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Integrated Management of Anthracnose (Colletotrichum capsici (Syd.)): Implications to Disease Reactions, Quality and Growth Parameters of Three Genotypes of Chili

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Abstract

Anthracnose (*Colletotrichum* spp) is one of the most important disease that decimate chili production in Ethiopia. The efficacy of three Trichoderma isolates viz., AAU-37, AAU-Th and AAU-69 with aqueous leaf extracts Onion, Garlic, Neem and *Cassia* spp were harmoniously applied on Oda Haro, Mareko Fana and Melka zala pepper varieties, with the aim to manage chili anthracnose in rainy season of 2013. The treatments were arranged in RCBD replicated thrice. Data on disease reaction, quality and growth characteristics of chili had been collected. Analysis of data was carried out using ANOVA. The lowest plant infection (12.8%), leaf infection per plant (15.2%), percent diseased leaf area(15.2%)and infected fruits per plot (17.4%) was observed on combined application of isolates *Trichoderma* spp, plant extracts and Ridomil in Maraqo fana variety. Regarding the growth parameters, viz. the highest Mean Percent establishment (81.67), mean days to 50% flowering (65.33), mean days to 50% maturity (82) days to first harvest (106.3) in was observed in T16, T16, T4, and T8, respectively. From the quality parameters, the highest mean number of branches per stem (9), mean canopy diameter (24.8), mean number of flowers per plant (9.6) and mean plant height (61.4) in T10, T15, T6 and T7, respectively. Both negative and positive control showed higher incidence and severity as compared to single and combined application of isolates *Trichoderma* spp, plant extracts and Ridomil. Therefore, integrated use of *Trichoderma* spp and plant extracts can be recommended. Conventional fungicides will be replaced by antagonists and botanicals. This will improving crop quality and growth maximize profitability of chili and ultimate sustenance.

KeyTerms: Anthracnose; infection; Quality; Growth Parameters; Integrated Disease Management; Plant Extracts.

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1. Introduction

Chili (*Capsicum frutscenes L.*) is a highly profitable cash crop popular among farmers and their markets [1], but its production poses significant risks. Peppers continue to grow under substantial pressure from pests and diseases. It is widely consumed in home, fresh seasoning, and as a cooking ingredient. Farmers mainly produce their crop for commercial marketing. Ethiopia's share in the world, however, is insignificant (5%) compared to India (36%) and China (11%) with a production of 1.25, 0.39 and 0.17 million tones [3]. The decline of hot pepper production (0.4 tones fruit yield/ha) is attributed to the prevalence of fungus among others [1, 4]. The reason for decline of hot pepper production is attributed to poor varieties, poor cultural practices, the prevalence of fungal (blights) and bacterial as well as viral diseases [4]. It is a serious threat to crop productivity during rainy weather [1]. This can be doubled or tripled through in the absence of appropriate disease management coupled with good agricultural practices. According to [6], the present situation indicates that in the study area there is no improved hot pepper varieties but there is one local variety named "*Mita Mito*" by local growers, the green pod yield (3 ton per hectare) of this local variety is very low compared to national average yield. As a result, information for the improvement of the crop for high fruit yield and quality in the existing agro-ecology is insufficient [5]. There has also been no research on evaluation of hot pepper which enables the growers to select the best performing varieties in the study area [6]. Conversely, the dose and frequency of fungicides being applied to control the disease is costing too much for the small scale farmers often without significant benefit.

The effectiveness of fungicides against chili anthracnose was lower or comparable to antagonists and botanicals [7-10]. Even though botanicals are safe, cheap and obtainable [11], their application is far below it was supposed to be. However, limited efforts have been made to screen plants that are suspected to possess antimicrobial properties for effect against *C. capsici*. Higher plants may contain secondary compounds that could effectively control plant diseases [12]. Yet, options have been identified to address these challenges. Conventional synthetic fungicides need to be replaced by bio-fungicides as the former lost their effectiveness due to pesticide treadmill [13, 14]. Environment friendly control tactics gained impetus due to growing socio-economic concerns. In pursuit of finding replacement of toxic pesticides scientists working in these lines started trying botanical extracts and such other substitutes. In the past decades, therefore, quite a few scientific published information became available on this subject. This research was, therefore, initiated with objective of managing chili anthracnose through integrated use of antagonists and plant extracts under field conditions.

2. Materials and Methods

2.1 Experimental site

The experiment was conducted at the FTC site in Alaba which is one of the most important pepper growing locations that have altitude of 1680 above sea level, is characterized by dry sub humid climate during June, 2013. Alaba has monthly mean minimum and maximum air temperature of 15°C and 29.5°C, respectively, and rain fall of 900-1300mm/year. This location is a hot spot area for anthracnose (*Colletotrichum* spp) and wilts [2, 15, 16].

2.2 Treatments

A total of 16 treatments, viz., Untreated (T0), combination of all (Extracts + *Trichoderma* spp.+ Ridom)(T1) Neem (T2), *Cassia* spp (T3), Onion (T4), Garlic (T5), Neem + Onion+ Cassia spp (T6), Neem + Onion + Garlic (T7), Ridomil (T8), AAU-Th (T9), AAU-37 (T10), AAU-69(11), AAU-Th + Garlic (T12), AAU-69 + AAU-Th + Onion(T13), AAU-37 + AAU-Th +Neem (T14), AAU-69 + AAU-37 +Neem(T15), and AAU-69 + AAU-37 + AAU-Th (16) had been used in this experiment.

2.3 The Fungal Pathogen

Sweet pepper fruits with anthracnose lesions were collected from farmers' fields in main chili growing areas in September 2012. Sections of 3-5 mm were cut from the margin of the infected lesions and sterilized for one minute in 1.0% sodium hypochlorite solution and rinsed in three changes of sterile distilled water (SDW). The sterile pieces were blotted dry using sterile filter papers and placed on Potato Dextrose Agar (PDA) in 9cm Petri dishes. The dishes were incubated at ambient conditions of light and temperature (30 ± 2°C) for 7 days after which cultures with salmon-pink sporulation typical of *Colletotrichum* spp were sub-cultured to obtain pure cultures [12]. Culture identification was confirmed by microscopic examination and comparison with reference cultures [14]. From these, virulent isolate of *C. capsici*, A38, was obtained from the Laboratory of the Department of Microbial, and Cellular and Molecular Biology, College of Natural and Computational Sciences, Addis Ababa University, Addis Ababa, Ethiopia. The fungal pathogen was maintained on potato dextrose agar (PDA) slants at 4^{O} C [14].

2.4 Preparation of Trichoderma spp isolates for the Experiment

Three isolates of *Trichoderma* spp with high biocontrol efficacies were cultured in Potato dextrose broth (PDB) and cells were collected by centrifugation at 3,000 rpm for 20 min. *Trichoderma* cells were washed twice with sterile distilled water and re-suspended. Then 20 µl of cell suspension of each strain of *Trichoderma* spp at concentration of $5x10^6$ cells/ml was added to the wound of 30 treated chili fruits. After air drying, 20 µl of *C. capsici*, $5x10^6$ cells/ml was added to the wound. Disease severity, as indicated by increased wound diameter, was counted after 5 days of inoculation. The ability to reduce disease incidence of each *Trichoderma* spp strain was observed and compared [17]. The most effective *Trichoderma* spp strain was selected for field studies.

2.5 Layout and Design of the Experiment

The experiment was laid in Randomized Complete Block Design (RCBD) and divided into three blocks and each block was divided into 17 plots. The plot size was 5m x 1.2m. Treatment was assigned to each block at random. The space between the blocks and between the plots was 1.00 m and 0.50 m, respectively. The first spray was given on the 21^{st} DAT as leaf spots could be located the day before. All the treatments (T0-T17) were administered as foliar spray. Plant extracts were formulated at 1:10 suspensions, T6 and T7 as 1:10 suspension cocktail. Ridomil (T8) was administered @ 0.2% suspension. Usually in the evening calm weather light spraying was done so that neighboring plots cannot share a wrong treatment. As the symptom bearing leaves/infected plants serve as a source of inoculum, field combination of all (Extracts + *Trichoderma* spp + Ridomil) was used as a treatment (T2). In this case all the fallen or hanging diseased leaves were collected removed and destroyed.

2.6 Data collection

Number of infected plants per plot, Number of infected leaves per plant, number of spots per leaf, Percent diseased leaf area (DLA %), were data collected on disease reactions. Data collected on Growth Parameters included Plant height, days to 50% flowering, number of flowers per plant, Days to first harvest, Canopy diameter (cm), Number of branches per stem and Dry weight content per plant. Data collected on Quality factors were fruit pericarp thickness (mm), Fruit dry weight content (g), fruit length (cm), and fruit diameter (cm).

2.7 Analysis of data

The data were statistically analyzed with the help of Analysis of variance (ANOVA). To compare the means, Fisher's Least significance Difference (FLSD) was used to compare the effect of the treatment at $p<0.05$ [18].

3. Results

The obtained data on different parameters are presented in the Tables (1-3). The effect differences of the treatments significantly varied from one another and gave a clear picture about the effects on disease reaction, quality and growth factors .

3.1 Effect of IDM on Disease reaction

3.1.1 Plant Infection

The results of this study revealed that the treatments (T1-T16) reduced the incidence of anthracnose of chili disease significantly compared to the control treatment through the observation period, i.e., Bako local, Oda Haro and Maraqo Fana. In all the observed varieties the control (T0) plots had the highest percent plant infection. The highest percentage of plants showing anthracnose of chili symptoms on Maraqo Fana was 85.33 in T0 (Control) and it was the lowest (12.80) in combinations of *Trichoderma* spp isolates, plant extracts and Ridomil (T1). Though numerically different, percent plant infection in T16 (AAU-69+AAU-37+AAU-Th) was in a statistically similar level of significance with T1 (combination of *Trichoderma* spp isolates, plant extracts and Ridomil). On Oda Haro variety, the highest percent plant infection was found in To (control) which was 89.6 and the lowest percent plant infection was found in T1 (*Trichoderma* spp isolates, plant extracts and Ridomil) which was 15.33. On Bako local variety, the highest (85.2) and the lowest (19.6) percent plant infection was observed in T0(control) and T1(*Trichoderma* isolates, plant extracts and Ridomil).

The AAU-Th and AAU-37 *Trichoderma* spp isolates (T9 and T10) in the same level of significance with 22.6 and 23.6, respectively. Overall, percent plant infection was found to be higher in aqueous plant extracts than isolates of *Trichoderma* spp. The infection in *Trichoderma* spp treated plots, on the other hand, was significantly lower than Ridomil (T8) treatment.

Table 1: Percent plant and Leaf infection per plant due to at Anthracnose of chili at different days after transplanting as in influenced by some management practices

Treat-Ments	Percent Plant Infection*			Leaf Infection Per Plant			% Diseased Leaf Area (%DLA)			% Fruit Infection Plant		
	MF	**OH**	**BL**	**MF**	**OH**	**BL**	**MF**	**OH**	**BL**	**MF**	**OH**	**BL**
T0	85.33k	89.6 i	85.2k	87.4g	89.9f	85.2g	87.4i	89.9 f	87.4g	89.9f	85.33f	81.8g
T1	12.8a	15.33a	19.6a	15.2a	17.4a	19.9a	15.2a	17.4a	19.9a	17.4a	19.9a	15.33a
T2	71.66j	73.7 i	78.66j	22.8d	25.33d	29.6e	32.8e	35.33d	39.6f	36.33d	49.6e	23.7d
T3	27.62f	44.54g	54.2i	23.66d	23.7c	28.66de	33.66e	33.7c	38.66e	35.7cd	48.66de	24.54de
T4	44.44i	49h	53.25i	20.62c	24.54cd	26.2cd	30.62d	34.54cd	36.2d	35.54c	46.2d	29f
T5	40.66h	46.22gh	51.23i	24.44df	29e	29.25e	34.44e	39e	39.25ef	39.11e	49.25e	26.22e
T6	33.14g	35.88f	41.56gh	20.66c	26.22d	28.23d	30.66d	36.22d	38.23e	37.22d	48.23d	25.88e
T7	27.66f	32.31ef	42.2h	22.14d	25.88d	26.56d	32.14de	35.88d	36.56d	37.88de	46.56d	22.31cd
T8	22.43d	30.6e	37.2g	24.66f	22.31bc	22.2a	34.66e	32.31c	32.2b	36.31d	42.2c	20.6b
T9	23de	19.19b	22.6a	21.43cd	20.6b	27.2d	31.43d	30.6b	37.2de	36.6d	47.2d	19.19b
T10	18.3c	19.9b	23.6ab	14 a	19.19b	22.6ab	24b	29.19b	32.6bc	29.99b	42.6c	19.9b
T11	22.6d	26.53d	29.9cd	17.3b	19.9b	23.6bc	27.3c	29.9b	33.6c	29.9b	43.6c	26.53e
T12	27.6f	29.9de	31.8d	23.6d	26.53d	29.9ef	33.6e	36.53de	39.9f	37.53d	49.9e	20.9b
T13	17.7c	20.3c	25.6bc	15.6a	20.9b	31.8f	25.6b	30.9bc	31.8b	36.9d	41.8c	20.3b
T14	21.6d	30e	35.5fg	15.7a	20.3b	25.6c	25.7bc	30.3b	35.6cd	36.3d	45.6cd	20b
T15	24e	28.2d	32.2df	18.6bc	20b	25.5c	28.6cd	30b	35.5c	38e	45.5c	21.2bc
T16	15ab	20.15bc	25.6bc	17ab	20.2b	23.2b	23b	30.2b	31.2b	33.2bc	38.2b	26.33e
LSD5%	2.25	4.2	4.4	3.1	1.53	2.94	3.59	3.3	2.2	2.6	3.4	2.3
CV	15.8	16.1	10.6	18.2	13.3	15.5	14.3	18.1	15.4	18.7	18.5	21.7

** Significant at 5% level; Means followed by the same letter (s) in a column did not differ at 5% level by LSD, MF=Maraqo Fana, OH=Oda Haro, BL= Bako local

Statistically identical results were recorded in Maraqo Fana plots in T10 (AAU-37) and T13 (AAU-69+Th + Onion) with values of 17.7 and 18.3, respectively. The next highest percent plant infection in Oda Haro was observed inT9 and T10, 19.19 and 19.9, respectively. Moderate infection was observed in T13(with value of 20.3) and T16 (with 20.15). In Bako local variety, the second lowest (29.9, 25.6 and 25.6) was observed in T11 (AAU-69), T13(AAU-69+AAU-Th+Onion) and T16 (AAU-69+AAU-Th+Onion).But treatment T8 (Ridomil) was chemical which was not environment friendly which also significantly differed from To(Control), had a value of 22.43, 30.6 and 37.2 percent plant infection, in Maraqo fana, Oda Haro and Bako local varieties. This higher infection may be due to the fact that Ridomil is a very toxic and injurious to human health and not an environment-friendly product it would have destroyed the beneficial microorganisms too.

3.1.2 Leaf Infection

Effect of different treatments on percent leaf infection are had revealed that there is statistical difference among the treatments at $p<0.05$. On Maraqo Fana variety, the highest percentage of leaf infection 87.4 % was observed in the treatment T0 (control). The result clearly indicated that the treatments had significant effect on percent leaf infection. The lowest (14) percent leaf infection was observed in treatment T10(AAU-37), T2 (combination of Trichoderma isolates, plant extracts and Ridomil), T13(AAU-69+AAU-Th+Onion), T14(AAU-37+AAU-Th+Neem) and T16 (AAU-69 + AAU-37+ AAU-Th) with values of 15.2, 15.6, 15.7 and 17 percent leaf infection, respectively (Table 1).

On Oda Haro variety, the highest percentage of leaf infection, 89.9, was observed in the treatment To (control) and this was significantly higher than under any other treatments. The result clearly indicated that the treatments had significant effect on percent leaf infection. The lowest (17.4) percent leaf infection was observed in treatment T2 (combination of Trichoderma isolates, plant extracts and Ridomil). The second lowest(19.19 and 19.9) percent leaf infection was observed in T10 (AAU-37) and T11(AAU-69) which were statistically similar to T13(AAU-69+AAU-Th+Onion), T15(AAU-69+AAU-37+Neem), T16 (AAU-69+AAU-37 + AAU-Th), T14 (AAU-69+AAU-Th+Neem), T9 (AAU-Th) and T8 (Redomil) having of 20.9%, 20, 20.2, 20.3, 20.6 and 22.31% respectively (Table 1).

The result clearly indicated that, on Bako local variety, the treatments had significant effect on percent leaf infection. The highest leaf infection, 85.2% , was observed in treatment To (control). The lowest (19.9 %) percent leaf infection was recorded in treatment T2 (combination of isolates *Trichoderma* spp, plant extracts and Ridomil). Percent leaf infection was statistically similar in T8 (Ridomil) and T_{10} (AAU-37) having of 22.2% and 22.6%, respectively. Regarding the second lowest infection, T16 (AAU-69+AAU-37 + AAU-Th), and T_{11} (AAU-69) were statistically similar having 23.2% and 23.6%, respectively. The rest of the treatments had shown statistically significant effect (Table 1).

3.1.3 Percent of Diseased Leaf Area (%DLA)

The result clearly indicated that the treatments had significant effect on percent diseased leaf area. On Maraqo Fana variety, the highest percent diseased leaf area was observed in To (control) having value 87.4 % and the lowest diseased leaf area was in T2 (combination of Trichoderma isolates, plant extracts and Ridomil). Many treatments had fallen in the second statistical significance category. Treatment T16 (AAU-69+AAU-37 + AAU-Th), T10 (AAU-37), T13 (AAU-69+AAU-Th+Onion) and T14 (AAU-69+AAU-Th+Neem) showed statistically similar significant effect having values 23.0 %, 24.0 % , 25.6% and 25.7 %, respectively. The rest of the treatments also showed significant effect (Table 1). Single (T9-T11) and combined (T9-T16) treatments of *Trichoderma* spp, that includes AAU-Th, AAU-37and AAU-69; and plant extracts which include extracts of Neem, Onion and Garlic as mixture spray was found more efficient than Ridomil. The relative efficiencies of treatments suffered only a slight change on other varieties probably due to environmental factors and the growth stage physiology of the plants. The disease development in the infected leaves at this period was rather low Maraqo fana compared to the Oda Haro variety.

On Oda Haro variety, the highest percent diseased leaf area was observed in To (control) having value 89.9 %

and lowest diseased leaf area was in T1 (combination of isolates of *Trichoderma* spp, plant extracts and Ridomil) having value 17.4 %. On the other hand, Treatment T9 (Th), T10 (37), T11 (69), T13 (69+Th+O), T14 (37+Th+N), T15(69+37+N)and T16 (69+37+Th) showed statistically similar effect having values 30.6 %, 29.19 %, 29.19%, 30.9%, 30.3%, 30% and 30.2 % respectively. The rest of the treatment also showed significant effect (Table 1). On Bako local variety, the highest percent diseased leaf area was observed in T0 (control) having value 87.4 % and the diseased leaf area was in T1(combination of Trichoderma isolates, plant extracts and Ridomil) having value 19.9 %. The second least infection was observed in Treatment 16 (AAU-69+AAU-37 + AAU-Th), T13 (AAU-69+AAU-Th+Onion),T10 (AAU-37) and T8 (Ridomil) with statistically similar effect having values 31.2 %, 31.8%, 32.6% and 32.2 %, respectively. The rest of the treatment also showed significant effect (Table 1).

3.1.4 Infected Fruits per plot

Effect of different treatments on percent fruit infection had shown that in Maraqo fana variety, all the treatments showed statistically significant effect on reducing percent fruit infection compared to control. The highest percent of fruit infection was observed in control plot To (89.9%) and the lowest percent of fruit infection was recorded in T1(17.4%).The treatments 16 (AAU-69 + AAU-37 + AAU-Th), T11(AAU-69) and T10 (AAU-37) had shown statistically similar significant effect with values of 32.2%, 29.9% and 29.99%, respectively (Table 1).

On Oda Haro variety, the treatments also showed statistically significant effect on percent fruit infection. The highest percent of fruit infection was observed in control plot To (85.33%) and the lowest percent of fruit infection was recorded in T1 (19.9%).The treatments 16 (AAU-69 + AAU-37 + AAU-Th) had shown the second lowest infection with value of 38.2%. On Bako local variety, the highest percent of fruit infection was observed in control plot To (81.8 %) and the lowest percent of fruit infection was recorded in T1(15.33%). The treatments T8 (Ridomil), T9 (AAU-Th), T10 (AAU-37), T12 (AAU-Th + Garlic), T13 (AAU-69 + AAU-Th + Onion), T14 (AAU-37 + AAU-Th + Neem), T15(AAU-69+ AAU-37+Neem) and T16 (AAU69+ AAU-37 + AAU-Th) showed statistically similar effect having values 20.6 %, 19.19 %, 19.9%, 20.9%, 20.3%, 20% and 21.2 %, respectively (Table 1). Control ($T_{0)}$ where no treatment was given, the % fruit infection on Bako local became less as compared to the situation observed on Maraqo fana and Oda Haro varieties. But the plants which received treatment, whichever it may be, the spread of the disease on the fruit was considered low. The highest fruit infection was observed in T_0 (Control) and significantly small difference in other treatments. From the tested Trichoderma spp isolates applied singly or in combination, the lowest infection was observed on AAU-69+AAU-37+AAU-Th. However, the efficacy of antagonists, extracts and fungicides, i. e, AAU-Th + Neem + Ridomil, appeared to be compatible and effective.

Among the botanical extracts the strongest anti-*Colletrotrichum capsici* (Syd) reaction has been shown in terms of percent fruit infection by Garlic leaf extract (39.11, 49.25 and 26.25, on Maraqo Fana, Oda Haro and Bako local varieties, respectively), which was lower than *Cassia* spp extract (35.7, 48.66 and 24.54, on Maraqo Fana, Oda Haro and Bako local varieties, respectively). Ridomil's effect in reducing % fruit infection was not as anticipated. It was lower than the antagonists and leaf extracts.

Throughout the experiment in all the parameters taken into account Integrated use of Antagonists, plant extracts and 0.2% application of Ridomil as foliar spray performed excellent.

This was the expected result too. Ridomil treatment was a positive control treatment as no treatment was considered as a control treatment. The aim was to compare the effects of the antagonist (*Trichoderma* spp isolates) and organic (botanicals) treatments with both.

The results and their analyses revealed that the test treatments, antagonists and botanical extracts, are capable of reducing anthracnose of chili in the cultivars Maraqo fana, Oda haro and Bako local quite significantly even when applied in combination and singly.

However, combination of antagonists and botanical extracts were more strong and effective even to a level that with minimum risk such treatment can replace a highly effective chemical fungicidal treatment.

3.2 Effect of IDM on Growth Performance of Hot pepper

There were significant variations among the tested genotypes in terms of the percent establishment, days to 50% maturity and days to first harvest (Table 2).

The result showed a range of 48.67 (T0) to 82.67(T11), 48.00 (T0) to 83.33(T11) and 49.67(T0) to 89.67(T4) for percent establishment; 43.0(T0) to 67.33(T13), 41.00 (T0 and T4) to 53.33(T10) and 36.33(T0) to 53.67(T5) for days to 50% flowering; 62.0(T0) to 82.0(T4), 65.33 (T0) to 79.67(T13) and 40.67(T0) and 81.0 (T14) for days to 50% of maturity; 78.67(T0) to 106.0(T8), 52.67 (T0) to 108.33(T13) and 51.67(T0) to 107.33(T13) for days to first harvest for Maraqo fana, Oda haro and Bako local varieties, respectively (Table 2).

Quality parameter trial, the result revealed that significant variations existed among the tested genotypes in terms of number of branches per stem, canopy diameter (cm), number of flowers per plant and plant height (Table 3). The result showed a range of 1.0 (T0) to 9.0(T10), 1.0 (T0) to 8.0(T4) and 2.0 (T0 and T13) to 8.0 (T11) for branches per stem; 5.80(T0) to 24.8(T15), 4.8 (T0) to 12.8 (T11) and 5.6 (T0) to 12.6 (T2) for canopy diameter (cm); 5.26 (T12) to 9.4 (T2), 4.7 (T1) to 9.6(T3) and 5.8(T0) to 10.8(T4) for number of flowers per plant, 13.9 (T0) to 61.4 (T7), 15.5 (T0) to 78.8 (T15) and 12.8 (T0) to 68 (T8) for plant height, on Maraqo Fana, Oda Haro, and Bako local varieties, respectively.

3.3 Effect of IDM on Quality Performance of Hot pepper

On another quality parameter trial, the result revealed that significant variations existed among the tested genotypes in terms of fruit diameter(in cm), Fruit pericarp thickness (mm), fruit length (cm) and fruit dry weight content (g) (Table 3).

The result showed a range of 0.5 (T0) to 3.3(T1), 0.6 (T0) to 1.9(T10) and 0.8(T0) to 3.6 (T14) fruit diameter(in cm); 0.35 (T0) to 1.38 (T5), 0.31 (T0) to 1.6 (T7) and 0.32 (T0) to 1.55(T6) for fruit pericarp thickness (mm); 5.25 (T0) to 9.7(T4), 4.69 (T1) to 9.59 (T3) and 6.3(T10) to 10.79(T4) for fruit length (cm); 4.9(T9) to 9.2

(T12), 6.74 (T13) to 11.0 (T1) and 6.5 (T13) to 10.7 (T3) for fruit dry weight content (g) on Maraqo Fana, Oda Haro, and Bako local varieties, respectively (Table 4).

Table 2: Effect of IDM on growth parameters of Hot pepper varieties in 2013 cropping season

Var.	***Establishment %**			**Days to 50% Flowering**			**Days to 50% Maturity**			**Days 1st Harvest**		
Treat	**MF**	**OH**	**BL**	**MF**	**OH**	**BL**	**MF**	**OH**	**BL**	**MF**	**OH**	**BL**
T 0	48.67a	48.00a	49.67a	43.00a	41.00a	36.33a	62.00a	65.33a	40.67a	78.67a	52.67a	51.67a
T 1	69.33b	72.00b	73.00bc	65.33f	48.00d	42.67b	70.00b	73.33cd	78.00e	100.00e	101.33b	102.00c
T 2	71.00bc	81.33d	74.00c	60.67e	42.00ab	43.33b	72.33bc	72.33b	76.67d	98.00cd	104.33c	100.33b
T 3	75.33d	77.33c	74.00c	54.00bc	42.67b	50.67f	78.67g	72.00b	70.00b	97.67c	102.33b	99.67b
T 4	74.67d	77.00c	89.67e	63.00ef	41.00a	46.33cd	82.00h	75.33d	80.67g	98.67d	102.67bc	98.67b
T 5	74.00cd	82.33d	71.67b	51.67b	46.33c	53.67g	79.67g	73.00bc	71.00bc	98.67d	106.00d	102.33c
T 6	81.67f	73.67b	73.00bc	56.33cd	46.33c	50.00df	73.67cd	77.00f	75.67d	97.67c	104.33c	102.67c
T 7	81.00f	81.33d	70.67b	57.33d	47.00d	44.00b	81.67h	78.33g	78.00e	100.0e	104.67cd	102.00c
T 8	81.33f	81.33d	73.00bc	59.67d	56.00g	44.67b	75.00de	78.33g	80.33g	106.3f	104.33c	102.67c
T 9	77.00de	82.33d	78.00d	58.00d	48.33d	50.00df	75.67e	79.00g	76.00d	97.00c	102.33b	100.33b
T 10	81.00f	81.67d	76.00d	56.00c	53.33f	45.00bc	76.67f	76.67ef	76.33d	95.33b	104.33c	106.00c
T 11	82.67f	83.33f	73.00bc	59.67de	51.67ef	45.67c	72.33bc	75.67e	80.33g	98.67d	104.00c	104.33c
T 12	81.33f	81.67d	74.00c	64.00f	52.00f	45.00bc	76.00e	79.33g	79.67fg	101.0e	105.33d	106.33c
T 13	80.00e	80.67d	71.33b	67.33g	46.33cd	47.67d	73.00c	79.67gh	79.00ef	100.0e	108.33e	107.33cd
T14	80.67ef	82.67e	76.00d	62.33e	45.33bc	43.33b	75.67e	75.67e	81.00gh	102.7e	106.00de	105.67c
T 15	72.00c	82.00d	70.67b	53.00b	52.33f	45.67c	79.00g	72.33b	73.33c	100.6e	104.33c	105.33c
T 16	81.67f	80.00d	75.33cd	65.33f	48.33de	51.33fg	76.00ef	72.67b	79.00ef	102.7e	101.67b	101.67bc
LSD(5%)	3.11	2.51	2.78	3.32	2.60	2.42	1.43	1.14	1.32	1.32	2.41	5.62
CV%	11.1	28.4	16.7	18.7	13.1	22.5	18.9	16.8	17.4	11.00	22.4	23.2

*Means followed by the same letter in the same column are not significant difference at P<0.05; MF= Maraqo Fana, OH= Oda Haro, BL= Bako local

Table 3: Effect of IDM Quality Parameters of three chili accessions at Alaba 2013

Treat-ments	Number of Branches Per Stem*			Canopy Diameter (cm)			Number of Flowers Per Plant			Plant Height (cm)		
	MF	OH	BL	MF	OH	BL	MF	OH	BL	MF	OH	BL
T0	1a	1a	2a	5.8a	4.8a	5.6a	6.7b	4.7a	5.8a	13.9a	15.5a	12.8a
T1	4. 3b	7de	6. 3c	12b	11.6c	12.6e	9.4e	4.7a	7.3ab	47.6d	61i	67.3g
T2	7d	2a	2.1a	13.8b	10.44b	11.3c	6.8b	8.2d	9.7cd	26.5b	47.2d	49.5d
T3	5.3c	2a	2.2a	12.8b	10.6b	11.1b	8.5d	9.6d	6.6a	37.5c	49.1e	40.7c
T4	2.5b	8ef	2.2a	24.6f	10.9b	10.7b	9.6e	8.2d	10.8d	37.1c	30.5b	58.9f
T5	3.6b	5bc	6bc	19.9d	11.4bc	10.89b	6.87b	7.1c	7.5b	36.7c	52.7f	57.99e
T6	4.7bc	4b	2.3a	16.8c	12.5d	10.84b	6.9bc	6.5bc	8.7bc	60.6h	59.4h	67.34g
T7	9e	7de	2.1a	19.6d	12.4d	12.1d	5.6a	7.9d	9.5c	61.4h	38c	60f
T8	2.6b	2a	3a	21.3de	12.6d	11.9d	6.7b	6.1b	9.1c	58.8g	49.3e	68g
T9	6.7cd	6cd	2.3a	18.7cd	11.8c	11.6c	7.6cd	7.6cd	7.8b	54.9e	69.4k	49.2d
T10	9e	9f	7.4c	19.6d	12.3d	11.7cd	6.3ab	8.2d	6.3a	55.8f	38.6c	49.9d
T11	3.33b	6cd	8cd	11.8b	12.8d	11.6c	6.7b	6.4b	7.8b	56.9f	49.5e	48d
T12	6c	5bc	4.2b	13.8b	11.9cd	11.8d	5.26a	7.3c	6.6a	59.2gh	57.2fg	39.1b
T13	8de	7de	2a	22.7e	11.3b	10.9b	5.44a	5.6a	7.5b	58.7g	67.4j	56.5e
T14	6c	6cd	3.6ab	16.8c	11.9c	12.2de	8.7de	5.8ab	8.2b	58.8g	47.6d	58ef
T15	5c	6cd	5.6b	24.8f	11.68c	10.96b	6.2a	7.8de	7.6b	56.4f	78.8m	58.76f
T16	4b	4b	6bc	23.3ef	11.7c	11.2bc	5.5a	8.5d	9.3c	57.1fg	72 l	59.7f
LSD(5%)	2.2	1.4	2.1	2.33	0.94	0.59	1.3	1.2	1.6	2.4	1.3	2.1
CV%	18.1	19.6	16.2	10.3	14.5	17.3	10.1	12.4	13.7	18.5	16.7	17.8

*Means followed by the same letter in the same column are not significant difference at P<0.05, MF=Maraqo Fana, OH=Oda Haro, BL= Bako local

Table 4: Effect of IDM Quality Parameters of three chili accessions at Alaba 2013

Treat.	*Fruit Diameter (cm)			Fruit Pericarp Thickness (mm)			Fruit Length (cm)			Fruit dry weight Content (g)		
	MF	OH	BL	MF	OH	BL	MF	OH	BL	MF	OH	BL
T0	0.5a	0.6a	0.8a	0.35a	0.31a	0.32a	6.7b	6.4b	7.8c	6.9b	9.5cd	8ab
T1	3. 3d	1.7b	2. 3cd	1.11b	0.95a	1.11b	9.4d	4.7a	7.3b	7.6cd	11d	7.3a
T2	1.2b	1.2a	2.1c	1.15b	1a	1.15b	6.8b	8.2d	9.7ef	6.5b	7.24a	9.5b
T3	1.4bc	1.0a	2.2c	1.13b	1.33b	1.13b	8.5c	9.6e	6.6b	7.5c	9.1bc	10.7c
T4	1.2b	1.8b	2.2c	1.21b	1.1b	1.21b	9.6d	8.2d	10.8f	7.1bc	10.5d	8.9b
T5	1.3b	1.5ab	1.6b	1.38bc	1.28b	1.38bc	6.87b	7.1c	7.5b	6.7b	8.27b	7.99a
T6	1.4bc	1.4a	2.3cd	1.55c	1.45b	1.55c	6.9bc	6.5bc	8.7d	6.6b	9.4c	7.34a
T7	1.9c	1.7b	2.1c	1b	1.6b	1b	5.6a	7.9d	9.5e	6.4b	8b	10bc
T8	1.1b	1.2a	2.3cd	1.32b	1.52b	1.32b	6.7b	6.1b	9.1de	5.8ab	9.3c	8ab
T9	1.0b	1.6b	2.3cd	1.22b	1.32b	1.22b	7.6c	7.6c	7.8c	4.9a	9.4c	9.2b
T10	1.9c	1.9b	2.4d	1.37b	1.17b	1.37b	6.3ab	8.2d	6.3a	5.8ab	8.6b	9.9b
T11	1.0b	1.6b	2.8e	1.21b	1.11b	1.21b	6.7b	6.4b	7.8c	6.9b	9.5cd	8ab
T12	1.3b	1.5ab	2.2c	0.88ab	0.98a	0.88ab	5.26a	7.3c	6.6b	9.2d	7.25a	9.1b
T13	1.8c	1.7b	2.0c	0.91b	0.87a	0.91b	5.44a	5.6a	7.5b	8.7d	6.74a	6.5a
T14	1.6c	1.6b	3.6f	1.13b	1.23b	1.13b	8.7cd	5.8ab	8.2cd	8.8d	10.6d	8ab
T15	1.6c	1.6b	1.6b	0.89b	0.9a	0.89b	6.2a	7.8cd	7.6bc	6.4b	7.88ab	8.76b
T16	1.4bc	1.4a	2.2c	0.94b	0.99a	0.94b	5.5a	8.5de	9.3e	7.1bc	7.2a	9.7b
LSD(5%)	0.4	0.98	0.31	0.56	0.68	0.57	1.11	1.12	1.1	1.4	1.23	2.21
CV%	10.1	11.6	15.2	12.3	16.5	19.3	20.1	18.4	14.5	13.5	14.7	19.8

*Means followed by the same letter in the same column are not significant difference at P<0.05, MF=Maraqo Fana, OH=Oda Haro, BL= Bako local

4. Discussions

This study revealed that antagonists and plant extract had very effective strong fungicidal effect. In some cases, the reported effect is more than that of chemical pesticides. Out of the many such reported promising plants, on the simple basis of availability Garlic, Neem, Onion and Cassia have been selected to assess their combat ability against *Collectrotrichum capsici*, that is the ability against anthracnose of chili. Different integrated practices like A total of 16 treatments, viz., Untreated (T0), combination of all (Extracts + Tricho.+ Ridomil) (T1) Neem (T2), Cassia spp (T3), Onion (T4), Garlic (T5), Neem + Onion+ *Cassia* spp (T6), Neem + Onion + Garlic (T7), Ridomil (T8), AAU-Th(T9), AAU-37(T10), AAU-69(11), AAU-Th + Garlic (T12), AAU-69 + AAU-Th + Onion (T13), AAU-37 + AAU-Th +Neem (T14), AAU-69 + AAU-37 + Neem (T15), and AAU-69 + AAU-37 + AAU-Th(16) had been used in this experiment.

Data on disease reaction, quality and growth parameters had been collected. Plant infection, leaf infection, leaf area diseased, and fruit infection, were the parameters for disease reaction. The highest average fruit yields however were observed under the treatment T_6 and T_7 and the lowest under the treatment *To*. As a result low yield was found in control plots and high in the plots where combined treatments were applied. The combined treatment had a highly significant effect on the fruit yield. The results obtained by Serawit and Tesfaye [11,19], reference [20] with the use of garlic and Kabir [21] with Neem *(Azadirachta indica)* leaf and Neem seed extracts nicely corroborate with the present findings.

The results obtained through this experiment indicated that a judicially designed combined organic treatment even may be profitable than a chemical fungicide treatment of all the fruit collection from the respective plots. The chili test plants which have received Ridomil @ 0.2% had the lowest disease intensity as well as severity parameters. Plot treated with antagonists, plant extracts and fungicides (T_1) has shown the highest disease control potential but significantly superior to the control(To). The plant extract treatments have shown significantly better control than the T8, though they varied widely amongst themselves. The combined treatments T_6(Neem + Onion + Cassia) and T_7 (Neem + Onion + Garlic) have shown very strong response though lesser than the T8 (Ridomil) in controlling anthracnose of chili. This is in conformity with [22,13].

The highest average fruit diameter however were observed under the treatment T1 and T10 and the lowest under the treatment To. As a result, low diameter was found in control plots and high in the plots where combined treatments were applied. The combined treatment had a highly significant effect on the fruit diameter. The results obtained by [21] with the use of garlic and Serawit and Tesfaye [11] with Neem *(Azadirachta indica)* leaf and Neem seed extracts nicely corroborate with the present findings.

5. Conclusions and Recommendation

The results obtained through this experiment indicated that a judicially designed combined organic treatment even may be profitable than a chemical fungicide treatment. Thus it can be concluded that the incidence and severity of Anthracnose of chili disease can significantly be reduced by the combined use of (*Trichoderma* spp + Plant Extracts) 1: 10 dilution suspension foliar spray in order to have a higher profitable yield and eventual higher economic return with minimum health risk as well as environmental pollution. However, meticulous with higher potency or efficacy must go on as the pathogenecity of the causal agent is quite dynamic. Therefore, the farmers may be advised to take an integrated approach which should include antagonists and plant extracts to raise a profitable production without polluting the environment and adding toxins in the food chain.

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