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Exploring the control measures of white rust- organic amendments, botanicals, biocontrol agents and chemicals

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Abstract
Three botanicals (Onion @5%, Eucalyptus@5%, and Neem @5%), two biocontrol agents (*Trichoderma viride* and *Pseudomonas flourescens*) and two fungicides (Ridomil MZ @2g/l and Carbendazim 50% @2g/l) were evaluated *in vivo* for their effectiveness to manage White rust of Mustard caused by *Albugo candida.* All treatments significantly reduced the severity of the disease with Ridomil MZ being most effective. Foliar spray of Ridomil MZ @2g/l significantly reduced White rust at (43%) followed by Eucalyptus@5% (45%), Neem@5% (47.6%), Onion@5% (54.8%), Carbendazim 50WP (56.4%), *Pseudomonas flourescens* (61.9%) and *Trichoderma viride* (63.4%) as compared to control. A maximum yield of (1670.3kg/ha) and minimum AUDPC (462.25) and infection rate of 0.0491 unit-days was recorded at Ridomil MZ. Seven organic matters (Vermicompost, FYM, Neem powder, Bone meal, Coir pith, VAM, Seaweed extract) were evaluated under greenhouse condition. All treatments significantly reduced the severity of the disease out of which Neem powder was most effective against Albugo candida with lowest recorded disease severity (22.80%) as compared to Control (46.63%) while lowest AUDPC (275.3) and Infection rate (0.007172 unit-days) was recorded in pots amended with Vermicompost. The current finding highlights the eco-friendly alternatives to manage White rust in the field over the conventional chemical pesticides.

Keywords: White rust, *Brasssica juncea*, botanicals, bio-control, organic matter

Introduction
Rapeseed and mustard is a group of cruciferous crops and also an important group of oilseed crops usually grown under wide-range as annual or biennial in India. This crop is economically important in domestic and international trade as it yields edible oil ranging from 30-48 percent which is used as the main cooking medium in Northern India. Rapeseed and mustard comprise Toria (*Brassica rapa* L. Syn *Brassica campestris* L.), Taramira (*Eruca sativa* Mill), Raya (*Brassica juncea* L.), Gobhi Sarson (*Brassica napus* L.) and African Sarson (*Brassica carinata* Braun) belonging to the Cruciferae family. Indian mustard [*Brassica juncea* (L.) Czern & Cosson] is one of the major oilseed crops developed in India and around the world. India is the major producer with an area under cultivation of 5.59 million ha and annual seed production is 6.61 million tonnes (GOI, 2009) [6]. Mustard being economically, ecologically and nutritionally of high significance; the production of these crops in Punjab has been reduced from 54 thousand tonnes in 2005-06 to 33 thousand tonnes in 2008-09. Several factors are responsible for the decline in production of Rapeseed-Mustard in Punjab. Among them, diseases caused by fungi constitute one of the most important factors which are responsible for low yield in this crop (Saharan, 1991) [19]. Several important diseases like Alternaria blight (*Alternaria brassicae*), White rust (*Albugo candida*), Downy mildew (*Peronospora parasitica*) and Sclerotinia rot (*Sclerotinia sclerotiorum*) created a serious threat to the successful cultivation of Rapeseed-Mustard in past few years. Among these diseases, White rust (*Albugo candida*) is one of the most important diseases which affect the crop severely (Saharan and Verma, 1992) [19]. Such a high level of losses can be prevented by understanding the pathogen population structure and mechanisms and by implementation effective disease management practices. With the growing awareness of harmful effects of pesticides, use of bioagents and plant extracts (botanicals) with less toxicity and ecological effects as anti-fungal spray is gaining importance in recent years (Mehta *et al*., 2005) [14]. The concept of integrated disease management seeks to minimize the advantages in the use of fungicide. In the present study different Organic amendments, Botanicals, Bio-control agents and chemical fungicides are used as foliar spray and soil amendments in mustard crop to find out its efficiency in effective and economical control against White rust.

Material and methods

Experiments were carried out in field plots (3m x3m) replicated thrice in RBD at Farm of Agriculture, Lovely Professional University during 2017-2018 *rabi* season. Sowing was done on 14th November' 2017 using highly susceptible cultivar (Varuna).

Preparation of inoculum and inoculation on test host

Suspension of sporangia from freshly infected leaves maintained separately in field were gently dislodged with a soft brush and allow to fall into a Petri plate containing double distilled water. Contents of the petri plate were stirred gently with the help of glass rod to disperse the sporangia. Incubate the plates at 18±1ºC for 4 hrs for production of zoospore from sporangia. Concentration of zoospores in inoculum suspension ($2.5x10^5$ zoospore/ml) was prepared using haemocytometer (Lakra and Saharan, 1988) [11]. Plants grown on fields were inoculated at 3-4 leaf stage with the zoospore suspension and allowed for development of symptoms and observations were recorded. The inoculum was purified and sprayed directly on seedling of susceptible mustard cultivar (Varuna) grown in pots (30cm in dia) under glasshouse condition (Singh *et al.*, 1999) [24].

Preparation and application of Botanical agents

Three commonly known plants *viz*., Onion, Eucalyptus, and Neem were evaluated. Fresh plant material (50g) was washed under tap water to remove any surface dirt and then with sterile water and ground using pestle and mortar. The herbal paste obtained was filtered through a double layer of sterilized muslin cloth and kept overnight to settle. The supernatant thus obtained were designated to be 100 percent concentration and were used as foliar spray @ 5% concentration adding sterile distilled water (Sanjay and Ashok, 2006).

Application of Bio-control agents and fungicides

Talcum based formulation of *Trichoderma viride* (JU Agri Sciences Pvt. Ltd) and *Pseudomonas flourescens* (International Panaacea Ltd.) was used for the field experiment. Two chemical fungicides *viz*., Ridomil MZ WP @ 2g/l water and Carbendazim 50WP @ 2g/l water were used for the field experiment. Foliar spray was given at 45DAS @ 10g/l of water followed by two more subsequent sprays at 15 days interval between sprays (Rathi and Singh, 2009) [17].

Fifteen plants per plot were selected randomly for taking observations. Based on the infected leaf area, leaves of each plant observation on percent white rust was recorded at 50, 65, 80 and 95 DAS using 0-6 disease rating scale of *A. candida* provided at Table 1 (Conn *et al*., 1990) [4].

Table 1: *Albugo candida* 0-6 disease rating scale

Rating score	Leaf area covered (%)	Disease reaction
0	No symptoms	Immune
1	0-5	Highly resistant
2	6-10	Resistant
3	11-20	Moderately Resistant
4	21-30	Moderately susceptible
5	31-50	Susceptible
6	>50	Highly susceptible

$$\text{Per cent disease index (\%)} = \frac{\text{Sum of numerical rating}}{\text{Total no.of samples x Maximum rating grade}} \text{ x } 100$$

Evaluation of Soil organic amendments against Albugo candida

Efficacy of different organic amendments were evaluated against White rust of Mustard in Poly-house condition, replicated thrice in CRD at Horticultural Farm of Agriculture, Lovely Professional University during 2017-2018 Rabi season. Sowing was done on 15th January 2018 using highly susceptible mustard cultivar Varuna.

Methods of mixing of certain organic matter sources in soil

Seven sources of organic matter *viz*., Vermicompost, Farm Yard Manure (FYM), Neem powder, Bone meal, Coir pith, Vesicular-Arbuscular Mycorrhiza (VAM), Seaweed extract (Table 2) were used. Ten gram of each organic source material was mixed separately with 1 kg of soil. The soil amended with different sources of organic matter were shifted in 2.0 kg capacity plastic pots and allowed to recycle its ingredients for 25 days. Non-amended soil was served as control. Uniform moisture was maintained throughout the decomposing period. The plastic pots size of 30cm in diameter was used and were filled each with organic matter recycled soil. The potted soil is inoculated with test pathogen and temperature was maintained at 26±3ºC (Bhardwaj, 2012) [3]. Pots were watered as per need after planting. Mustard seeds "Varuna T- 59" were sown in these pots @10 seeds/pot. Three pots were replicated for each treatment. The pots were watered regularly to maintain the optimum soil moisture for the growth of pathogen.

Germination percent was recorded after 07 days of sowing with following formula 1:

Formula 1

$$\text{Germination (\%)} = \frac{\text{Seedgerminated}}{\text{Total seeds sown}} \text{ x } 100$$

Vigour Index (%) =Seed germination (%) ×Seedling length (shoot+root length)

Five plants per plot were selected randomly for taking observations. The disease severity was recorded at 65, 80 and 95DAS by using 0-6 rating scale (Table 1) proposed by Conn *et al*. (1990) [4].

Table 2: Description of Organic amendments used against White rust of Mustard

Treatment	Trade name	Manufacturer
Vermicompost	Cocogarden Enriched	Cloudtail India
FYM	Farm yard manure	Indiamart
Neem powder	Cocogarden	Cloudtail India
Bone meal	INSEJ Bone meal	Excel Impex
Coir pith	Nutri- coir	Agro Green Biolife
VAM	Root care	Casa De Amor
Seaweed extract	Sea Gold	Casa De Amor

Area under disease progress curve

Area under disease progress curve (AUDPC) is used to calculate disease severity over time by integrating the amount of disease over time, rather than at a particular time point and can be measured by using trapezoidal method (Madden *et al.*, 2007) [12]. In the present investigation AUDPC of White rust was calculated using Formula 2 given below (Shaner and Finney, 1977) [20].

Formula 2

$$AUDPC = \left[\frac{\left(\frac{D_1 + D_2}{2} \times T \right) + \left(\frac{D_2 + D_3}{2} \times T \right) + \left(\frac{D_3 + D_4}{2} \times T \right)}{n - 1} \right]$$

Where,
D = Per cent disease index at different dates (D1, D2, D3…Dn)
T = Time interval (days) between two observations
n = Total number of observations

Table 3: AUDPC of White rust of Mustard

S. No.	Time of observation (days)	Disease severity (%)	Time interval (days)	Average disease Severity (%)	Time interval × average disease severity
1.	50	DS	0	-	-
2.	65	DS	15	(1+2)/2	15 X avg. D.S.
3.	80	DS	15	(2+3)/2	15 X avg. D.S.
4.	95	DS	15	(3+4)/2	15 X avg. D.S.

Infection rate
Logarithmic infection rates were calculated by using following formula 3 at 15 days interval (Vanderplank, 1963) [25].

Formula 3

$$r_l = \frac{2.3}{t_2 - t_1} \log_{10} \frac{x_2}{x_1}$$

Where,
r – Apparent rate of infection on two dates
t_1 - time of first disease measurement
t_2 - time of second disease measurement
x_1 - disease intensity measured at time t_1
x_2 - disease intensity measured at time t_2

Statistical analysis
Poly-house and filed investigations data were statistically analysed as per CRD and RBD design by Duncan multiple range test (DMRT) using IBM SPSS 22 analysis software at significance level of $P \leq 0.05$.

Results and discussion
Effect of Botanicals, Bio-control agents and Chemicals on the disease severity of White rust of Mustard
Observations of White rust disease severity were taken at 50,65, 80 and 95DAS. The perusal of the data presented in Table 4 indicated that at 65DAS, Ridomil MZ (33.4%) was found to be most effective and significantly maximum in reducing the disease severity followed by Eucalyptus@5% (33.5%), Trichoderma viride (34.1%), Neem@5% (34.5%), Carbendazim 50WP (34.9%), Onion @5% (35%) and *Pseudomonas flourescens* (35.8%) as compared to control (36.3%). At 80DAS, Ridomil MZ (35.2%) was found to be most effective and significantly minimum disease severity followed by Eucalyptus@5% (36.7%), Neem@5% (44.9%), Onion @5% (50.4%), Carbendazim 50WP (51.1%), *Pseudomonas flourescens* (52.2%) and *Trichoderma viride* (53.2%) as compared to control (63.1%). And at 95DAS, significantly minimum disease severity (PDI) was observed in Ridomil MZ (43%), Eucalyptus@5% (45%), Neem@5% (47.6%), Onion @5% (54.8%), Carbendazim 50WP (56.4%), Pseudomonas flourecens (61.9%) and *Trichoderma viride* (63.4%) as compared to control (72%).
The disease severity of Ridomil MZ was significantly different from Onion, Neem, *Trichoderma viride*, *Pseudomonas flourescens*, and Carbendazim, but the disease severity in Ridomil MZ was at par to Eucalyptus. Eucalyptus (5%) and Garlic bulb extract gave best results against White rust of Mustard (Yadav *et al*., 2009) [26]. Patni *et al.* (2003) [15] also concluded in their experiment that botanical extract of Eucalyptus @5% was highly effective against *Albugo candida*. Singh *et al.*, (2017) [23] reported Garlic extract followed by Neem extract @15% as the best plant extract for the management of White rust of Mustard. Earlier experiments has also highlighted the importance of Bio-control agents like *Trichoderma* and *Pseudomonas* in effectively controlling foliar pathogens in Mustard crop (Jackson and Kumar, 2019; Ahmad and Ashraf, 2016; Singh *et al*., 2014) [8, 1, 21]. The present study show strong favors towards plant botanical extracts and antagonistic strains of bio-agents as an alternate source for managing *Albugo candida* against conventional chemical pesticides.

Area under disease progress curve (AUDPC) and infection rate
All the treatments (Table 5) were significant in reducing AUDPC over control however, minimum AUDPC (462.25) with infection rate 0.0491 unit-days was recorded in plots sprayed with Ridomil MZ followed by Eucalyptus @5% (475.25) with infection rate 0.0501 unit-days. The calculation for AUDPC and r-value (apparent infection rate) in crop sown on different dates could identify the speed of progress in the disease severity on leaves and pods of *Alternaria* blight of Mustard cultivars (Kumar and Kolte 2001) [10].

Yield component
Data in Table 6 revealed that maximum seed yield per hectare was recorded in Ridomil MZ (1670.3kg/ha) followed by Eucalyptus @5% (1598.3kg/ha), Carbendazim (1382kg/ha), *Trichoderma viride* (1341kg/ha), Neem @5%(1318.1kg/ha), Onion @5% (1253.3kg/ha) and Pseudomonas flourescens (1241.6kg/ha) as compared to control (799kg/ha). All the treatments were found significantly different from each other in increasing the grain yield of Mustard. The current finding is strongly supported by the significantly higher grain yield of Mustard crop attained by treatments with *T. harzianum*, *P. flourescens*, and Indofil M-45 in earlier experiments of Jackson and Kumar (2019) [8]. Prasad *et al.* (2007) recorded maximum grain yield of Mustard with Garlic bulb @1%. Singh and Singh (2006) [22] observed that 1000 seed weight and yield was highest in combined treatment of Mancozeb and Ridomil MZ. Ferdous *et al.* (2002) [5] also recorded maximum yield with the spray of Garlic and Neem leaf crude extracts. The present study revealed that all the treatments were effective against White rust of Mustard and significantly reduced PDI, infection rate and AUDPC over control and increased the yield of the crop.

Effect of organic amendments in soil, inoculated with the test pathogen

Green house experiment was conducted to observe the effect of organic amendments in soil inoculated with test pathogen. Various observations i.e. Seed germination, Vigour Index and Disease severity were recorded. The data is presented in Table 7 and 8.

Seed germination

Data in Table 7 revealed that maximum seed germination was recorded in Coir pith (100%) followed by VAM (96.6%), Seaweed extracts (96.6%), Vermicompost (93.3%), FYM (93.3%), Neem powder (90%), Bone meal (86.6%) as compared to control (83.3%). Germination in different types of organic matter amended soils were significantly different to each other.

Seedling length

Maximum seedling length was observed in Vermicompost (21.50) followed by Coir pith (20.63), Bone meal (19.37), Seaweed extract (18.50), VAM (17.13), FYM (16.47) and Neem powder (14.00) as compared to control (13.33). The seedling length in Vermicompost amended soil was similar to Coir pith amended treatment. The seedling length of Seaweed extract was at par to bone meal and coir pith whereas Neem cake was significantly different to each other. While the seedling length of FYM was at par to VAM (Table 7).

Vigour Index

Maximum vigour index was recorded in Coir pith (2063.33) Vermicompost (2005.95), Seaweed extract (1787.10), Bone meal (1677.15) and VAM (1655.08), FYM (1536.34) and Neem powder (1260). as compared to control (1110.39). The vigour index in Coir pith was significantly similar to each other whereas Vermicompost was significantly at par to Seaweed extract and also Bone meal were significantly par to VAM, but Neem cake amended soils showed significantly different vigour index.

Disease severity (PDI) and infection rate

The data presented in Table 8 indicated that at 60DAS, minimum disease severity was reported in Neem powder (12.77%) followed by Bone meal (14.47%), VAM (15.03%), FYM (19.70%), Coir pith (22.33%), Seaweed extract (22.43%) and Vermicompost (23.30%) as compared to control (28.40%). The PDI in Neem powder was significantly different to Bone meal, FYM, Coir pith, Seaweed extract, Vermicompost, but the PDI was at par to VAM and Bone meal. Vermicompost was significantly at par to Coir pith and Seaweed. At 75DAS, Neem powder was found to be most effective with significantly minimum PDI of 18.93% followed by VAM (20.23%), FYM (25.47%), Vermicompost (25.83%), Seaweed extract (28.23%), Bone meal (32.57%) and Coir pith (35.53%) as compared to control (36.27%). The PDI of Neem powder was significantly different to FYM, Vermicompost, Seaweed extract, Bone meal and Coir pith, but the PDI in Neem powder was at par to VAM. At 90DAS, Neem powder (22.80%) was found to be most effective and significantly minimum disease severity followed by VAM (27.93%), Vermicompost (28.90%), FYM (30.43%), Seaweed extract (34.65%), Bone meal (36.03%) and Coir pith (41.50%) as compared to control (46.63%). The PDI in Neem powder was significantly different to Bone meal, FYM, Coir Pith and Seaweed while, VAM and Vermicompost were significantly at par to each other.

Area under disease progress curve

The data in Table 8 revealed that all the treatments were significant in reducing AUDPC over control. However, minimum AUDPC was recorded in pots amended with Neem powder (275.3) followed by VAM (312.8), FYM (379), Vermicompost (389.5), Seaweed extract (425.8), Bone meal (433.6), Coir pith (505.8) and Control (553,3).

Infection rate

Minimum infection rate was recorded in pots amended with Vermicompost with 0.007172 unit-days followed by Seaweed extract with 0.014479 unit-days, FYM with 0.014481unit-days (Table 9).

As per report of Perumal *et al.* (2003) [16], soil amended with 7 kg biodynamic compost, 7 kg Vermicompost, 250 mg cow horn manure and 1kg cow pat pit manure showed no occurrence of any disease in carrot crop until the harvesting stage. Earlier investigation of Kannangara *et al.*, (2000) [9] revealed 40-80 % reduction in disease severity of stem root rot of cucumber with the application of Vermicompost. Aryantha *et al.* (2000) [2] reported that the disease severity of root rot and dieback of Tomato was reduced upto 90% by using animal manure. Mallesh *et al.* (2008) [13] reported that soil amended with FYM showed 62.5% reduction in root rot of sage disease incidence. So far, no any report is available on effect of organic amendments against White rust of Mustard. Our current investigation leads us to conclude that Neem powder, VAM, Vermicompost and FYM contains antifungal compounds which are released during the decomposition period and were inhibitory to test pathogen.

Conclusions

Based on the present study it was observed that foliar spray with Ridomil MZ proved to be most effective against White rust with lowest disease severity (43%) whereas minimum AUDPC (475.25) with infection rate 0.0501 unit-days was observed in Eucalyptus@5%. The results could be correlated with the studies made by Singh and Singh (2006) [22] who concluded that the combinations of Mancozeb and Ridomil MZ-72 resulted in reducing the incidence of leaf blight, pod blight, and White rust diseases of Mustard. Among the Plant extracts, Eucalyptus was the most effective against A. candida, although Neem and Onion extracts were also found to be significantly effective in controlling the foliar pathogen as comparison to control. Soil amended with Neem powder was proved to be most effective against White rust with lowest disease severity (22.80%), minimum AUDPC (275.3) while minimum infection rate was recorded in pots amended with Vermicompost with (0.007172 unit-days). Among the seven organic amendments Neem powder was the most effective treatment closely followed by VAM and Vermicompost as soil amendment in comparison to control. On the basis of results obtained, it may be concluded that even though Neem powder was found more effective over other in inhibiting the pathogen spread, yet maximum germination percentage (100%) was found in Coir pith treatment whereas maximum seedling length was found in Vermicompost (21.50 cm) and Vigour index was found maximum in Coir pith amended treatment (2063.33).

Increasing public concern about environmental health is also a major problem in the use of fungicides although chemical remains more effective in reducing disease in plants. The acceptance of biological control methods came positive in certain parts of the world as the commercialization and production of biological control came out on an industrial

scale. These findings will shade some light on future works to be pursued in the never ending search for a better crop management system with special emphasis drawn towards use of organic amendments and other biological management options for foliar pathogens apart from the conventional yet environmentally hazardous use of Chemical pesticides.

Table 4: Effect of botanicals, biocontrol and chemicals on disease intensity of White rust on mustard crop and AUDPC

Treatment	50DAS	65DAS	80DAS	95DAS	AUDPC
Onion@ 5%	4.5	35.0	50.4	54.8	575.25
Eucalyptus@ 5%	4.7	33.5	36.7	45.0	475.25
Neem@ 5%	4.6	34.5	44.9	47.6	527.50
Trichoderma viride	3.7	34.1	53.2	63.4	604.25
Pseudomonas flourecens	4.1	35.8	52.2	61.9	605.00
Ridomil MZ	4.7	33.4	35.2	43.0	462.25
Carbendazim	4.9	34.9	51.1	56.4	583.25
Control	3.6	36.3	63.1	72.0	686.00
	Treatment (A)		Duration (B)		(AxB)
SEm	0.662		0.468		1.325
CD@ 5%	0.877		1.327		3.754

Table 5: Effect of botanicals, biocontrol agents and fungicides on Infection rate of *Albugo candida* on mustard crop recorded at 15 days interval

Treatment	r1	r2	r3	'r' value
Onion@ 5%	0.136598	0.024282	0.005574	0.0555
Eucalyptus@ 5%	0.130785	0.006075	0.013577	0.0501
Neem@ 5%	0.134176	0.017546	0.003889	0.0519
Trichoderma viride	0.147898	0.029617	0.011681	0.0631
Pseudomonas flourecens	0.144302	0.025114	0.01135	0.0603
Ridomil MZ	0.130586	0.003495	0.013329	0.0491
Carbendazim	0.130736	0.025391	0.006572	0.0542
Control	0.153886	0.036819	0.008786	0.0665
'r' value = Apparent infection rate				

Table 6: Effect of botanicals, biocontrol and fungicides on yield (kg/ha)

Treatment	Plant height (m)	Primary branches	Secondary branches	1000 seed weight	Yield kg/ha
Onion@5%	2.12	6.3	13	5.3	1253.3
Eucalyptus @5%	2.18	7.3	15.3	5.6	1598.3
Neem @5%	2.13	6	13.6	5.46	1318.6
Trichoderma viride	2.03	7.3	13.3	5.43	1341.0
Pseudomonas flourescens	2.25	6	13.6	5.3	1241.6
Ridomil MZ	2.36	7.6	16.3	5.6	1670.3
Carbendazim	2.33	7.6	14	5.5	1382.0
Control	2.22	6	13	5.4	799.6
CD at 5%	0.20	1.39	1.13	0.14	2.80
CV at 5%	5.23	11.64	4.56	1.49	0.12

Table 7: Effect of organic amendments against White rust under greenhouse conditions

Treatment	Germination (%)	Shoot length	Root length	Seedling length (cm)	Vigour index
Vermicompost	93.3	17.03	4.47	21.50	2005.95
FYM	93.3	14.13	2.33	16.47	1536.34
Neem powder	90	11.67	2.33	14.00	1260.00
Bone meal	86.6	16.67	2.70	19.37	1677.15
Coir pith	100	16.50	4.13	20.63	2063.33
VAM	96.6	13.00	4.13	17.13	1655.08
Seaweed extract	96.6	15.17	3.33	18.50	1787.10
Control	83.3	11.27	2.07	13.33	1110.39
SEm	2.88	0.84	0.10	0.88	15.89
CD@ 5%	8.65	2.52	0.31	2.66	47.65

Table 8: PDI at different stages of mustard crop and AUDPC for different soil amended treatments against *Albugo candida*

Treatment	60DAS	75DAS	90DAS	AUDPC
Vermicompost	23.30	25.83	28.90	389.5
FYM	19.70	25.47	30.43	379
Neem powder	12.77	18.93	22.80	275.3
Bone meal	14.47	32.57	36.03	433.6
Coir pith	22.33	35.53	41.50	505.8
VAM	15.03	20.23	27.93	312.8
Seaweed extract	22.43	28.23	34.65	425.8
Control	28.40	36.27	46.63	553.3

	Treatment (A)	Duration (B)	(AxB)
SEm	0.796	0.487	1.378
CD 5%	2.270	1.390	3.932

Table 9: Effect of organic amendments on infection rate of *Albugo candida* on mustard crop recorded at fifteen days interval

Treatment	r1	r2	'r' value
Vermicompost	0.006873	0.00747	0.007172
FYM	0.017098	0.011865	0.014481
Neem powder	0.026243	0.012375	0.019309
Bone meal	0.054035	0.006736	0.030386
Coir pith	0.030925	0.010337	0.020631
VAM	0.019782	0.021475	0.020629
Seaweed extract	0.015313	0.013644	0.014479
Control	0.016282	0.016742	0.016512
'r' value = Apparent infection rate			

References

1. Ahmad A, Ashraf Y. *In Vitro* and *in Vivo* Management of Alternaria Leaf Spot of *Brassica campestris* L. Plant Pathology & Microbiology. 2016; 7:7. DOI: 0.4172/2157-7471.1000365
2. Aryantha IP, Cross R, Guest DI. Suppression of *Phytophthora cinnamom* in potting mixes amended with un-composted and composted animal manures. Phytopathology. 2000; 90(7):775-782.
3. Bhardwaj N. Impact of some micronutrients, essential oils, organic amendments, botanicals, bio-agents and chemicals on the management of red rot of sugarcane. M.Sc. (Plant Pathology) Thesis submitted to GBPAU, Uttarakhand, 2012.
4. Conn KL, Tewari JP, Awasthi RP. A disease assessment key for Alternaria black spot in rapeseed and mustard. Can. Plant Dis. Surv. 1990; 70:19-22.
5. Ferdous SM, Meah MB, Hossain MM. Comparative effect of plant extracts and fungicide on the incidence of Alternaria blight of mustard. Bangladesh J Training Dev. 2002; 15(1-2):207-210.
6. GOI. (Government of India), Agriculture Statistics at a Glance 2009. Agriculture Statistics Division, Dept Agril. & Coop., Ministry Agriculture, GOI, New Delhi, 2009.
7. Guleria S, Kumar A. Azadirachta indica leaf extract induces resistance in sesame against Alternaria leaf spot disease. Journal of Cell and Molecular Biology. 2006; 5:81-86.
8. Jackson K, Kumar A. Management of alternaria leaf spot on indian mustard through chemical and biological agents. Plant cell biotechnology and molecular biology. 2019; 20(3-4):162-178.
9. Kannangara T, Utkhede RS, Paul JW, Puja ZK. Effects of mesophilic and thermophilic composts on suppression of Fusarium root and stem rot of greenhouse cucumber. Canadian Journal of Microbiology. 2000; 46:1021-1028.
10. Kumar Brajesh, Kolte SJ. Progression of Alternaria blight of mustard in relation to components of resistance. Indian Phytopathol. 2001; 54:329-331.
11. Lakra BS, Saharan GS. Efficacy of fungicides in controlling white rust of mustard through foliar sprays. Indian J Mycol. Plant Pathol. 1988; 18:157-163.
12. Madden LV, Hughes G, Bosch F. The study of plant disease epidemics. American Phytopathological Society (APS Press), 2007.
13. Mallesh SB, Narendrappa T, Ramanujan B. Evaluation of microbiological antagonists and organic amendments on root rot of sage (*Salvia officinalis*) by Fusarium solani and *Rhizoctonia solani*. Karnataka Journal of Agricultural Sciences. 2008; 21(2):301-302.
14. Mehta N, Sangwan MS, Saharan GS. Fungal diseases of rapeseed-mustard. Diseases of oilseed crops, 2005, 15-86.
15. Patni CS. Alternaria Blight of Mustard Variability in Alternaria Brassicae Host Resistance and Effect of Some Botanicals in Disease Management (Doctoral dissertation, Govind Ballabh Pant University of Agriculture and Technology; Pantnagar), 2003.
16. Perumal K, Chakraparthy K, Vatsala TM. Influence of nutrient management on quality and yield of carrot (*Doucuscarota* L.). Journal of Soils and crops. 2003; 13(2):204-210.
17. Rathi A, Singh D. Integrated management of Alternaria blight and white rust in Indian mustard. Proceedings of 16th Australian Research Assembly on Brassicas on changing foods, changing climate, changing canola held at Ballarat, 2009.
18. Saharan GS. Assessment of losses, epidemiology and management of black spot disease of rapeseed-mustard. Proceedings GCIRC 8th Int. Rapeseed Congress (July 9-11), Saskatoon, Canada. 1991; 84:465-470.
19. Saharan GS, Verma PR. White rusts: a review of economically important species. IDRC, Ottawa, ON, CA, 1992.
20. Shaner G, FInney RE. The effect of nitrogen fertilization on the expression of slow-mildewing resistance in Knox wheat. Phytopathology. 1977; 67:1051-1056.
21. Singh D, Prasad R, Yadav SP, Kumar S. Characterization of *Alternaria brassicae* causing alternaria blight of rapeseed-mustard (*Brassicae juncea* L.) and it's management. The Bioscan. 2014; 9(3):1207-1212.
22. Singh J, Ratan V, Singh R. Management of foliar diseases of mustard through chemicals. Annals Plant Protec. Sci. 2006; 14(1):142-145.
23. Singh K, Lal AA, Kumar D, Meena NK. Evaluation of Selected Bio Agents, Plant Extracts and Fungicides for the Management of Alternaria Leaf Blight of Indian Mustard. Int. J Curr. Microbiol. App. Sci. 2017; 6(4):26-31.
24. Singh US, Doughty KJ, Nashaat NI, Bennett RN, Kolte SJ. Induction of systemic resistance to *Albugo candida* in *Brassica juncea* by pre-or inoculation with an incompatible isolate. Phytopathology. 1999; 89(12):1226-1232.
25. Vanderplank JP. Plant diseases: Epidemics and controls. Academic Press, New York, 1963.

26. Yadav MS. Biopesticidal effect of botanicals on the management of mustard diseases. Indian Phytopathology. 2009; 62(4):488-492.