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RESEARCH **P**APER

Antifungal activity of some selected medicinal plants against *Fusarium solani* causing wilt and rot in Pearl millet

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Fusarium solani is a soil-borne fungus which causes wilt and rot disease in pearl millet. Pearl millet belongs to family Poaceae, contains carbohydrates, vitamins, protein and high amount in minerals *i.e.* iron, zinc, calcium and other minerals. It maintains human health. To control the soil-borne diseases in Pearl millet with the use of chemicals under in field condition is hazardous, loss of soil fertility and causes serious environmental pollution, thus use of plant extract as an ecofriendly means is needed. *Fusarium solani* treated with *Allium sativum, Zingiber officinale, Momordica charantina, Mentha arvensis, Allium cepa* and *Capsicum annum* using poisoned food technique at 10%, 25%, 50% and 75% concentration on 3rd, 5th, 7th day incubation period under *in vitro* condition. The selected plant extracts were significantly ($P \leq 0.05$) effective against *F. solani* but *Allium sativum* was most effective compared to others. *Allium sativum* inhibited 100% mycelial growth of *F. solani* at 10% concentration on 3rd day of incubation period. *Zingiber officinale* and *Capsicum annum* inhibited 71.2% and 75.7% mycelial growth of *F. solani* under *in vitro* condition respectively.

Key words : Pearl millet, *Fusarium solani*, Soil-borne, Wilt and rot, Plants extract

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INTRODUCTION

India is a geographically subtropical country with warm and humid climate that provides an appropriate environment for developing and spread of numerous plant pathogens (Amin *et al.*, 2015). *Fusarium solani* is a soil-borne fungus and is worldwide in distribution. *Fusarium solani* produced mycotoxin which is secondary metabolites that creates a serious threat to plants and animals. In case of plant, it causes wilt and rot disease on wide variety of crop at least 111 plants species (Bogale *et al.*, 2008). *Fusarium solani* causes disease in pearl millet and decreases plant yield productivity and consequently economic losses. Pearl millet (*Pennisetum glaucum*) is an economic crop which grown for food and forage in India, Africa and worldwide. It belongs from family Poaceae. India was the first producer and developed hybrids seeds of pearl millet in 2014-15 with the total production (Malik, 2015). Pearl millet contains carbohydrates, proteins, vitamins, fats and high amount in minerals *i.e.* iron, zinc, calcium, magnesium, phosphorus, potassium, sodium, copper, manganese, selenium and dietary fibre content that help human health (Prasad and Dwivedi, 2017).

The chemical affects serious threat to the environment, health hazardous and toxicity of some beneficial microbes present in soil which promote plant growth (Dwivedi and Prasad, 2016). The use of medicinal plant extract is an eco-friendly way to control *Fusarium solani*. The aqueous medicinal plant's extract has effective antagonistic properties against pathogen at

different concentration using poisoned food technique (Dwivedi and Sangeeta, 2014). The aim of the present study was to study the antifungal efficacy of some selected medicinal plant extract *i.e*. *Allium sativum, Zingiber officinale, Momordica charantina, Mentha arvensis, Allium cepa* and *Capsicum annum* at 10%, 25%, 50% and 75% concentration on 3^{rd}, 5^{th}, 7^{th} day against *F. solani* using poisoned food technique under *in vitro* condition.

RESEARCH METHODOLOGY

Sample collection:

The samples were collected from infected agriculture field of pearl millet crop from Bijnaur, Lucknow. The collection of infected pearl millet crop was carried out in sterilized polythene bags and preserved for further studies.

Isolation of *Fusarium solani*:

The pathogenic fungus *Fusarium solani* was isolated from collected infected root of pearl millet. The collected root of pearl millet was washed under running tap water to remove soil around the plant root and after then again washed with sterilized distilled water. The collected infected plant part were cut into small pieces and sterilized with 0.2 % mercuric chloride ($HgCl_2$) solution for few seconds and washed with sterilized distilled water and dried at room temperature. The small tissue section were placed onto potato dextrose agar Petriplate and incubated at 27 ± 1^0 C in an incubator for seven days. After seven days, extended fully mycelial growth of *F. solani* was identified on the basis of morphology (colour, shape, diameter and appearance of colony, septation in mycelium, presence of specific reproductive structures, structure of conidia, the presence of sterile mycelium, spore size, spore bearing structure, conidiophores, arrangement of spores) and available standard literature (Gilman, 2001; Barnett and Hunter, 1998) and maintained on PDA slant for further studied.

Selection of medicinal plant:

The medicinal plants were collected from South City area, Lucknow. Six plants were selected for antagonistic potentiality are given Table A.

Preparation of medicinal plant extract:

The medicinal plants *Allium sativum, Zingiber officinale*, *Momordica charantina*, *Mentha arvensis*, *Allium cepa*, *Capsicum annum* were collected from South city, Lucknow. Took 200 g of collected each sample and washed first under tap water and then sterilized with distilled water. The samples were placed in 0.2% mercuric chloride solution for few second and the washed 3 to 4 time with sterilized distilled water to remove the mercuric chloride. The washed samples were dried on sterilized tissue paper. The plants part was crushed in motor pestle and were filtered by muslin cloth and centrifuge it at 3000 rpm for 5 minutes then filter through Vacuum Seitz filter (Dwivedi and Sangeeta, 2013). The extract was collected in sterile conical flask which is ready for further analysis. The required concentration i.e. 10%, 25%, 50% and 75% was prepared and then added to potato dextrose agar medium separately in sterilized Petri plate.

Efficacy of medicinal plant extract against *Fusarium solani*:

The antagonistic efficacy of aqueous extract of medicinal plants was tested against *Fusarium solani* using poisoned food technique (Grover and Moore, 1962). The aqueous extract of plant extract at 10%, 25%, 50% and 75% concentration was poured onto autoclaved sterilized Petri plates. After solidification, 5 mm block of fresh culture of *Fusarium solani* was placed in the centre of each Petri plate and plates were incubated at 27 ± 1^0 C. For each treatment and control three replicates were maintained. The mycelial growth of *F. solani* was

Table A : Selected medicinal plants and their utilized part

Sr. No.	Common name	Botanical Name	Utilized plant part
1.	Garlic	*Allium sativum*	Storage leaves
2.	Ginger	*Zingiber officinale*	Rhizome
3.	Bitter gourd	*Momordica charantina*	Stem
4.	Pudina hara	*Mentha arvensis*	Leaves
5.	Onion	*Allium cepa*	Storage leaves
6.	Chilli	*Capsicum annum*	Leaves

recorded on 3rd, 5th and 7th day. The percent inhibition of mycelial growth of *F. solani* was calculated by using the formula given below.

$$I = \frac{C - T}{C} \times 100$$

where, I= Per cent inhibition of mycelial growth of *Fusarium solani*

C= Mycelial growth of *Fusarium solani* in control Petri plate

T= Mycelial growth of *Fusarium solani* in treatment Petri plate

Data analysis:

The data were expressed as Mean ± SD and analyzed statistically using analysis of variance technique, DMRT and least significant difference test ($P \leq 0.05$) were applied.

RESEARCH FINDINGS AND ANALYSIS

The tested aqueous plant extract showed antifungal activity against *Fusarium solani*. The present study showed that *Allium sativum*, *Zingiber officinale*, *Momordica charantina*, *Mentha arvensis*, *Allium cepa*

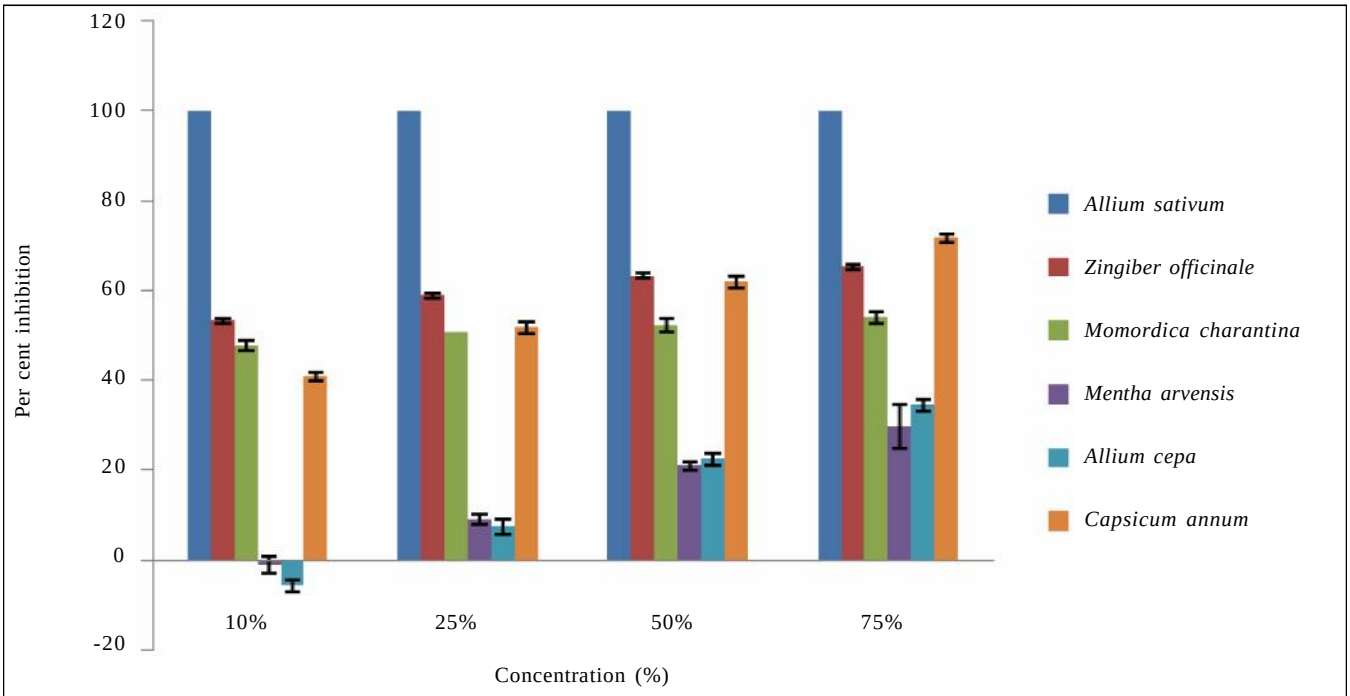

Fig. 1 : Per cent inhibition of *F. solani* treated with some selected medicinal plant extract at different concentrations on 3th day incubation period under *in vitro* condition

Table 1 : Treatment of mycelial growth (in mm) of *F. solani* with some selected plant extract at different concentrations on 3rd day incubation period under *in vitro* condition

Treatments	Concentration						
	Control	10%	25%	50%	75%	**CV%	***LSD0.05
Allium sativum	*40.25±1.50	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	8.333	1.011
Zingiber officinale	40.25±1.50	19.75±0.5	18.5±0.58	16.75±0.50	14.5±0.58	3.766	1.245
Momordica charantina	40.25±1.50	22.00±1.15	21.00±0.00	20.75±1.50	19.5±1.29	4.958	1.846
Mentha arvensis	43.5±1.29	44.00±1.83	39.5±1.29	34.00±0.82	30.5±5.06	6.707	3.871
Allium cepa	43.5±1.29	46.5±1.29	40.25±1.70	33.75±1.26	28.5±1.29	3.58	2.707
Capsicum annum	43.5±1.29	25.75±0.96	21.00±1.32	16.5±1.29	12.25±0.96	5.03	1.804

*Mean±SD
**CV% = Co-efficient of variation
***LSD = Least significant difference test

and *Capsicum annum* had antifungal activity against mycelial growth of *Fusarium solani* under *in vitro* condition.

Efficacy of medicinal plant extract against *Fusarium solani*:

Allium sativum plant extract inhibits (100%) maximum mycelial growth of *Fusarium solani* compared to *Zingiber officinale*, *Momordica charantina*, *Mentha arvensis*, *Allium cepa* and *Capsicum annum* at 10% concentration on 3rd day of incubation period under *in vitro* condition. On 3rd day (Fig.1 and Table 1), the aqueous plant extract of *Allium sativum* inhibited the growth by 100% followed by *Zingiber officinale* (53.3%), *Momordica charantina* (47.9%) and *Capsicum annum* (40.8%) compared to *Mentha arvensis* (-1.1%) and *Allium cepa* (-5.7%) (significantly P≤ 0.05) at 10% concentration respectively. At 25% concentration, the aqueous plant extract of *Allium sativum* inhibited the growth by 100% followed by *Zingiber officinale* (59%), *Momordica charantina* (50.7%) and *Capsicum annum* (51.7%) (significant P≤0.05) compared to *Mentha arvensis* (9.1%), *Allium cepa* (7.4%) on 3rd day. Whereas the aqueous plant extract at 50% concentration,

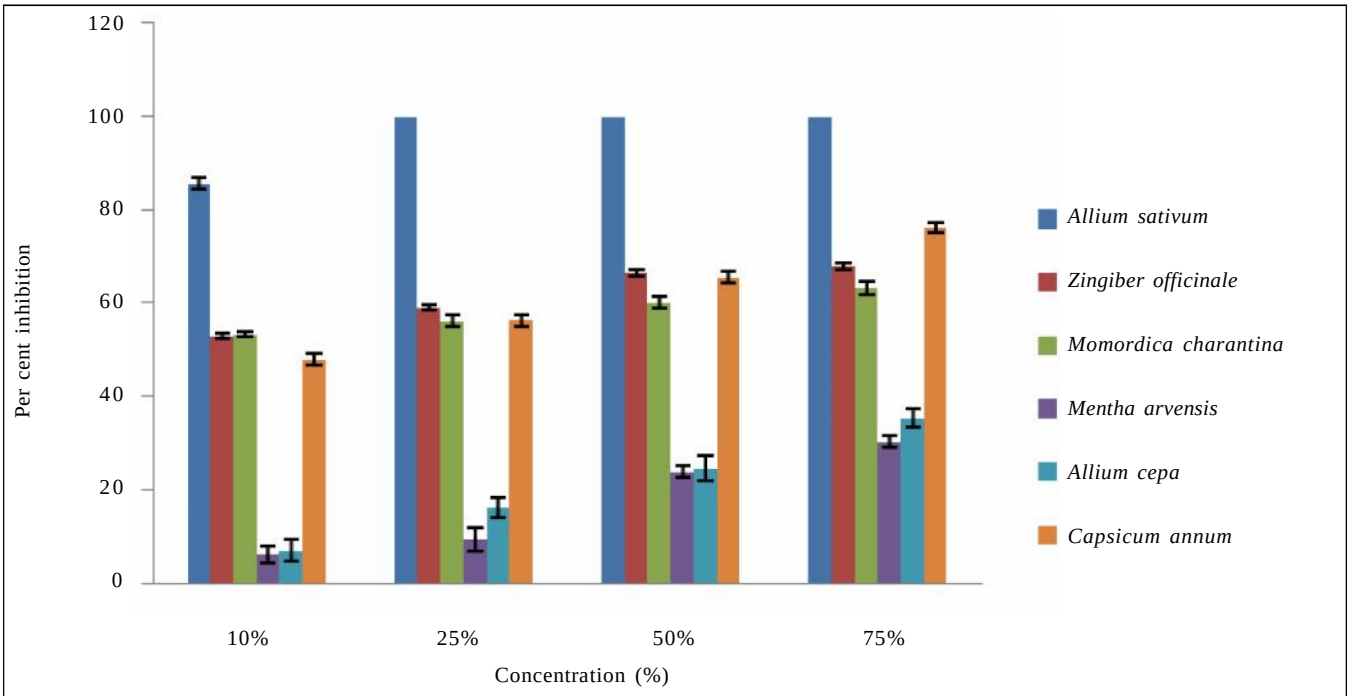

Fig. 2 : Per cent inhibition of *F. solani* treated with some selected medicinal plant extract at different concentrations on 5th day incubation period under *in vitro* condition

Table 2 : Treatment of mycelial growth (in mm) of *F. solani* with some selected plant extract at different concentrations on 5th day under *in vitro* condition

Treatments	Concentration						
	Control	10%	25%	50%	75%	**CV%	***LSD0.05
Allium sativum	*63±1.16	9.00±1.16	0.00±0.00	0.00±0.00	0.00±0.00	5.072	1.1
Zingiber officinale	63±1.16	29.50±0.58	25.75±0.5	21.00±0.82	21.50±0.58	2.376	1.151
Momordica charantina	63±1.16	29.25±0.50	27.5±1.29	25.00±1.16	24.75±1.50	3.448	1.762
Mentha arvensis	68.5±1.92	64.00±1.83	57.00±2.45	51.75±1.26	47.50±1.29	3.048	2.717
Allium cepa	68.5±1.92	63.50±2.39	57.25±2.23	51.50±2.65	54.00±1.83	3.761	3.341
Capsicum annum	68.5±1.92	35.50±1.29	29.75±1.26	23.50±1.29	16.25±0.96	3.972	2.077

*Mean±SD
**CV% = Co-efficient of variation
***LSD = Least significant difference test

significantly (P≤0.05) inhibited the growth of *F. solani* at different level *i.e. Allium sativum* (100%), *Zingiber officinale* (63.3%), *Momordica charantina* (52.2%), *Capsicum annum* (62%) compared to *Mentha arvensis* (21%), *Allium cepa* (22.4%) on 3rd day incubation period. At 75% concentration, the aqueous plant extract inhibited growth of *F. solani* at different level i.e *Allium sativum* (100%), *Zingiber officinale* (65.4%), *Momordica charantina* (54%), *Capsicum annum* (71.2%) *Mentha arvensis* (29.8%), and *Allium cepa* (34.4%) (significantly P≤0.05) on 3rd day under *in vitro* conditon.

On 5th day (Fig. 2 and Table 2), the aqueous plant extract of *Allium sativum* inhibited the growth by 85.7% followed by *Zingiber officinale* (53.1%), *Momordica charantina* (53.5%) and *Capsicum annum* (48.1%) compared to *Mentha arvensis* (6.5%) and *Allium cepa* (7.2%) (significant P≤0.05) at 10% concentration respectively. At 25% concentration, the aqueous plant extract of *Allium sativum* inhibited 100% mycelial growth of *F. solani* followed by *Zingiber officinale* (59.1%), *Momordica charantina* (56.3%) and *Capsicum annum* (56.5%) compared to *Mentha arvensis* (9.6%) and *Allium cepa* (16.4%) significantly (P≤0.05) on 5th day whereas at 50% concentration, the aqueous plant extract of *Allium sativum* inhibited growth the of *F solani* by 100% followed by *Zingiber officinale* (66.6%),

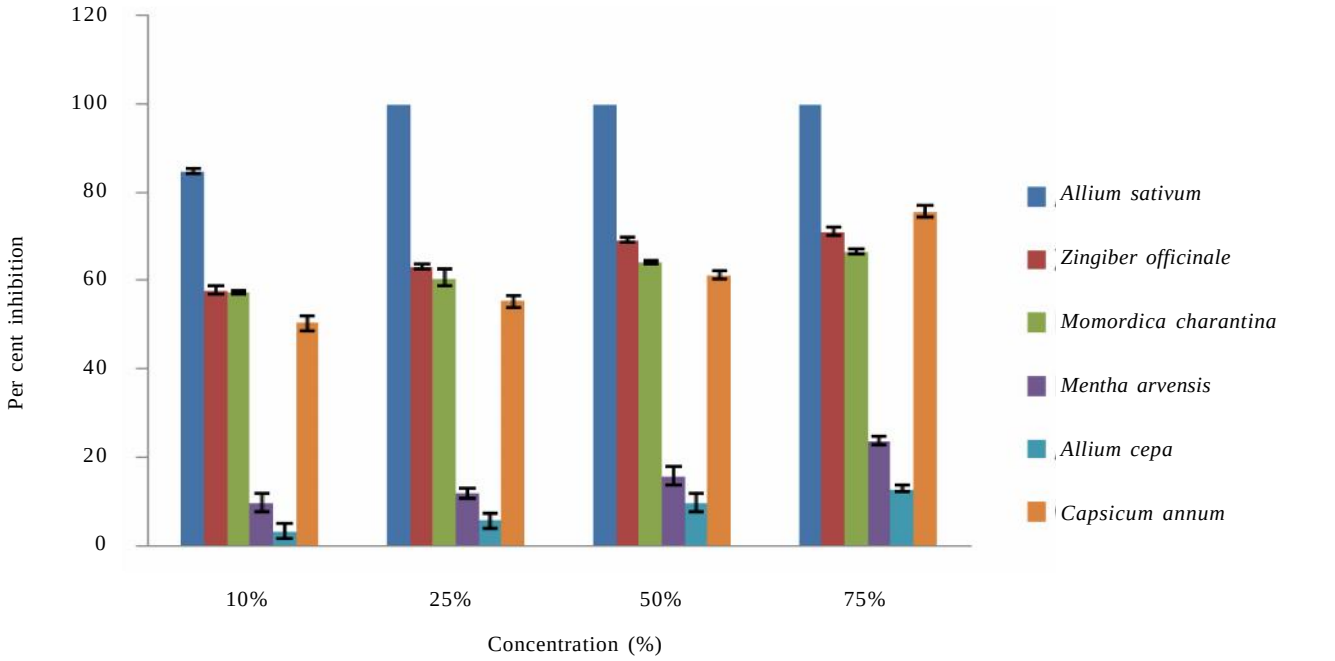

Fig. 3 : Per cent inhibition of *F. solani* treated with some selected medicinal plant extract at different concentrations on 7th day incubation period under *in vitro* condition

Table 3 : Treatment of mycelial growth (in mm) of *F. solani* with some selected plant extract at different concentrations on 7th day under *in vitro* condition

Treatments	Concentration						
	Control	10%	25%	50%	75%	**CV%	***LSD0.05
Allium sativum	*82.75±0.96	12.5±0.58	0±0.00	0±0.00	0±0.00	2.625	0.753
Zingiber officinale	82.75±0.96	34±0.81	30.5±0.58	25.25±0.5	23.75±0.96	2.001	1.183
Momordica charantina	82.75±0.96	35.25±0.5	32.5±1.92	28.25±0.5	27.5±0.58	2.499	1.568
Mentha arvensis	80.5±1.92	72.5±2.08	70.75±1.26	67.25±2.22	60.75±0.96	2.324	2.645
Allium cepa	80.5±1.92	77.75±1.70	75.75±1.70	72.5±2.09	70±0.82	2.243	2.566
Capsicum annum	80.5±1.92	39.75±1.70	35.5±1.29	31±0.82	19.5±1.29	3.526	2.192

*Mean±SD
**CV% = Co-efficient of variation
***LSD = Least significant difference test

Momordica charantina (60.3%), *Capsicum annum* (65.6%), *Mentha arvensis* (24%) and *Allium cepa* (24.8%) on 5th day. At 75% concentration, the aqueous plant extract inhibited the growth the of *F solani* at different level *i.e. Allium sativum* (100%), *Zingiber officinale* (68%), *Momordica charantina* (63.4%), *Mentha arvensis* (30.6%), *Allium cepa* (35.6) and *Capsicum annum* (76.2%) (significant $P \leq 0.05$).

On 7th day (Fig.3 and Table 3), the aqueous plant extract of *Allium sativum* inhibited growth of *F. solani* by 84.8% followed by *Zingiber officinale* (58%), *Momordica charantina* (57.4%), and *Capsicum annum* (50.6%) compared to *Mentha arvensis* (9.9%) and *Allium cepa* (3.4%) significantly ($P \leq 0.05$) at 10% concentration. At 25% concentration, the aqueous plant extract of *Allium sativum* inhibited the growth of *F. solani* by 100% followed by *Zingiber officinale* 63.4%), *Momordica charantina* (60.7%) and *Capsicum annum* (55.5%) compared to *Mentha arvensis* (12%) and *Allium cepa* (5.9%) significantly ($P \leq 0.05$) on 7th day whereas at 50% concentration, the aqueous plant extract inhibited the mycelial growth of *F. solani* at different level *i.e. Allium sativum* (100%), *Zingiber officinale* (69.4%), *Momordica charantina* (64.3%), *Capsicum annum* (61.4%) *Mentha arvensis* (16%), *Allium cepa* (9.9%) significantly ($P \leq 0.05$) on 7th day. At 75% concentration of aqueous plant extract inhibited the growth of *F. solani* at different level *i.e. Allium sativum* (100%), *Zingiber officinale* (71.2%), *Momordica charantina* (66.8%), *Capsicum annum* (75.7%) *Mentha arvensis* (24%), *Allium cepa* (13%) (significant $P \leq 0.05$) on 7th day under *in vitro* condition.

All aqueous plants extracts exhibited antifungal activity against *Fusarium solani* at different concentrations. All selected six medicinal plants were non toxic and environmental eco-friendly. Amongst them *Allium sativum* inhibited 100% mycelial growth of *F. solani* at 10% concentration on 3th day under *in vitro* condition compared to other plants extract. The plant extracts were eco-friendly and effective than synthetic chemical against test pathogen (Dwivedi and Sangeeta, 2014). Shahi and Shahi (2013) studied that ginger oil was potent against fungal pathogens and inhibited mycelial growth at different concentration under *in vitro* condition as an eco-friendly. Bashar and Chakma (2014) tested antagonistic activity of seven soil fungi and plants extract at different concentration against *F. solani* under *in vitro* condition. It was found that the plants extract were most effective compared to soil fungi. Ramaiah and Garampalli (2015) reported that all selected botanical extracts were most effective, cost effective, non-hazardous and human and environment eco-friendly against *F. solani* under *in vitro* condition. Some selected plants extract having antifungal activity against pathogen and also with infrared analysis showed similar absorption signal for plants extract. The plants extract were significantly effective for environmental and economically (Jasso *et al*., 2007). Shrestha and Tiwari (2009) studied that six medicinal plants extract as antifungal activity inhibited mycelial growth of *F. solani* at different concentration under *in vitro* condition. *Terminalia nigrovenulosa* bark extract having methanolic compound that contain antifungal activity at different concentration which inhibited mycelial growth of *F. solani* under *in vitro* study (Nguyen *et al.*, 2013; Zaker and Mosallanejad, 2010). Shukla and Dwivedi (2012) reported that some selected medicinal plants extract *viz*., bitter guard, turmeric, garlic and black pepper were effective against the test pathogen at 5%, 10%, and 15% concentration under *in vitro* condition. It was found that the plants extract significantly reduced the mycelial growth of pathogen.

Dwivedi and Dwivedi (2012) reported that medicinal plants extract were significantly effective against *F. solani*. The negative environmental effect of fungicides and pesticides, used for everyday fungi, pest and disease control; one of the effective method, using plants extract for fungi and disease control as natural antifungal activity against plant pathogen (Onaran and Saglam, 2016).

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