RESEARCH ARTICLE

Removal of Old Leaves and Soil Touching Unproductive Branches of Tea Bushes for Controlling Red Rust Disease in Bangladesh

Islam M. Syeful[1*], Raihan M. Himel[2]

Abstract

Only leaf reduction (Cultural measure), in treatment T_4 [treated with leaf removal above 15 inches (38.10 cm) from ground level], maximum yield (2185.00 kgha^{-1}) was found to result 21.64% more over the control. T_3 [10 inches (25.40 cm)] and T_5 [20 inches (50.80 cm)] gave similar responses having 20 and 20.68% increased yield over the control. The lowest severity (21.38 PDI) was found in T_5 [20 inches (50.80 cm)] that was statistically identical to T_4 [15 inches (38.10 cm)] and T_3 [10 inches (25.40 cm)] having a decrease trend of 58.28, 50.26 and 42.59%, respectively. There is 92.99% impact of leaf reduction in reducing disease severity of red rust having a decrease trend of 7.2 PDI for removal of leaf by 5 inches (12.70 cm) from the soil level. Similarly, there is 81.44% impact of leaf reduction in increasing yield of made tea (kg ha^{-1}) having an increase trend of 103.01 unit for removal of leaf by 5 inches (12.70 cm) from the soil level. In leaf reduction (Cultural measure) with one round chemical application, treatment T_{13} [treated with leaf removal above 15 inches (38.10 cm) from ground level with one round of Carbendazim 50 WP] gave maximum yield (2,310.00 kgha^{-1}) resulted 28.61% more over the control followed by T_{15} [20 inches (50.80 cm) with one round of Carbendazim 50 WP] and T_{14} [20 inches (50.80 cm) with one round of Copper-oxichloride 50 WP] having 28.18 and 27.69% increased yield of made tea. Lowest severity (9.63 PDI) was found in T_{15} [20 inches (50.80 cm) with one round of Carbendazim 50 WP] having 41.21% reduction over control followed by identical PDI in T_{12} [15 inches (38.10 cm) with one round of Copper-oxichloride 50 WP], T_{13} [15 inches (38.10 cm) with one round of Carbendazim 50 WP] and T_{14} [20 inches (50.80 cm) with one round of Copper-oxichloride 50 WP] having 77.40, 77.31 and 77.79% reduction, respectively. There is 78.24% impact in reducing the disease severity of red rust, with a decrease trend of 2.23 PDI for removal of leaf by 5 inches (12.70 cm) from the soil level with one round chemical fungicide application. Similarly, there is a 51.76% impact in increasing the yield of made tea (kg ha-1) with an increase trend of 30.21 unit for removal of leaf by 5 inches (12.70 cm) from the soil level with one round chemical fungicide. From the benefit cost analysis it is projected that the treatment T_3 [10 inches (25.40 cm)] received the highest marginal rate of return (1202.17%) followed by 1152.17% in treatment T_4 [treated with leaf removal above 15 inches (38.10 cm). One round of systemic fungicides like Carbendazim 50 WP with this cultural practice gave 1034.21% and 1091.42% marginal rate of return, respectively. Considering yield of made tea, disease severity and benefit cost analysis viewpoint, it can be concluded that, the cost-effective treatment is removal of soil touching old leaves attached with tea bushes of MSK and LSK pruned sections within 10 inches (25.40 cm) to 15 inches (38.10 cm) from the soil level.

Keywords: Old leaves, Unproductive branches, Red rust, Yield, Economics.

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Introduction

Tea is the most popular and inexpensive beverage produced from the young shoots comprising of three leaves and a bud of the commercially cultivated tea plant (*Camellia sinensis* (L.) O. Kuntze). Tea being a perennial monocultural crop consists of a stable microclimate for a number of pests and diseases. Crop loss (loss in the yield) in tea due to pests, diseases and weeds recorded as high as 43%.[1] The perennial habit of the tea plant, unique cultural conditions and warm humid climate of the tea growing areas are highly favorable for disease infection. A number of diseases have been recorded in tea of which the majority is of fungal origin except red rust disease caused by an algal pathogen *Cephaleuros parasiticus* Karst. and *Cephaleuros virescens*. Bacteria, algae and viruses[2] cause a few. In a study on tea diseases, Chen and Chen[3] described nearly 400 pathogens of tea. Among the tea diseases, leaf diseases are very important because tea plants are cultivated for its young succulent leaves for manufacturing tea.[4] Of the leaf diseases, red rust is an important disease prevalent in both young and mature tea fields under adverse soil and climate conditions. The algae can infect the branches at any stage of growth. When tea plants are affected by parasitic red rust disease, the leaves become variegated (yellow or white) and whole coverage of spots in leaf due to epiphytic red rust. In extreme cases, red rust causes severe damage to young tea plants by killing stem tissues in patches. Once the branch is infected, the algae remain latent for a year. In the following year, depending on the first rain fruiting bodies of the pathogen are produced.[5] The predisposing factors of the disease are mainly poor fertility, alkalinity and lack of aeration of the soil, hardpan, inadequate or complete absence of shade, drought and waterlogging.[6]

Cephaleuros species are filamentous green algae and parasites of higher plants. As this plant pathogen is an algal species, it thrives under similar conditions as other algal organisms. *Cephaleuros* prefer moist, humid weather. This pathogen flourishes

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in areas with frequent rain and warm to high temperatures.[7,8] Infection occurs when either the sporangia or thallus filaments are deposited on the tissues of a susceptible plant host. Frequent rains and warm weather are favorable conditions for these pathogens. For hosts, poor plant nutrition, poor soil drainage, and stagnant air are predisposing factors to infection by the algae. The algae can be transmitted and spread more by the soil touching unproductive branches. These branches also obstruct proper aeration in the tea sections which causes hot and humid situation. Removal of soil touching unproductive branches as well as very old leaves can be helpful in checking the disease. Pruning of low-hanging branches that are affected by the disease, collecting and discarding all aged leaves around the tea plants reduce relative humidity, plant stress, fertilizing plants, and improving soil drainage.

Available literature in relation to control the disease suggests that potash fertilizer plays an important role in red rust infection. It is reported that nitrogen and potash are major elements for tea plant growth.[9] Tea plants become weak and vulnerable to disease at low nitrogen levels. Potassium plays an important role in developing bush frame as well as providing rigidity to the bushes. The incidence of red rust is low in the tea garden fertilized with a balance mixture of fertilizers, including potash. Healthy leaves of clones and seedlings contain more nitrogen and potash than that of the red rust infected ones.[10] Though red rust disease is a major threat to the Bangladesh Tea Industry, effective and acceptable management practices are yet to develop. During the last several decades, control of diseases in tea fields is predominantly done by the use of synthetic chemical fungicides.[11] To control the disease, copper oxychloride, mancozeb, Mancozeb + Metalaxyl and carbendazim are recommended to the tea planters.[12] Though broad-spectrum fungicides offer powerful incentives in the form of good control, increased yield and high economic returns, they have serious drawbacks such as development of resistance to fungicides, the resurgence of pathogens, outbreak of secondary diseases, harmful effects on human health and environment and presence of undesirable residues. Early days, red rust was controlled by manually removing the infected leaves and burning them in the field.

To overcome this alarming situation, such kind of study was taken To find out the best cultural practices for controlling Red rust disease by reducing very old leaves and soil touching unproductive branches during LSK and MSK pruning operation.

Materials and Methods

A field experiment was conducted during 2020 - 2021 in D2 Thal- an experimental tea field of Bangladesh Tea Research Institute (BTRI), Srimangal to standardized best cultural practice for controlling red rust disease of tea. The experiment was laid out in a randomized complete block design (RCBD) with fifteen treatments having three replications of each. The unit plot size was 8×5m. Number of bushes in each plot was counted. To minimize the variation in per plot bush number, bushes in all unit plots of the experimental field were counted and divided by the total number of unit plots. The average number of bushes in each plot was considered for data computing. The treatments were T_1= Control, T_2= 5 inches (12.70 cm), T_3= 10 inches (25.40 cm), T_4= 15 inches (38.10 cm), T_5= 20 inches (50.80 cm), T_6= Copper-oxichloride 50 WP, T_7= Carbendazim 50 WP, T_8= T_2+ Copper-oxichloride 50 WP, T_9= T_2+ Carbendazim 50 WP, T_{10}= T_3+ Copper-oxichloride 50 WP, T_{11}= T_3+ Carbendazim 50 WP, T_{12}= T_4+ Copper-oxichloride 50 WP, T_{13}= T_4+ Carbendazim 50 WP, T_{14}= T_5+ Copper-oxichloride 50 WP and T_{15}= T_5+ Carbendazim 50 WP. Treatments T_2, T_3 T_4 and T_5 were applied after MSK and LSK skiff pruning operation in tea plants during February of the year. During May to June Copper-oxichloride 50 WP and Carbendazim 50 WP were sprayed single and along with T_2, T_3 T_4 and T_5. For single application of the said chemical one repeat application was sprayed at 7 days interval for Copper-oxichloride 50 WP and 15 days for Carbendazim 50 WP. No repeat spray was done for combined treatment with T_2, T_3 T_4 and T_5. Copper-oxichloride 50 WP was sprayed @ 2.8 $kgha^{-1}$ and Carbendazim 50 WP was applied @ 750 gm ha^{-1}.

Data on production of green leaves and severity of red rust disease were recorded. Green leaves were harvested at seven to ten days interval maintaining plucking standard. Per plot yield of green leaves was recorded and following converted to made tea in $kgha^{-1}$ based on 23% recovery. To collect data on severity of red rust, twenty bushes were selected in each plot following simple random technique. Close observation was made on the selected bushes and disease severity was graded on the basis of a 0-5 scale, where 0= no infection, 1=1-20%, 2=21- 40%, 3= 41- 60%, 4= 61- 80%, and *5*= 81- 100% infection[13]. The severity was expressed in percent disease index (PDI), which was computed following a standard formula as described below[14]

$$\text{Percent Disease Index (PDI)} = \frac{\text{Sum of all disease ratings}}{\text{Total number of ratings} \times \text{maximum disease grade}} \times 100$$

Data Analysis

Collected data were analyzed statistically by Statisticx 10- computer programme. Means were compared following LSD test using the same computer programme. Cost analysis was done as per[15].

Results and Discussion

All treatments regarding with control measures of Epiphytic Red rust (Leaf rust) showed more or less significant increase of made tea yield and reduced disease severity compared to control where no control measures were taken. Old leaves reduction from tea bushes of MSK and LSK pruned sections has a great positive effect on the reducing the severity of Red rust (Leaf rust) disease and increasing the yield of made tea (kg/ ha). In case of only leaf reduction (Cultural measure), in treatment T_4 [treated with leaf removal above 15 inches (38.10 cm) from ground level], there was found maximum yield (2185.00 $kgha^{-1}$) resulted 21.64% more over the control (Table 1). This is statistically similar to T_3 [10 inches (25.40 cm)] and T_5 [20 inches (50.80 cm)] having 20 and 20.68% increased yield of made tea over the control. These are followed by T_2 [5 inches (12.70 cm)] and T_1 [no leaf removal] with 5.67 and 00%, respectively (Table 1). In case of reduction of disease severity over the control, the lowest severity (21.38 PDI) was found in T_5 [20 inches (50.80 cm)]. This is statistically identical to T_4 [15 inches (38.10 cm)] and T_3 [10 inches (25.40 cm)] having a decrease trend of 58.28, 50.26 and 42.59% over the control, respectively (Table 1).

There is 92.99% impact of leaf reduction in reducing disease severity of red rust having a decreasing trend of 7.2 PDI for removal of leaf by 5 inches (12.70 cm) from the soil level (Figure 1). Similarly, there is 81.44% impact of leaf reduction in increasing yield of made tea (kg ha^{-1}) having an increase trend of 103.01 unit for removal of leaf by 5 inches (12.70 cm) from the soil level (Figure 2).

In case of leaf reduction (Cultural measure) with one round chemical application, in treatment T_{13} [treated with leaf removal above 15 inches (38.10 cm) from ground level with one round of Carbendazim 50 WP], there was found maximum yield (2,310.00 $kgha^{-1}$) resulted 28.61% more over the control followed by T_{15} [20

Table 1: Effect of leaf reduction level on the severity of Red rust disease and yield of made tea (kg ha^{-1})

Treatment	*Percent disease index (PDI)*		*Yield of made tea (kg ha^{-1})*	*% Increased over the control*
	PDI	*% Reduction*		
T_1= Control	51.25 a	00	1,796.20 c	00
T_2= 5 inches (12.70 cm)	38.16 b	25.54%	1,898.10 b	5.67%
T_3= 10 inches (25.40 cm)	29.42 c	42.59%	2,155.60 a	20%
T_4= 15 inches (38.10 cm)	25.49 cd	50.26%	2,185.00 a	21.64%
T_5= 20 inches (50.80 cm)	21.38 d	58.28%	2,167.80 a	20.68%
CV	7.72		0.57	
LSD (P= 0.05)	7.20		32.68	

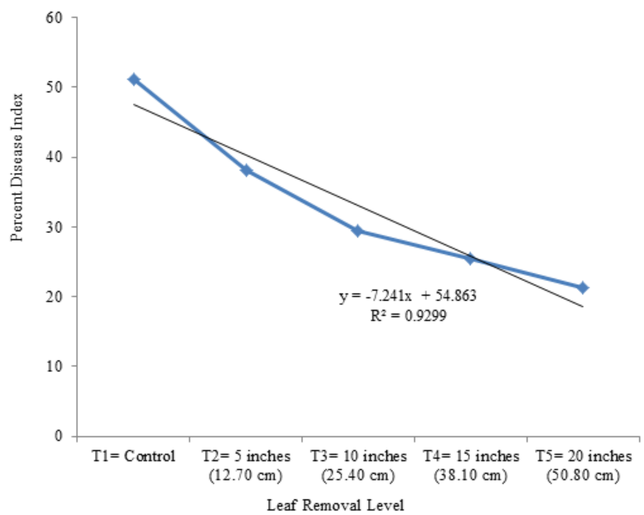

Figure 1: Regression between disease severity and level of leaf reduction from soil

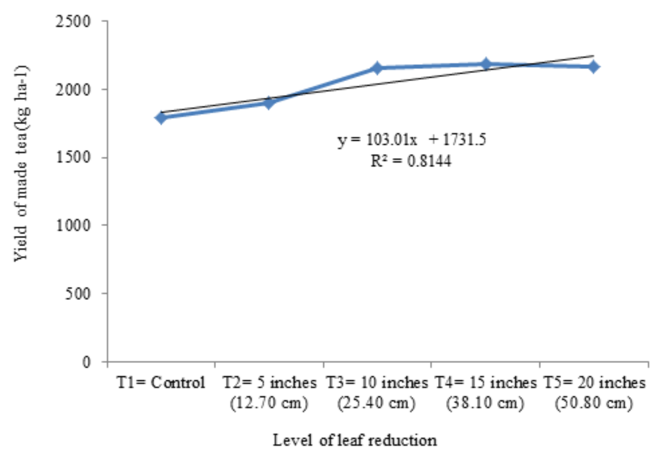

Figure 2: Regression between yield of made tea and level of leaf reduction from soil

Table 2: Effect of leaf reduction level and fungicides on the severity of Red rust disease and yield of made tea (kg ha^{-1})

Treatment	*Percent disease index (PDI)*		*Yield of made tea (kg ha^{-1})*	*%Increased over the control*
	PDI	*% Reduction*		
T_1= Control	51.25 a	00	1796.20 o	00
T_2= 5 inches (12.70 cm)	38.16 b	25.54	1898.10 l	5.67
T_3= 10 inches (25.40 cm)	29.42 c	42.59	2155.60 i	20.00
T_4= 15 inches (38.10 cm)	25.49 d	50.26	2185.00 g	21.64
T_5= 20 inches (50.80 cm)	21.38 e	58.28	2167.80 h	20.68
T_6= Copper-oxichloride 50 WP	20.40 ef	60.20	1822.70 n	1.48
T_7= Carbendazim 50 WP	20.00 f	60.98	1840.00 m	2.44
T_8= T_2+ Copper-oxichloride 50 WP	17.61 g	65.64	2018.20 k	12.37
T_9= T_2+ Carbendazim 50 WP	19.41 f	62.13	2138.00 j	19.04
T_{10}= T_3+ Copper-oxichloride 50 WP	13.55 i	73.56	2206.40 f	22.85
T_{11}= T_3+ Carbendazim 50 WP	16.00 h	68.78	2246.20 e	25.06
T_{12}= T_4+ Copper-oxichloride 50 WP	11.58 j	77.40	2296.10 d	27.84
T_{13}= T_4+ Carbendazim 50 WP	11.63 j	77.311	2310.00 a	28.61
T_{14}= T_5+ Copper-oxichloride 50 WP	11.38 j	77.79	2298.30 c	27.96
T_{15}= T_5+ Carbendazim 50 WP	9.63 k	81.21	2302.20 b	28.18
CV	2.02		1.02	

inches (50.80 cm) with one round of Carbendazim 50 WP] and T_{14} [20 inches (50.80 cm) with one round of Copper-oxychloride 50 WP] having 28.18 and 27.69% increased yield of made tea over the control (Table 2).

In case of reduction of disease severity over the control, the lowest severity (9.63 PDI) was found in T_{15} [20 inches (50.80 cm) with one round of Carbendazim 50 WP] having 41.21% reduction over control followed by identical PDI in T_{12} [15 inches (38.10 cm) with one round of Copper-oxychloride 50 WP], T_{13} [15 inches (38.10 cm) with one round of Carbendazim 50 WP] and T_{14} [20 inches (50.80 cm) with one round of Copper-oxychloride 50 WP] having 77.40, 77.31 and 77.79% reduction respectively (Table 2).

There is a 78.24% impact of leaf reduction in reducing the disease severity of red rust, with a decreasing trend of 2.23 PDI for removal of leaf by 5 inches (12.70 cm) from the soil level with one round chemical fungicide application (Figure 3). Similarly, there is 51.76% impact of leaf reduction with one round chemical fungicide application in increasing yield of made tea (kg ha^{-1}) having an increasing trend of 30.21 unit for removal of leaf by 5 inches (12.70 cm) from the soil level with one round chemical fungicide (Figure 4).

From the benefit cost analysis (Table 3), it can be projected that the treatment T_3 [10 inches (25.40 cm)] received the highest marginal rate of return (1202.17%). It means that if the planter has spent an additional 100 taka, they will get an extra income of taka 1202.17 over the control followed by the treatment T_4 [treated with leaf removal above 15 inches (38.10 cm). One round of systemic fungicides like Carbendazim 50 WP with this cultural practice gave 1034.21 and 1091.42% marginal rate of return, respectively (Table 3).

Plants and plant parts are some of the best reservoirs of disease organisms. Destroy or remove crop residues, culled fruits, unused

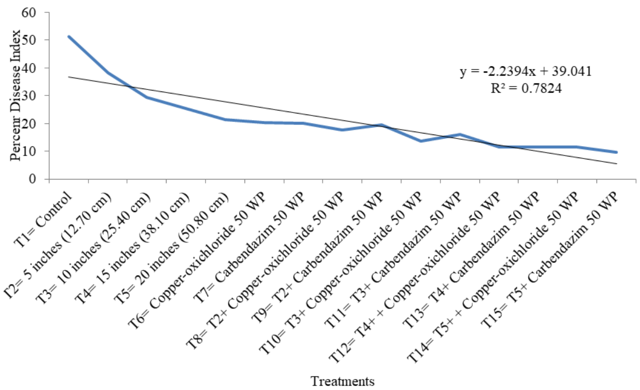

Figure 3: Regression between disease severity and level of leaf reduction from soil with one round chemical fungicide

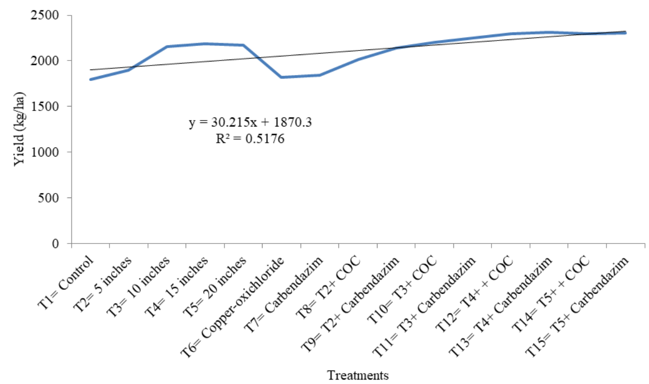

Figure 4: Regression between yield of made tea and level of leaf reduction from soil with one round chemical fungicide

Table 3: Benefit cost analysis of different treatments used in controlling Leaf rust disease

Treatment	*Yield of made tea (kgha^{-1})*	*Gross Return (Tkha^{-1})*	*Variable cost (Tkha^{-1})*	*Gross margin (Tkha^{-1})*	*Marginal gross margin*	*Margin variable cost*	*Margin rate of return (%)*
T_1= Control	1,796.20 o	3,59,240.00	00.00	3,59,240.00	00.00	00.00	00
T_2= 5 inches (12.70 cm)	1,898.10 l	3,79,620.00	4,830.00	3,74,790.00	15,550.00	4,830.00	321.94
T_3= 10 inches (25.40 cm)	2,155.60 i	4,31,120.00	5,520.00	4,25,600.00	66,360.00	5,520.00	1202.17
T_4= 15 inches (38.10 cm)	2,185.00 g	4,37,000.00	6,210.00	4,30,790.00	71,550.00	6,210.00	1152.17
T_5= 20 inches (50.80 cm)	2,167.80 h	4,33,560.00	6,900.00	4,26,660.00	67,420.00	6,900.00	977.10
T_6= Copper-oxichloride 50 WP	1,822.70 n	3,64,540.00	9,844.00	3,54,696.00	-4,544.00	9,844.00	-46.16
T_7= Carbendazim 50 WP	1,840.00 m	3,68,000.00	4,830.00	3,63,170.00	3,930.00	4,830.00	81.36
T_8= T_2+ Copper-oxichloride 50 WP	2,018.20 k	4,03,640.00	9,752.00	3,93,888.00	34,648.00	9,752.00	355.29
T_9= T_2+ Carbendazim 50 WP	2,138.00 j	4,27,600.00	7,245.00	4,20,355.00	61,115.00	7,245.00	843.54
T_{10}= T_3+ Copper-oxichloride 50 WP	2,206.40 f	4,41,280.00	10,442.00	4,30,838.00	71,598.00	10,442.00	685.67
T_{11}= T_3+ Carbendazim 50 WP	2,246.20 e	4,49,240.00	7,935.00	4,41,305.00	82,065.00	7,935.00	1034.21
T_{12}= T_4+ + Copper-oxichloride 50 WP	2,296.10 d	4,59,220.00	11,132.00	4,48,088.00	88,848.00	11,132.00	798.13
T_{13}= T_4+ Carbendazim 50 WP	2,310.00 a	4,62,000.00	8,625.00	4,53,375.00	94,135.00	8,625.00	1091.42
T_{14}= T_5+ + Copper-oxichloride 50 WP	2,298.30 c	4,59,660.00	11,822.00	4,47,838.00	88,598.00	11,822.00	749.43
T_{15}= T_5+ Carbendazim 50 WP	2,302.20 b	4,60,440.00	9,315.00	4,51,125.00	91,885.00	9,315.00	986.42

seedbed plants, and pruning as soon as the crop is harvested or the cultural operation is completed. Crop residues may be destroyed by burning or composting, or buried by cultivation. Shredding crop residues hastens their decomposition. Take care that disease organisms are not transported in plant parts and soil from one field to another by cultivation equipment, crates, sacks, pots, or tools used in planting, pruning, spraying, cultivating, and harvesting. Removal of infected plant parts by pruning has been recommended for the control of fungal pathogens of perennial crops, for example, black Sigatoka disease during the establishment phase of plantains[16], while pruning of infected plant parts and removal and destruction of plant debris form an integral part of the management of *Botrytis* in greenhouses[17]. Removal of plant debris by burning was shown to reduce severity of tan spot (*Pyrenophora tritici-repentis*) in wheat and to increase yields[18]. Reducing the sowing density of barley can decrease the severity of *R. secalis* epidemics[19], probably by decreasing the crop canopy density thereby altering microclimate and ensuring inadequate leaf wetness for germination of *R. secalis* conidia[20]. The findings of present study are partially revealed by the above. The mechanism for controlling plant diseases through cultural approaches are the same.

Conclusion

Considering yield of made tea, disease severity and benefit-cost analysis viewpoint, it can be concluded that, the cost-effective treatment is the removal of soil touching old leaves attached with tea bushes of MSK and LSK pruned sections within 10 inches (25.40 cm)- 15 inches (38.10 cm) from the soil level. Further research may be conducted with the combinations of Integrated Disease Management components and new fungicide molecules to find a better result.

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