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IMPACT OF CONSERVATION AGRICULTURE ON WHITE RUST (*ALBUGO CANDIDA*) INFECTION IN MUSTARD UNDER RICE-MUSTARD CROPPING SYSTEM

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A study was conducted in rice-mustard cropping system during 2014-15 with different conservation agricultural practices to find its effects on white rust (*Albuga candida*) infection in mustard. There were eight treatments in which mustard was grown during winter (*rabi*) season (November- March) under rice-mustard cropping system. Daily weather parameters were recorded and incidence of white rust (*Albugo candida* L.) was recorded in disease scale (0-9) for each leaf of the tagged plants followed by calculation of percent disease index (PDI). Among the eight treatments, highest PDI of 22% was recorded in conventional agriculture treatment 8 (Transplanted Rice- Conventional Till Mustard) and lowest PDI (13%) was obtained in conservation agriculture treatment 6 (Mung Bean Residue + Zero Till Direct Seeded Rice – Rice Residue + Zero Till Mustard). Maximum mustard yield was also obtained in treatment 6 (2.57 t ha^{-1}). This study suggests that the microenvironment modification through different conservation agriculture treatments may decrease disease infection in mustard thereby reducing complete dependency on harmful chemicals. Therefore, it could be included as one of the important component in the integrated pest management module for a sustainable food production.

Keywords: Conservation agriculture, Cropping system, Mustard, No tillage, White rust

I. INTRODUCTION

Increasing crop production without increase in acreage to feed the burgeoning population is the foremost challenge for agricultural scientists. Moreover, increase in crop production should be achieved on a sustainable basis. The oilseed Brassica plays a crucial role in the Indian oil economy by contributing to approximately 23 percent of the total oilseed production. India's production in the world is 17.5 and 10.8 percent of the total acreage and production, respectively [1;2]. Despite considerable increase in productivity and production, a wide gap exists between yield realized and yield potential at farmer's field, which is mostly due to biotic and abiotic stresses [3]. The crop can be damaged by several diseases, including downy mildew [*Hyaloperonospora parasitica* (Pers.) Constant], Alternaria blight [*Alternaria brassicae* (Berk.) Sacc.], Sclerotinia rot [*Sclerotinia*

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sclerotiorum (Lib.) de Bary], white rust [*Albugo candida* (Pers. Ex Lev.) Kuntze], and powdery mildew (*Erysiphe cruciferarum* Opiz ex L. Junell). Among these biotic stresses, white rust caused by *Albugo candida* (Pers. ex. Lev.) Kuntze has been reported to be one of the most widespread and destructive fungal diseases of rapeseed-mustard throughout the world [4]. Losses in yield from 23 to 54.5 per cent due to both phases (leaf and stag head) of white rust have been reported from India [5;6].

Among the various factors, environmental factors like temperature, relative humidity and rainfall play an indispensible role in the development of white rust. The development of white rust is generally favoured by a mean temperature ranging between 11.4 to 17.7°C along with an average relative humidity of more than 70%.

Application of fungicide can minimize disease and thus increase the genetic potential thereby increasing the yield. However, excess application of toxic chemicals is detrimental to environment, thus, posing threat to land, water and atmosphere. The recent awareness of sustainable agriculture has revived interest in non chemical pest control methods. With a focus on sustainable development in agriculture, management techniques such as crop rotation, specific site selection, early sowing dates, plant density and row spacing, stubble retention are all used to minimize disease [7; 8; 9; 10].

Conservation agriculture (CA) practices offer a great potential to minimize white rust infection. Fundamentally, it considers all the factors for sustainable crop production *i.e.* economy, ecology and performance. The rice-mustard cropping system is a popular cropping system after rice-wheat cropping system in northern India. In the regions of less availability of irrigation, this cropping system is also followed. As India is a net importer of edible oil, to improve the national economy by curtailing the outflow of foreign exchange, rice-mustard cropping system may be preferred over rice-wheat cropping system and more studies are needed to be done in this cropping system. Thus, to meet these requirements, various factors affecting crop production should be considered. Apart from agronomy and soil, studies on impact of weather and climate including microclimate on conservation agriculture and *vice-versa* are necessary. Thus, reduction in white rust infection by modifying microclimate instead of completely relying on harmful pesticides can prove beneficial for environment in the long run along for having sustainable food production.

The studies on crop microenvironment under conservation agriculture and conventional practices in relation to diseases incidence are very limited. Review has been done for habitat management focussing attention on practices favouring natural predators and parasitoids and implementation of conservation biological control [11]. System and management affecting microclimate of the crop should be understood properly for effective management [12]. Thus, present study was undertaken in which a conservation agriculture (CA) system was being practised for three years (2012-2015) which included rice (rainy season)-mustard (winter season).

Our objective was to find the effect of microclimate modification through conservation agriculture on white rust disease incidence and yield of mustard in rice-mustard cropping system under conservation and conventional agriculture.

II. MATERIALS AND METHOD

Field experiments were carried out in mustard under rice-mustard cropping system (cultivar- Pusa Mustard-25) (Table 1) in winter (November-March) season of 2014-15 on a fairly leveled topography at the ICAR-Indian

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Agricultural Research Institute (IARI), New Delhi. The study site was located at 28°35' N, 77°12' E and with an altitude of 228.16 m above the mean sea level. The climate of the site was characterized by a typical semi-arid with dry hot summer and mild winters and with an average annual rainfall of 710 mm (80% is received during southwest monsoon during July–September). The surface soil (0–30 cm) is sandy loam in texture with 52.1% sand, 22.6% silt and 25.3% clay. The average bulk density was 1.48 Mgm^{-3}; pH (1:2.5 soil : water suspension) 8.0; organic C, 0.57%; available N, 170.6 kg ha^{-1} and available P and K, 18.6 and 275 kg ha^{-1}, respectively. Sowing of crop was done on 11th November 2014. For each treatment three plots were maintained as replications and standard agronomic practices were followed to ensure optimum plant vigour during the experimental period.

White Rust- The incidence of white rust (*Albugo candida* L.) was recorded in disease scale (0-9) as per [13] Couture (1980) for each leaf of the tagged plants. The Percent Disease Index (PDI) was calculated using the formula [14]. Daily meteorological data on maximum temperature (T_{max}) and minimum temperature (T_{min}); morning relative humidity (RH_{max}) and afternoon relative humidity (RH_{min}); wind speed (WS); hours of bright sunshine (SS); rainfall (RF) and open pan evaporation (EVP) for all locations were collected from adjacent standard meteorological observatories.

Profile Relative Humidity and Temperature and of crop- Profile relative humidity and temperature of crop were measured at different heights from the ground (0 cm, 30 cm, 60 cm, 90 cm, 120 cm and top of canopy) for mustard with the help of a pocket weather tracker (Model: Kestrel 4000) around 14:00 hours.

Crop Yield- An area of 1 m x 1 m was harvested manually from each plot after physiological maturity of mustard. After sufficient air drying, these 29 samples were weighed to get final above ground biomass (g m^{-2}). Then plant samples were thrashed in the laboratory and the seeds were separated.

Statistical Analysis- The data sets were processed for analysis of variance as applicable to randomized block design, to test differences among the various treatments and their interactions using Statistical Analysis System (SAS).

III. RESULTS AND DISCUSSION

3.1 White Rust

Disease infection and its spread are more determined by tillage than compared to other cultural or agronomic practices such as cropping patterns and pesticide usage. Moreover, tillage interaction with other agronomic practices affects the changes in pest communities. Time taken for the first appearance of white rust and its subsequent attainment of peak population in presented in TABLE 2. The study revealed that throughout the ascending phase of the white rust infection right up to its observed peak, the maximum temperature showed decreasing trend till maximum diseases infection was reached. When weather parameters were not found to be congenial, descending phase of the disease was observed. Humid environment and lower mean profile temperature within the canopy are congenial for disease and pest infestation. White rust disease appeared in the mustard crop around 51st SMW which had maximum temperature 16°C while minimum temperature was 5.7°C while relative humidity was 69%. These conditions were quite favourable for disease incidence. Thereafter it increased slowly till 2nd SMW but rapidly after that (Fig. 2).

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Peak value of percent disease index (PDI) was recorded on third week of February in 7th SMW (Table 2). Among the treatments significantly higher PDI of 22% was recorded in T8 (TPR- CTM) followed by T2 (ZT DSR+ BM- ZTM) (24%) and lowest PDI was obtained in T6 (MBR+ ZT DSR- RR+ ZTM) (13%). Significant negative and positive correlation was observed between PDI of white rust, the mean profile temperature and PDI of white rust, mean relative humidity respectively**.** [15] also reported that an average temperature of 10 to 18°C with an average relative humidity of more than 65% favoured the development of white rust pustules.

3.2 Mean Temperature and Relative Humidity Profile within the Canopy

The mean profile temperature and relative humidity of the mustard crop in three different days after sowing for mustard crop is presented in TABLE 3. [16] have reported that an average temperature of 20-25°C while an average relative humidity of more than 55-65% favour the development of these diseases. Thus, mean profile temperature of T8 (TPR-CTM) (16°C) and its mean profile humidity 68% favoured more infection in this treatment compared to conservation. Positive correlation between PDI of white rust and the mean profile temperature was obtained along with negative correlation between PDI and relative humidity and this was observed in case of T8 (TPR-CTM) and T2 (ZT DSR+ BM-ZTM) which showed higher mean profile temperature and lower mean profile humidity, thereby, causing more disease incidence. Conservation treatment T6 showed lowest PDI throughout the growing season due to unfavourable microclimate for the disease development. Mean profile temperature remained highest throughout the season while mean profile relative humidity was low which was not congenial for disease development. However, conservation treatment T2 (ZT DSR+ BM-ZTM) reported higher disease incidence due to availability of congenial temperature and humidity for the disease. This shows that T2 (ZT DSR+ BM-ZTM) microclimate became favourable for the diseases but reason for this is difficult to explain. Twenty eight percent of the species and their damage increased with decreasing tillage, 29% showed no significant influence of tillage, and 43% decreased with decreasing tillage [17].Therefore, conservation agriculture modifies the microclimate which directly impacts disease infection.

3.3 Above ground dry final biomass and seed yield

Above ground biomass and yields of mustard crop in all treatments (conservation and conventional) is given in Table 4. In mustard, final above ground biomass and yield was observed maximum in T6 (MBR+ ZT DSR- RR+ ZTM) (7.80 t ha^{-1} and 2.57 t ha^{-1} respectively) due to low damage done by white rust infection. T8 (TPR-CTM) showed the lowest final biomass (5.63 t ha^{-1}) and yield (1.67 t ha^{-1}) followed by T1 (ZT DSR- ZTM) and T2 (ZT DSR + BM – ZTM). Thus, despite being more disease population in T2 yield reduction was less compared to conventional treatment T8 (TPR – CTM).

IV. CONCLUSION

Micrometeorology plays crucial role in checking the population of white rust disease without causing environmental degradation. In this study, all the conservation plots showed lower percent disease index (PDI) in mustard except T2 (Zero Tillage Direct Seeded Rice + Brown Manuring – Zero Tillage Mustard). Treatment T6 (Zero Tillage Direct Seeded Rice+ Mungbean Residue- Rice Residue + Zero Tillage Mustard) showed PDI

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whereas conventional treatment T8 (Transplanted Rice - Conventional Till Mustard) showed maximum disease incidence. Mean profile temperature was highest and mean relative humidity was lower in T6 than rest of the other treatments. This created unfavourable condition for severe disease infection. This study revealed that certain agronomic practices such as conservation agriculture can prove an efficient way to manage disease infection below economic threshold level. High incidence of disease in conservation plot T2 is unexplainable and could be an area of further research. Microclimate modifying conservation agriculture practices can be used to reduce white rust population thereby decreasing the yield losses. Hence, it can be included in integrated pest management approach in future which would be best method of disease management without environmental pollution.

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TABLES

Table 1: Treatments adopted in the experiment

Table 2: Temporal variation of white rust in mustard as influenced by different treatments under conservation and conventional agriculture during winter (*rabi*) season (2014-15)

Table 3: Temporal variation in mean profile temperature within the canopy in mustard in different treatments under conservation and conventional agriculture during *winter (rabi)* season (2014-15)

Table 4: Final biomass and yield of mustard in different treatments under conservation and conventional practices during winter (*rabi*) season (2014-15)

FIGURES

Fig. 1: Weather parameters for winter (*rabi)* season (2014-15).

Fig. 2: Effects of different treatments under conservation and conventional agriculture on white rust infection in mustard during winter (*rabi)* season of (2014-15).

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TABLES

Table 1: Treatments adopted in the experiment

S. no.	Treatment description	Treatment short form	Treatment code
1	Zero Tillage Direct Seeded Rice–Zero Tillage Mustard	ZT DSR - ZTM	T1
2	Zero Tillage Direct Seeded Rice + Brown Manuring – Zero Tillage Mustard	ZT DSR + BM -ZTM	T2
3	Zero Tillage Direct Seeded Rice +Mustard Residue–Rice Residue + Zero Tillage Mustard	ZT DSR + MR – RR + ZTM	T3
4	Zero Tillage Direct Seeded Rice + Mustard Residue + Brown Manuring – Rice Residue + Zero Tillage Mustard	ZT DSR + MR + BM –RR + ZTM	T4
5	Zero Tillage Direct Seeded Rice+ Mungbean Residue- Zero Tillage Mustard	ZT DSR + MBR – ZTM	T5
6	Zero Tillage Direct Seeded Rice+ Mungbean Residue- Rice Residue + Zero Tillage Mustard	ZT DSR + MBR – RR + ZTM	T6
7	Transplanted Rice - Zero Tillage Mustard	TPR – ZTM	T7
8	Transplanted Rice - Conventional Till Mustard	TPR – CTM	T8

Treatments T1 to T7 were considered conservation agriculture (CA) treatments and treatments T8 was considered conventional treatments.

Table 2: Temporal variation of white rust in mustard as influenced different treatments under conservation and conventional agriculture during *rabi* season (2014-15)

SMW Treatments	51st	3rd	5th	7th
T1	14.89^{AB}	17.21^{AB}	18.54^{B}	21.20^{BC}
T2	17.54^{A}	18.21^{A}	19.32^{AB}	24.05^{A}
T3	10.37^{C}	16.12^{B}	18.90^{AB}	21.23^{BC}
T4	8.89^{CD}	13.44^{C}	16.23^{B}	19.12^{C}

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T5	8.37^{CD}	16.21^{B}	18.21^{B}	20.99^{BC}
T6	4.60^{D}	9.12^{D}	11.14^{ABC}	12.98^{D}
T7	11.11^{BC}	16.21^{B}	19.11^{AB}	20.98^{BC}
T8	11.85^{BC}	18.87^{A}	21.98^{A}	21.52^{B}

Values followed by same letter do not differ significantly by DMRT ;SMW- Standard Meteorological Week

Table 3: Temporal variation in mean profile temperature within the canopy in mustard in different treatments under conservation and conventional agriculture during winter *(rabi)* season (2014-15)

TREATMENTS	**Mean Profile Temperature**			**Mean Relative Humidity**		
	70 DAS (3^{rd} SMW)	80 DAS (5^{th} SMW)	95 DAS (7^{th} SMW)	70 DAS (3^{rd} SMW)	80 DAS (5^{th} SMW)	95 DAS (7^{th} SMW)
T1	15.70^{DE}	16.53^{BC}	21.33^{ABC}	70.53^{AB}	49.78^{BCD}	49.64^{ABC}
T2	15.63^{E}	16.30^{C}	21.07^{BC}	71.41^{A}	53.52^{AB}	50.58^{AB}
T3	16.00^{BC}	16.67^{AB}	21.35^{ABC}	68.49^{C}	49.93^{D}	45.27^{DE}
T4	16.23^{AB}	16.67^{AB}	21.67^{AB}	68.30^{C}	49.56^{BCD}	45.81^{DE}
T5	16.07^{BC}	16.63^{ABC}	21.83^{AB}	68.78^{BC}	51.59^{ABC}	47.80^{BCD}
T6	16.33^{A}	16.73^{A}	22.00^{A}	68.11^{C}	50.99^{ABC}	46.87^{CDE}
T7	16.07^{BC}	16.52^{BC}	21.20^{BC}	71.19^{A}	49.10^{CD}	44.26^{E}
T8	15.63^{E}	16.13^{D}	20.87^{C}	71.46^{A}	53.29^{A}	51.78^{A}

Values followed by same letter do not differ significantly by DMRT; DAS- Days after sowing; SMW- Standard Meteorological Week

Table 4: Final biomass and yield of mustard in different treatments under conservation and conventional practices during winter (*rabi*) season (2014-15)

TREATMENTS	**Final Biomass (t ha^{-1})**	**Yield (t ha^{-1})**
T1	5.50	1.54
T2	6.50	1.64
T3	6.40	2.04
T4	7.55	2.18
T5	6.83	1.89
T6	7.80	2.57
T7	6.03	1.63
T8	5.63	1.67
LSD ($p < 0.05$)	1.20	0.32

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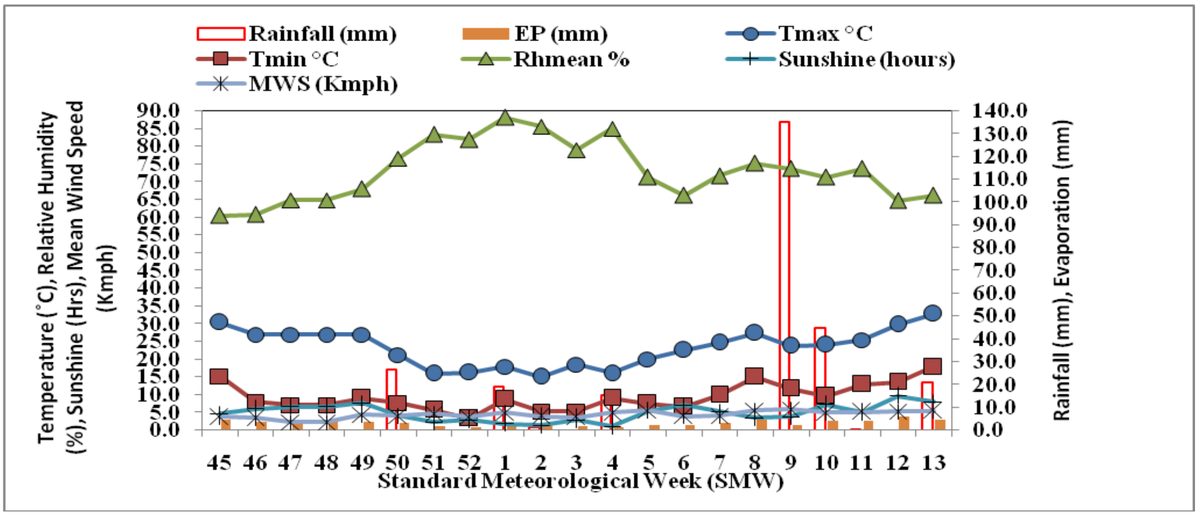

Fig 1: Weather parameters for winter (*rabi)* season (2014-15)

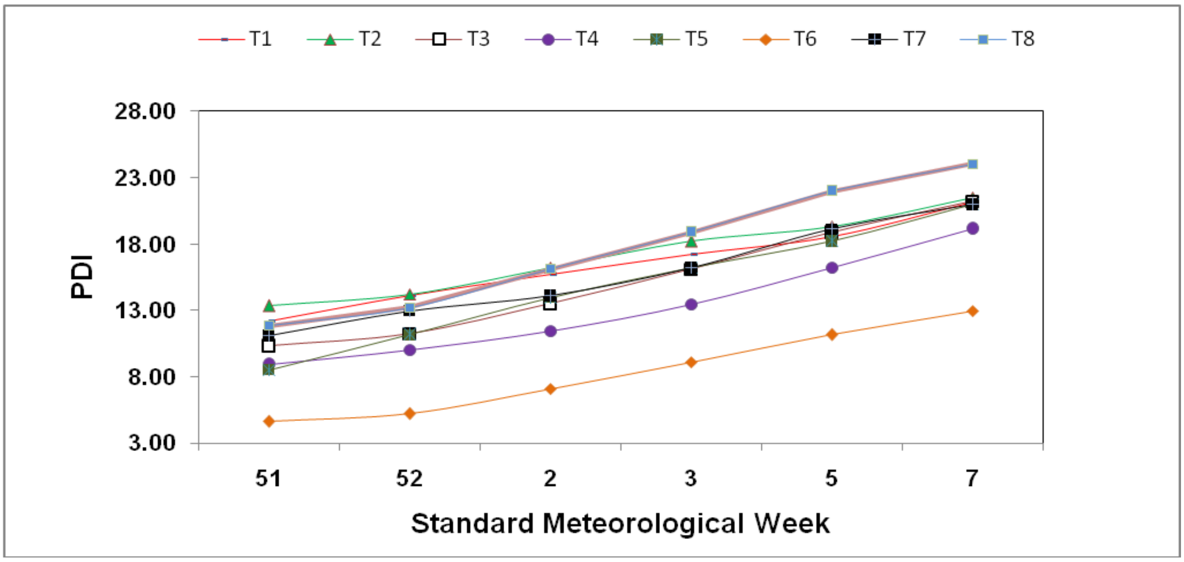

Fig 2: Effect of different treatments under conservation and conventional agriculture on White Rust (PDI) in Mustard at IARI farm during *rabi* season of 2014-15

T 1 = ZT DSR– ZTM, T 2 = ZT DSR + BM – ZTM, T 3 = MR + ZT DSR – RR + ZTM,
T 4 = MR + ZT DSR + BM –RR + ZTM, T 5 = MBR + ZT DSR – ZTM,
T 6 = MBR + ZT DSR – RR + ZTM, T 7 = TPR – ZTM, T 8 = TPR – CTM