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Effect of Mancozeb on Disease Severity, Infection Rate and Seed Weight of Mustard [*Brassica juncea* (L.) Czen & Coss.] Caused by *Alternaria* spp.

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A B S T R A C T

In case of fungicidal trails all the treatments reduced the disease severity in comparison to unsprayed plots. The severity of disease after eight spray of Mancozeb @ 0.2 % was found minimum disease severity (5.0 %) followed by seven spray (6.0 %) and six spray (10.33 %), respectively. Maximum seed yield of 2000kg/ha was recorded with eight spray of Mancozeb @ 0.2% followed by seven spray (1922.22 kg/ha), and six spray (1902.77 kg/ha), respectively. Similar trend was recorded in case of test weight also. All the treatments avoided test weight loss of 5.70 to 21.81 %. Maximum being with eight and seven spray of Mancozeb @ 0.2 % (21.81 %) followed by six spray (21.67 %) and five spray (20.81 %).Maximum yield loss of 48.61 per cent was also avoided with eight spray of Mancozeb @ 0.2 % followed by seven sprays (46.53 %) and five spray (45.94 %).The maximum benefit cost ratio of 1:7.94 and 1:7.18 were obtained with four and three spray of Mancozeb @ 0.2 % followed by five sprays (1:6.82) and two spray (1:6.11).

Introduction

Oilseed crops play an important role in agricultural economy of India. Oilseed brassicas often called rapeseed-mustard Kumar *et al.*, (2014) placed in *Brassicaceae* family which contains about 3500 species and 350 genera, is one of the 10 most economically important plant families. According to ancient scripture and literature, it has been cultivated as early as 5000 BC. There is evidence of its cultivation in Neolithic age. Seeds of mustard were found from the Channhudaro of Harrapan civilization ca. 2300-1750 BC. Among the oilseed brassicas, mustard (*Brassica juncea*), yellow sarson (*B. campestris* var. *yellow sarson*), brown sarson (*B. campestris* var. *brown sarson*), toria (*B. campestris* var. *toria*), oilseed rape (*B. napus*) and Karan rai (*B. carinata*) are grown for edible oil whereas black mustard (*B. nigra*) is used as a condiment for pickle making Kumar *et al.*, (2014).

Among rapeseed-mustard, Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is one

of the most important oilseed crops which contribute about 85 per cent of total rapeseed-mustard produced in India (Kumar and Chauhan (2005). Green leaves of young plants are used as vegetable. The oilseed brassicas usually contain 38-57% of erucic acid, 4.7-13% of linolenic acid and 27% of oleic and linoleic acids Kumar *et al.,* (2014). The protein content ranges between 24-30 per cent of the whole seed and 35-40 per cent of the meal.

Among the entire oilseed crops producing states in India and in U.P. the area under cultivation is 6.39 lakh hac, with production of 7.9 lakh metric tonnes and productivity of 12.36 q/ha (Anonymous, 2013). This lower production is attributable mainly due to biotic and abiotic stresses. Among the biotic stresses, fungal folior diseases, *viz.* Alternaria blight caused by *Alternaria brassicae* (Berk) Sacc. and *Alternaria brassicicola* (Schwin) Wiltshire, White rust caused by *Albugo candida* (Lev.) Kunze, Downy mildew caused by *Peronospora parasitica* (Pers.) ex Fr. and Powdery mildew caused by *Erysiphe cruciferarum* Opiz ex. Junell are most important and individually or collectively, cause enormous losses.

Among the various diseases, Alternaria blight is caused by *Alternaria brassicae* (Berk) Sacc. and *Alternaria brassicicola* (Schwin) Wiltshire is one of the most severe yield destabilizing factor causing reduction from 35 to 45 per cent Kolte *et al.,* (1987); Saharan (1992); Kolte (2002) and inflicts very severe losses up to 70 per cent in yield of rapeseed and mustard crops of yellow and brown *sarson* Saharan (1992); Kolte (2002). The disease also adversely affects quality by reducing seed size, impairing seed colour and oil content.

The blight disease of brassicas caused by *A. brassicae* was first time reported in England on English cabbage Berkley (1836). In India, it was first recorded from Tirhoot division, (Pusa) in 1901 on *sarson* by Butler (1918). In subsequent years this disease was also reported from many other parts of world Ceylon Bond (1947), Germany Borg (1952). In Utter Pradesh (Presently Uttarakhand) it was reported from Pantnagar by Kolte and Tiwari (1978).

The resistance identified in different genotypes of mustard is partial. The extent of losses caused by this disease was also variable from place to place, depending upon the severity of disease (Barma and Bhagawati (1995). Keeping in view, to know the development of disease in different genotypes and extent of losses caused by this disease under different spray schedule. Considering the above point on view, the study was undertaken on the present investigation as "Effect of mancozob on disease severity, infection rate and seed weight of Mustard [*Brassica juncea* (L.) Czern & Coss.] caused by *Alternaria* spp".

Materials and Methods

The present investigation was carried out at the Student's Instructional Farm (2013-2014) Department of Plant Pathology, College of Agriculture, Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P). Different varieties/ genotypes of *Brassica juncea* were procured from the All India Co-ordinated Research Project on Rapeseed-Mustard, Department of Genetics and Plant Breeding of the University.

Land preparations and raising of crop

The land was well prepared by one deep ploughing with soil turning plough, followed by two cross harrowing. Entire field was marked with rope to have sowing in rows at 30 cm spacing between two rows. Field was also divided in blocks and plots to provide channels for irrigation and drainage.

Fertilizers applications

The recommended dose of fertilizers (N: P: K-120:60:60kg/ha) was applied in the form of urea, single super phosphate and murate of potash. Half dose of nitrogenous fertilizer and full dose of phosphorus and potash were applied in furrows as basal dressing at the time of sowing. Remaining half dose of nitrogenous fertilizer was given as top dressing in two split doses, one after first irrigation and second at the time of flowering.

Studies on development of Alternaria blight in different genotypes

This experiment was conducted during *Rabi* 2013-2014 at Student's Instructional Farm of the N.D. University of Agriculture and Technology, Kumarganj, Faizabad by planting fifteen genotypes of the Indian mustard namely NDWR-05-1, NDRE-22, Varuna, NDR-8501, NDRE-7, NDR-2011, NDRS-2010, NDRE-4, PRB-2004-3, Ashirwad, JD-6, NDRE-8213, NDYR-32, NDRE-16 and NDYR-8. Each genotypes were sown in well prepared and fertilized field in five lines of three meter length having spacing of 30 cm from line to line and 10 cm from plant to plant on October 22, 2013. All the entries were also flanked by two rows of susceptible check. All the cultural operations were adopted as per recommendation for raising the good crop.

Observations recorded

After germination the crop was regularly observed for first appearance of disease. The number of spots was counted per 10 cm^2 leaf area on different tagged leaves with the half of a glass slide, on which 5×2 cm^2 area was marked with permanent markers. Observations were taken on lower leaf, middle leaf and upper leaf at five places per leaf lamina on upper surface of leaf, starting from lower most leaf to the upper most fully developed leaves. This method of counting of spots was followed in all the successive observations. Average number of spots calculated. Alternaria blight spots were also counted on pods, one week prior to maturity of the plant. A total of twenty five pods @ 5 pods per plant per genotype per replication were observed and average number of spots per pod was calculated.

Randomly five plants were selected in each genotype for measuring the spot size. From each plant, five leaves were randomly selected on which diameter of randomly selected spots were measured in mm.

Average size of leaf spot in each genotype was calculated. Five largest spots per infected pod of the selected plants were measured and average was calculated on the basis of fifty spots /genotype.

The spore production in different genotypes at different intervals on spots of Alternaria blight, the affected leaves were thoroughly washed in running tap water and the lesion of similar size were taken at different intervals and separated by cork borer (8mm). These lesions were surface sterilized with 0.1% mercuric chloride and further washed repeatedly in sterilized distilled water. Sporulation was observed by suspending sporulated lesions in vials containing a mixture of distilled water + lactophenol in the ratio of 9:1. These lesions were than shaken vigourously and scrapped with the help of a camel hair brush. The conidia were counted with the help of a haemocytometer.

The infected pods of above genotypes were collected from the field at different intervals and thoroughly washed in running tap water. The pods were cut in 6 mm pieces containing single spot. Fifteen such surface sterilized pieces were incubated in Petri plates in a moist chamber for 48 hours at room temperature (25°c) with alternating 12 hours

light and 12 hours dark periods. Conidia were counted as per method described above.
The observations on disease severity were recorded by selecting five plants randomly from each genotype. The disease severity was recorded at 10 days intervals to till maximum disease severity by using 0-6 rating scale as suggested in the Proceedings of All India Co-ordinated. Research Project on Rapeseed-mustard pathology, Planning and Review session-2009-10 given below.

Observations were noted on lower, middle, and upper leaves of randomly selected five plants from each genotype and in each replication.

The per cent disease intensity (PDI) was calculated by employing formula mentioned below:

$$PDI = \frac{\text{Sum of total numerical ratings}}{\text{Total number of leaves observed}} x \frac{100}{\text{Highest grade}}$$

The period from the initial appearance of symptoms and the final incidence of the disease was also considered and the apparent infection rate of the disease spread was calculated according to the following formula (Vander plank, 1963).

$$\text{Infection rate (r)} = \frac{2.3}{t_2 - t_1} \log_e \frac{x_2 (1 - x_1)}{x_1 (1 - x_2)}$$

Where,

t_1 = time during first observation

t_2 = time (days) during second observations

$t_2 - t_1$ = time intervals between two observations

x_1= percent disease intensity value in decimal at corresponding t_1 time

x_2 = percent disease intensity value in decimal at corresponding t_2 time
Log e = natural log

The Area under Disease Progress Curve (AUDPC) was calculated by the formula as under:

$$AUDPC = \sum_{i=1}^{n} [(Y_{i+1} + Y_i) \times 0.5][T_{i+1} + T_i]$$

Where,

Y_i= Alternaria blight severity (%) at the Ist observation

T_i= Time (days) of the Ist observation

n= Total number of observations

For the observations of leaf defoliation, leaves were counted from basal to top.

Average was taken based on 5 plants of each genotype in each replication and per cent leaf defoliation was calculated by employing formula mentioned below.

$$\text{Leaf Defoliation (\%)} = \frac{\text{Sum of total infected defoliate leaves}}{\text{Total number of leaves}} x100$$

Seed yield was recorded in each genotype separately to determine the differences in yield between each genotype and yield kg ha^{-1} was calculated.

Spraying of chemical

Solution of required amount of Mancozeb prepared with water and volume made up to the desired level. This prepared solution was sprayed by using high volume Knap sack sprayer of 10 liter capacity.

As per technical programme eight sprays of Mancozeb were given starting from first appearance of disease followed by 10 days intervals in the plots.

Statistical analysis

The data wherever required was statistically analyzed following standard statistical procedures Fisher and Yates (1957).

Result and discussion

Development of disease on different genotypes

The data presented in Table 1, showed the number of spots/10 cm^2 on leaves and pods, size of spots (mm) on leaves and pods, conidia per spots on leaves and pods. The disease first appeared on the genotype NDRS-2010 (38 DAS) followed by genotypes Ashirwad (42 DAS), Varuna (44 DAS) and NDR- 8501 (45 DAS). The latest appearance of disease was noted on genotype JD-6 (63 DAS) (Table 2).

Yield of different genotypes

The seed yield was ranged from 1090.0 to 1608.3 kg/ha in different genotypes/cultivar. The maximum seed yield was recorded in cultivar NDRE-7 (1608.3 kg/ha) followed by NDWR-05-1(1516.7 kg/ha) and NDRE-4 (1425.0% kg/ha). The NDRE-7 (1608.3 kg/ha) and NDWR-05-1(1516.7 kg/ha) were at par in respect of seed yield. However, the genotype NDER-4 (1425.0 kg/ha) significantly differ from NDRE-7 and NDWR-0501. The minimum yield was recorded on cultivar Varuna (1090.0kg/ha) followed by NDRS-2010 (1250.0 kg/ha), Ashirwad (1283.0kg/ha) and NDR-2011 (1300.0kg/ha) (Table 2).

Correlation coefficient among different components of partial resistance and yield of mustard genotypes

All the components were highly significant and positively correlation with each other except sporulation which have negative correlation with yield. The highest value of correlation was recorded between disease index and infection rate (R= 0.966) followed by disease index and AUDPC (R= 0.960), whereas lowest value of correlation was recorded between leaf defoliation and sporulation (R= 0.032). It means disease index is the most determinant factor for partial resistance that greatly influences the development and progression of epidemic.

The number of spot were positively associated with size of spot (0.949), disease index (0.905), leaf defoliation (0.954), AUDPC (0.917), infection rate (0.878) and negatively associated with yield kg/ha (-0.952). Size of spot is highly significant and positive correlated with disease index (0.891), leaf defoliation (0.907), AUDPC (0.828) infection rate (0.917) and negatively correlated with yield kg/ha (-0.877). Disease index is highly significantly associated with leaf defoliation (0.912), AUDPC (0.960), infection rate (0.966) and negatively correlated with yield kg/ha (-0.812). Leaf defoliation was significantly positively correlated with AUDPC (0.932), infection rate (0.861) and negatively correlated with yield kg/ha (-0.952). Sporulation was positive correlation with AUDPC (0.331), infection rate (0.147) and negatively correlated with yield kg/ha (-0.001). AUDPC was significantly positive associated with infection rate (0.892) and negatively associated with yield kg/ha (-0.860) and infection rate was significantly negatively correlated with yield (-o.761).

Per cent disease severity (PDI)

The results revealed that all the treatments significantly reduced the disease severity in comparison to untreated plot. The disease severity (PDI) on leaves ranged from 5.0 to 71.33 %. The minimum disease severity of 5.0% was recorded with eight spray of Mancozeb @0.2 followed by Seven spray of

Mancozeb @ o.2% (6.0 %), Six spray of Mancozeb @ 0.2 % (14.00 %), Five spray of Mancozeb @ 0.2 % (20.17%), Four spray of Mancozeb @ 0.2% (36.0 %), and Three spray of Mancozeb @ 0.2% (45.0%). The maximum disease severity (PDI) was recorded in untreated plot (71.33 %). No significant difference was noted seven spray of Mancozeb @ 0.2 % and eight spray of Mancozeb @ 0.2 % while all other treatments were significantly differed from each other. Foliar spray of Mancozeb (@ 0.2 %) found effective in reducing the disease severity. Similar finding was reported by Meena *et al.,* (2004); Mondal *et al.,* (2008); Prasad *et al.,* (2009)

In case of pod infection the disease severity (PDI) ranged from 0 to 61.07 %. The zero disease severity (PDI) was recorded on pods with Eight spray of Mancozeb @ 0.2 % followed by Seven spray of Mancozeb @ 0.2 % (3.50 %), Six spray of Mancozeb @ 0.2 % (10.33, Five spray of Mancozeb @ 0.2 % (12.67 %), Four spray of Mancozeb @0.2 % (20.0 %), Three spray of Mancozeb @ 0.2 % (32.38 %), Two spray of Mancozeb @ 0.2 % (40.07 %), One spay of Mancozeb @ 0.2 % (50.0 %) and maximum disease severity (PDI) was found in Unsprayed plot (61.07 %). There was no significant difference among treatment T_5 and T_6. However, all other treatments were significantly differing from each other Girish *et al.,* (2007)

Detail of Treatments

T_1 One spray of Mancozeb at disease initiation.
T_2 Two sprays of Mancozeb at disease initiation and after 10 days.
T_3 Three sprays of Mancozeb first at disease initiation and after 10 days intervals thereafter.
T_4 Four sprays of Mancozeb after 10 days intervals starting from first appearance
T_5 Five sprays of Mancozeb after 10 days intervals starting from first appearance
T_6 Six sprays of Mancozeb after 10 days intervals starting from first appearance
T_7 Seven sprays of Mancozeb after 10 days intervals starting from first appearance
T_8 Eight sprays of Mancozeb after 10 days intervals starting from first appearance
T_9 Control (untreated)

Rating scale (0-6)	Description of scale	Host reaction
0	No visible symptoms	Free
1	Up to 5% leaf area covered	Highly Resistant
2	5-10% leaf or pod area covered with small pin head spots on the leaves and superficial pinhead spots on pods	Resistant
3	10-20% leaf or pod area covered with small spots on the leaf and superficial pin head spots on pods	Moderately Resistant
4	20-30% leaf or pod area covered with bigger spots with initiation of coalesces on leaves and deep lesion on pods	Moderately Susceptible
5	30-50% leaf or pod area covered with bigger spots commonly coalescing spots on leaves and deep lesion on pods	Susceptible
6	More than 50% leaf or pod area covered giving blighting appearance	Highly Susceptible

Table.1 Effect of Mancozeb under different spray schedule on the disease severity (PDI) of Alternaria blight of mustard cv. Varuna during 2013-2014

Treatments	Per cent disease severity (PDI)								15 days before harvest	AUDPC
	On leaves								On pod	
	4-12-2013	14-12-13	24-12-13	3-1-14	13-1-14	23-1-14	2-2-14	12-2-14		
T_1	0.03 (0.62)	0.47 (3.88)	1.47 (6.90)	12.50 (20.68)	26.33 (30.87)	45.00 (42.13)	55.00 (47.88)	68.00 (55.55)	50.00 (45.00)	1747.83
T_2	0.03 (0.62)	0.43 (3.74)	1.37 (6.68)	9.43 (17.86)	19.33 (26.07)	39.60 (38.99)	48.63 (44.22)	56.00 (48.44)	40.07 (39.27)	1468.17
T_3	0.00 (0.03)	0.40 (3.61)	1.17 (6.15)	8.30 (16.73)	14.53 (22.39)	30.60 (33.58)	41.00 (39.81)	45.00 (42.13)	32.80 (34.93)	1185.00
T_4	0.03 (0.62)	0.40 (3.54)	1.13 (6.10)	6.73 (14.97)	9.70 (18.14)	18.23 (25.25)	24.00 (29.33)	36.00 (36.86)	20.00 (26.55)	782.17
T_5	0.03 (0.62)	0.40 (3.61)	1.07 (4.76)	3.50 (10.78)	5.25 (13.24)	8.00 (16.42)	18.03 (25.12)	20.17 (26.68)	12.67 (20.83)	463.50
T_6	0.00 (0.03)	0.30 (3.11)	1.00 (5.61)	3.00 (9.97)	4.95 (12.85)	5.10 (13.05)	8.00 (16.42)	14.00 (21.97)	10.33 (18.69)	293.50
T_7	0.00 (0.03)	0.30 (3.11)	0.50 (2.73)	2.25 (8.62)	4.35 (12.03)	4.75 (12.58)	4.95 (12.85)	6.00 (14.17)	3.50 (10.78)	201.00
T_8	0.00 (0.03)	0.27 (2.86)	0.75 (2.04)	2.13 (8.39)	4.11 (11.69)	4.50 (12.24)	4.75 (12.58)	5.00 (12.92)	0.00 (0.03)	190.07
T_9	0.03 (0.62)	0.53 (4.13)	2.13 (8.38)	15.17 (8.39)	42.50 (40.68)	55.17 (47.97)	60.53 (51.09)	71.33 (57.64)	61.07 (51.40)	2117.17
SEm±								**1.007**	**1.053**	
CD at 5%								**3.020**	**3.159**	

Table.2 Effect of Mancozeb on apparent infection rate (r) of Alternaria blight of mustard cv. Varuna during 2013-14

Treatments	Infection rate on leaves (DAS/Date)							
	4-12-13 to 14-12-13	15-12-13 to 24-12-13	25-12-13 to 3-1-14	4-1-14 to 13-1-14	14-01-2014 to 23-1-14	24-2-14 to 2-2-14	3-2-14 to 12-2-14	Mean
T_1	0.377	0.165	0.323	0.131	0.118	0.057	0.079	0.179
T_2	0.367	0.165	0.288	0.119	0.144	0.052	0.042	0.168
T_3	0.355	0.150	0.263	0.057	0.104	0.050	0.082	0.152
T_4	0.355	0.141	0.173	0.061	0.064	0.133	0.020	0.135
T_5	0.0	0.154	0.291	0.090	0.136	0.065	0.023	0.126
T_6	0.0	0.173	0.160	0.074	0.005	0.069	0.090	0.095
T_7	0.0	0.073	0.217	0.097	0.013	0.006	0.029	0.073
T_8	0.0	0.148	0.151	0.097	0.014	0.008	0.008	0.071
T_9	0.396	0.200	0.300	0.203	0.073	0.031	0.069	0.182

Table.3 Effect of Mancozeb under different spray schedule on test weight (1000 seed weight in gm) and seed yield of mustard cv. Varuna 2013-14

Treatment	Test weight (gm)	Avoidable test weight loss (%)	Seed yield		
			Kg/plot	Kg/ha	Avoidable loss
T_1	4.56	5.70	1.29	1072.22	4.14
T_2	4.69	8.31	1.57	1311.11	21.61
T_3	5.02	14.34	1.85	1541.66	33.33
T_4	5.30	18.86	2.12	1763.88	41.73
T_5	5.43	20.81	2.18	1819.44	43.51
T_6	5.49	21.67	2.28	1902.77	45.94
T_7	5.50	21.21	2.31	1922.22	46.53
T_8	5.50	21.81	2.40	2000.00	48.61
T_9	4.30	-	1.23	1027.77	-
SEm±	0.14	-	0.07	64.33	-
CDat 5%	0.44	-	0.23	193.01	-

Table.4 Economics of treatments for the management of Alternaria blight of mustard through different spray schedule

Treatmens	Yield (kg/ha)	Yield increase over control (kg/ha)	Value of increased yield (Rs./ha)	Cost of treatment application (Rs/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	Additional income (Rs/ha)	Cost benefit ratio
T_1	1072.22	44.45	1444.62	753.0	34847.15	34094.15	691.62	1:1.9
T_2	1311.11	283.34	9208.55	1506.0	42611.07	41105.07	7702.55	1:6.11
T_3	1514.66	486.89	15823.92	2259.0	49226.45	46967.45	13564.92	1:7.18
T_4	1763.88	736.11	23923.57	3012.0	57326.1	54314.1	20911.57	1:7.94
T_5	1819.44	791.67	25729.27	3765.0	59131.8	55366.85	21964.27	1:6.82
T_6	1902.77	875.00	28437.5	4518.0	61840.02	57201.15	23919.5	1:6.29
T_7	1922.22	894.45	29069.62	5271.0	62472.15	58976.0	23798.62	1:5.51
T_8	2000.0	972.23	31597.47	6024.0	65000.0	-	25573.47	1:5.24
T_9	1027.77	-	-	-	33402.52	-	-	-

Note: Mustard Price- Rs 32.5/kg, Labour charge-Rs125/day, Efficiency of sprayer 800m^2/day, Mancozeb-Rs380/kg.

Infection rate

Spray of mancozeb was started after first appearance of disease. The progress of disease was recorded at 10 days interval. The perusal of the Table 1 showed that infection rate of the disease was maximum in between 24-12-13 to 3-1-14. After that infection rate gradually decreased in all the treatments. The minimum infection rate on mean basis was recorded in Eight spray of Mancozeb @0.2 % (0.071) followed by Seven spray of Mancozeb @ 0.2 % (0.073), Six spray of Mancozeb @ 0.2 % (0.095), Five spray of Mancozeb @ 0.2 % (0.126), Four spray of Mancozeb @ 0.2 % (0.135),Three spray of Mancozeb @ 0.2 % (0.152), Two spray of Mancozeb @ 0.2 % (0.168), One spray of Mancozeb @ 0.2 % (0.179) respectively. Maximum infection rate was recorded in unsprayed plot (0.182) (Table 1).

Area under Disease Progress Curve (AUDPC)

All the treatments reduced the AUDPC in comparison to unsprayed plot. The minimum AUDPC was recorded with Eight spray of Mancozeb @ 0.2 % (190.07) followed by Seven spray of Mancozeb @ 0.2 % (201.0), Six spray of Mancozeb @ 0.2 % (293.50), Five spray of Mancozeb @ 0.2 % (463.50), respectively. Diseases severity increased with decreased number of spraying of fungicide

mancozeb. Maximum AUDPC was recorded in unsprayed plots (2117.17).

Yield of treatments

All the treatments also increased the seed yield in comparison to unsprayed plot (Table 4). The seed yield ranged from 1027.77 kg/ha to 2000 kg/ha in different treatments. The maximum seed yield was recorded in Eight spray of Mancozeb @ 0.2 % (2000 kg/ha) followed by Seven spray of Mancozeb @ 0.2 % (1922.22 kg/ha), Six spray of Mancozeb @ 0.2 % (1902.77), Five spray of Mancozeb @ 0.2 % (1819.44 kg/ha), Four spray of Mancozeb @ 0.2 % (1763.88kg/ha), Three spray of Mancozeb @ 0.2 % (1541.66 kg/ha), Two spray of Mancozeb @ 0.2 % (1311.11 kg/ha), One spray of Mancozeb @ 0.2 % (1072.22 kg/ha) and minimum seed yield was recorded in unsprayed plot (1027.77 kg/ha). No significant difference was noted among treatment unsprayed plot and One spray of Mancozeb @ 0.2 %. Similarly treatment five spray of Mancozeb @ 0.2 %, seven spray of Mancozeb @ 0.2 % and eight spray of Mancozeb @ 0.2 % were at par. However, the two spray of Mancozeb @ 0.2 %, three spray of Mancozed @ 0.2 % and four spray of Mancozeb @ 0.2 % were significantly differ with each other. Yadav *et al.,* (2002) Jagana *et al.,* (2013)

Avoidable yield loss

The yield loss was avoided from 4.14 to 48.61 per cent in different treatments. The maximum yield loss was avoided with Eight spray of Mancozeb @ 0.2 % (48.61 %) followed by treatment seven spray of Mancozeb @ 0.2 % (46.53 %), Six spray of Mancozeb @ 0.2 % (45.94 %), Five spray of Mancozeb @ 0.2 % (43.51 %), Four spray of Mancozeb @ 0.2 % (41.73 %), Three spray of Mancozeb @ 0.2 % (33.33 %), Two spray of Mancozeb @ 0.2 % (21.61 %) and One spray of Mancozeb @ 0.2 % (4.14 %), respectively. Prasad and Lallu (2006)

Test weight (1000 seed weight in gm)

The test weight ranged between 4.30 to 5.50g. The maximum test weight recorded in eight spray of Mancozeb @ 0.2 % (5.50g) followed by seven and six spray of Mancozeb @ 0.2 % (5.49g), Five spray of Mancozeb @ 0.2 % (5.43gm), Four spray of mancozeb @ 0.2 % (5.30gm), Three spray of Mancozeb @ 0.2 % (5.02gm), Two spray of Mancozeb @ 0.2 % (4.69gm), One spray of Mancozeb @ 0.2 % (4.56gm) and minimum test weight was recorded in unsprayed plot (4.30gm). The treatment T_9 (4.30), T_1 (4.46) and T_2 (4.69) which was at par with each other and treatment T_3 (5.02), T_4 (5.30), T_5 (5.43), T_6 (5.49), T_7 (5.50) and T_8 (5.50) significantly differ from T_9, T_1 and T_2 (Table 3). Similar results were recorded by Patni and Kolte (2006). They reported that the maximum test weight (g/1000 seeds) was observed in mancozeb sprayed plants (4.22 g)

Cost benefit ratio

On the basis of economics the maximum cost benefit ratio (1:7.94) was obtained with four spray of Mancozeb @ 0.2 % followed by three spray of Mancozeb @ 0.2 % (1:7.18), five spray of Mancozeb @ 0.2 % (1:6.82), six spray of Mancozeb @ 0.2 % (1:6.29), two spray of Mancozeb @ 0.2 % (1:6.11), seven spray of Mancozeb @ 0.2 % (1:5.51) and eight spray of Mancozeb @0.2 % (1:5.24), respectively. Minimum cost benefit ratio of 1:1.9 was found with one spray of Mancozeb @0.2 % respectively (Table 4). Chattopadhyay and Bhunia (2003)

The use of resistant varieties/ genotypes is considered to be best method of disease control. Therefore, the studies were carried out to find out the sources of resistance

against the Alternaria blight. A total of fifteen genotypes/varieties of Indian mustard were evaluated for their reaction against the disease under field condition.

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