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Study the Antifungal Activity of Selected Plant Extracts in Chilli

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ABSTRACT:

This study was mainly focused on antifungal activity ofselected seven plant species viz. A. indica, A. vasica, A. sessilis, C.hirsutus, M. parvifolia, P. paniculata, and T. bellirica. The present study is concluded as follows: Our investigations on the phytochemical analysis of selected plant extracts have revealed presence of organic compounds & their other constituents. These compounds are valuable sources of biologically active molecules including antifungal compounds. These compounds are found to beeffective against C. capsici. Hence, plant extracts can be used for controlling the pre- & postharvest pathogens of different horticulture crops. In this study, aqueous, ethanolic, and methanolic and hexane solvent were selected for the plant extractions. Ethanolic extracts were found tobe more effectiveagainst the C. capsici than aqueous, hexane and methanol extract.

Keywords: Aqueous, ethanolic and methanolic plants extracts, antifungal activity, chilli etc.

1. Introduction

Chilli is an ambiguous spice crop grown in all of India's states, and the quality varies by state.

For example, Karnataka chilli is known for its high oil content, but chilli from Gujarat and Rajasthan state has a bright hue and is often used in pickle preparation. Similarly, chilli produced in Assam is recognized for its intense pungency, whilst chilli from Andhra Pradesh is utilized in vegetables. Andhra Pradesh (which has the country's largest chilli cultivation area, as well as Telangana (35%), Karnataka (14%), Tamil Nadu (7%), Orissa (7 percent), Maharashtra (6 percent), West Bengal (6%), and MadhyaPradesh (4%), with the remainder distributed among Rajasthan, Gujarat, and other states. Currently, India is primary source of red chilli in worldwide market, consuming over 6.2 million tons of chilli, accounting for almost 90% of the country's total production (Gade et al., 2020).

Capsicumannuum L. is one of most widely cultivated species in genus. Other domesticated chilli species include C. baccatum, C. chinensis,C. frutescens, and C. pubescens (Tong et al., 1999).

C. annuum produces sweet (bell pepper) and pungent (chilli) fruits of various sizes & forms. Chilli is high in ascorbic acid, folic acid, potassium, and vitamins A (Pathirana, 2012).

Chilli is widely regarded as a key ingredient in many tropical and subtropical cuisines. Chilli has been considered a native of tropical America, & it is often farmed in its natural condition. Chilli arrived in India via Columbus' expedition, which brought chilli seeds from Spain and spread to Africa & Asia (Heiser, 1995).

One of the most amazing facts is that fresh green chillies have more vitaminC than citrus fruits, while red chillies contain more vitamin A than carrots (Pathirana 2012). Chilli is commonly used as a condiment, spice, vegetable, and in medications and drinks. Chilli's active components include capsaicin and caretenoids. Capsaicinoids are non-volatile alkaloids that are the most active elements in chilli, giving it its spicy flavor. Caretenoids, on the other hand, give the chilli fruit its color as well as nutritional value.

India is world's fifth-largest chilli producer, followed by China, Maxico, Turkey, & Indonesia. India has become world's top producer & exporter of chilli, with exports to United States, Canada, the United Kingdom, Vietnam, Germany, East and South Asia, and many other nations worldwide. India (25%) and China (24%) are the world's top chilli exporters. Indian chilli is well-known across the world for its vivid color and high pungency levels, and these two characteristics provide Indian chilli economic value.

Chilli crops are vulnerable to a variety of pests and infections both before and after harvest, and mycotoxins are a major obstacle to chilli growth. Capsicum is vulnerable to a variety of pests, weeds, fungal, bacterial, & viral pathogens worldwide, with anthracnose, dieback, and fruit-rot of chillies being the most common fungal diseases that cause increased losses during production, shipping, and storage (Dev et al., 2012).

Fungal mycotoxins can enter the body primarily by food, inhalation, or skin absorption. Mycotoxins and fungicide residues can enter food chain through infected crops, which are then consumed directly or indirectly by people or animal-based products such as meat, milk, and eggs (Hojnik et al., 2017).

Mycotoxins have a negative impact on agricultural productivity and trade across the world. According to the data published by Eskola et al. (2020), mycotoxins have contaminated around 60-80% of crops. Mycotoxins are tenacious and difficult to eliminate once they reach food chain. Mycotoxins in agricultural business cause loss not only in plants, but also in livestock output owing to lower growth rates and increased mortality rates in animals (Thipe et al., 2020).

Mycotoxin contamination of agricultural commodities reduces nutritional value, quality, and food safety. Several nations have established regulatory limitations on mycotoxins in agricultural products in order to reduce the dangers to human and animal health from mycotoxin exposure. Mycotoxins are associated with the illness mycotoxicosis, which has immunosuppressive, carcinogenic, genotoxic, hepatotoxic, mutagenic, nephrotoxic, and

teratogenic features. The most important mycotoxins for agriculture are aflatoxins (AFs), ochratoxins (OTA), fumonisins (FBs), trichothecenes, & zearalenone (ZEN), which have attracted significant attention due to their high potential health concerns in people and animals (Celik, 2020).

Several ways have been used to manage & prevent mycotoxins in food, including chemical and microbiological procedures (biocontrol agents), as well as fungal infection prevention by the use of plant extracts at pre- and postharvesting phases (Adebiyi et al., 2019).

The strategies described above are successful in reducing the proliferation of toxigenic fungi as well as the generation of related mycotoxins before, during, and after harvest of agricultural commodities. Chemical approaches for decontaminating mycotoxins include the use of synthetic fungicides, ammonia, sodium hydroxide, hydrochloric acid, butylated hydroxytoluene, butylated hydroxyanisole, & oltipraz (Čolović et al. 2019).

Objectives of Thestudy

1. To evaluate antifungal properties of plant extracts after post-harvest fruits to observe the disease incidence, decay inhibition, and effect of different storage temperatures.

2. Review Of Literature

According to Anum Haq Nawaz et al. (2024), Anthracnose disease, caused by the fungus Coll capsici, is a severe fungal problem in chilies (Capsicum annuum L.) over the world, leading in a decrease in worldwide production. It may be treated with synthetic fungicides, but these chemicals may upset the environmental and ecological balance. As a result, additional strategies are necessary to manage this critical fungal illness. In their investigation, they produced commercially viable silver nanoparticles (AgNPs) and found that they have antifungal action against Colletotrichum capsici, which causes anthracnose. AgNPs were made from Colchicum luteum leaf extract. The findings indicate that AgNPs are efficient antifungal agents against C. capsici, exceeding AgNO3 and conventional fungicide treatments. These findings lend support to future study into the practical application of AgNPs as a potential alternative strategy for treating fungal infections in agricultural settings.

Syeda Noureen Fatima et al. (2023) compared the antifungal activity of plant extracts with standard fungicides against C. capsici. Morphologically identifiable strains of C. capsici were examined for infectiousness, with strain CC-2 demonstrating a highly virulent response. In-vitro experiments found that Ginger (15% concentration) inhibited fungal mycelial development and spore germination at levels comparable to Nativo and Antracol at 1000 ppm. In the protective and curative experiments, ginger extract at 15% showed the highest crop protection activity (84%) and medicinal value (70%). As a consequence, among fungicides, Antracol at 1000 ppm had the highest crop protection activity (92%) and curative effectiveness (96%). Pot experiments found that Ginger significantly decreased C. capsici and improved plant growth, while Antracol outperformed Nativo as a fungicide. PCA looked explored the association between growth indices in chili plants injected with plant extracts and fungicides.

Cheng et al. (2022) found that ethanolicextract of pomelo fruit inhibited the development of Colletotrichum gloeosporioides. The IC50 for pomelo fruit extract was reported to be 3.2 ml/l.

Kumaret al. (2021) investigated in vitro & in vivo actions of neem (Azadirachta indica), kusum (Schleichera oleosa), karanj (Pongamia pinnata), and jatropha (Jatropha curcas) essential oils against Colletotrichum musae. Schleichera oleosa oil outperformed the others in terms of in-vitro & in-vivo activity percent against C. Musae, which causes banana anthracnose disease.

Dias et al. (2020) studied aromatic extracts from noni fruits (Morindacitri folia L.) & leaves of the lemongrass(Cymbopogon citratus DCStapf), Mastruz (Chenopodium is ambrosioides L.), Citronella(Cymbopogon nardus L. Rendle), & Rosemary pepper (Lippiasidoides Cham) against the conidial development and mycelialgrowth of Colletotrichum gloeosporioides, & observed that loss of fruits fresh mass was 7% reduced contrasted to the untreated papa.

Santos et al. (2019) investigated antimicrobial activity of Cymbopogon citratus leaf extracts (aqueous, ethanolic, & methanolic) against Colletotrichum gloeosporioides during guava postharvest. C. citratus extract suppressed C. gloeosporioides growth in vitro, but was ineffective in vivo.

Zhao et al. (2018) identified 31 fungal isolates from maritime plants and investigated their antibacterial and antifungal properties against phytopathogens. The most common fungus among the 31 detected strains were Alternaria sp. and Fusarium equiseti. The extracts of Fusarium equiseti (isolate No. P18) and Alternaria sp. (isolate no. P8) included two anthraquinone derivatives (compounds 1 and 2) and two perylenequinones (compounds 3 and 4). These extracts were chosen because they demonstrated strong antifungal activity against two phytopathogenic fungus (Pestallozzi atheae and Alternaria brassicicola) and a phytopathogenic bacteria (Clavibacter michiganensis).

Choudhury et al. (2017) used the poisoned food approach to test the effects of a chloroformextract of ginger (Zingiber officinaleRoscoe.) rhizome and a methanolic extract of mature leaves ofClerodendrum (Clerodendruminfortunatum L.) and Polyalthia (Polyalthialongifolia) on C. capsici. The study found that extract doses of 20, 100, 200, and 400 µg/ml decreased C. capsici radial development, spore germination, and biomass production.

Adeogun et al. (2016) tested acetone, aqueous, ethanol, and hexane extracts of Thaumatococcus daniellii leaves against 11 food spoiling fungi (Aspergillus aculeatus, A. niger, A. flavus, Rhizopusstolonifer, Issatchenkiaorientalis, Meyerozyma guilliermondii,Fusarium oxysporum, Paecilomycesvariotii, Penicillium is crustosum, Tricoderma harzianum). Acetone & ethanol leaf extracts had antifungal action against all examined fungi, and the extracts included alkaloids, saponins, tannins and flavonoid.

Bhuyan et al. (2015) investigated the resistance of six plant species, Cinnamomumimpressinervium, Cinnamomumtamala, Cymbopogoncitratus, Cymbopogon jwarancusa, Catharanthusroseus, and Tithonia diversi, against Alternaria Colletotrichum gloeosporioides and Fusarium monilforme. Cinnamomum impressinervium has the greatest antifungal action against C. gloeosporiodes and A. alternative when compared to Cinnamomum tamala, Cymbopogon jwarancus, and Cymbopogon citratus.

Alvarez et al. (2014) investigated the antifungal impact of flavonoid-containing asparagus extract. The aqueous extract was shown to suppress Fusarium oxysporum, F. oxysporumf.sp. dianthi, F. oxysporumf.sp. asparagi, and F. oxysporum.

Ademe et al. (2013) investigated their antifungal activity. Lantanacamara, Lantana viburnoides,Echinops sp, & Rutachalepensis have high antifungal properties, while Lanatana camara ethyl acetate extract inhibited fungal growth.

Bussaman et al. (2012) extracted Piper sarmentosum using 80% ethanol, methanol, and chloroform and discovered that it has extremely significant antifungal activity against Colletotrichum gloeosporioides. Methanolic extracts completely inhibited fungal mycelium development, followedby chloroformextract (81.85%) & ethanol extract (45.50%).

Mukherjee et al. (2011) found that 30%, 40%, 50%, 60%, and 70% aqueous leaf extracts of tobacco and seeds of keora, mahogoni, garlic, and ginger have antibacterial activity against Colletotrichum gloeosporioides. At a 50% concentration, garlic extract was shown to be effective against C. gloeosporioides, followed by keora seed, ginger, mahogany, and tobacco.

Al- Reza et al.(2010) investigated hexane & methanol extractsof Cestrum nocturnum & its essential oil against plant pathogenic fungus suchas Botrytis cinerea, Colletotrichumcapsici, Fusarium oxysporum,Fusariumsolani, and Scleotinia scleotiorum. The chloroform extract of plant had stronger antifungal activity against Colletotrichum capsici than ethanol and methanol extracts, and the essential oil of the extract did not impede C. capsici conidia germination.

Antifungal Activity of Crude Extracts

Theantifungal efficacy of medicinal plant leaf and stem extracts will be evaluated using food poison technique. The plantextracts will be dissolved in 0.5% DMSO (SRL) at five concentrations (1, 2, 3, 4, and 5 mg/ml) in a 500 µl container. After combining the extract, put 500 µl to a 90 mm petri dish, followedby 9.5 ml of potato carrot agar. The plate was kept at room temperature to allow the extract to permeate into media. Carmel antifungal (carbendazim 12% + mancozeb 63%) will be used as a positive control, with DMSO as the negative control. A 4 mm diameter mycelial disc will be put in the center of each petri dish using a cork borer and stored in an incubator at 25°C±2. Radial growth from the center will be monitored after the first, third, and fifth days of incubation. The percentage ofgrowth inhibition will be determined using followingformula.

Growth Inhibition % = $\frac{(C-T)}{C} \times 100$

Where, C = diameter of a fungalcolony in control.

T = diameter of a fungalcolony in treatment.

The food poison technique will also be used to determine minimal inhibitory concentration (MIC) & inhibitory concentration (IC50), which are defined as more than 50% fungal growth.

The growth inhibition of conidia from each extract and control will be estimated using the following formula: -

Conidia Germination % = $\frac{(GC-GT)}{GC} \times 100$

Where, GC = germination in control; GT = germination in the treatment.

The disease incidence wasdetermined using following equation(Bill et al., 2014):

Disease incidence = $\frac{Number\ of\ infected\ wounds}{Total\ number\ of\ inoculated\ fruit} \times 100$

The fresh weightloss was calculated by following formula.

FWL % = $\frac{Initial\ weight - Final\ weight}{Initial\ weight} \times 100$

Plant defense enzyme assays for phenylalanine ammonia-lyase (PAL), peroxidase (POD),polyphenol oxidase (PPO),superoxide dismutase (SOD), & catalase (CAT) weredetermined from treated extract, fungicide and untreated control by the modified method of Yeoh and Ali (2016). 3.0 g of sample tissuewas mixed, and homogenizedwith 15ml of ice-cold 100 mM L^{-1}sodium phosphatebuffer (pH 7.8) for PPO, POD, & CAT enzyme analysis & centrifuged at 10,000 × g for 25 min at 4 °C. Then, supernatant will be taken from the homogenate sample to determine the PPO, POD, and CAT activity.

3 .Result And Discussion

Extracts at various doses (1, 2, 3, 4, and 5 mg/ml) that decreased fungus radial development by more than 20% were tested for antifungal efficacy against C. capsici. Table 1 summarizes the effects of aqueous, ethanolic, and methanolic leaf & stem extracts at various concentrations on radial development of C. capsici.

Table 1: Effect Ofaqueous, Ethanolic And Methanolic Plants Extracts On Radial Growth (Percent) Of C. Capsici.

PLANT PARTS USED	**SOLVENTS**			
	AQUEOUS	**ETHANOL**	**METHANOL**	**HEXANE**
*A.vasica*Leaf	27.63±1.46	93.66±0.16	82.18±3.04	-
*A.vasica*Stem	24.43±7.38	91.35±1.88	73.07±1.18	8.46±2.76
*A.indica*Leaf	-	91.25±1.87	72.86±0.42	-
*A.indica*Stem	21.91±1.38	94.27±0.17	77.45±3.65	-
*A.sessilis*Leaf	-	86.95±2.93	79.01±4.28	-
*A.sessilis*Stem	-	87.71±2.42	60.56±2.41	-
*P.paniculata*Leaf	-	88.83±2.55	43.88±4.41	-
*P.paniculata*Stem	-	-	55.31±4.85	7.25±2.42
*T.bellirica*Leaf	-	69.08±3.82	42.46±3.48	9.37±2.76
*T.bellirica*Stem	21.85±4.25	-	79.88±0.92	-
*M.parvifolia*Leaf	-	41.41±2.96	32.23±0.96	-
*M.parvifolia*Stem	-	53.88±2.98	27.48±0.69	-
*C.hirsutus*Leaf	-	-	48.46±1.99	-
*C.hirsutus*Stem	-	-	-	-

There was no significantdifference in C. capsici growth b/w aqueous leaves & A. indica stem extract. A. vasica and T. bellirica at all concentration. The maximum radial growth inhibition was exhibited 27.63 ± 1.46%, 21.96 ± 1.38% and 21.85 ± 4.25% at 5 mg/ml concentration of A. vasica (leaf), T. bellirica (stem) and A. indica (stem) over control (Table 2 & Fig.1).

Table 2 Effect of Aqueous Plant Extracts On Percentage Growth Inhibition on C. Capsici

CONCENTRATIONS (MG/ML)	**A.INDICA**		**A.VASICA**		**A.SESSILIS**		**M.PARVIFOLIA**		**P.PANICULATA**		**T.BELLIRICA**		**C.HIRSUTUS**	
	LEAF	STEM	LEAF	STEM	LEAF	STEM	LEAF	STEM	LEAF	STEM	LEAF	STEM	LEAF	STEM
1	-	05.01 ±1.01^{c}	00.45 ±2.14^{c}	06.05± 1.21^{c}	-	-	-	-	-	-	-	04.56± 0.55^{c}	-	-
2	-	08.24± 4.35^{c}	02.23± 1.88^{c}	10.98± 1.53^{c}	-	-	-	-	-	-	-	07.15± 2.85^{c}	-	-
3	-	08.66± 1.35^{c}	15.75± 2.63^{b}	14.51± 1.56^{b}	-	-	-	-	-	-	-	13.01± 1.02^{b}	-	-
4	-	18.46± 2.86^{b}	18.07± 1.34^{b}	16.78± 7.16^{b}	-	-	-	-	-	-	-	17.27± 6.25^{b}	-	-
5	-	21.96± 1.38^{a}	27.63± 1.46^{a}	24.43± 7.38^{a}	-	-	-	-	-	-	-	21.85± 4.25^{a}	-	-

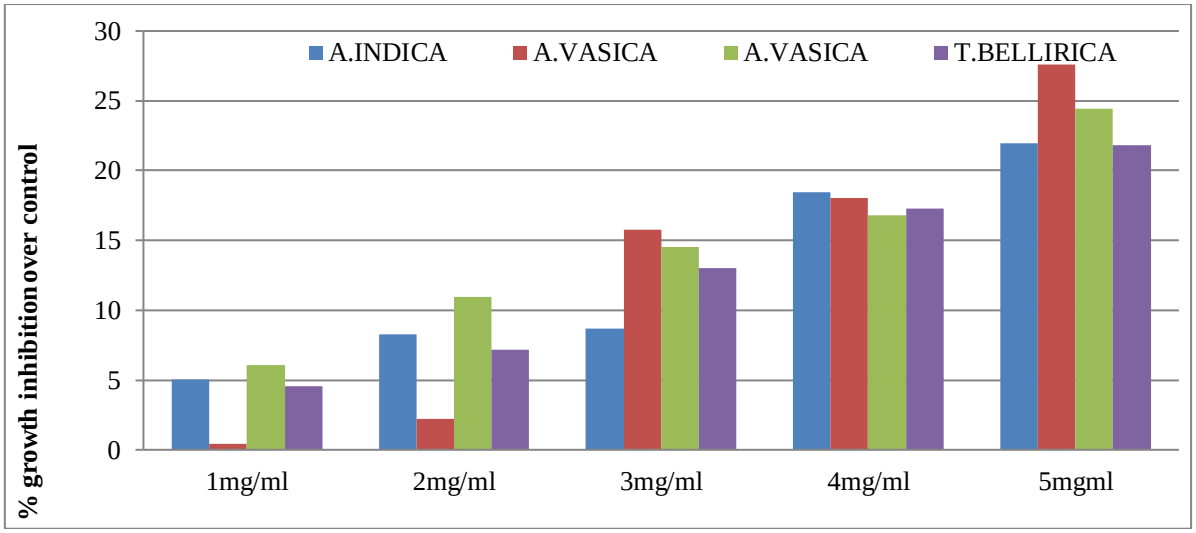


Fig. 1 Effect Of Aqueous Extract On Percentage Growth Inhibition In C. Capsici

Table 3 and Figure 2 illustrate the effects of ethanolic leaf (a) and stem (b) extracts on C. capsici at concentrationsranging from 1 to 5 mg/ml. The findings suggest that A. indica, A. vasica, and A. sessilis ethanolic extract had a larger percentage of growth inhibition than M. parvifolia, P. paniculata, and T. bellirica. The ethanolic stem extract of A. indica showed the highest radial inhibition (91.70 ± 2.49%), followed by A. vasica stem extract (82.72 ± 2.69%) at a dosage of 2 mg/mL. The ethanolic stem extract of T. bellirica at a dosage of 2 mg/ml showed the lowest growthinhibition (24.86 ± 2.11%). P. paniculata expressed 54.18 ± 3.12% and 43.7 ± 5.32% in ethanolic leaf and stem extracts, respectively. Eachvalue is given as mean of triplicates, & columns with same alphabeticalletters do not differ substantially ($p < 0.05$). - There is no impediment in radial development.

At a dosage of 3 mg/ml, A.indica and A. sessilis demonstrated over 80% growth inhibition. The ethanolic extract of A. indica and A. sessilis (leaf and stem) at 3 mg/ml concentration suppressed it by 82.07 ± 3.01%, 94.54 ± 0.84%, 81.83 ± 0.89%, and 80.53 ± 0.22%, respectively. In contrast, ethanolic extracts of M. parvifolia and T. bellirica (leaf and stem) showed less than 50% suppression of radial development. The ethanolic leaf and stem extract of M.parvifolia and T. bellirica at a concentration of 3 mg/ml showed 36.71 ± 4.32%, 44.42 ± 5.20%, 48.58 ± 6.48%, and 40.32 ± 2.82%, respectively.

At a dosage of 4 mg/ml, the ethanolic extract modestly increased radial growth inhibition. However, there was asignificant difference in ethanolic leaf extract of P. paniculata at 4 mg/ml concentration vs 3 mg/ml.

At a dosage of 5 mg/ml, ethanolic stem extract of A. indica was shown to be the most efficient in preventing radial growth of C. capsici when compared to the other ethanolic extracts tested. At a dosage of five mg/ml, A. indica inhibited C. capsici growth by 94.28 ± 1.09%. The ethanolic leaf & stem extracts of A. vasica inhibited growth diameter by 93.34 ± 1.89% and 91.34 ± 1.89 percent, respectively.

Each valueis given as mean of triplicates, & columns with same alphabetical letters do not differ substantially ($p< 0.05$). - exhibits no inhibition of radial development.

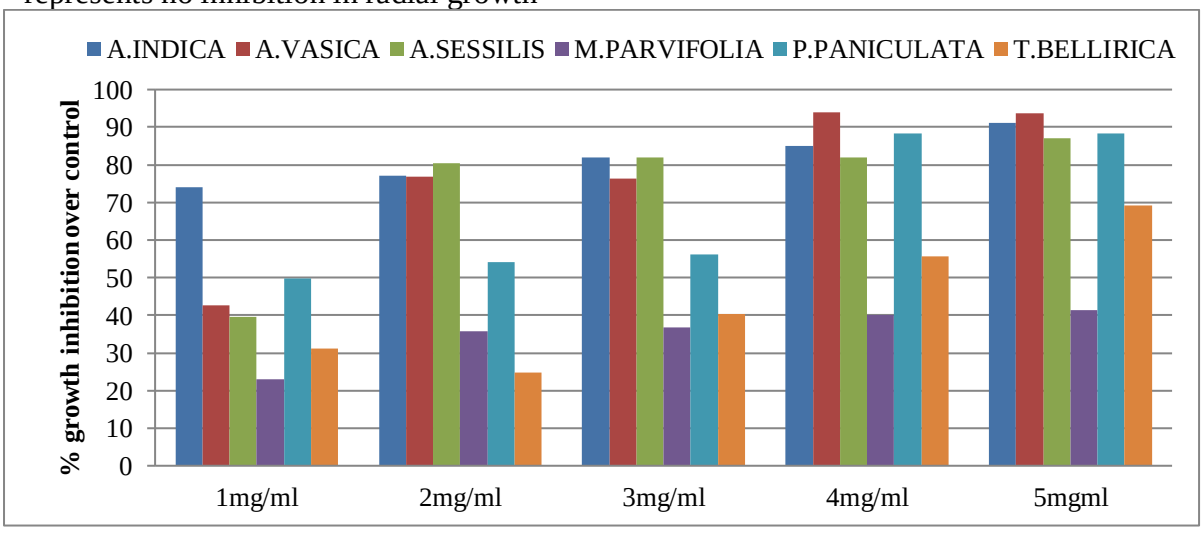
Overall, result revealed that among all concentration of plant extract of leaves and stem, 5 mg/ml concentration of leaves and stem extract were more effective against C. capsici whereas M. parvifolia was found less effective {41.40 ± 2.97% and 53.89 ± 2.99% (leaf and stem)} in inhibiting the growth.

Table 3 Effect Of Ethanolic Plant Extract (Leaf And Stem) On Percentage Growth Inhibition In C. Capsici.

CONCENTRATIONS(MG/ML)	*A.INDICA*		*A.VASICA*		*A.SESSILIS*		*M.PARVIFOLIA*		*P.PANICULATA*		*T.BELLIRICA*		*C.HIRSUTUS*	
	LEAF	STEM	LEAF	STEM	LEAF	STEM	LEAF	STEM	LEAF	STEM	LEAF	STEM	LEAF	STEM
1	74.01 ±2.85^{b}	81.60 ±3.22^{b}	42.53 ±5.00^{c}	80.12 ±2.24^{b}	39.53 ±2.36^{b}	62.23 ±1.15^{c}	22.88 ±4.61^{b}	24.38 ±2.86^{c}	49.86 ±5.04	37.27 ±4.84	31.25 ±0.46^{d}	28.93 ±8.81^{d}	-	-
2	77.14 ±0.33^{b}	91.70 ±2.41^{a}	76.78 ±6.89^{b}	82.72 ±2.69^{b}	80.45 ±3.36^{a}	74.16 ±3.04^{b}	35.75 ±1.6^{a}	36.59 ±0.97^{c}	54.18 ±3.12	43.7 ±5.32	24.86 ±2.11^{d}	55.84 ±2.17^{c}	-	-
3	82.07 ±3.01^{a}	94.54 ±0.84^{a}	76.35 ±5.29^{b}	84.75 ±0.75^{b}	81.83 ±0.89^{a}	80.53 ±0.22^{ab}	36.71 ±4.3^{a}	44.42 ±5.20^{b}	56.05 ±2.15	48.58 ±6.48	40.32 ±2.82^{c}	62.18 ±1.41^{b}	-	-
4	84.99 ±1.26^{a}	94.74 ±1.09^{a}	93.97 ±1.02^{a}	85.09 ±2.27^{b}	82.01 ±1.06^{a}	86.17 ±3.14a	40.15 ±2.3^{a}	46.53 ±0.48^{ab}	88.22 ±1.00	58.92 ±2.89	55.70 ±2.98^{b}	69.52 ±1.26^{ab}	-	-
5	91.26 ±1.88^{a}	94.28 ±0.18^{a}	93.65 ±0.17^{a}	91.34 ±1.89^{a}	86.96 ±2.92^{a}	87.70 ±2.41^{a}	41.40 ±2.9^{a}	53.89 ±2.99^{a}	88.22 ±2.54	69.03 ±4.4	69.09 ±3.81^{a}	74.27 ±1.45^{a}	-	-

Each value isexpressed as mean of triplicates, & column sharing same alphabetical letters are not significantly different ($p \leq 0.05$).

– represents no inhibition in radial growth



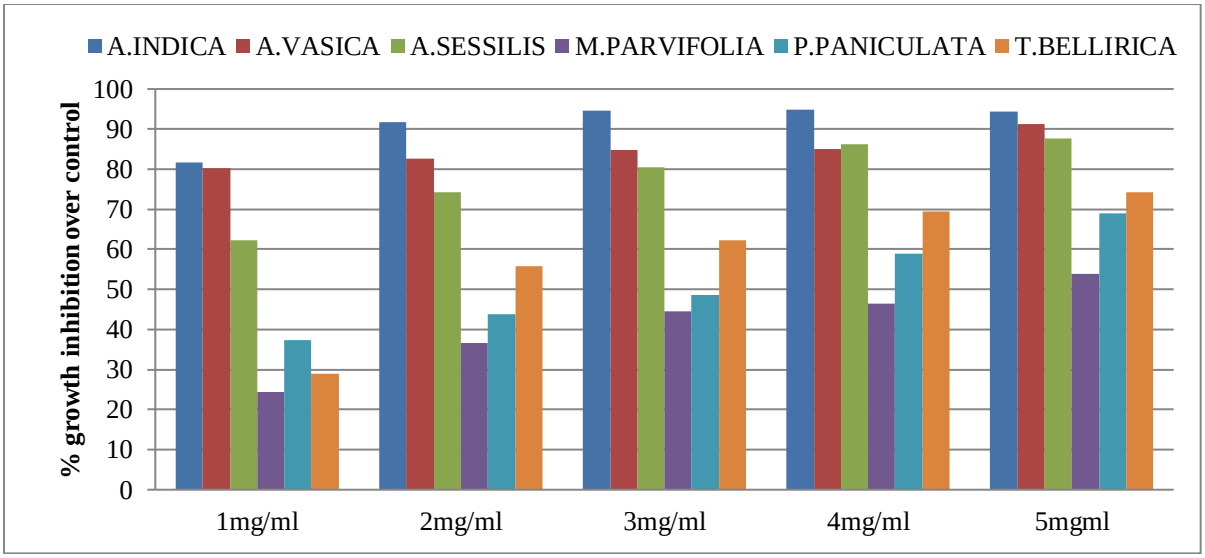


Fig. 2: Effect Of Ethanolic Leaf (A) & Stem (B) Extracts On % Growth Inhibition In C. Capsici.

Table 4 and Figure 3 demonstrate the influence of methanolic plant extracts on radial development in C. capsici. At aconcentration of 1 mg/ml, methanolic extracts of M. parvifolia, P. paniculata, T. bellirica (leaf and stem), and C. hirsutus (leaf) had no effect on C. capsici growth, as did aqueous extracts. Growth inhibition was (16.69 ± 2.89%, 8.97 ± 3.99%), (19.21 ± 8.19%, 16.28 ± 8.9%), (28.73 ± 2.29%, 27.87 ± 2.67%), and 14.37 ± 4.77%, respectively, compared tocontrol.

At a dosage of 2 mg/ml, methanolicextracts of A. indica (leaf & stem) and A. vasica leaf extract inhibited radial growth of C. capsici by 71.29 ± 11.50%, 66.74 ± 5.93%, and 64.78 ± 10.25% respectively. At 2 mg/ml concentrations of A.vasica stem, leaf, & stem of A. sessilis, M. parvifolia, P. paniculata, T. bellirica, and leaf of C., radial growth inhibition decreased by 45.34 ± 11.34%, (37.05 ± 2.45%, 32.33 ± 0.51%), (23.59 ± 5.56%, 20.79 ± 3.23%), (20.02 ± 2.5%, 17.78 ± 5.48%), (29.80 ± 1.17%, 25.34 ± 3.87%), and 29.02 ± 1.

Table 4 Effect Ofmethanolic Plant Extract (Leaf & Stem) On % Growth Inhibition On C. Capsici.

)NCENTRATIONS(MG/ML)	*A.INDICA*		*A.VASICA*		*A.SESSILIS*		*M.PARVIFOLIA*		*P.PANICULATA*		*T.BELLIRICA*		*C.HIRSUTUS*	
	LEAF	**STEM**	**LEAF**	**STEM**	**LEAF**	**STEM**	**LEAF**	**STEM**	**LEAF**	**STEM**	**LEAF**	**STEM**	**LEAF**	**STEM**
1	56.89 ±13.16^{b}	58.72 ±4.00^{b}	58.06 ±4.29^{b}	49.94 ±11.40^{b}	32.88 ±3.68^{c}	27.75 ±3.37^{c}	16.69 ±2.89^{b}	8.97 ±3.99^{b}	19.21 ±8.19^{d}	16.28 ±8.9^{c}	28.73 ±2.29^{b}	27.87 ±2.67^{c}	14.37 ±4.77^{c}	-
2	71.29 ±11.50^{a}	66.74 ±5.93^{b}	64.78 ±10.25^{ab}	45.34 ±11.34^{b}	37.05 ±2.45^{c}	32.33 ±0.51^{bc}	23.59 ±5.56^{ab}	20.79 ±3.23^{a}	20.02 ±2.5^{c} ^{d}	17.7 ±5.4^{c}	29.80 ±1.17^{b}	25.34 ±3.87^{c}	29.02 ±1.56^{b}	-
3	78.19 ±5.10^{a}	77.79 ±1.77^{a}	64.54 ±5.6^{a} ^{b}	68.08 ±9.61^{a}	69.58 ±0.69^{b}	41.61 ±7.83^{b}	26.10 ±4.41^{ab}	22.91 ±1.33^{a}	25.43 ±1.06 ^{c}	43.96 ±2.4^{b}	30.97 ±2.89^{b}	52.45 ±2.39^{b}	43.96 ±2.46^{a}	-

4	80.78 ±1.24^{a}	72.15 ±2.15^{a}	67.45 ±1.66^{a}	66.44 ±8.52^{a}	75.00 ±1.06^{ab}	54.97 ±1.38^{a}	28.21 ±2.62^{ab}	26.73^{a} ±0.49	33.28 ±1.74^{b}	48.94 ±0.7^{a}	35.58 ±1.31^{ab}	72.83 ±1.27^{a}	46.66 ±1.97^{a}	-
5	82.19 ±3.03^{a}	73.08 ±1.19^{a}	72.87 ±0.41^{a}	74.44 ±3.64^{a}	79.00 ±4.29^{a}	60.55 ±2.40^{a}	32.22 ±0.97^{a}	27.49 ±0.68^{a}	43.89 ±2.77^{a}	55.3 ±4.8^{a}	42.47 ±3.49^{a}	79.89 ±0.91^{a}	48.45 ±1.98^{a}	-

Each value isexpressed as mean of triplicates, & column sharing same alphabetical letters are notsignificantly different ($p \leq 0.05$).

– represents no inhibition in radial growth.

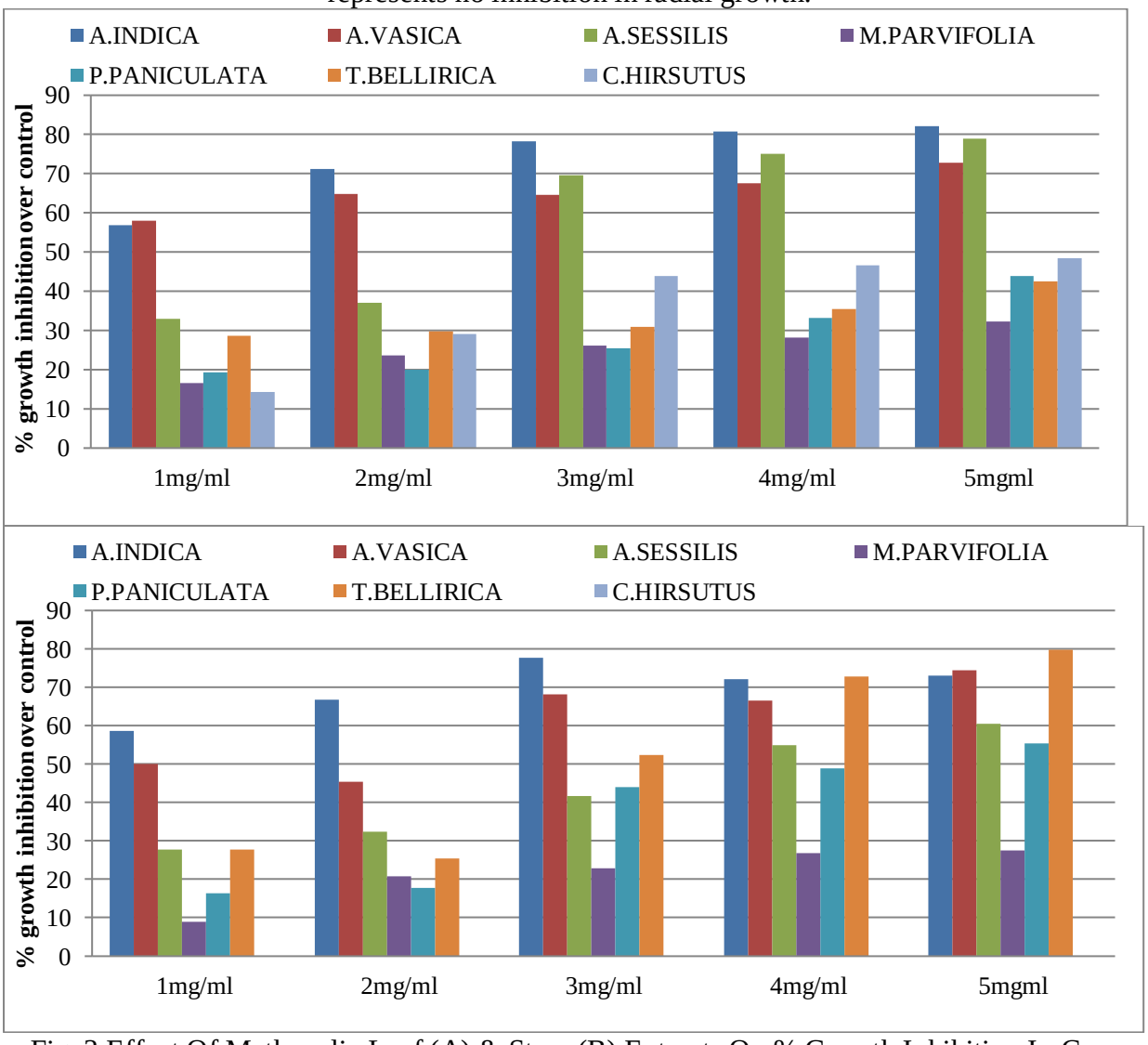


Fig. 3 Effect Of Methanolic Leaf (A) & Stem (B) Extracts On % Growth Inhibition In C. Capsici.

3mg/ml concentration of methanolic extract of A. indica, A.vasica and A. sessilis (leaves & stem) were found effective (78.19 ± 5.10%, 77.79 ± 1.77%), (64.54 ± 5.60%, 68.08 ± 6.91%) and (69.58 ± 0.69%, 41.61 ± 7.83%) in inhibiting radial growth of C. capsici than M. parvifolia, P. paniculata, T. bellirica and C. hirsutus.

Finally, methanolic extracts of leaves at a dosage of 4 mg/ml were shown to be more efficient than stem extracts in inhibiting C. capsici's radial growth. A. indica, A.vasica, and A. sessilis leaf extracts showed considerable radial growth (80.78 ± 1.24%, 67.45 ± 2.66%, and 75.00 ± 1.06%, respectively). Methanolic stem extractsof A. indica, A.vasica, and A. sessilis were less efficacious than leaves at a concentration of 4 mg/mL. Stem extracts of A.indica, A. vasica, and A. sessilis inhibited radial growth by 72.15 ± 2.15%, 66.44 ± 8.52%, and 54.97 ± 1.38%, respectively. At a concentration of 4 mg/ml, methanolic stem extractof T. bellirica inhibited C. capsici growth more effectively (72.83 ± 1.27%) than leaf extract (35.58 ± 1.31%).

The methanolic (leaf and stem) extract had the greatest effect on C. capsici growth at a dosage of 5 mg/ml. The methanolic leaf extractof A. indica showed highest growth inhibition (82.19 ± 3.03%), followed by A. sessilis (79.00 ± 4.29%) and A. vasica (72.87 ± 0.41%). In methanolic stem extract, T. bellirica showed the strongest growth inhibition (79.89 ± 0.91%) compared to A. v asica (74.44 ± 3.64%) and A. vasica (73.08 ± 1.19%).

4. Conclusions

1. This study was mainly focused on antifungal activity ofselected seven plant species viz. A. indica, A. vasica, A. sessilis, C.hirsutus, M. parvifolia, P. paniculata, and T. bellirica. The present study is concluded as follows:
2. Our investigations on the phytochemicalanalysis of selected plant extracts have revealed presence of organic compounds & their other constituents. These compounds are valuable sources of biologically active molecules including antifungal compounds. These compounds are found to beeffective against C. capsici. Hence, plant extracts can be used for controlling the pre- & postharvest pathogens of different horticulture crops.
3. Inthis study, aqueous, ethanolic, and methanolic and hexane solvent were selected for the plant extractions. Ethanolic extracts were found tobe more effectiveagainst the C. capsici than aqueous, hexane and methanol extract.
4. The antifungal capacity of plant extracts was altered by trypsin digestion. This demonstrates that the active antifungal components comprised proteinaceous molecules and had high heat stability.
5. In-vivo & in-vitro studies on efficiency of crude plantextracts, fractions and purified secondary metabolites were found to show significant growth inhibition against C. capsici.
6. In an in-vivo trial, A. sessilis leaf extract reduced the spread of anthracnose in chili the most of any extract tested.
7. A. sessilis decreased disease incidence and severity while improving decay inhibition in chilli fruits. Furthermore, A. sessilis leaf extract increased the shelf life of chilli fruit by up to 30 days at 4 °C without compromising food quality.
8. Antifungalactivity of A. sessilis was found moreeffective in before inoculation of chilli than after inoculation at 25 ℃ and 4 ℃.
9. A. sessilis leaf extract boosted the defensive enzymes (PPO, POD, CAT, PAL, and SOD) in chilli. So, our study concluded that defense-related enzymes are the key protection systems, and that plant extract-induced defensive mechanisms will assist small producers in storing chilli fruits for an extended period of time without deterioration. To meet the consumer's need for agricultural goods free of hazardous toxic chemicals, farmers can employ natural products that are both environmentally and consumer-friendly. However, additional research is needed to discover the key bio-compounds in A. sessilis extract that are important for disease management.

5. References

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