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Research Article

# Growth Inhibitory Effect of Medicinal Plant Extracts on Insect Pests and Pathogenic Fungi

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## Abstract

Leaf extracts of eight medicinal plants were examined for insecticidal and fungicidal activities against two insect pests and five pathogenic fungi. Two polar solvents were used separately for the extraction. Extracts in solvent-I indicated substantial eggs and larval mortalities in either case of the insects. Among the treatments, Solanum xanthocarpum indicated highest egg (52-61%) and larval (38-56%) mortalities of Pieris brassicae and Helicoverpa armigera insects. Moreover, moderate egg (18-47%) and larval (18-50%) mortalities were found in Ocimum sanctum, Calotropis procera, Euphorbia hirta, and Plectranthus barbatus treatments. Comparatively less efficacies were observed in treatments of solvent-II extracts. Antifungal activities depicted in terms of growth inhibition zones, such zones were found in all the treatments with variable sizes. S. xanthocarpum treatment exhibited highest fungicidal activities against all the five fungi with growth inhibition zones from 13.7 to 18.3 mm and 11.0 to 13.7 mm diameter respectively, in solvent-I and solvent-II extracts.

**Keywords:** Egg, Larvae, P. brassicae, H. armigera, Inhibition zone, Leaf extracts

## Introduction

Several reports had emphasized on necessity of eco-friendly remediation of pest and disease constraints in sustainable agriculture and ultimately minimization of environmental toxicity due to contamination of health hazardous and long persistent chemical pesticides (Datta, 2012, 2010). Biological control measures are real directions for pest and disease management, which are harmless and may be effective alternative of synthetic pesticides (Eric et al., 2012). Development and mass-production of botanicals, bio-agents and biopesticides are inventive initiatives to overcome the biotic stress in various crops. Unfortunately, overwhelming crop infestations and scarce availability of botanicals and biopesticides are compelling the end users to apply chemical pesticides as an immediate tool for different crop protection. On the other hand, ample availability of synthetic pesticides and rapid results, pest and diseases management have mainly confined to the chemical pesticides and become an integral intervention of the agriculture (Sumitra et al., 2006). It has been estimated that only 0.1% of applied pesticides reach to the targeted pests and remaining 99.9% affect the environment (Pimentel, 1995). Thus, persistent pesticides contaminate the entire environment through bio-magnification and may affect non-target organisms.

Medicinal plants represent a richest source of organic compounds such as alkaloids, glycosides, flavanoids, steroids, terpenoids, phenolics and also of insecticidal and fungicidal compounds. Naturally occurring botanical bio-active compounds are generally assumed to be more acceptable and less hazardous than synthetic pesticides. Therefore, present investigation was aimed to examine the pesticidal activity of some medicinal plants leaf extracts on selected pests and pathogenic fungi under laboratory conditions.

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## Materials and Methods

Extraction of eight locally available medicinal plants leaves such as; Calotropis procera Ait (Asclepiadaceae), Cannabis sativa L. (Cannabaceae), Euphorbia hirta L. (Euphorbiaceae), Ocimum sanctum L. (Lamiaceae), Plectranthus barbatus L. (Lamiaceae), Solanum xanthocarpum Serb. and Wende (Solanaceae), Tinospora cordifolia Willd. (Menispermaceae) and Withania somnifera L. (Solanaceae) was carried out using mixture solvents such as, acetonitrile: water (7:3, v/v) and acetone: methanol (1:1, v/v). Eight hundred gram of the leaf samples were collected separately and washed thoroughly with running water and finally in sterile distilled water and air dried up to dryness under shade. The shade-dried samples were fine powdered using mixer. Twenty five gram of leaf powder was taken in 250 mL conical flasks and 150 mL of solvents such as, acetonitrile: water (7:3, v/v, solvent-I) and acetone : methanol (1:1, v/v, solvent-II) mixtures were added separately in triplicates and shaken on incubator shaker for 16 hrs. The extracts were filtered and again 150 mL of the corresponding solvents were added and shaken for next 4 hrs and filtered. Total filtrate was pooled after completion of the process. Filtrates were concentrated using rotary vacuum evaporator at 40°C and around 200 mL final volume was made by adding sterile water. The aqueous leaf extracts were partitioned three times with equal amount of dichloromethane in separatory funnels. Dichloromethane fractions were collected and passed through a column (50 cm × 15 mm i.d.) packed with anhydrous $Na_2SO_4$ to remove trace of water and at last 50 mL pure dichloromethane was poured into the columns to wash out the intact bound active molecules with $Na_2SO_4$. Finally the extracts were concentrated near to dryness by rotary vacuum evaporator and then 5 mL final volume was made in sterile double distilled water and stored at -20°C for experiments.

## Collection of Egg and Larvae Samples

Cabbage and tomato were cultivated in small plots (50×30 m) to attract cabbage butterfly (Pieris brassicae L.) and American bollworm (Helicoverpa armigera Hübner) for infestation and multiplication in the field and no control measures were applied. The eggs and larvae (3rd instars) of insects were collected separately in collection jars from the fields along with their host plant parts and jars were covered with muslin cloth letting gaseous exchange. Host plant materials were washed prudently for decontamination of predators and parasites before placing it in sterilized rearing containers. Samples were collected in triplicates for each treatment and stored aseptically at room temperature (18°C 32°C) with 50-70% humidity. To keep up moisture level up to 50-70%, a water-filled and cotton plugged vial was placed inside the jars. Utmost care was taken to maintain aseptic conditions throughout the experiment. Rearing containers were regularly cleaned and monitored for egg hatching and survival of larvae after different treatments.

## Revival of Fungal Strains

Five plant pathogenic fungal strains such as, Aspergillus niger, Botrytis cinerea, Geotrichum candidum, Penicillium expansum, and Penicillium italicum were procured from Division of Plant Pathology, Indian Agricultural Research Institute, New Delhi. All the pure cultures were multiplied and maintained aseptically on potato dextrose agar (PDA) and on Streptomycin-Rose-Bengal medium (Martin 1950). Streptomycin-Rose-Bengal medium was prepared with the composition of peptone 5.0 g, dextrose 10.0 g, $KH_2PO_4$ 1.0 g, $MgSO_47H_2O$ 0.5 g, rose bengal 0.03g, agar 15.0 g in one liter of double distilled water with 3.8- 4.0 pH and then medium was autoclaved at 1.05 kg $cm^2$ pressure and 121°C temperature for 15 min. One mL streptomycin solution (0.3 g in 10 mL sterile water) was added when temperature of the medium decreased down up to 48°C. Pure cultures of the fungi were preserved at -20°C for the experimentation.

## Contact Toxicity

Plant leaf extracts were examined for contact toxicity on larval growth and egg hatching of the test insects. Twenty eggs were glued (using rice starch) on filter paper (Whatmanno.1, 2 ×2") and different extracts were diluted in sterile water (1:10, v/v) and applied separately onto the egg bunches and for wetting the filter paper. Similarly, 20 larvae (3rd instars) were treated dorsally by uniform wetting and immediately transferred into a jar containing fresh host plant leaves. Parallel procedure was also followed for eggs and larvae using only sterile water as positive control. All the treatments were prepared in three replicates and incubated at 28 ± 2°C and~70% relative humidity. Percent egg hatching (till hatching period) and larval mortality were recorded daily for four days after treatments. Total number of killed eggs and larvae were counted and compiled in tabular form for interpretation.

## Fungicidal Activity

The antifungal activities of the leaf extracts were examined by disc diffusion method (Taylor et al., 1995). The potato dextrose agar (PDA) medium plates were prepared and incubated for 24 hrs at 30°C. Autoclaved filter paper (Whatman no.1) discs (5 mm diameter) were made and soaked (2 hrs) in diluted leaf extracts (1:1, v/v, extract: sterile water). The wetted paper discs were placed on sterile glass slides and dried completely inside the laminar air flow cabinet. Similarly, some paper discs were saturated with

corresponding solvents only and dried to use as control. Pre-incubated petri-dishes were taken out from the incubator and examined for any fungal or bacterial growth, and then three treated paper discs and one without treated (control) paper discs were fixed symmetrically.

In these plates, different pathogenic fungal strains were inoculated by smearing evenly by singly touched spreader to the full grown sporangium of the fungus in petri plates. Growth inhibition zone due to antifungal activity of the different leaf extracts became visible after 24 hrs, but final observations were recorded after 48 hrs of incubation. The diameters of the inhibition zones were recorded manually in mm.

## Statistical Analysis

Data were analyzed by complete randomized design (CRD) and analysis of variance (ANOVA) for each treatment was used to determine the significant effect of medicinal plant extracts on egg and larval development of insects and pathogenic fungal growth. SAS statistical software was used for the analysis and significance was defined as ($p \leq 0.05$).

## Results and Discussion

Number of reports revealed that the certain medicinal plants have contact insecticidal, antifeedant (Rani and Rajasekharreddy, 2009) and antifungal activities (Sateesh et al., 2004). Keeping in view, leaf extracts of eight medicinal plants were examined to find out potential leaf extracts for the management of P. brassicae and H. armigera and pathogenic fungi. The extraction efficiencies of the solvents were tested in terms of comparative efficacies on egg and larval mortalities and pathogenic fungal growth inhibition under laboratory conditions. Comparatively, solvent-I was found more effective than solvent-II for the extraction of potential components against egg, larval and fungal growth and development.

## Egg mortality of P. brassicae and H. armigera

### Solvent-I

Eggs of either the insects indicated delayed or no hatching after the different treatments. Among the treatments, highest egg mortality (52.3 ± 1.5%) of P. brassicae was observed in S. xanthocarpum treatment followed by O. sanctum, P. barbatus and C. procera treatments i.e. 47.0 ± 2.3%, 44.0 ± 1.7% and 41.0 ± 1.7% egg mortalities were recorded respectively (Table 1). But no significant variations were observed among these treatments. Significantly ($P \leq 0.05$) lowest toxic effect on the eggs hatching was found in T. cordifolia treatment (28.0 ± 2.1%). Likewise, C. sativa, E. hirta and W. somnifera treatments also indicated egg hatching inhibitory effects viz. 31.7 ± 1.5% to 34.0 ± 2.3% reduced egg hatching were recorded (Table 1). Whereas, S. xanthocarpum exhibited significant ($P \leq 0.05$) inhibitory effect on H. armigera egg hatching. In this treatment 61.3 ± 2.3% eggs could not be hatched, which was maximum reduction in egg hatching of the H. armigera eggs, followed by C. procera (35.0 ± 1.2%) treatment (Table 1). In W. somnifera treatment lowest toxic effect on egg hatching was noticed. As compared the W. somnifera treatment, P. barbatus, C. sativa and E. hirta treatments were also found significantly ($p \leq 0.05$) more effective in terms of reduced egg hatching (Table 1). A number of reports (Hiiesaar et al., 2001) pointed out the broad spectrum lethal, antifeedant, repellent and growth regulatory and also antifungal activities of plants origin compounds (Sateesh et al., 2004). Similarly, Kona et al., (2014) applied Neem and Jatropha seed extracts on eggs and larvae of Tuta absoluta and found 20-26% egg mortality within 4 days in different concentrations of the extracts with no significant differences between the concentrations. While, moderate ovicidal activities of Catharanthus roseus and O. sanctum treatments were recorded on S. lituraeggs (Lall et al., 2014).

**Table 1.Per cent mortality of egg and larvae of P. brassicae and H. armigera after treatment of medicinal plants leaf extracts (acetonitrile: water, 7:3 v/v solvent-I)**

| Treatments | *P. brassicae* | | *H. armigera* | |
|---|---|---|---|---|
| | Egg | Larvae | Egg | Larvae |
| C. procera | 41.0 ± 1.7 | 47.0 ± 2.3 | 35.0 ± 1.2 | 41.7 ± 1.5 |
| C. sativa | 34.0 ± 2.3 | 40.3 ± 2.0 | 31.7 ± 1.5 | 32.0 ± 1.7 |
| E. hirta | 34.0 ± 3.2 | 40.7 ± 1.5 | 25.0 ± 1.7 | 25.0 ± 1.2 |
| O. sanctum | 47.0 ± 2.3 | 44.3 ± 1.4 | 19.0 ± 1.2 | 18.0 ± 1.7 |
| P. barbatus | 44.0 ± 1.7 | 50.0 ± 1.7 | 32.7 ± 4.5 | 27.7 ± 1.5 |
| S. xanthocarpum | 52.3 ± 1.5 | 55.7 ± 2.6 | 61.3 ± 2.3 | 56.7 ± 3.0 |
| T. cordifolia | 28.0 ± 2.1 | 34.7 ± 1.2 | 20.0 ± 1.5 | 29.3 ± 2.3 |
| W. somnifera | 31.7 ± 1.5 | 37.7 ± 2.0 | 18.0 ± 1.7 | 30.0 ± 1.7 |
| CD at 5% | 6.48 | 5.76 | 6.89 | 5.74 |

### Solvent-II

Another extraction solvent, acetone: methanol (1:1, v/v) was used for the extraction of same medicinal plant leaves and different treatments were applied symmetrically. In case of P. brassicae, reduction in egg hatching ranged from 21.3 ± 1.5 to 42 ± 2.3%. Among the treatments, S. xanthocarpum leaf extracts indicated upper limit of the egg mortalities, followed by C. procera and O. sanctum treatments (Table 2). Whereas, least egg mortalities were observed in T. cordifolia treatment i.e. only 21.3 ± 1.5% reduced egg hatching was recorded. Other than these both upper and lower limits of S. xanthocarpum and T. cordifolia treatments; moderate egg mortalities were recorded in C. procera, O. sanctum, E. hirta, C. sativa, P. barbatus and W. somnifera treatments. Though, there were no significant differences among these former treatments (Table 2). Likewise, these treatments were also tested on egg hatching of the H. armigera and egg hatching inhibitory effects ranged from 13.0 ± 1.2 to 37.0 ± 4.6% in different treatments. S. xanthocarpum treatment again indicated upper (p≤0.05) limit for the egg mortalities. As compared to the efficacies on eggs of P. brassicae, less sensitivity was observed in eggs of H. armigera. No significant difference was observed among the C. procera, C. sativa, E. hirta and P. barbatus treatments, while these treatments exhibited moderate egg mortalities viz. 23.0 ± 1.2%, 23.0 ± 2.3%, 19.7 ± 1.4% and 24.0 ± 1.2% egg hatching inhibitory effects respectively were recorded (Table 2). Likewise, Kumar et al., (2009) observed constant increase in per cent killing of egg masses of Plutella xylostella with the increase of concentrations of extracts of Melia azedarach (leaf); Lantana camara (seed), Artemisia annua (seed) and Cannabis sativa (leaf). Reduced progeny emergence of S. zeamais and C. maculatus were observed after treatment of Z. xanthoxyloides extracts (Udo et al., (2004).

efficacies for the larval growth inhibition or mortality. All the plant leaf extracts exhibited considerable mortalities of P. brassicae larvae. The highest mortality (55.7 ± 2.6%) was found in S. xanthocarpum treatment, followed by P. barbatus (50.0 ± 1.7%) and C. procera (47.0 ± 2.3%) treatments. But no significant differences between P. barbatus and C. procera treatments were observed. Among the treatments, larval mortality of P. brassicae ranged from 34.7 ± 1.2% to 50.0 ± 1.7% (Table 1). In T. cordifolia, treatment larval mortality was found 34.7 ± 1.2%, which was significantly lower than all the treatments except W. somnifera (Table 1). Similarly, larvae of H. armigera indicated less sensitivity with these plant extracts. Per cent mortality of H. armigera larvae ranged from 18.0 ± 1.7 to 56.7 ± 3.0% after four days of treatment (Table 1). Highest (p≤0.05) mortality 56.7 ± 3.0% was found in S. xanthocarpum treatment, followed by C. procera and C. sativa treatments. Lowest larval mortality of H. armigera was found 18.0 ± 1.7% in O. sanctum treatment (Table 1).

### Solvent-II

Comparatively, extracts in solvent-II exhibited low larval mortalities of P. brassicae and H. armigera (Table 2). In case of P. brassicae, larval mortality ranged from 19.7 ± 1.5% to 48.0 ± 1.7% only; whereas, it ranged from 34.7 ± 1.2% to 55.7 ± 2.6% in solvent-I (Table 1). Highest larval mortality (48.0 ± 1.7%) of P. brassicae was observed in S. xanthocarpum treatment, followed by P. barbatus (30.0 ± 1.7%) and W. somnifera (28.7 ± 1.4%) treatments (Table 2). Similarly, low larval mortality of H. armigera was also found, which ranged from 13.3 ± 1.5% to 38.0 ± 1.8% in solvent–II extracts. Highest (p≤0.05) larval mortality of H. armigera was found in S. xanthocarpum treatment, whereas, treatments of C. sativa and P. barbatus were also indicated significant larval mortalities as compared

**Table 2.Per cent mortality of egg and larvae of P. brassicae and H. armigera after treatment of medicinal plants leaf extracts (acetone: methanol, 1:1, v/v, solvent-II)**

| Treatments | *P. brassicae* | | *H. armigera* | |
|---|---|---|---|---|
| | Egg | Larvae | Egg | Larvae |
| C. procera | 34.0 ± 2.7 | 19.7 ± 1.5 | 23.0 ± 1.2 | 17.0 ± 2.3 |
| C. sativa | 30.0 ± 1.7 | 25.7 ± 1.2 | 23.0 ± 2.3 | 21.3 ± 0.9 |
| E. hirta | 31.7 ± 2.0 | 20.3 ± 1.5 | 19.7 ± 1.4 | 13.3 ± 1.5 |
| O. sanctum | 32.7 ± 3.4 | 24.3 ± 1.5 | 14.7 ± 2.0 | 19.7 ± 1.4 |
| P. barbatus | 28.0 ± 1.7 | 30.0 ± 1.7 | 24.0 ± 1.2 | 21.3 ± 1.4 |
| S. xanthocarpum | 42.0 ± 2.3 | 48.0 ± 1.7 | 37.0 ± 4.6 | 38.0 ± 1.8 |
| T. cordifolia | 21.3 ± 1.5 | 24.0 ± 1.9 | 16.0 ± 1.7 | 18.3 ± 1.3 |
| W. somnifera | 28.0 ± 1.7 | 28.7 ± 1.4 | 13.0 ± 1.2 | 15.7 ± 1.8 |
| CD at 5% | 6.68 | 4.65 | 6.75 | 4.86 |

## Larval mortalities of P. brassicae and H. armigera

### Solvent-I

Third instar larvae of P. brassicae and H. armigera were treated by the different plant leaf extracts to observe their

to lower limit of W. somnifera treatment (Table 2). Mostly larval mortalities after botanicals treatment is found due to antifeedant activities. Pavunraj et al. (2011) pointed out antifeedant activity on larvae of S. litura after Pergularia daemia treatment. Likewise, Rathi and Gopalakrishnan

(2005) observed toxic effects of methanol extracts of Synedrella nodiflora against S. litura. Similar antifeedant activities were also observed against S. litura larvae with crude acetone extracts of Tectona grandis, Tamarindus indica, Madhuca indica, Momordica charantia and Jatropha curcas (Devanand and Rani, 2008).

## Fungal Growth Inhibitory Effects

### Solvent-I

Extracts of the S. xanthocarpum leaves in solvent-I and solvent-II indicated significantly ($p \leq 0.05$) more antifungal activities (Tables 3 and 4). Fungal growth inhibition zones were measured in mm diameter (dia) from central region of the paper disc to periphery of the zone and compared altogether. No growth inhibition zones were found near untreated paper discs. Whereas, all the treatments revealed some growth inhibitory effect on A. niger pathogenic fungus but maximum growth inhibitory zone of 17.0 ± 1.0 mm dia was observed in S. xanthocarpum treatment, followed by P. barbatus (15.0 ± 1.0 mm) and O. sanctum (13.3 ± 0.5 mm) treatments. Lowest growth inhibitory effect (5.3 ± 1.5 mm) was found in T. cordifolia treatment. Almost similar antifungal effects were recorded in T. cordifolia (5.3 ± 1.5 mm), E. hirta (6.0 ± 1.0 mm) and C. sativa (6.3 ± 0.5 mm) treatments (Table 3). As compared to all the treatments, moderate range of growth inhibitory effects of C. procera (11.0 ± 1.0 mm) and W. somnifera (10.0 ± 2.0 mm) were recorded in A. niger trial. Growth inhibitory effect on B. cinerea was also recorded under these treatments. S. xanthocarpum indicated highest antifungal activity on B. cinerea with 18.3 ± 1.5 mm dia zone of inhibition, which followed by O. sanctum (13.6 ± 1.5 mm) and P. barbatus (11.6 ± 1.5 mm) and W. somnifera (11.3 ± 2.5 mm) treatments. While, lowest adverse effect was found in C. sativa (5.7 ± 1.5 mm) treatment. Compared to C. sativa treatment, significantly more growth inhibitory effects were observed in E. hirta (10.0 ± 1.0 mm) and C. procera (9.7 ± 1.5 mm) treatments (Table 3). Similarly, suppressed growth of G. candidum was observed in all the treatments. Lowest growth inhibitory effects on G. candidum were recorded by C. sativa (5.3 ± 1.5 mm) and T. cordifolia (6.7 ± 2.5 mm) treatments. Whereas all other treatments indicated significantly ($p \leq 0.05$) more growth inhibitory effects on G. candidum, ranged from 10.0 ± 2.0 to 13.7 ± 2.5 mm dia growth inhibition zone (Table 3).

In case of fungus P. expansum, the treatments of C. procera (5.6 ± 2.1 mm), C. sativa (6.3 ± 1.1 mm) and E. hirta (5.6 ± 1.5 mm) exhibited lower growth inhibitory effects, while significantly ($p \leq 0.05$) more growth inhibitory effects of S. xanthocarpum (15.6 ± 2.5 mm), O. sanctum (13.6 ± 2.1 mm), P. barbatus (13.6 ± 1.5 mm) were noticed. Similarly, P. italicum fungus was also found sensitive with these treatments. Under different treatments diameter of zone of inhibition (mm) ranged from 5.0 ± 1.7 to 12.3 ± 1.7 mm. Among the treatments, highest adverse effects on growth of P. italicum was recorded under S. xanthocarpum treatment i.e. 14.6 ± 3.5 mm dia growth inhibition zone was observed, the trend followed by O. sanctum (12.6 ± 3.5 mm), W. somnifera (12.6 ± 2.1 mm) and P. barbatus (9.3 ± 2.5 mm) treatments. Comparatively, lowest adverse effect of C. procera was recorded viz. 5.6 ± 1.5 mm dia growth inhibition zone was recorded. While, moderate adverse effects on P. italicum were found in the treatments of C. procera and T. cordifolia (Table 3).

**Table 3.Growth inhibitory effect of medicinal plants leaf extracts on pathogenic fungi (zone of inhibition mm diameter) on PDA medium in petri dishes (acetonitrile: water, 7:3 v/v, solvent-I)**

| Treatments | Plant pathogens | | | | |
|---|---|---|---|---|---|
| | ***A. niger*** | ***B. cinerea*** | ***G. candidum*** | ***P. expansum*** | ***P. italicum*** |
| C. procera | 11.0 ± 1.0 | 9.7 ± 1.5 | 10.0 ± 2.0 | 5.6 ± 2.1 | 8.0 ± 3.0 |
| C. sativa | 6.3 ± 0.5 | 5.7 ± 1.5 | 5.3 ± 1.5 | 6.3 ± 1.1 | 5.6 ± 1.5 |
| E. hirta | 6.0 ± 1.0 | 10.0 ± 1.0 | 10.0 ± 2.0 | 5.6 ± 1.5 | 6.3 ± 2.3 |
| O. sanctum | 13.3 ± 0.5 | 13.6 ± 1.5 | 12.0 ± 2.0 | 13.6 ± 2.1 | 12.6 ± 3.5 |
| P. barbatus | 15.0 ± 1.0 | 11.6 ± 1.5 | 10.6 ± 2.5 | 13.6 ± 1.5 | 9.3 ± 2.5 |
| S. xanthocarpum | 17.0 ± 1.0 | 18.3 ± 1.5 | 13.7 ± 2.5 | 15.6 ± 2.5 | 14.6 ± 3.5 |
| T. cordifolia | 5.3 ± 1.5 | 6.0 ± 2.0 | 6.7 ± 2.5 | 8.0 ± 3.0 | 8.0 ± 3.0 |
| W. somnifera | 10.0 ± 2.0 | 11.3 ± 2.5 | 12.6 ± 2.5 | 10.6 ± 2.0 | 12.6 ± 2.1 |
| CD at 5% | 2.0 | 3.0 | 3.9 | 3.7 | 4.8 |

**Solvent-II**

Reduced growth of A. niger was observed in all the treatments. E. hirta, O. sanctum and S. xanthocarpum treatments indicated significantly reduced fungal growth with 11.0 ± 3.0, 12.8 ± 2.0 and 13.0 ± 3.0 mm diameter of zones of growth inhibition, respectively. Lowest diameter of the zone was recorded in C. sativa and T. cordifolia treatments i.e. only 5.3 ± 2.5 mm and 4.6 ± 2.0 mm diameter zone of growth inhibition were observed. On the other hand, moderate antifungal effects were also noticed in C. procera, P. barbatus and W. somnifera treatments (Table 4).

Moreover, growth inhibitory effects were observed in B. cinerea petri plates too under different treatments. Longer diameter of growth inhibition zone was found in S. xanthocarpum (13.3 ± 2.0 mm) and O. sanctum (12.4 ± 3.5 mm) treatments. Whereas, C. procera, C. sativa, P. barbatus and T. cordifolia indicated 5.0-7.0 mm dia zone of growth inhibition viz. these treatments indicated significantly ($p \leq 0.05$) less dia of zone of growth inhibition. Treatments of E. hirta and W. somnifera presented moderate effects on growth inhibition of B. cinerea (Table 4). Similarly, varying susceptibilities were recorded in case of G. candidum fungal growth. S. xanthocarpum treatment indicated highest zone of inhibition of G. candidum, while the fungus exhibited less susceptibility with C. procera and T. cordifolia treatments. Likewise, P. expansum fungal growth was also found susceptible towards the different treatments. Growth inhibition zones of this fungus ranged from 6.0 ± 2.0 to 11.0 ± 2.0 mm dia. But there were no significant variations among the treatments. Whereas, P. italicum fungal growth was found susceptible ($p \leq 0.05$) towards O. sanctum, S. xanthocarpum and W. somnifera treatments i.e. 12.0 ± 2.0 mm, 12.3 ± 1.7 mm and 10.3 ± 3.0 mm dia zones of growth inhibition were recorded. Among the treatments of C. procera, C. sativa, E. hirta, P. barbatus and T. cordifolia; zone of growth inhibition ranged from 5.0 ± 1.7 mm to 6.7 ± 1.8 mm dia. However, there were no significant variations among these treatments (Table 4).

Several studies revealed that the crude extracts of botanicals have great potential for antifungal activities (Lee et al., 2007). Qadeer et al., (2014) recorded well defined zones of growth inhibition of pathogenic fungus, A. niger, A. flavus, A. candidus, A. parasiticus in treatment of plant powdered extract of S. xanthocarpum. Antifungal effect of C. procera latex was also reported by Nenaah and Ahmed (2011).

The latex methanolic extract was most effective against fungal strains such as, Candida albicans, C. tropicalis, Penicillium chrysogenum and Saccharomyces cerevisiae with varying growth inhibition zones. Leaf extract of C. sativa had excellent antifungal potential against C. lunata, A. zinniae, followed by leaf extract of P. hysterophorus and A. solani (Tapwal et al., 2011). Similarly, Vidya et al., (2005) observed biocidal activity of essential oil of O. sanctum against A. niger, Fusarium solani, Penicillinum funiculosum, Rhizomucor auricus and Trichderma reesi. Thereafter, Nilani et al., (2006) documented antifungal activity of Coleus forskohlii and Coleus barbatus on all the selected fungi, A. niger, A. fumigatus, A. ruantii, Proteus vulgaris and Candida albicans. Likewise, Khan and Nasreen (2010) applied 10% (v/v) methanol extract of W. somnifera leaves on different pathogenic fungi such as, Colletotrichum capsici, Colletotrichum lindemuthianum, Fusarium moniliforme, Alternaria alternate, Bipolaris oryzae, Curvularia lunata, Rhizoctonia solani, Macrophomina phaseolina, Pyricularia oryzae and Fusarium oxysporum and reported 55-78% growth inhibition. Bahraminejad et al., (2012) examined multiple plant extracts against Phytophthora drechsleri and found Xanthium strumarium had the strongest growth inhibitory activity against P. drechsleri followed by extracts of Glycyrrhiza glabra, Verbascum sp., Hypericum perforatum, Centaura depressa, Centaura sp., Lamium amplexicaule and Haplophyllum perforatum.

While, Shinde and Wadje (2011) applied bark extracts of five Terminalia spp (T. alata, T. arjuna, T. bellerica, T. catappa and T. chebula) in aqueous, alcoholic and ethyl acetate against five seed borne pathogenic fungi, Aspergillus flavus,

**Table 4.Growth inhibitory effect of medicinal plants extracts on pathogenic fungi (zone of inhibition mm diameter) on PDA medium in petri dishes (acetone: methanol, 1:1 v/v, solvent-II)**

| Treatments | Plant pathogens | | | | |
|---|---|---|---|---|---|
| | ***A. niger*** | ***B. cinerea*** | ***G. candidum*** | ***P. expansum*** | ***P. italicum*** |
| C. procera | 9.0 ± 2.0 | 5.5 ± 2.0 | 5.0 ± 1.7 | 8.5 ± 2.5 | 5.0 ± 1.7 |
| C. sativa | 5.3 ± 2.5 | 5.3 ± 2.5 | 8.3 ± 1.5 | 7.0 ± 2.0 | 6.3 ± 1.5 |
| E. hirta | 11.0 ± 3.0 | 8.6 ± 3.0 | 7.7 ± 1.5 | 6.0 ± 2.6 | 5.5 ± 2.0 |
| O. sanctum | 12.8 ± 2.0 | 12.4 ± 3.5 | 9.5 ± 2.5 | 9.7 ± 2.5 | 12.0 ± 2.0 |
| P. barbatus | 8.7 ± 2.5 | 6.3 ± 2.5 | 6.3 ± 2.5 | 8.8 ± 2.1 | 6.3 ± 2.5 |
| S. xanthocarpum | 13.0 ± 3.0 | 13.3 ± 2.0 | 13.7 ± 2.0 | 11.0 ± 2.0 | 12.3 ± 1.7 |
| T. cordifolia | 4.6 ± 2.0 | 6.6 ± 1.6 | 5.3 ± 2.0 | 6.0 ± 2.0 | 6.7 ± 1.8 |
| W. somnifera | 9.3 ± 3.5 | 8.7 ± 2.0 | 9.6 ± 2.5 | 9.4 ± 3.0 | 10.3 ± 3.0 |
| CD at 5% | 4.6 | 4.6 | 3.8 | N/A | 3.9 |

Aspergillus niger, Alternaria brassicicola, Alternaria alternata and Helminthosporium tetramera and observed fungal growth inhibitory effect more than the control fungicide.

## Conclusions

In present study, crude extracts of all the eight plant leaves shown insecticidal and fungicidal activities. The composite of crude leaf extracts were applied to examine their efficacies on mentioned test materials and found significant results. Among these extracts, S. xanthocarpum exhibited highest efficacies as ovicide, larvicide and fungicide. Other plant leaf extracts, O. sanctum, C. procera, E. hirta, and P. barbatus had shown moderate range of ovicidal, larvicidal and fungicidal activities. Probably, few or single component of the extracts may be applicable for type of activities. Therefore, these plant materials may be exploited for multiple pest and disease management by applying identified active compounds from these plant materials.

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**Conflict of Interest:** None

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