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Short Communication

Evaluations of Garlic Varieties and Fungicides for the Management of White Rot (Sclerotium cepivorum Berk.) in West Showa, Ethiopia

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Abstract

Garlic (Allium sativum L.) is the second most widely cultivated vegetables next to onion in Ethiopia and mainly produced for its medicinal and nutritional purpose white rot caused by a soil borne fungus (Sclerotium cepivorum Berk.) is a major production threat of garlic where ever the crop is grown. Therefore, this study was carried out to evaluate the effectiveness of fungicides, and garlic varieties against garlic white rot in West Shewa, Ethiopia. The field experiment was conducted at Ambo University, Gudar campus experimental field in 2018/2019 cropping season, arranged in 5 x 3 factorial treatment combination of five varieties namely Holeta, Chefe, Tseday (G-493), kuriftu and local cultiver (as check) and two fungicides namely Pro-seed plus 63 WS and Tebuconazole (Natura 250 EW) along with the untreated control plots in randomized complete block design with three replications. Garlic cloves were treated using fungicides before planting. A total of fifteen treatments were evaluated per replication. Two fungicides were effective in reducing the disease epidemics and improving garlic yield over untreated plots. However, among fungicides used, plots treated with Pro-seed plus was the most effective in reducing the disease epidemics and gave better yield advantage. Pro-seed plus 63 Ws treated plots 57.12 %, 35 % and 64.25 % reduced initial, final incidence and final severity was recorded respectively as compared to untreated plots. The results showed significantly highest marketable yield was recorded from Tseday varieties treated with Pro-seed plus 63 WS (3.047t ha-1) followed by Kuriftu varieties treated with the same fungicides (2.973t ha-1) compared to the untreated control plots. Significantly, higher net profit was obtained from Pro-seed plus 63WS treated varieties compared to Tebuconazole and untreated control plots. Among the garlic varieties, Tseday (G-493) was promising in reducing the disease epidemics and gave better total and marketable bulb yield. Further research should be conducted with the same varieties combinations with fungicides against white rot under multi locations and in different seasons.

Keywords: Garlic, White rot, Sclerotium cepivorum, Disease epidemics, Fungicides, Pro-seed plus, Tebuconazole

Introduction

Garlic *(Allium sativum* L.*)* is a member of *Alliaceae* family with an erect biennial herb normally grown as annual crop and it's originated in the north-western side of the Tien-Shan Mountains of Kirgizia in the arid and semi-arid areas of central Asia (Etoh and Simon, 2002). It is an excellent source of several minerals and vitamins that are essential for health and has medicinal role for centuries such as antibacterial, antifungal, antiviral, antitumor and antiseptic properties (Deresse, 2010; Sovova and Sova, 2004). In Ethiopia, garlic has been used as medicine for a range of skin and stomach problems and to treat many conditions such as common cold (Kero, 2010). Its Economic significance in Ethiopia is quite considerable. It is grown as spice and used for flavoring local dishes, and contributes to the national economy as export commodity (Fekadu and Dandena, 2006). Production of cash crops like garlic and other spices is proved to be income generating activity for farmers, especially for those who have limited cultivated land or small holder farmers (FAO, 2016).

The world garlic cultivation is increasing from 771,000 ha of lands in 1989/90 to 26,573,001 ha of lands in 2016 with total production from 6.5 million to 26.6 million tons, and productivity from 8.43 quintals/ha to 180.915 quintals/ha, respectively (FAO, 2016). In Ethiopia, the total area under garlic production in 2016/17 reached 15,381.01 ha and the production is estimated to be over 1,386,643.07 quintals, percent distribution (6.71%) and yield 90.15 quintals/ha (CSA, 2016-2017). In West Shewa zone, the garlic is widely cultivated using rain.

In spite of its importance and increased production, garlic productivity in many parts of the world is low due to genetic, abiotic and biotic factors (Nonnecke, 1989). Numerous production problems accounted for the low yield of garlic in Ethiopia: lack of proper diseases and insect pest management practices, lack of improved planting materials, inappropriate agronomic practices and marketing facilities are the main constraints (Zeray and Mohammed 2013). However, the most important constraint for garlic production and productivity are fungal diseases. Of the fungal diseases, white rot caused by *Scerotium cepivorum* is the most destructive disease of garlic throughout the world including Ethiopia (Dennis, 1986). According to Amin *et a.l*, 2014, white rot is the most pressing problem to the subsistence onion and garlic farming community more than any other category of vegetable diseases in Ethiopia., Around Northern Shewa of Ethiopia, white rot incidence was reported at a level ranging from 37.28 to 42% in farmers' fields and the yield loss has been found to range between 20.7 and 53.4 % (Tamire *et al*., 2007).

Management of diseases caused by soil-borne pathogens like *S. cepivorum* needs a multi-pronged management strategy. In Ethiopia research efforts on host resistant against white rot is very limited. Fungicides are among the most effective options for garlic white rot management. According to Tamire *et al*. (2007), systemic as well as non-systemic fungicides significantly reduce incidence of white rot, its progress rate, severity, and there by improved garlic yield. Tebuconazole was the effective in reducing the incidence and progress of the disease and in increasing the yield when applied as clove treatment (Melero-Vara *et al*., 2000; Duff *et al*., 2001). In Ethiopia, no detailed information available on the integrated management of garlic white rot involving varieties and fungicides. This study, therefore, was carried out to evaluate the best combination (s) of garlic varieties and fungicides to manage white rot, and assess garlic yield losses incurred due to the diseases in Gudar, West Shewa, Ethiopia.

Materials and methods

Description of the study area

The field experiment was conducted at Ambo University, Gudar campus experimental farms, during 2018/19 main cropping season under rain fed. Gudar is located 130 km West of Addis Ababa at 8°98' North latitude, 37°83' East longitude and altitude ranging from 2000-2010. The area receives annual rainfall between 900-1100 mm, and temperature ranging from 10-27 ºC, with an average of 18 ºC.

The soil type of the study site is vertisol with a pH value of 6.7 (EARO, 2004). The trial was conducted in experimental field naturally infested with white rot sclerotia based on the previous year's history that it was planted to garlic and onion infested by *S. cepivorum*.

Experimental materials used

Varieties used: Five garlic varieties viz. Holeta (G-HL), Chefe (G-104-1/94), Tsedey (G-493), Kuriftu (G-59-2/94) and local were used for the field trial. Holeta, Chefe, Kuriftu and Tsedey are improved varieties released by Debre Zeit Agricultural Research Center, while the local variety was obtained from Gudar areas locally cultivated by farmers.

Table1.Characteristics of garlic varieties used in this experiment.

Garlic varieties	Genotype	Year released	Breeder/Maintainer
Holeta	(G - HL)	2015	DebreZeit ARC/ EIAR /
Chefe	(G -104-1/94)	2015	DebreZeit ARC/ EIAR /
Kuriftu	(G-59-2/94)	2010	DZARC/EIAR
Tsedey	(G-493)	1999	DZARC/EIAR
Local	*	*	Gudar Farmers

Fungicides used, their Preparation and applications:

The registered fungicides, Tebuconazole (Natura 250 EW 0.5lts/ha), which is recommended for garlic white rot is used as a standard check and Pro-seed plus 63 WS (200g/100kg) which is registered for soil and seed borne diseases were used as test fungicide. Fungicides were obtained from Lion International Trading PLC, Addis Ababa, Ethiopia. Clove coating with wettable powders of Pro-seed plus 63 WS was done by making slurry of the required fungicide in 5 ml of water and then coating on 480 g cloves in a polythene bag by rotating repeatedly. Cloves dip treatment of Tebuconazole was done by dipping 480 g cloves in solution of 1ml Tebuconazole in one liter of water for 5 hr and also each variety are compared with control separately (Getachew *et al.*, 2011).

Experimental Design and Management

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications in 3 m^2 plots with 1 m spacing between blocks and 0.5 m between plots. The experiment was arranged in two factors of each at three levels (5 x 3) factorial experiment of five varieties and two fungicides along with the untreated control. The trial was conducted in a field naturally infested by white rot sclerotia.

Uniform size and healthy cloves of garlic varieties treated with fungicides were planted in experimental fields on August 7, 2018 at Gudar Campus. The planting was done in a plot of five rows with 0.30 m between rows and 0.15m between plants in the row.

Data collection:

Data for initial and final plant stand count at emergence and harvest, and the disease incidence (percent diseased plants) was recorded from each plot. Garlic initial stand establishment was determined as percentage of germinated cloves at 30 DAP (days after planting) and final stand count as the bulb harvested. Plant height was also recorded from 15 randomly selected plants at the maximum growth stage. White rot incidence was recorded six times every 15 days interval from the first appearance of the disease in the plots.

The number of infected plants were counted from three central rows of 12 pre tagged plants per each plot at 45, 60, 75, 90, 105 and 120 DAP (days after planting). Disease incidence was calculated according to the following equation:

$$\text{Disease incidence } \% = \frac{\text{Number of diseased plants}}{\text{Total number of plants inspected}} \text{x100}$$

Bulbs were harvested from the middle three rows and the bulbs collected from each plot were allowed to dry for 15 days and weighed to determine yield and other yield components like bulb diameter, number of cloves per bulb, total and marketable yields and infected bulbs were selected from harvested bulbs and severity was rated on 0-5 scale where 0 = healthy; 1 = bulb covered with mycelium but not rotted; 2 = 1-25% of the bulb rotted; 3 = 25-50% of the bulb rotted 4 = 50-75% of the bulb rotted and 5 = 75-100% of the bulb rotted (Tian and Bertolini, 1995). Disease severity scores were converted into percentage as per procedures stated below:

$$\text{Disease severity } (\%) = \frac{\text{Total Point score}}{\text{Total number of bulbs scored} * \text{highest score on the scale}} \text{X } 100$$

Area under disease progress curve (AUDPC) was calculated for each treatment from the assessment of disease incidence using the formula:

$$AUDPC = \sum_{t-1}^{n-1}\left[\frac{1}{2}(X_i + X_{i+1})(t_{i+1} - t_i)\right)$$

Where xi is the disease incidence in percentage at ith assessment, ti is the time of the ith assessment in days from the first assessment date, and n is the total number of days the disease was assessed (Campbell and Madden, 1990). Because incidence was expressed in percent and time in days, AUDPC was expressed in %-days.

Disease incidence was transformed using linear model ln(y/l-y) (Campbell and Madden, 1990) transformation before analysis. Transformed data were subjected to linear regression to determine disease progress rate. The disease progress rate for each plot was estimated as the slope of the regression line of the disease progress data. In all cases, DAP (Days after planting) was used as predictor and incidence as response variables.

The relative losses in yield of each treatment were determined as percentage of the treated plots of the experiment. Losses were calculated separately for each of the treatments. Percentage of the protected plots and yield loss was calculated based on the formula (Lotz *et al*., 1990).

$$RYL(\%) = \frac{(Yp - Yt)}{Yp} * 100$$

Where, RYL =Relative Yield Loss in percent, YP =Yield from the maximum treated plots and Yt= yield from other plots.

Data Analysis

All data were analyzed and ANOVA was performed for a randomized completely blocks designs with factorial arrangement of treatments to evaluate the effect of fungicides and varieties using SAS software (SAS Institute, 2008). Treatments means were compared using fisher's least significant difference (LSD).

Cost - benefit Analysis

Prices of garlic bulbs (Birr ton^{-1}) were obtained from local market and total sale from one hectare was computed. The price of all improved and local garlic cultivar was birr 24000/800 kg. The price of fungicides, Tebuconazole and Pro-seed Plus 63 WS were 625 birr per liter and 960 birr per kilogram, respectively.

Cost benefit analysis was performed using partial budget analysis. Partial budget analysis is a method of organizing data and information about the cost and benefit of various agricultural alternatives (CIMMYT. 1988). It provides the value of benefit obtained per the amount of additional cost incurred in percentage. The formula is as follows.

$$MRR = \frac{DNI}{DIC} * 100$$

Where, MRR is marginal rate of returns, DNI, difference in net income compared with control, DIC, difference in input cost compared with control,

The following points were considered during cost benefit analysis using partial budget.

- Costs for all agronomic practices were uniform for all treatments.
- Price of garlic bulb per tons for each variety was taken based on local price
- Costs of labor was taken based on local price
- Costs and benefit were calculated per hectare basis.

Results and discussions

White rot incidence, severity and AUDPC

In this study, the white rot symptoms were noticed 40 days after planting. Infected plants had yellowish lower leaves, and wilting symptoms. Significantly lowest initial and final disease incidence was observed on fungicide treated plots as compared to untreated plots. The results showed that in plots treated with Pro-seed plus 63 WS and Tebuconazole, the average final disease incidences were, respectively, reduced by 35% and 11% as compared to the untreated plots. The lowest initial and final white rot incidence was recorded from the interaction of fungicide with a variety as compared with untreated ones.

The results showed that the lowest initial (2.78%) and final (33.33%) diseases incidences were recorded from Tseday variety treated with a Pro-seed plus **63WS** as compared with other interactions. The highest initial and final incidences were recorded from untreated varieties viz. local, Holeta and Chefe, in order, as compared to other treatments. The results showed that the variety Tseday and Pro-seed plus 63 WS fungicides were promising in reducing diseases incidence followed by Kuriftu variety and Tebuconazole treated plots (Table 2).

Table 2. Interaction effect of fungicide and varieties on white rot incidence, severity and AUDPC at Gudar, West Shewa, Ethiopia during 2018/2019*

Treatments	**IWRI (%)**	**FWRI (%)**	**WRS (%)**	**AUDPC**
Holeta + Tebuconazole	16.67[e]	55.55[c]	13.33[bcd]	2667[f]
Holeta + Proseed plus 63 WS	8.33[bc]	41.67[b]	12.00[bcd]	2000[bc]
Holeta control	16.67[e]	58.33[c]	18.67[d]	3062[g]
Chefe + Tebuconazole	8.33[bc]	47.22[b]	13.33[bcd]	2292[de]
Chefe + Proseed Plus63WS	8.33[bc]	41.67[b]	6.67[ab]	1833[b]
Chefe control	13.89[de]	66.67[d]	29.33[e]	3188[g]
Tseday + Tebuconazole	8.33[bc]	44.45[b]	9.33[abc]	2104[cd]
Tseday + Proseed plus 63WS	2.78[a]	33.33[a]	4.00[a]	1354[a]
Tseday control	16.67[e]	55.55[c]	12[bcd]	2458[ef]
Kuriftu + Tebuconazole	8.33[bc]	55.55[c]	13.33[bcd]	2396[e]
Kuriftu + Proseed plus 63WS	5.55[ab]	41.67[b]	10.67[abc]	1937[bc]
Kuriftu control	13.89[de]	55.55[c]	18.67[d]	2521[ef]
Local + Tebuconazole	11.11[cd]	47.22[b]	16.00[cd]	2146[cd]
Local +Proseed plus 63WS	8.33[bc]	44.45[b]	9.33[abc]	1771[b]
Local control	16.67[e]	66.67[d]	42.67[f]	2958[g]
CV (%)	**25.4**	**7**	**30.7**	**6.1**
LSD (5%)	**4.68**	**6.05**	**7.9**	**241.8**

*Means in every columns with same letters are not significant difference at ($P<0.05$)
CV= Coefficient of Variation; LSD= Least Significant Difference, (IWRI) =Initial white rot incidence at 45 days after planting (DAP), (FWRI) =Final white rot incidence at 120 days after planting (DAP), (WRS) =white rot severity on harvested bulbs; AUDPC = Area under Disease Progress Curve

Disease severity data recorded on harvestable bulbs also indicated the significant differences among treatments ($p<0.05$). Significantly highest severity was recorded on untreated control plots when compared to fungicide treated plots. In Pro-seed plus 63 WS treated plots, disease severity was reduced by 64.25%, while it was reduced by 46.15% in Tebuconazole treated plots as compared to untreated control plots. Significant difference of disease severity was recorded among treatment combinations involving varieties and fungicides (Table 2). The highest percentage of diseases severity was recorded from untreated local variety (42.67%) and the lowest percentage of disease severity was recorded from Tseday variety treated with Pro-seed plus 63 (4.0%).

Statistically significant differences were observed among treatments on Area under Disease Progress Curve (AUDPC) value at ($P<0.05$). As compared to other treatments, the lowest AUDPC (1354 % -days) was recorded from Tseday variety treated with Pro-seed plus, while the highest AUDPC was recorded from untreated Chefe variety (3188%-days). Even if the two fungicide treatments were effective in reducing white rot incidence, severity and AUDPC as compared to untreated plots, complete control was not attained. This result is in line with the previous research findings of different authors. For instance, Tamire *et al*. (2007) reported that the systemic as well as non-systemic fungicides significantly reduced incidence of white rot, its progress rate, severity, and there by improved garlic yield. Similarly, Duff *et al.* (2001) reported that Tebuconazole was effective in reducing the incidence, severity and progress of the disease and increased yield when applied as clove treatments. Fullerton and Stewart (1991) also found that the disease incidence was reduced by up to 85% in Tebuconazole treated plots compared with untreated plots in onion.

Getachew *et al.* (2011) reported that fungicide treatments protected plants not only from white rot at different stages, but also reduced the formation of sclerotia in the soil as recorded at the time of harvesting. In this study the degree of disease control achieved by treating with Pro-seed plus 63 WS was higher than that treated by Tebuconazole and untreated control plots. Melero-Vara *et al*. (2000) achieved similar result that treatment of garlic cloves with Tebuconazole and basal spray resulted in significant reduction of disease progress rate and the final incidence of plant death by white rot.

Similarly, Prados-Ligero *et al*. (2002) reported significant reduction of disease incidence, severity and AUDPC values in solarized and Tebuconazole treated cloves, and thereby resulted in quantitative and qualitative yield improvement. Other researchers were also reported that the combinations of Tebuconazole and bio-agents enhanced the control of onion white rot (Clarkson *et al.*, 2006; Ararsa and Selvaraj, 2013).

Table 3. Garlic white rot incidence progress rate under treatment combination involving fungicides and varieties.

Treatments	Intercept	SE* of Intercept	Disease progress rate **	SE*of rate	R^2 (%)	Significant
Holeta + Tebuconazole	-2.646	0.153239	0.02422	0.02348	94%	0.0001
Holeta + Proseed Plus63WS	-3.458	0.274383	0.02783	0.07529	88%	0.0001
Holeta control	-2.538	0.214271	0.02533	0.04591	91%	0.0001
Chefe + Tebuconazole	-3.426	0.268787	0.02971	0.0722	89%	0.0001
Chefe + Proseed Plus63WS	-3.625	0.236035	0.02854	0.05571	91%	0.0001
Chefe control	-3.163	0.322257	0.03339	0.1038	88%	0.0001
Tseday + Tebuconazole	-3.6	0.258694	0.03025	0.0669	90%	0.0001
Tseday + Proosed plus63WS	-2.104	0.758219	0.009534	0.5749	5%	0.191
Tseday control	-2.839	0.192369	0.02514	0.03701	92%	0.0001
Kuriftu + Tebuconazole	-3.811	0.167512	0.03517	0.0281	97%	0.0001
Kuriftu + Proosedplus63WS	-2.956	0.609545	0.02272	0.37155	48%	0.001
Kuriftu control	-3.109	0.262097	0.02833	0.0687	89%	0.0001
Local + Tebuconazole	-3.215	0.214645	0.02663	0.04607	91%	0.0001
Local +Proseed plus63WS	-3.976	0.248679	0.03203	0.0618	92%	0.0001
Local control	-2.838	0.141665	0.02875	0.02007	97%	0.0001

*Standard error of the parameter estimates; R^2= coefficient of determination. **Disease progress rate is measure in unit per days.

Disease progress rate:

The effect of different fungicides on disease incidence was assessed six times during the cropping season. The rate of disease progress was significantly different among treatments at (P<0.05). The rate of disease progress and coefficient of determination on five varieties are given in (Table 3). Significant difference in disease development among fungicides treated plots was observed. Least disease progress rate was observed in Tseday variety treated with Pro-seed plus (0.009534unit day^{-1}) followed by Kuriftu variety treated with Pro-seed plus (0.02272 unit day $^{-1}$). The fastest diseases progress rate was recorded in untreated Chefe variety (0.03339 unit days $^{-1}$).

Almost similar rate of disease development was observed among untreated garlic varieties (Table 3). A similar result was reported by Melero-Vara *et al*. (2000) who stated that the treatment of garlic cloves with Tebuconazole and basal spray was achieved significant reduction in disease progressive rate and the final incidence of plant death by white rot. Moreover, Tamire *et al*. (2007) also reported that the systemic fungicides significantly reduced progress rate of white rot and there by improved garlic yield.

Yield and yield components:

The interaction results showed that significantly varied plant height was observed among treatments at (P <0.05) and the highest plant height was recorded from Tseday variety treated with Pro-seed plus followed by local variety treated with the same fungicide which is statistically different and the lowest plant height was recorded from untreated Holeta and Chefe varieties.

The number of harvested bulbs (expressed as percent of final stand) was evaluated and there were a significant differences at (P<0.05) among treatments (Table 4). Significantly highest marketable yield was recorded from Tseday variety treated with Pro-seed plus 63 WS (3.047t ha^{-1}) followed by Kuriftu variety treated with the same fungicide (2.973t ha^{-1}) compared to the untreated control plots, which gave the lowest yield. The significant difference in total and marketable yield among garlic varieties were also observed with Tseday variety recorded higher marketable yield compared to the other four varieties (Table 4). The results are in agreement with what Duff *et al*. (2001) achieved that highest marketable yields were obtained from Tebuconazole treated garlic cloves compared with Procymidone treated garlic cloves on the trial conducted in heavily infested field with sclerotia of *S. cepivorum*. Similarly, Prados-Ligero *et al*. (2002) also reported significant reduction of disease incidence and severity in Tebuconazole treated cloves, resulting in quantitative and qualitative yield improvement. In this study, plots planted to Pro-seed plus 63 WS treated Tseday garlic variety gave significantly increased total and marketable yield as compared to the other four garlic varieties.

The relative yield losses due to white rot on the marketable bulb yield of garlic**.** The variation in yield losses was observed between treatments. Losses on bulb yield for different fungicide treated plots were calculated relative to the higher yield recorded plots. In untreated (control) plots, the yield losses were distinctly higher than in plots treated with fungicide. Similarly, Zeray and Mohammed (2013) also reported that during favorable weather conditions and when susceptible varieties are in the production system the white rot disease can cause 100% yield loss. In Ethiopia yield loss due white rot has been found to range between 20.7% and 53.4% (Tamire *et al.*, 2007).

Cost benefit Analysis of variances showed that significant difference was observed among treatments in total income, input cost, marginal cost, net benefit (P<0.05) . Significantly, higher net profit was obtained from Pro-seed plus63 WS treated varieties compared to Tebuconazole treated and untreated control plots. Therefore, application of Pro-seed plus 63 WS, provided net benefit birr 55275 (ETB/ha) in Holeta, 33225 (ETB/ha) in Chefe, 112155 (ETB/ha) in Tseday (G-493), 108825 (ETB/ha) in Kuriftu and 93390 (ETB/ha) in Local varieties. The corresponding value of marginal rate of return was 5759.38, 3584.38, 7325, 7193.75 and 8665%, respectively (Table 5). The significant differences among garlic variety on net benefit was observed (P<0.01). Tseday (G-493) variety treated with Pro-seed plus shows highest net benefit (112155) birr t^{-1} over the other four garlic variety with zero and minimum input difference (Table 5). The additional input cost in fungicide treated plots was 625.00 and 960.00 birr in Tebuconazole and Pro-seed Plus, respectively. It was found that Pro-seed plus 63 WS treated plots provided significantly higher net benefit over Tebuconazole and untreated control plots. The best recommendation for treatments not subjected to the highest marginal rate of return, rather based on the minimum acceptable marginal rate of return and the treatment with the highest net benefit together with an acceptable MRR becomes the tentative recommendation (CIMMYT, 1988).

Table 4. Effect of treatment combinations on yield and yield components of garlic varieties treated with fungicides at Gudar, west Shewa, Ethiopia**.**

Treatments	**IPS**	**PH**	**HB**	**NC**	**BD**	**TY**	**MY**
Holeta + Tebuconazole	41.88^{g}	50.8^{h}	76.97^{de}	5.53^{e}	20.41^{def}	1.87^{gh}	0.88^{h}
Holeta + Proseed Plus63WS	52.14^{f}	55.27^{fgh}	84.24^{cd}	6.2^{de}	23.79^{bcd}	2.11^{f}	1.78^{ef}
Holeta Control	29.92h	44.39i	72.12^{ef}	4.73^{e}	16.16^{f}	1.74^{hi}	0.53^{h}
Chefe + Tebuconazole	40.17^{g}	52.15^{gh}	76.36^{e}	6.27^{de}	19.44^{def}	1.74^{hi}	0.88^{h}
Chefe + Proseed Plus63WS	51.28^{f}	59.83^{def}	84.24^{cd}	7.2^{cd}	22.46^{cde}	2.00^{fg}	1.29^{fg}
Chefe Control	40.17^{g}	51.13^{h}	64.85^{f}	5.67^{de}	17.49^{ef}	1.61^{i}	0.50^{h}
Tseday + Tebuconazole	73.5^{cde}	64.68^{cd}	92.73^{ab}	9.27^{ab}	28.74^{ab}	3.62^{b}	2.24^{cd}
Tseday + Proseedplus63WS	82.05^{abc}	71.77^{a}	95.15^{a}	9.93^{a}	32.54^{a}	4.04^{a}	3.047^{a}
Tseday control	72.65^{de}	58.94^{ef}	84.24^{cd}	8.4^{abc}	26.59^{bc}	2.88^{d}	1.46^{fg}
Kuriftu + Tebuconazole	66.67^{e}	60.75^{de}	93.94^{ab}	8.67^{abc}	22.06^{cde}	3.14^{c}	2.19^{d}
Kuriftu + Proseedplus63WS	77.78^{bcd}	69.02^{abc}	90.91^{abc}	9.33^{ab}	24.1^{bcd}	3.53^{b}	2.97^{ab}
Kuriftu control	51.28^{f}	56.25^{efg}	86.67^{bc}	8.13^{bc}	21.54^{cde}	2.36^{e}	1.42^{fg}
Local + Tebuconazole	84.62^{ab}	66.03^{bc}	95.15^{a}	8.73^{abc}	28.28^{ab}	3.13^{c}	1.96^{de}
Local + Proseed plus 63WS	90.6^{a}	70.39^{ab}	96.97^{a}	9.07^{ab}	28.59^{ab}	3.96^{a}	2.63^{bc}
Local Control	77.78^{bcd}	61.07^{de}	93.33^{ab}	8.13^{bc}	21.12^{def}	2.94^{d}	0.76^{h}
CV (%)	**10.1**	**5.5**	**4.9**	**11.8**	**13.6**	**3.3**	**14.97**
LSD (5%)	**9.17**	**4.87**	**7.34**	**1.54**	**5.32**	**0.15**	**0.41**

IPS=Initial plant stand (%), PH=Plant Height (cm), HB=Harvested Bulb (%), TY=Total yield (t/ha), MY-Marketable yield (t/ha), NC=Number of clove/ bulb, BD=Bulb diameter (cm).

Table 5.Partial budget analysis for management of garlic white rots using fungicides and host resistance in Gudar, West Shewa, Ethiopia.

Treatments	Cost benefit data							
	MY	SP	SR	TIC	MC	NB	MB	MRR
Holeta + Tebuconazole	0.88	45000.00	39465.00	24625.00	625.00	14840.00	14855.00	2376.80
Holeta + Proseed Plus	1.78	45000.00	80235.00	24960.00	960.00	55275.00	55290.00	5759.38
Holeta control	0.53	45000.00	23985.00	24000.00	0.00	-15.00	0.00	0.00
Chefe + Tebuconazole	0.88	45000.00	39600.00	24625.00	625.00	14975.00	16160.00	2585.60
Chefe + Proseed Plus	1.29	45000.00	58185.00	24960.00	960.00	33225.00	34410.00	3584.38
Chefe control	0.51	45000.00	22815.00	24000.00	0.00	-1185.00	0.00	0.00
Tseday + Tebuconazole	2.24	45000.00	100665.00	24625.00	625.00	76040.00	34205.00	5472.80
Tseday + Proosed plus	3.05	45000.00	137115.00	24960.00	960.00	112155.00	70320.00	7325.00
Tseday control	1.46	45000.00	65835.00	24000.00	0.00	41835.00	0.00	0.00
Kuriftu + Tebuconazole	2.20	45000.00	98865.00	24625.00	625.00	74240.00	34475.00	5516.00
Kuriftu + Proosed plus	2.97	45000.00	133785.00	24960.00	960.00	108825.00	69060.00	7193.75
Kuriftu control	1.42	45000.00	63765.00	24000.00	0.00	39765.00	0.00	0.00
Local + Tebuconazole	1.96	45000.00	88200.00	24625.00	625.00	63575.00	53375.00	8540.00
Local +Proseed plus	2.63	45000.00	118350.00	24960.00	960.00	93390.00	83190.00	8665.63
Local control	0.76	45000.00	34200.00	24000.00	0.00	10200.00	0.00	0.00

MY=Marketable Yield (t/ha), SP=selling price ((Birr t^{-1}), SR=Selling Revenue, TIC= Total input cost (ETB/ha), MC=Marginal Cost (ETB/ha), NB=Net Benefit (ETB/ha), MB=Marginal Benefit (ETB/ha), MRR= Marginal Ret of Return (%)

Conclusions

The present study identified that white rot incidence, severity, AUDPC, disease progress rate and other yield and yield components was varied among fungicides and varieties. Even if the two fungicides were effective in reducing the disease incidence, diseases severity, diseases progress rate and AUDPC over untreated control plots, Pro-seed plus 63 WS was the most effective in reducing the disease incidence, diseases severity, diseases progress rate and area under progress than Tebuconazole treated plots. Significantly higher increment on total and marketable yield as well as other yield and yield components was observed in Proseed plus 63 WS treated plots as compared to Tebuconazole and untreated control plots. Although it is not as much as effective as Pro-seed plus, Tebuconazole was also reduced the incidence, severity, diseases progress rate and area under progress curve as compared to untreated varieties. Among garlic varieties, Tseday (G-493) was promising in reducing the disease epidemics and gave better total and marketable bulb yield and yield components followed by Kuriftu (G-59. Hence, compared with other treatments, combination of Tseday variety with Proseed plus 63 WS was the most effective in reducing white rot epidemics and improving garlic yield and yield components. It is, however, suggested that for wider application of this treatment combination should be further verified under multi location and different season before recommending.

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