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Research Article
Efficacy of Selected Plant Extracts in the Management of Tomato Early Blight Disease Caused by *Alternaria solani*

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Abstract

Background and Objective: Control of tomato early blight has relied almost exclusively on the application of synthetic fungicides. The use of plant extracts is a safe and eco-friendly alternative of managing many plant pathogens. The present study examined the severity of early blight on tomato and evaluated the efficacy of some leaf extracts in the management of the disease. **Materials and Methods:** The experiment was laid in a randomized complete block design with three replicates. The treatments consisted of plots sprayed with dried extracts of *Chromolaena odorata*, *Euphorbia heterophylla*, *Tithonia diversifolia*, *Azadiractha indica*, *Carica papaya* and the control. Data were collected on disease severity, number of fruits, fruit length and fruit weight (yield). **Results:** Significantly early blight severities were observed in the control plots at 4, 5, 6 and 7 week after transplanting. *Carica papaya* proved most effective in reducing the severity of early blight on tomato. Plot treated with *C. papaya* produced a significantly ($p \leq 0.05$) higher number of fruits (104.0) and higher fruit length (66.0 mm). The least fruit length was recorded in the control plot (46.2 mm). Significantly ($p \leq 0.05$) higher fruit weight (328 g) was recorded in plot treated with *C. papaya* while the lowest fruit yield (106.7 g) was observed in the control plot. There was no significant difference in fruit weight of tomato in plots treated with *C. odorata*, *A. indica* and *E. heterophylla*. Plots treated with *T. diversifolia* and the control gave statistically similar fruit weights (126 and 106 g, respectively). **Conclusion:** The use of plant extracts minimizes the risks and hazards associated with toxic fungicides, especially, on crop plants produced for fresh consumption. Further studies are, however, suggested to unfold the potential of other botanicals in the management of *A. solani* on tomato.

Key words: Tomato, early blight, leaf extracts, disease severity, number of fruits, fruit yield

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is an important vegetable cultivated all over the world. It is a vegetable of great nutritional value owing to its high content of vitamins A and C as well as lycopene, a natural antioxidant which is not found in other solanaceous crops[1].

Although, Nigeria has a comparative advantage and potential to lead the world in tomato production and exports, the country ranked as the 16th largest producer with a production figure of 1.8 million mt, representing only 10.8% of Africa's production estimate[2]. Like other vegetables, tomato is vulnerable to attack by biotic and abiotic constraints[3]. Prominent among the biotic constraints are pests and diseases which reduce the yields and quality of marketable fruits[4].

Early blight caused by *Alternaria solani* is the most common and destructive disease of tomato, causing significant reduction in the quantity and quality of fruit yields[5]. The disease is characterized by the appearance of brown to dark brown necrotic spots with concentric rings on foliage, stem and fruits[1]. Yield losses of up to 80% have been attributed to early blight under field conditions[6].

Due to variability in pathogenic isolates, prolonged active disease cycle phase and broad host range, early blight is very difficult to manage[1]. Control of the disease has relied almost exclusively on the application of fungicides. Although, synthetic fungicides are useful in sustaining the production of crops and protecting plants from fungal pathogens, their application is expensive and pose serious threat to human health[7]. Recent efforts have therefore focused on developing environmentally safe, long-lasting and effective bio-control methods and treatments for the management of plant diseases.

The use of plant extracts has been shown to be eco-friendly and effective against many plant pathogens[8-11]. Extracts from plants are being evaluated in order to find safe alternative control methods to the human and the environment[12] and are explored as useful sources of new agrochemicals for the management of plant diseases[13]. Botanicals have the potential to suppress population of foliar pathogens and are now widely incorporated into integrated pest management programs[14]. Therefore, the present study was carried out to quantify the severity of early blight on tomato and to evaluate the efficacy of leaf extracts of *Azadirachta indica* (neem), *Carica papaya* (pawpaw), *Tithonia diversifolia* (tree marigold), *Euphorbia heterophylla* (milk weed) and *Chromolaena odorata* (siam weed) in the management of tomato early blight disease.

MATERIALS AND METHODS

This study was carried out at the Teaching and Research Farm of Landmark University, Omu-Aran, Kwara State, Nigeria. Omu-Aran is located in the North central part of Nigeria with a latitude of 8.9° N and longitude of 50°61 E. The annual rainfall pattern of the area is 600-1500 mm between the months of April and October, with peaks in June. The humidity ranges from 50% in the dry season to about 85% during wet season.

The land used for this study was previously used for growing tomato for two consecutive planting seasons, from July-October, 2014 and July-October, 2015. During these growing seasons, early blight of tomato was observed in the field, although, the incidence and severity were not assessed.

Collection of botanicals: Leaves of *Azadirachta indica*, *Carica papaya*, *Tithonia diversifolia*, *Euphorbia heterophylla* and *Chromolaena odorata* were collected from Landmark University Campus, Omu-Aran, dried separately in full exposure to sunlight and fine powdered in an electric grinder machine.

Extract preparation: Aqueous extracts of leaves of the botanicals were prepared by soaking the powdered leaves separately for 24 h in distilled water (10 g powder and 90 mL distilled water). After 24 h, the suspension was filtered through Whatman's filter paper and 30% concentration of each extract was prepared with distilled sterilized water.

Source of seed and nursery establishment: Seeds of UC82B tomato cultivar used in this experiment were obtained from the Teaching and Research Farm of Landmark University, Omu-Aran. UC82B was used in this experiment because it is the commonly grown cultivar in the agro-ecological zone where the study was carried out. The seeds were raised in nursery beds for 3 weeks before transplanting to the experimental field.

Experimental design and treatment application: Field plots (3×3.5 m) comprised of two rows and 5 plants per row, with three plots used as replications for each treatment as well as for the untreated control. The experiment was laid in a randomized complete block design with 6 treatments. Each plot was separated from the adjacent bed by 0.5 m alley. The treatments consisted of plots sprayed with 30% concentration of *Chromolaena odorata* (T1), *Euphorbia heterophylla* (T2), *Tithonia diversifolia* (T3), *Azadiractha indica* (T4), *Carica papaya* (T5) and the control (T6). The extracts were sprayed

twice during the growing season following appearance of early blight symptoms at 2 and 4 Weeks after Transplanting (WAT). The study was carried out from February-May, 2016 under natural infection. The temperature ranged between 27.2-28.6°C during the growing season.

Data collection and analysis: Weekly data were collected on disease severity for 4 weeks after treatment application. Number of fruits, fruit length and fruit weight (yield) were also recorded. Ten plants from each replication were tagged for data collection. Disease severity assessment was carried out on a scale of 0-9 according to Latha *et al.*[10], where:

0 = Healthy
1 = 1-5% of leaf area infected with early blight symptoms
2 = 6-10% of leaf area infected with early blight symptoms
3 = 11-25% of leaf area infected with early blight symptoms
5 = 26-50% of leaf area infected with early blight symptoms
7 = 51-75% of leaf area infected and with early blight symptoms
9 = >75% of leaf area infected with early blight symptoms

The data were subjected to analysis of variance (ANOVA) using the statistical software of Sokal and Rohlf[15] and the means were separated using Duncan Multiple Range test (DMRT) at 5% probability level.

RESULTS

Disease severity: Significantly early blight severities were observed in the control plots at 4, 5, 6 and 7 WAT (Table 1). There was no significant difference ($p \leq 0.05$) in disease severity among plots treated with *Chromolaena odorata*, *Euphorbia heterophylla* and *Azadirachta indica* at 4 WAT. Plots treated with *Tithonia diversifolia* and *Carica papaya* also had statistically similar disease severities (2.4 and 2.6, respectively) at 4 WAT.

At 5 WAT, no significant difference was observed in disease severity in plots treated with *Chromolaena odorata*, *Euphorbia heterophylla*, *Tithonia diversifolia* and *Azadirachta indica* while the lowest disease severity (2.3) was recorded in plot treated with *C. papaya*. Similar trend of results were also noticed at 6 and 7 WAT.

Number of fruits: Plot treated with *C. papaya* produced a significantly ($p \leq 0.05$) higher number of fruits (104.0) than all other treatments (Table 2). There was no significant difference in number of fruits in plots treated with *C. odorata*, *E. heterophylla*, *T. diversifolia* and *A. indica*. Significantly lower number of fruits were recorded in the control plot (62.7).

Table 1: Effect of different plant extracts on severity of early blight disease of tomato

Treatments	DS at 4 WAT	DS at 5 WAT	DS at 6 WAT	DS at 7 WAT
Chromolaena odorata	4.3[b]	3.9[b]	2.7[b]	1.5[b]
Euphorbia heterophylla	4.0[b]	3.7[b]	2.5[b]	1.4[b]
Tithonia diversifolia	2.4[c]	3.8[b]	1.6[b]	1.3[b]
Azadirachta indica	3.3[b]	3.0[b]	2.5[b]	1.8[b]
Carica papaya	2.6[c]	2.3[c]	1.1[c]	0.3[c]
Control	7.3[a]	8.0[a]	8.8[a]	10.1[a]

Values are means of three replicates. DS: Disease severity, WAT: Weeks after transplanting, Means in the same column followed by the same alphabet are not significantly different according to Duncan's Multiple Range test ($p \leq 0.05$)

Table 2: Effect of different plant extracts on number of fruits produced on tomato infected with early blight disease

Treatments	No. of fruits
Chromolaena odorata	77.0[b]
Euphorbia heterophylla	84.7[b]
Tithonia diversifolia	88.7[b]
Azadirachta indica	79.3[b]
Carica papaya	104.0[a]
Control	62.7[c]

Values are means of three replicates. Means in the same column followed by the same alphabet are not significantly different according to Duncan's Multiple Range test ($p \leq 0.05$)

Table 3: Effect of different plant extracts on fruit length of tomato infected with early blight disease

Treatments	Fruit length (mm)
Chromolaena odorata	54.6[b]
Euphorbia heterophylla	44.5[c]
Tithonia diversifolia	42.3[c]
Azadirachta indica	52.6[b]
Carica papaya	66.0[a]
Control	46.2[d]

Values are means of three replicates. Means in the same column followed by the same alphabet are not significantly different according to Duncan's Multiple Range test ($p \leq 0.05$)

Fruit length: Plot treated with *C. papaya* showed a significantly higher fruit length (66.0 mm) while the least fruit length was recorded in the control plot (46.2 mm) (Table 3). There was no significant difference in fruit length of tomato in plots treated with *C. odorata* and *A. indica* as well as plots treated with *E. heterophylla* and *T. diversifolia*.

Fruit weight: Plot treated with *C. papaya* gave a significantly ($p \leq 0.05$) higher fruit weight (328 g) than all other treatments (Table 4). There was no significant difference in fruit weight of tomato in plots treated with *C. odorata*, *A. indica* and *E. heterophylla*. Plots treated with *T. diversifolia* and the control gave statistically similar fruit weights (126 and 106 g, respectively).

Table 4: Effect of different plant extracts on yield of tomato infected with early blight disease

Treatments	Fruit weight (g)
Chromolaena odorata	240.0[b]
Euphorbia heterophylla	236.7[b]
Tithonia diversifolia	126.7[c]
Azadirachta indica	253.3[b]
Carica papaya	328.0[a]
Control	106.7[c]

Values are means of three replicates. Means in the same column followed by the same alphabet are not significantly different according to Duncan's Multiple Range test ($p \leq 0.05$)

DISCUSSION

The current study investigated the efficacy of leaf extracts of *Chromolaena odorata*, *Euphorbia heterophylla*, *Tithonia diversifolia*, *Azadiractha indica* and *Carica papaya* in the management of early blight on tomato. The results showed that application of the extracts had a significant influence on early blight severity, number of fruits produced, fruit length and fruit weight. Among the botanicals tested, leaf extracts of *C. papaya* was the most effective in reducing the severity of tomato early blight. All plant extracts examined in this trial increased the yield of tomato plants compared to the control.

Several studies have shown that extracts of plants are effective in controlling fungal plant pathogens[16-18]. Curtis *et al*.[18], Krebs *et al*.[19] and Latha *et al*.[10] also reported that plant extracts from 20 non-host plant species significantly reduced the early blight disease and inhibited the mycelial growth of *A. solani*. Findings of Arya and Perello[20] also indicated that the susceptibility of *A. solani* to aqueous plant extracts of *Azadirachta indica*, *Lantana camara*, *Eucalyptus globules* and *Capsicum annuum* caused inhibition in the radial growth of the mycelia of the pathogen. In a related study, Vijayan[21] reported that the bulb extract of *A. sativum,* leaf extract of *Aegle marmelos* and flower extract of *Catharanthus roseus* inhibited the spore germination and mycelial growth of *A. solani*.

Leaf extracts of *Acacia nilotica* and *Sapindus mukorossi* have been demonstrated to be effective in enhancing root length, shoot length, root weight and shoot weight of chickpea infected with root rot fungi such as *Rhizoctonia solani*, *Macrophomina phaseolina* and *Fusarium* spp. on leguminous and non-leguminous crops[7].

Natural plant products have the potential to reduce populations of foliar pathogens, thereby controlling plant diseases[14,22]. These extracts are environmentally safe alternatives that form an essential component of integrated pest management programs. Investigations on the mechanism of disease suppression by plant products suggested that the active ingredient present in the extracts may either act on the pathogen directly[23] or induce systemic resistance in host plants, leading to a reduction in disease development[13]. Plant extracts could exert toxic effects by disrupting the normal metabolic activities of the pathogenic organism[24].

CONCLUSION

The fungicidal activity of the plant extracts against *A. solani* indicates the potential of these plant species as a natural source of fungicidal material. Antifungal activity was confirmed in all the tested plant species, although the results showed that the different plant extracts varied in their efficacy in reducing the severity of early blight disease on the tomato. The study shows that among the extracts tested, *C. papaya* was the most effective in reducing the severity of early blight of tomato. Significantly higher yields were also obtained with *C. papaya*.

Thus, the use of plant extracts minimizes the risks and hazards associated with toxic fungicides, especially, on crop plants that are produced for fresh consumption. Further studies are, however, suggested to unfold the potential of other botanicals in the management of *A. solani* on tomato.

SIGNIFICANT STATEMENTS

There is a need to focus on environmentally safe, long lasting control of plant diseases. Botanicals have these attributes and are currently incorporated into integrated pest management programs. The use of plant extracts minimizes the risks and hazards associated with toxic fungicides, especially, on crop plants produced for fresh consumption.

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