

Original Research Article

<https://doi.org/10.20546/ijcmas.2018.703.429>**Management of Storage Diseases of Onion by Using Different Botanicals**A.S. Futane^{1*}, B.P. Dandnaik², P.P. Jadhav¹ and S.S. Salunkhe¹¹Department of plant pathology, College Of Agriculture, Latur, India²Department of plant pathology, college of Agriculture, Osmanabad, VNMKV, Parbhani, India**Corresponding author***ABSTRACT****Keywords**Storage diseases, Onion, Different botanicals, *Allium***Article Info**Accepted:
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Black mold and *Fusarium* base rot of onion is caused by *Aspergillus niger* and *Fusarium oxysporum f.sp. cepae* are the most destructive diseases of onion in storage causing accountable losses of about 80 per cent and more than 50 per cent respectively. All the botanicals evaluated *in vitro* were found fungistatic/antifungal against both pathogen. In the botanicals viz. *A. sativum* and *O. sanctum* were found most antifungal to *A. niger* and *Fusarium oxysporum f.sp. cepae* with maximum mycelial growth inhibition.

Introduction

Onion (*Allium cepa* L.), is a member of class Liliaceae and family Alliaceae, widely distributed and grown in tropical, sub-tropical and temperate climatic zones (Fritsch and Friesen, 2002). It is biennial crop (Bohanec *et al.*, 2003), and in India it is grown twice (*Rabi* and *Kharif*) in a year (NHRDF, 2009). The name “wild onion” is applied to a number of *Allium* species but *A. cepa* is exclusively known from cultivation and its wild original form is not known.

Onion rightly called as “Queen of kitchen” is one of the oldest known and an important vegetable crop grown in India Onion is

supposed to have its origin in the Middle East Asian Countries and introduced in India from Palestine. It belongs to family Alliaceae, and genus *Allium* with about 300 species. As vegetable and spice it is used both as tender and mature bulb. In bulb group vegetables the most important crop is onion. The bulb composed of concentric, fleshy, in large leaf bases or scales. Onion contains phenolics and flavonoids that have potential anti-inflammatory, anticholesterol, anticancer and antioxidant properties. Onion is grown in three season i.e. *Kharif*, *Rabi*, and summer. In *Kharif* season, during May-June seeds are sown and transplanted during July-Aug months and onion become ready for harvesting during Oct-Nov month.

The post – harvest losses, viz. sprouting, rotting, and physiological loss in weight pose a great problem. It is reported that annual storage losses were over 40 per cent (Bhagchandani *et al.*, 1980) and between 40-60 per cent (Maini *et al.*, 1984) in India.

The onion produce is available in market during October – November (20 per cent) as *kharif* crop, January- February (20 per cent) as late *Kharif* crop and April-May (60 per cent) as *rabi* crop. The *rabi* crop produce having more ability in storage and used for domestic, export and seed bulbs purposes from June to November. This is the critical period in whole country, where there is no fresh harvest onion and hence, storage become paramount importance for steady supply. Nearly two million tones needs to be stored during this period (Tripathi and Lawande, 2003).

Losses of onion during storage are considerable mainly due to sprouting and contamination by several microorganisms. Nearly 40% of the production is lost during post harvest handling and sprouting. Microbial spoilage alone contributes approximately 15-20% of the total loss (Pantastico and Bantista, 1976; Bhagchandani *et al.*, 1980). Earlier, (Quadri *et al.*, 1982) stated that the spoilage caused by *Aspergillus niger* was as high as 80%.

Materials and Methods

Experimental site

All the experiments (*In vitro*) were conducted at the Department of Plant Pathology, College of Agriculture, Latur.

Collection of disease samples

Onion bulbs showing symptoms of rot, black, brown and discolouration were randomly collected in the bags from the various markets

and fields in the Osmanabad and Latur district. These collected bulbs were brought to the Plant Pathology, Laboratory, College of Agriculture, Latur and subjected for further studies.

Culture media

Potato dextrose agar (PDA), the common laboratory culture medium was used as basal medium for isolation, purification, multification and maintenance of the pure culture of diseases.

Chemicals

Standard chemicals, reagents, fungicides, culture media etc. required for the experimentation were obtained from the department of Plant Pathology, college of Agriculture, Latur.

Glass-wares

The common glass-wares (Borosil and corning make) viz., Petri dishes, test tubes, conical flasks, volumetric flasks, measuring cylinder, glass rods, beakers, funnel, pipettes etc. were obtained from the Department of Plant Pathology, College of Agriculture, Latur.

Equipments

The laboratory equipments viz., Autoclave, Hot air oven, Laminar-airflow Cabinet, BOD incubator, Refrigerator, Binocular Research Microscope, Electronic balance, pH meter, Mixer-cum-grinder etc. available at the Department of Plant Pathology, College of Agriculture, Latur were utilized, as and when required.

Miscellaneous

Inoculation needle, forceps, blotter papers, paper bags, polythene bags, spirit lamp,

mercuric chloride, labels, scales, etc. available at the Department of Plant Pathology were used.

Plant extracts/botanicals

Plant species reported with potential antifungal and therapeutic properties (Alice, 1984) against fungal pathogens and available locally were collected from the farms of Oilseeds Research Station, College of Agriculture, Latur and adjoining fields. Following locally available 9 plant species/botanicals were used for *in vitro* studies.

***In vitro* evaluation of botanicals (Plant extracts)**

Plant leaf extracts of nine botanicals viz., Tulsi, Garlic, Ginger, Ashoka, Dhatura, Lantana camera, Jakhamjudi, Karanj, and Neem oil were evaluated against *Aspergillus niger* and *Fusarium oxysporum f.sp.cepae*. Leaf extracts were prepared by grinding with mixer cum grinder the 100 g washed leaves of each plant species in 100 ml distilled water and filtered through double layered muslin cloth. The filtrates obtained were further filtered through Whatman No. 1 filter paper using funnel and volumetric flasks (100 ml cap.). The final clear extracts obtained formed the standard leaf extracts of 100% concentration, which were evaluated by applying poisoned food technique.

For the purpose, PDA was used as basal culture medium. An appropriate quantity of each leaf extract (100%) was separately mixed thoroughly in PDA medium in conical flasks (250 ml cap.) to obtain desired concentrations i.e. 10%, 15% and 20% and autoclaved at 15 lbs/inch² pressure for 15 to 20 minutes. Sterilized and cooled PDA amended with leaf extracts was then poured (15 to 20 ml/plate) into sterile glass Petri plates (90 mm dia.) and

allowed the medium to solidify at room temperature. Each plant leaf extract and its respective concentrations were replicated thrice. The plates containing PDA without any extract were maintained as control. Upon solidification of PDA, all the plates were aseptically inoculated by placing in the centre a 5 mm mycelial disc obtained from a week old culture of *A. niger* grown on agar plates. Plates containing plain PDA and inoculated with test fungus served as untreated control. All these plates were then incubated at $27 \pm 1^{\circ}$ C temperature for a week or till the untreated control plates were fully covered with mycelial growth of the test fungus.

Experimental details

Design: C.R.D.

Replication: Three

Treatment: Ten

T1: Ginger (*Zingiber Officinale*)

T2: Tulsi (*Osmium sanctum*)

T3: Garlic (*Allium Sativum*)

T4: Ashok (*Polyalthia longifolia*)

T5: Dhatura (*Datura metal*)

T6: Ghaneri (*Lantana camera*)

T7: Jakhamjudi (*Tridax procumbens*)

T8: Karanj (*Pongamia pinnata*)

T9: Neem oil (*Azadirachta indica*)

T10: Control

Observations on radial mycelial growth/colony diameter of the test fungus were recorded treatment wise at 24 hours intervals and continued till mycelial growth of the test fungus was fully covered in the untreated control plates. Per cent inhibitions of mycelia growth over untreated control were calculated by applying the formula given by Vincent (1947).

$$\text{Inhibition (\%)} = \frac{\text{Colony growth in control plate} - \text{Colony growth in poisoned plate}}{\text{Colony growth in control plate}} \times 100$$

Statistical analysis

The data obtained in all the experiments (*in vitro*) was statistically analyzed. The percentage values were transformed into Arcsine values. The standard error (SE) and critical difference (C.D.) at level P=0.01% were worked out and results obtained were compared statistically.

Results and Discussion

In vitro efficacy of plant extracts against *A. niger*

A total of nine botanicals viz., tulsi (*Osimum sanctum*), garlic (*Allium sativum*), ginger (*zingiber officinale*), ashok (*Polyalthia longifolia*), datura (*Datura metal*), ghaneri (*Lantana camera*), Jakhamjudi (*Tridax procumbens*), karanj (*Pongamia pinnata*), neem oil (*Azadirachta indica*) were evaluated (@10, 15 and 20 % each) *in vitro* against *A. niger* applying Poisoned Food Technique (Nene and Thapliyal, 1993) and using PDA as a basal medium.

Effect of these botanicals / phytoextracts on radial mycelial growth and inhibition of the test pathogen were recorded. All the treatments were replicated thrice and a suitable untreated control (without plant extract) was also maintained.

Radial mycelial growth

Result revealed that all the botanicals / plant extracts tested exhibited a varied range of radial mycelial growth of the test pathogen and depending upon their concentrations used and it was decreased with increase in concentrations of the botanicals tested. At 10 per cent, radial mycelial growth of the test pathogen ranged from 47.85 mm (*A. sativum*) to 83.04mm (*D. metal*). However, it was maximum with *D. metal* (83.04mm). This was

followed by *P. longifolia* (81.42mm), *Z. officinale* (80.19mm), *P. pinnata* (78.21mm), *T. procumbens* (78.09mm), *L. camera* (77.14mm), *A. indica* (69.99mm) and *O. sanctum* (57.96mm). Significantly least radial mycelial growth was recorded with *A. sativum* (47.85mm) over untreated control (90.00mm).

At 15 per cent, radial mycelial growth of the test pathogen ranged from 42.67mm (*A. sativum*) to 80.15mm (*D. metal*). However, it was maximum with *D. metal* 80.15mm. This was followed by *P. longifolia* (78.30mm), *T. procumbens* (76.94mm), *Z. officinale* (76.66mm), *P. pinnata* (76.50mm), *L. camera* (74.15mm), *A. indica* (68.22mm) and *O. sanctum* (53.73mm). Significantly least radial mycelial growth was recorded with *A. sativum* (42.67mm) over untreated control (90.00mm).

At 20 per cent, radial mycelial growth of the test pathogen ranged from 36.32mm (*A. sativum*) to 78.00mm (*D. metal*). However, it was maximum with *D. metal* (78.00mm). This was followed by *P. longifolia* (76.98mm), *T. procumbens* (75.98mm), *P. pinnata* (75.14mm), *L. camera* (73.25mm), *Z. officinale* (71.17mm), *A. indica* (65.50mm) and *O. sanctum* (49.29mm). Significantly least radial mycelial growth was recorded with *A. sativum* (36.32mm) over untreated control (90.00mm).

The mean radial mycelial growth recorded with the plant extracts tested (@10, 15 and 20 % each) ranged from 42.01mm (*A. sativum*) to 80.39mm (*D. metal*). However, highest mean radial mycelial growth was recorded with *D. metal* (80.39mm), and was followed by *P. longifolia* (78.90mm), *T. procumbens* (77.00mm), *P. pinnata* (76.61mm), *Z. officinale* (76.00mm), *L. camera* (74.84mm), *A. indica* (67.90mm), and *O. sanctum* (53.66mm). Significantly least radial mycelial growth was recorded with *A. sativum* (42.01mm), over untreated control (90.00mm).

Mycelial growth inhibition

Result revealed that all the plant extracts tested, significantly inhibited mycelial growth of the test fungus over untreated control (00.00%). Further, it was found that per cent mycelial growth inhibition of the test pathogens was increased with increase in concentrations of the botanicals tested. At 10 per cent, radial mycelial growth inhibition of the test pathogen ranged from 7.73% (*D. metal*) to 46.83% (*A. sativum*). However, significantly highest mycelial growth inhibition was recorded with *A. sativum* (46.83%). This was followed by *O. sanctum* (35.60%), *A. indica* (22.23%), *L. camera* (14.28%) and least growth inhibition was recorded, *T. procumbens*, *P. pinnata*, *Z. officinale*, *P. longifolia* and *D. metal*. over untreated control (00.00%).

At 15 per cent, radial mycelial growth inhibition of the test pathogen ranged from 10.94% (*D. metal*) to 52.58% (*A. sativum*). However, significantly highest mycelial growth inhibition was recorded with *A. sativum* (52.58%). This was followed by *O. sanctum* (40.30%), *A. indica* (24.20%), *L. camera* (17.61%), *P. pinnata* (14.99%), *Z. officinale* (14.82%), *T. procumbens* (14.51%), *P. longifolia* (13.00%) and very less growth inhibition was recorded *D. metal* (10.94%) over untreated control (00.00mm).

At 20 per cent, radial mycelial growth inhibition of the test pathogen ranged from 13.33% (*D. metal*) to 59.64% (*A. sativum*). However, significantly highest mycelial growth inhibition was recorded with *A. sativum* (59.64%). This was followed by *O. sanctum* (45.23%), *A. indica* (27.22%), *Z. officinale* (20.92%) and very less growth inhibition was recorded, *L. camera* (18.61%), *P. pinnata* (16.51%), *T. procumbens* (15.57%), *P. longifolia* (14.46%) and *D. metal* (13.33%) over untreated control (00.00mm).

Mean percentage mycelial growth inhibition recorded with all the botanicals tested ranged from 10.66% (*D. metal*) to 53.01% (*A. sativum*). However, *A. sativum* was found most fungistatic and recorded significantly highest mean mycelial growth inhibition (53.01%). The second and third best plant extracts found were *O. sanctum* (40.37%) and *A. indica* (24.55%). The remaining all plant extracts found least effective against the test pathogen

Thus, on the basis of mean mycelial growth inhibition, the botanicals were found most antifungal against *Aspergillus niger*. The effectiveness of these botanicals extracts may be due to the presence of bioactive and antifungal compounds like phenolic substances, nonvolatile compounds. The presence of ajoene and alliicin in *A. sativum* might be the reason for inhibition of *Aspergillus niger* (Yoshida *et al.*, 1987; Naganawa *et al.*, 1996). The ineffectiveness of the other plant extracts on *A. niger* might be due to insolubility of their active compounds in water (Qasem and Abu-Blan, 1996; Amadioha, 2000).

These results of the present study are in consonance with the finding of several previous workers. Botanical / plant extracts viz., *A. sativum*, *Z. officinale*, *D. metal*, *P. pinnata* and *A. indica* were reported antifungal / fungistatic against *Aspergillus niger*, earlier by several workers (Irkin and Korukluoglu, 2007; Avasthi *et al.*, 2010; Sonawane *et al.*, 2012; Khan and Nasreen 2013;)

In vitro* efficacy of plant extracts against *Fusarium oxysporum f. sp. cepae

A total of nine botanicals viz., tulsi (*Osimum sanctum*), garlic (*Allium sativum*), ginger (*zingiber officinale*), ashok (*Polyalthia longifolia*), datura (*Datura metal*), ghaneri

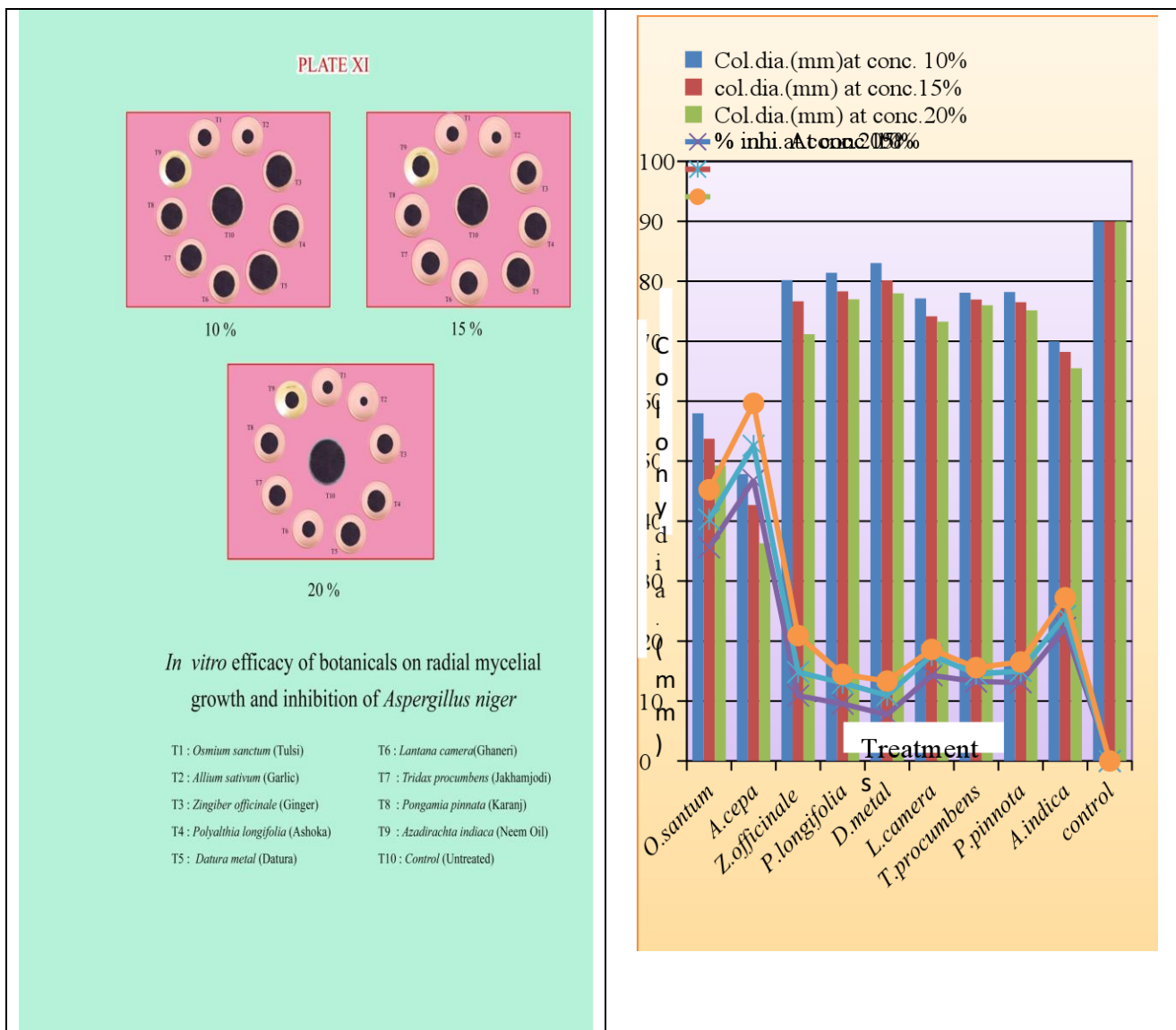
(*Lantana camera*), Jakhamjudi (*Tridax procumbens*), karanj (*Pongamia pinnata*), neem oil (*Azadirachta indica*) were evaluated (@10, 15 and 20 % each) *in vitro* against *Fusarium oxysporum f.sp.cepae*, applying Poisoned Food Technique (Nene and Thapliyal, 1993) and using PDA as a basal medium. Effect of these botanicals / phytoextracts on radial mycelial growth and inhibition of the test pathogen were recorded. All the treatments were replicated thrice and a

suitable untreated control (without plant extract) was also maintained.

Radial mycelial growth

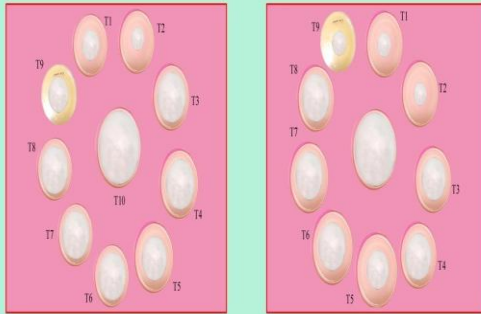
Result revealed that all the botanicals / plant extracts tested exhibited a varied range of radial mycelial growth of the test pathogen and depending upon their concentrations used and it was decreased with increase in concentrations of the botanicals tested.

In vitro efficacy of the botanicals on mycelial growth and inhibition of *Aspergillus niger*



In vitro efficacy of the botanicals on mycelial growth and inhibition of *Fusarium oxysporum f. sp. cepae*

PLATE XIV



10 %

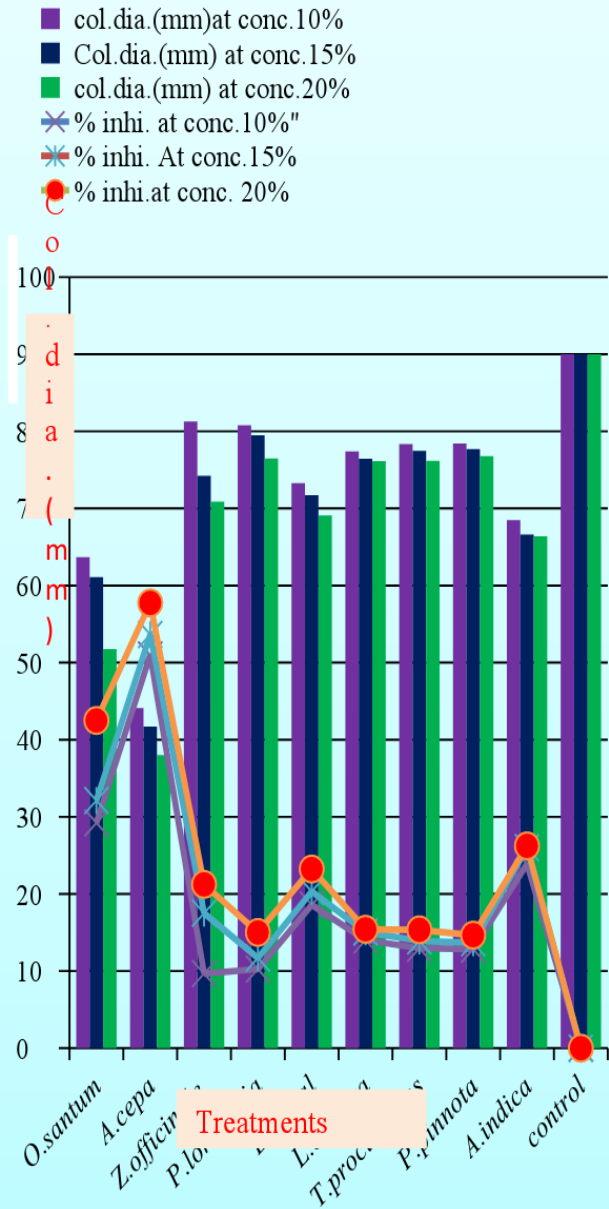
15 %



20 %

In vitro efficacy of botanicals on radial mycelial growth and inhibition of *Fusarium oxysporum f.sp.cepae*

- | | |
|--|--|
| T1 : <i>Osmium sanctum</i> (Tulsi) | T6 : <i>Lantana camera</i> (Ghaneri) |
| T2 : <i>Allium sativum</i> (Garlic) | T7 : <i>Tridax procumbens</i> (Jakhamjodi) |
| T3 : <i>Zingiber officinale</i> (Ginger) | T8 : <i>Pongamia pinnata</i> (Karanj) |
| T4 : <i>Polyalthia longifolia</i> (Ashoka) | T9 : <i>Azadirachta indica</i> (Neem Oil) |
| T5 : <i>Datura metal</i> (Datura) | T10 : Control (Untreated) |



Plant extracts/botanicals

Sr. No	Local name	Scientific Name	Plant Part Used	Sr. No.	Local name	Scientific Name	Plant Part Used
1.	Ginger	<i>Zingiber Officinale</i>	Rhizome	6	Ghaneri	<i>Lantana camera</i>	Leaf
2.	Tulsi	<i>Osmium sanctum</i>	Leaf	7	Jakhamjudi	<i>Tridax procumbens</i>	Leaf
3.	Garlic	<i>Allium Sativum</i>	Bulb/Petal	8	Karanj	<i>Pongamia pinnata</i>	Leaf
4.	Ashoka	<i>Polyalthia longifolia</i>	Leaf	9	Neem oil	<i>Azadirachta indica</i>	Oil
5.	Datura	<i>Datura metal</i>	Leaf				

In vitro effect of different plant extracts on mycelia growth and inhibition of *A. niger*

Tr. No.	Treatments	Colony Diameter (mm)*at conc.			Mean (mm)	% Inhibition* at conc.			Mean % Inhib.
		10%	15%	20%		10%	15%	20%	
T1	Tulsi	57.96	53.73	49.29	53.66	35.6 (20.86)	40.30 (23.76)	45.23 (26.89)	40.37 (23.83)*
T2	Garlic	47.85	42.67	36.32	42.01	46.83 (27.94)	52.58 (31.72)	59.64 (36.62)	53.01 (32.09)
T3	Ginger	80.19	76.66	71.17	76.00	10.9 (6.25)	14.82 (8.48)	20.92 (12.07)	15.54 (8.93)
T4	Ashok	81.42	78.30	76.98	78.90	9.53 (5.46)	13 (7.46)	14.46 (8.31)	12.33 (7.07)
T5	Datura	83.04	80.15	78.00	80.39	7.73 (4.43)	10.94 (6.28)	13.33 (7.66)	10.66 (6.12)
T6	Ghaneri	77.14	74.15	73.25	74.84	14.28 (8.20)	17.61 (10.13)	18.61 (10.71)	16.83 (9.68)
T7	Jakhamjudi	78.09	76.94	75.98	77.00	13.23 (7.59)	14.51 (8.33)	15.57 (8.99)	14.43 (8.30)
T8	Karanj	78.21	76.50	75.14	76.61	13.10 (7.51)	14.99 (8.57)	16.51 (9.86)	14.86 (8.64)
T9	Neem oil	69.99	68.22	65.50	67.90	22.23 (12.84)	24.20 (14)	27.22 (15.79)	24.55 (14.21)
T10	Control	90.00	90.00	90.00	90.00	00.00	00.00	00.00	00.00
	S.E.+-	0.96	0.72	0.70	-	0.70	0.50	0.53	-
	C.D. (P=0.01)	2.85	2.12	2.07	-	2.08	1.49	1.58	-

*: Figures in parenthesis are sin transformed value

Mean of three replications

Conc. = Concentration

Inhib. = Inhibition

In vitro effect of different plant extracts on growth and inhibition of *Fusarium oxysporum f. sp. cepae*

Tr. No.	Treatments	Colony Diameter (mm)*at conc.			Mean (mm)	% Inhibition at conc.			Mean % Inhib.
		10%	15%	20%		10%	15%	20%	
T1	Tulsi	63.70	61.09	51.75	61.21	29.22 (16.98)	32.12 (18.73)	42.50 (25.15)	34.61 (20.28)*
T2	Garlic	44.10	41.71	38.02	41.27	50.99 (30.65)	53.65 (32.44)	57.75 (35.27)	54.13 (32.78)
T3	Ginger	81.29	74.24	70.88	75.47	9.67 (5.54)	17.51 (10.08)	21.24 (12.26)	16.14 (9.29)
T4	Ashok	80.77	79.47	76.49	55.57	10.25 (5.88)	11.69 (6.71)	15.01 (8.67)	12.31 (7.08)
T5	Datura	73.27	71.71	69.09	71.35	18.58 (10.70)	20.32 (11.72)	23.23 (13.43)	20.71 (11.95)
T6	Ghaneri	77.38	76.43	76.12	76.64	14.02 (8.03)	15.07 (8.70)	15.42 (8.90)	14.83 (8.54)
T7	Jakhamjudi	78.33	77.48	76.18	77.33	12.96 (7.43)	13.91 (7.98)	15.35 (8.86)	14.07 (8.09)
T8	Karanj	78.43	77.70	76.80	77.64	12.85 (7.36)	13.66 (7.46)	14.66 (8.42)	13.72 (7.74)
T9	Neem oil	68.49	66.60	66.38	67.75	23.9 (13.82)	26 (15.06)	26.24 (21.24)	28.71 (16.70)
T10	Control	90.00	90.00	90.00	90.00	00.00	00.00	00.00	00.00
	S.E.±	0.49	0.54	0.64	-	0.35	0.37	0.45	-
	C.D. (P=0.01)	1.45	1.59	1.90	-	1.04	1.10	1.35	-

*: Figures in parenthesis arc sin transformed value

Average of three replications

Conc. = Concentration Inhib. = Inhibition

At 10 per cent, radial mycelial growth of the test pathogen ranged from 44.10mm (*A. sativum*) to 81.29mm (*Z. officinale*). However, it was maximum with *Z. officinale* (81.29mm). This was followed by *P. longifolia* (80.77mm), *P. pinnata* (78.43mm), *T. procumbens* (78.33mm), *L. camera* (77.38mm), *D. metal* (73.27mm), *A. indica* (68.49mm) and *O. sanctum* (63.70mm). Significantly least radial mycelial growth was recorded with *A. sativum* (44.10mm) over untreated control (90.00mm). At 15 per cent, radial mycelial growth of the test pathogen ranged from 41.71mm (*A. sativum*) to

79.47mm (*P. longifolia*). However, it was maximum with *P. longifolia* (79.47mm). This was followed by *P. pinnata* (77.70mm), *T. procumbens* (77.48mm), *L. camera* (76.43mm), *Z. officinale* (74.24mm), *D. metal* (71.71mm), *A. indica* (66.60mm) and *O. sanctum* (61.09mm). Significantly least radial mycelial growth was recorded with *A. sativum* (41.71mm) over untreated control (90.00mm).

At 20 per cent, radial mycelial growth of the test pathogen ranged from 38.02mm (*A. sativum*) to 76.80mm (*P. pinnata*). However, it was maximum with *P. pinnata* (76.80mm).

This was followed by *T. procumbens* (76.18mm), *L. camera* (76.12mm), *P. longifolia* (76.49mm), *Z. officinale* (70.88mm), *D. metal* (69.09mm), *A. indica* (66.38mm) and *O. sanctum* (51.75mm). Significantly least radial mycelial growth was recorded with *A. sativum* (38.02mm) over untreated control (90.00mm). The mean radial mycelial growth recorded with the plant extracts tested (@10, 15 and 20 % each) ranged from 41.27mm (*A. sativum*) to 78.91mm *P. longifolia*.

However, highest mean radial mycelial growth was recorded with *P. longifolia* (78.91mm), and was followed by *P. pinnata* (77.64), *T. procumbens*(77.33mm), *L. camera* (76.64mm), *Z. officinale* (75.47mm), *D. metal* (71.35mm), *A. indica* (67.75mm), *O. sanctum* (61.21mm) and. Significantly least mean radial mycelial growth was recorded with *A. sativum* (41.27mm), over untreated control (90.00mm).

Mycelial growth inhibition

Result revealed that all the plant extracts tested, significantly inhibited mycelial growth of the tests fungus over untreated control (00.00%). Further, it was found that per cent mycelial growth inhibition of the test pathogens was increased with increase in concentrations of the botanicals tested.

At 10 per cent, radial mycelial growth inhibition of the test pathogen ranged from 9.67 (*Z. officinale*) to 50.99% (*A. sativum*). However, significantly highest mycelial growth inhibition was recorded with *A. sativum* (50.99%). This was followed by *O. sanctum* (29.22%), *A. indica* (23.90%), *D. metal* (18.58%) and least growth inhibition was recorded, *L. camera*, *T. procumbens*, *P. pinnata*, *P. longifolia*, *Z. officinale*, over untreated control (00.00%).

At 15 per cent, radial mycelial growth inhibition of the test pathogen ranged from 11.69 (*P. longifolia*) to 53.65% (*A. sativum*). However, significantly highest mycelial growth inhibition was recorded with *A. sativum* (53.65%). This was followed by *O. sanctum* (32.12%), *A. indica* (26.00%), *D. metal* (20.32%) and least growth inhibition was recorded, *Z. officinale*, *L. camera*, *T. procumbens*, *P. pinnata* and *P. longifolia* over untreated control (00.00%).

At 20 per cent, radial mycelial growth inhibition of the test pathogen ranged from 14.66% (*P.pinnata*) to 57.75% (*A. sativum*). However, significantly highest mycelial growth inhibition was recorded with *A. sativum* (57.75%). This was followed by *O. sanctum* (42.50%), *A. indica* (26.24%), *D. metal* (23.23%) and least growth inhibition was recorded, *Z. officinale*, *L. camera*, *T. procumbens*, *P. longifolia* and *P. pinnata* over untreated control (00.00%).

Mean percentage mycelial growth inhibition recorded with all the botanicals tested ranged from 12.31% (*P. longifolia*) to 54.13% (*A. sativum*). However, *A. sativum* was found most fungistatic and recorded significantly highest mean mycelial growth inhibition (54.13%). The second and third best plant extracts found were *O. sanctum* (34.61%) and *A. indica* (28.71%). The remaining all plant extracts found least effective of the test pathogen. Thus, all the plant extracts tested were found fungistatic/ antifungal against *Fusarium oxysporum f.sp.cepae*.

Thus, on the basis of mean mycelial growth inhibition, the botanicals found most antifungal against *Fusarium oxysporum f.sp.cepae*. The effectiveness of these botanical extracts may be due to the presence of bioactive and antifungal compounds like phenolic substances, nonvolatile compounds. The presence of ajoene and alliicin in *A.*

sativum might be the reason for inhibition of *Fusarium oxysporum f.sp.cepae* (Mahadevan, 1982; Yoshida *et al.*, 1987; Naganawa *et al.*, 1996; Sahavaraj *et al.*, 2006).

These results of the present study are in consonance with the finding of several previous workers. Botanical / plant extracts viz., *A. sativum*, *Z. officinale*, *D. metal*, *P.pinnata* and *A. indica* were reported antifungal / fungistatic against, *Fusarium oxysporum f. sp.cepae* earlier by several workers (Brower and Locky, 2000; Agbenin and Marley, 2006; Taskeen-Un-Nisa *et al.*, 2011; Hadi and Kashefi, 2013; Singh *et al.*, 2014).

Aqueous extracts of 9 botanicals evaluated *in vitro* (10%, 15% and 20%) were found fungistatic/antifungal to *A.niger*. However, *A. sativum* was found most fungistatic and recorded significantly highest mean mycelial growth inhibition (53.01%). The second and third best plant extracts found were *O. sanctum* (40.37%) and *A. indica* (24.55%). The remaining all plant extracts found least effective of the test pathogen. Aqueous extracts of 9 botanicals evaluated *in vitro* (10%, 15% and 20%) were found fungistatic/antifungal to *Fusarium oxysporum f.sp.cepae*. However, *A. sativum* was found most fungistatic and recorded significantly highest mean mycelial growth inhibition (54.13%). The second and third best plant extracts found were *O. sanctum* (34.61%) and *A. indica* (28.71%). The remaining all plant extracts found least effective of the test pathogen. Thus, all the plant extracts tested were found fungistatic/ antifungal against *Fusarium oxysporum f.sp.cepae*.

Thus from the results obtained on various aspects during investigation on post-harvest and storage diseases of onion, following conclusions are being drawn
Aqueous extracts of all the nine botanicals

evaluated *in vitro* found fungistatic/antifungal to both the pathogen (*A.niger* and *Fusarium oxysporum f. sp. cepae*). However, *A.sativum*, *O. sanctum* and neem oil were effective against both the pathogen.

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