4)
$ZnSO_4$ + Borax + Gypsum	23.2 (28.8)	28.3 (32.1)	35.9 (36.8)	37.8 (37.9)	31.3 (34.0)
Spray of slaked lime @ 1%	29.4 (32.8)	35.0 (36.3)	42.7 (40.8)	43.3 (41.0)	37.6 (37.8)
Spray of Dithane M-45 @ 0.2%	18.9 (25.8)	21.1 (27.3)	24.9 (29.9)	25.9 (30.6)	22.7 (28.5)
Untreated check	33.9 (35.6)	43.3 (41.2)	48.3 (44.0)	48.9 (44.4)	43.6 (41.3)
CD (Pd"0.05)	4.9	3.2	2.7	2.4	1.2
CV (%)	9.0	5.3	4.0	5.0	2.2

Values in parenthesis are angular transformed; *Disease severity was observed on the basis of randomly selected 50 plants in each replication

Table 2 : Effect of different micronutrients alone and in combinations on Alternaria leaf blight severity in Indian mustard

Treatments	Alternaria leaf blight severity* (%)				
	2008-09	2009-10	2010-11	2011-12	Mean
$ZnSO_4$ @ 15kg ha^{-1} (Zn)	31.9 (34.4)	38.2 (38.2)	30.7 (33.6)	30.4 (33.5)	32.8 (34.9)
Borax @ 10 kg ha^{-1} (B)	33.9 (35.6)	39.4 (38.9)	31.2 (33.9)	31.1 (33.9)	33.9 (35.6)
Gypsum @ 250 kg ha^{-1} (S)	29.4 (32.8)	38.3 (38.2)	31.4 (34.1)	28.1 (32.0)	31.8 (34.3)
$ZnSO_4$ + Borax	30.6 (33.6)	35.6 (36.6)	29.2 (32.7)	28.2 (32.1)	30.9 (33.8)
$ZnSO_4$ + Gypsum	27.8 (31.8)	35.0 (36.3)	28.8 (32.4)	26.7 (31.1)	29.6 (33.0)
Borax + Gypsum	25.6 (30.4)	33.3 (35.2)	27.9 (31.9)	27.8 (31.8)	28.7 (32.4)
$ZnSO_4$ + Borax + Gypsum	22.1 (28.0)	30.0 (33.2)	26.4 (30.9)	26.5 (30.3)	26.3 (30.9)
Spray of slaked lime @ 1%	29.4 (32.8)	38.3 (38.2)	30.7 (33.6)	28.9 (32.5)	31.8 (34.3)
Spray of Dithane M-45 @ 0.2%	20.0 (26.6)	23.9 (29.3)	20.9 (27.2)	16.3 (23.8)	20.3 (26.8)
Untreated check	41.1 (39.9)	45.0 (42.1)	35.0 (36.2)	33.3 (35.2)	38.6 (38.4)
CD (Pd"0.05)	5.4	4.6	3.0	3.4	1.5
CV (%)	9.7	7.3	5.4	6.3	3.2

Values in parenthesis are angular transformed; *Disease severity was observed on the basis of randomly selected 50 plants in each replication

provide at par better tolerance to both the diseases as compared to single treatment of each chemical. Available literature indicates that application of Zn to soil reduced infections by *Fusarium graminearum* and root rot diseases in wheat, however, the role of gypsum in tolerance against pathogens was found to have different effects as in some cases it decreased or increased, and in others had no effect on plant susceptibility to diseases (Dordas, 2008). Zinc also plays an important role in protein and starch synthesis, and therefore low zinc concentration induces accumulation of amino acids and reducing sugars in plant tissue (Mengel and Kirkby, 2001). As an activator of Cu/Zn-SOD (superoxide dismutase), Zn is involved in membrane protection against oxidative damage through detoxification of superoxide radicals (Cakmak, 2000). Impairments in membrane structure, caused by free radicals lead to increased membrane leakage of low-molecular-weight compounds, the presence of which favors pathogenesis (Mengel and Kirkby, 2001).

Boron has direct function in cell wall structure and stability and has beneficial effect in reducing disease severity. However, the function of B in disease resistance or tolerance is least understood as compared to all essential micronutrients for plants. In the present investigation, boron, in the form of Borax applied as sole dose, was found least effective in providing protection against both the diseases (Tables 1, 2 and 3). However, the function of B in cell wall structure, cell membrane permeability, stability or its role in metabolism of phenolics or lignin cannot be ruled out for reducing disease susceptibility (Brown *et al*., 2002; Blevins and Lukaszewski, 1998). Boron has been reported to reduce disease infection, or lessen its effects as it also plays a role in the production of disease protection compounds and structures within plants. In B deficient conditions plant exudates contain higher amount of compounds such as sugars and amino acids that promotes establishment of most fungal infections (Dordas and Brown, 2005). When all the three chemical fertilizers were

Table 3 : Effect of different micronutrients alone and in combinations on seed yield in Indian mustard

Treatments	Seed yield (kg ha^{-1})				
	2008-09	2009-10	2010-11	2011-12	Mean
$ZnSO_4$ @ 15kg ha^{-1} (Zn)	1205	1480	1407	1633	1431
Borax @ 10 kg ha^{-1} (B)	1178	1429	1416	1709	1433
Gypsum @ 250 kg ha^{-1} (S)	1265	1502	1473	1609	1462
$ZnSO_4$ + Borax	1236	1437	1425	1956	1514
$ZnSO_4$ + Gypsum	1281	1465	1438	1906	1523
Borax + Gypsum	1320	1533	1542	1729	1531
$ZnSO_4$ + Borax + Gypsum	1366	1656	1618	1807	1612
Spray of slaked lime @ 1%	1205	1413	1405	1716	1435
Spray of Dithane M-45 @ 0.2%	1393	1649	1627	1900	1642
Untreated check	1047	1415	1399	1485	1337
CD (Pd"0.05)	138.0	72.2	62.6	148.0	102.1
CV (%)	6.4	2.8	9.2	6.9	4.7

applied *i.e.* soil application of $ZnSO_4$ @ 15 kg ha^{-1} + Borax @ 10 kg ha^{-1} + Gypsum @ 250 kg ha^{-1} as basal dose, there was a significant reduction in both the diseases of Indian mustard, where a minimum disease severity of both white rust (31.3 %) and Alternaria blight (26.3 %) was observed as compared to the severity of white rust (43.6%) and Alternaria blight (38.6%) in the untreated check. Significant increase in seed yield (1612 kg ha^{-1}) was also recorded in this treatment as compared to the yield (1337 kg ha^{-1}) in untreated check (Table 3). However, maximum reduction in severity of both the diseases and maximum increase in seed yield was recorded, when Dithane M-45 @ 0.2 % was sprayed after 50-60 DAS (Tables 1, 2 and 3). Meena *et al*. (2011) also reported that chemicals like, calcium sulphate, Borax and sulphur significantly reduced the severity Alternaria blight in mustard.

The present study clearly indicates that combined application of S in the form of Gypsum, Zn in the form of zinc sulphate and B in form of Borax, when applied with the recommended doses of N and P played a definite role in altering the tolerance level of the host crop. Nutrients can affect disease development by affecting plant physiology or by affecting pathogens, or both. Plant growth can be influenced by the level of nutrients, which can affect microclimate, therefore affecting infection and sporulation of the pathogen. Furthermore, the level of nutrients can affect the integrity of cell walls, membrane leakage and chemical composition of the host, growth rate of the host which can enable the plants to escape/avoid infection when they are at the most susceptible stages. In addition, chemical fertilizers, by influencing the soil environment and plant growth, can affect the development of the pathogen.

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