Int J Pharma Res Health Sci. 2018; 6 (1): 2239-44
DOI:10.21276/ijprhs.2018.01.26
D K Sharma
CODEN (USA)-IJPRUR, e-ISSN: 2348-6465

PHS Scientific House
PHARMAHEALTHSCIENCES

International Journal of Pharma Research and Health Sciences

Available online at www.pharmahealthsciences.net


Original Article

# Non-Hazardous Management of *Xanthomonas axonopodis* pv. *vesicatoria* (Doidge) Dye in Chilli (*Capsicum* spp.) Using Leaf extracts of Medicinal Plants

D K Sharma *
Vardhaman Mahaveer Open Universiy, Kota, Rajasthan, India

ARTICLE INFO

Received: 05 Feb 2018
Accepted: 23 Feb 2018

ABSTRACT

The leaf extracts of several medicinal plants were used to study their antimicrobial strength against *Xanthomonas axonopodis* pv. *vesicatoria* (Doidge) Dye in chilli. Plant extracts at various concentrations (100, 50, 30 or 25%) were used to evaluate their antibacterial effects using filter paper disc assay, seeded agar method but in case of seed treatment *Tabarnaemontea divaricata* and seed treatment methods. Aqueous leaf extracts of *Parthenium hysterophorus* and *Lantana camara* individually were found most effective against the pathogen in filter paper and seeded agar method improve seed germination and control of pathogen at 100% concentration as compared to check. The present study indicates the bio-efficacy of botanicals in effectively controlled of the pathogen or reduction the disease incidence significantly.

**Keywords:** *in vitro* study, antibacterial activity, filter paper disc assay, seeded agar method, standard blotter method, bacterial incidence, aqueous leaf extracts, *Xanthomonas axonopodis* pv. *vesicatoria.*

## 1. INTRODUCTION

Bacterial leaf spot (BLS) disease of sweet pepper (*Capsicum annuum*) and tomato (*Lycopersicon esculentum*) is a major disease in tropical and subtropical climates appeared on mature and green fruits caused by *Xanthomonas axonopodis* pv. *vesicatoria.* It is reported from several countries of eastern and southern Africa, USA, Ethiopia, Kenya, Malawi, Mozambique and South Africa[1,2]. XAV suspected from symptoms on tomato and sweet pepper fruit was confirmed by isolation on semi-selective media including Tween B[3]. In

**Corresponding author ***
**Dr D K Sharma**
Vardhaman Mahaveer Open Universiy, Kota, Rajasthan, India
E-Mail: drdilipsharma12@gmail.com

India, bacterial leaf spot disease was first reported from Pune, Maharastra in 1948 by Patel *et al.* in chilli. In Rajasthan, the disease caused 7.5 to 16.6 per cent loss in the yield of fruits and pathogen required a temperature range of 22-34°C with high humidity for maximum infection [4,5].

*Xanthomonas axonopodis* pv. *vesicatora* (Doidge) Dye (syn: *Xanthomonas campestris* pv. *vesicatoria*) (XAV) is a gram-negative, rod-shaped bacterium that produce spot on leaf, fruit and cankers on stem. The disease occurs universally are relatively warm and moist environment cause lesions which reduce quality and nutritive value of fresh fruit for sale and processing [6-10].

The disease started early in the crop before flowering and losses in marketable fruits may be more than 50% [8,11]. The pathogen was found seed-borne (10-15%) also subsists on infected plant debris, weeds and volunteer tomato plants [12]. The incidence was less than 5% persisted from one season to next in crop debris or on weed hosts [13]. The pathogen has been reported to be seed-borne in chilli.

## 2. MATERIALS AND METHODS

**Collection of plant materials**

Plant leaves of selected seven plants were collected from Jaipur, Rajasthan, India for this experiment (Table 1, 2). The seven medicinal plants leaf extracts namely mexican prickly poppy (peeli kataili, *Argemone mexicana* L.) of family Papaveraceae, crape jasmine (chandani, *Tabernaemonatna divaricata)* of family Apocynaceae, glorybower (bharangi, *Clerodendrum inerme*) of Verbenaceae, Madagascar periwinkle (sadabahar, *Catharanthus roseus*) of Apocynaceae, Lantana (Kuri, *Lantana camara*) of Verbenaceae, withania (ashwagandha, *Withania somnifera*) of Solanaceae, congress grass (gajar ghas, *Parthenium hysterophorus*) of Asteraceae were tested *in vitro* for control of pathogen. For the experiments 10 g fresh leaves of each plant was taken, washed thoroughly by distilled water followed with tap water. Now the surface sterilized leaves were crushed in sterile distilled water at the rate of 1g tissues in 1 ml of water (1: 1 w/v) using pestle and mortar. The extract was filtered through double layered cheesecloth and this filtrate was treated as stock solution.

**Seed treatment in SBM**

Two seed samples of chilli, Ca-1227 and Ca-1234 naturally infected with XAV were treated individually with the aqueous leaf extracts of 7 medicinal plants for 4 hrs in two different concentrations, pure (100%, w/v) and diluted (30% v/v) in triplicate (100 seeds/ sample) were used. Seeds soaked in sterile distilled water were treated as check. All the treated and untreated seeds were incubated on moistened blotter papers and per cent seed germination, seedling symptom, incidence of the bacteria and inhibition of the pathogen observed on 8$^{th}$ days in standard blotter method[17]. The percent control of pathogens was calculated by the following formula-

[Percent control = Incidence in check (C) - incidence in treatment (T) /Incidence in check (C) x 100]

**Filter paper disc assay and seeded agar method**

Two another methods namely seeded agar method and filter paper disc method (disc diffusion method) were also carried out to find out the antibacterial activity against XAV[18-20]. Bacterial suspension (10 ml) of test bacterium was spread by a sterile L-rods or cotton swab on nutrient agar medium. Filter paper discs of 8 mm diameter impregnated with plant extracts were placed in the inoculated plates. Filter paper discs soaked in double sterile distilled water placed in the middle of the plate used as check. The plates were incubated at 30±2° C for 48 hrs. In seeded agar method the wells (8 mm diameter) on nutrient agar medium (already seeded) using sterilized cork borer were yielded. The (1 ml v/v) crude form of suspension of leaf extracts was place in wells by using sterile syringe. The diameter or zone of inhibition was recorded upto 6 days in intervals of 24 hrs at 25 ± 2°C for each test agent.

The inhibition zones were measured in diameter (mm) around of the discs and calculated to compare the antibacterial activity of the test plant extracts. The inhibition annulus was calculated by following formula[19-21]-

[Activity index (AI) = Inhibition zone of sample/ Inhibition zone of standard]

The bacterium was identified by available detailed description on the basis of morphological and biochemical characterstics [14, 15, 22-26].

## 3. RESULTS AND DISCUSSION

Plants and their derivatives are good alternative source of agrochemicals in managing bacterial diseases using secondary metabolites or bioactive compounds as alkaloids, flavonoids, tannins, saponins and terpenoids and can be used as source of natural pesticides [27, 28]. Medicinal plant extracts are eco-friendly and economical sources to control the plant diseases. Currently the scientific research showed much interest in control of various microbes or pests by exploit the antibacterial activity of medicinal plants to reduce the toxicity of chemicals to manage the plant diseases. The chemicals having several hazardous tend to accumulate in animal tissues posing threat to human health. Green plants are effective chemotherapeutants and can provide valuable sources of natural pesticides [29, 30]. Plant extract have a potential as environmentally safe alternatives chemicals in integrated disease management programs [31]. The bioactive and biochemical compounds of medicinal plant are of origin of non-phytotoxic and easily biodegradable [35-39]. Leaf extracts of various plants are known to possess antimicrobial activity [32-34].

In the present study, aqueous leaf extracts of 7 medicinal plants tried and found effective to control the bacterial pathogen XAV to control by *Parthenium hysterophorus* followed by *Lantana camara* in filter paper method and seeded agar method gave best results at 100% concentration.

In standard blotter method *Tabernaemontana divericata* and *P. hysterophorus* found most effective at 100% concentration as compared to check. The maximum improvement in seed germination was shown by *P. hysterophorus* (90 and 86.7%) followed by *T. divericata* (90 and 86.7%) at 100% concentration in both the tested samples. The incidence of the pathogen was reduced by *T. divericata* (26.7 and 23.3%) at 100% concentration followed by *P. hysterophorus* (30 and 33.3%) at same concentration as compared to check (60 and 63.3%) in both the samples. The per cent control of the pathogen was shown by *T. divericata* (55.6 and 63.5%) followed by *P. hysterophorus* (50 and 46.8%) at 100% concentration (Table 1).

**Table 1: *in vitro* effects on seed treatment of leaf extracts on seed germination, incidence and control of *Xanthomonas axanopodis* pv. *vesicatoria* in chilli on SBM**

| S. No. | Leaf extracts used | Conc. (%) (w/v) | SEED SAMPLES ON SBM | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Ca-1227 | | | Ca-1234 | | |
| | | | Seed germination (%) | Incidence of pathogen (%) | Control of pathogen (%) | Seed germination (%) | Incidence of pathogen (%) | Control of pathogen (%) |
| 1. | **Check** | - | 76.7 (61.14) | 60.0 (50.77) | 0(0.00) | 66.7(54.76) | 63.3(52.71) | 0(0.00) |
| 2. | ***Clerodendrum inerme*** | **100** | 76.7 (61.14) | 56.7 (48.85) | 5.6(13.69) | 70.0(56.79) | 53.3(46.89) | 16.7(24.12) |
| | | **30** | 76.7 (61.14) | 56.7 (48.85) | 5.6(13.69) | 66.7(54.76) | 56.7(48.85) | 10.3(18.72) |
| 3. | ***Withinia somnifera*** | **100** | 80.0 (63.44) | 53.3 (46.89) | 11.1(19.46) | 76.7(61.14) | 43.3(41.15) | 30.9(33.77) |
| | | **30** | 80.0 (63.44) | 56.7 (48.85) | 5.6 (13.69) | 70.0 (56.79) | 46.7 (43.11) | 25.4 (30.26) |
| 4. | ***Lantana camara*** | **100** | 76.7 (61.14) | 53.3 (46.89) | 11.1(19.46) | 76.7 (61.14) | 53.3 (46.89) | 15.1 (22.87) |
| | | **30** | 76.7 (61.14) | 56.7 (48.85) | 5.6 (13.69) | 76.7 (61.14) | 53.3 (46.89) | 14.3(22.22) |
| 5. | ***Tabernaemontana divericata*** | **100** | 90.0** 71.56) | 26.7**(31.11) | 55.6**(48.22) | 86.7**(68.61) | 23.3** 28.86) | 63.5** (52.83) |
| | | **30** | 90.0** 71.56) | 33.3**(35.24) | 44.4**(41.78) | 80.0(63.44) | 33.3**(35.24) | 47.6**(43.62) |
| 6. | ***Argimone mexicane*** | **100** | 80.0 (63.44) | 46.7 (43.11) | 22.2 (28.11) | 76.7 (61.14) | 46.7 (43.11) | 26.9 (31.24) |
| | | **30** | 76.7 (61.14) | 50.0 (45.0) | 16.7 (24.12) | 66.7 (54.76) | 56.7 (48.85) | 10.3 (18.72) |
| 7. | ***Catheranthus roseus*** | **100** | 90.0**(71.56) | 33.3 (35.24) | 44.4 (41.78) | 73.3 (58.89) | 43.3 (41.15) | 31.7 (34.24) |
| | | **30** | 86.7** 68.61) | 36.7 (37.29) | 38.9 (38.59) | 70.0 (56.79) | 43.3 (41.15) | 30.9 (33.77) |
| 8. | ***Parthenium hysterophorus*** | **100** | 90.0**(71.56) | 30.0**(33.21) | 50.0**(45.0) | 86.7**(68.71) | 33.3(35.24) | 46.8**(43.17) |
| | | **30** | 86.7 (68.61) | 36.7 (37.29) | 38.9 (38.59) | 86.7**(68.71) | 36.7 (37.29) | 42.1**(40.46) |
| | *CD at 5%*<br>**CD at 1%** | - | 4.06<br>5.60 | 5.16<br>7.11 | 16.83<br>22.09 | 9.97<br>13.77 | 10.60<br>14.61 | 20.76<br>28.60 |

Values are the mean of 3 replicates; Values in parentheses are angular transformed values.

In the earlier studies the bio-efficacy of six medicinal plant extracts was tested *in vitro* using filter paper disc assay and seed treatment method against *Pseudomonas syringae* pv. *pisi* in pea. The maximum antibacterial activity was shown by aqueous extract of *A. sativum* (IA=455.98mm$^2$) followed by *T. chebula* (IA=415.25mm$^2$). Seed treatment with aqueous extract of *A. sativum* improved seed germination (94.6%) as compared to check (56.3%) and control the incidence of the pathogen in seeds (85.5%) [19].

Seed treatment with these medicinal plants extracts improved seed germination and control of pathogen due to the presence of bioactive compounds[40]. Seed treatment with *T. bellirica* and *A. sativum* showed maximum seed germination and control of *Xanthomonas pisi* [20]. Plant extracts of *T. chebula* is reported to be an antimicrobial, hepatoprotective, anti-inflammatory, immunomodulatory, an antioxidant and adaptogenic[41-44]. The antibacterial activity of 30 leaf extracts against 11 strains of *X. campestris* pv. *mangiferaeindicae* tried out of them 12 leaf extracts showed antibacterial activity remaining 18 leaf extracts had not shown any inhibitory effect. *Terminalia thorelii* followed by *Azadirachta indica, Callistemon rigidus, Butea monosperma, Calistemon rigidus, Capsicum annum, Caesalpinia pulcherima, Datura inoxia, Dolichandrone falcate, Holoptelea integrifolia, Lantana camera, Lawsonia inermis* and *Vitex negundo* also showed good antibacterial activity. In another study, 2300 plant species screened to know their antibacterial activity against the bacteria like *Escherichia coli* and *Staphylococcus aureus*[45]. Pawar (1999) has screened 110 leaf extracts, 09 root extracts, 36 fruit extracts, 05 stem extracts, 10 seed extracts, 04 bark extracts, 08 gum and 06 latex against 05 bacterial phytopathogens[46]. Aqueous extracts of leaves of *Tamarindus indica* showed good antibacterial activity gainst Gram positive bacteria and hydroalcoholic extracts of leaves in Gram negative bacteria [47] and have wide range of antibacterial activity against gram positive and gram negative bacterial strains [48]. Hot water extract of garlic showed good inhibitory effect against *Xanthomonas citri and Erwinia carotovora* and human pathogens[49]. In this study, the improvement in seed germination was shown by all the tested aqueous plant extracts in seed treatment method (Table 2). The relative percent seed germination by plant extracts was as follows-

***T. divaricata* > *P. hysterophorus* >*C. roseus* >*A.maxicana*= *W. somnifera*> *L. camara*= *C. inerme***

The highest percentage seed germination showed by *T. divaricata, P. hysterophorus* and *C. roseus* at 100% concentration as compared to control (76.7%). There was no improvement in germination by the leaf extract of *L. camara* and *C. inerme* after seed treatment. The relative percent control of the pathogen was as follows-

***T. divaricata* > *P. hysterophorus* >*C. roseus* >*A.maxicana*> *W. somnifera*> *L. camara*> *C. inerme***

Seven aqueous leaf extracts were tested at three different concentrations (25, 50 and 100%) using filter paper disc assay method or seeded agar method against the bacterial

colonies of XAV. The leaf extract showed potential activity against bacterial pathogen as compare to check (Fig. 1).

Bacterial blight was more effectively controlled by the water and methanol extracts of *Vitex negundo* than the other plant extracts[50]. The methanolic leaf extracts of *Acacia nilotica, Sida cordifolia, Tinospora cordifolia, Withania somnifera* and *Ziziphus mauritiana* against *Bacillus subtilis, Escherichia coli, Pseudomonas fluorescens, Staphylococcus aureus* and *Xanthomonas axonopodis* pv. *malvacearum* has been reported [51]. The aqueous extracts of garlic, clove and onion were found effective against *X. axonopodis* pv. *vignaradiatae* during foliar application [52]. *Terminellia chebula* showed an inhibitory effect against *Xanthomonas campestris* pv. *citri* [41]. The plant extracts of *Allium cepa, Azadirachta indica, Tamarix aphylla, Vernonia anthelmentica, Plumbago zelanicum,* and *Tegetis erecta* showed significant antibacterial activity at 50% concentration against *X. campestris* pv. *campestris in vitro* and showed improved seed germination and as compare to streptomycin [53].

In the present study the aqueous leaf extracts of *P. hysterophorus* and *L. camara* individually were found most effective against the pathogen at 100% concentration in filterpaper and seeded agar method as compared to check. Seven plant leaf extracts were used and leaf extract of *P. hysterophorus* at 100% concentration showed the highest inhibition zone and activity index was 28.67 mm and 3.85 followed by *L. camara* being 15.33 mm and 1.92 respectively against the pathogen in filter paper and seeded agar method.

**Table 2: *In vitro* evaluation of antibacterial activity of some plant extracts against seed-borne bacterium (*Xathomonas axonopodis* pv. *vesicatoria*) in chilli on filter paper method and seeded agar method**

| | Leaf extracts | Concentration (w/v) | Test Bacterium IZ (mm) | AI |
|---|---|---|---|---|
| 1. | *Lantana camara* | 100 | 15.33 | 1.92 |
| | | 50 | 13.33 | 1.67 |
| | | 25 | 11.33 | 1.42 |
| 2. | *Clerodendrum inerme* | 100 | 11.33 | 1.42 |
| | | 50 | 10.00 | 1.25 |
| | | 25 | 9.33 | 1.17 |
| 3. | *Tabernaemontana divericata* | 100 | 13.67 | 1.71 |
| | | 50 | 11.00 | 1.38 |
| | | 25 | 10.33 | 1.29 |
| 4. | *Parthenium hysterophorus* | 100 | 28.67 | 3.58 |
| | | 50 | 24.33 | 3.04 |
| | | 25 | 16.67 | 2.08 |
| 5. | *Withinia somnifera* | 100 | 12.67 | 1.58 |
| | | 50 | 11.00 | 1.38 |
| | | 25 | 09.00 | 1.13 |
| 6. | *Argimone mexicane* | 100 | 11.00 | 1.38 |
| | | 50 | 10.33 | 1.29 |
| | | 25 | 09.33 | 1.17 |
| 7. | *Catheranthus roseus* | 100 | 11.66 | 1.46 |
| | | 50 | 10.33 | 1.29 |
| | | 25 | 10.33 | 1.25 |

* Diameter of filter paper (well) disc (8 mm) included inhibition zone in check.

**Fig 1: *In vitro* control of *Xanthomonas axonopodis* pv. *vesicatoria* using leaf extracts in seeded agar method (note the zone of inhibition)**

## 4. CONCLUSION

The present study revealed that among seven different plant leaf extracts (aqueous) used for their antibacterial activity, *Parthenium hysterophorus* and *Lantana camara* on filter paper method and seeded agar method gave the promising results against *Xav* causing bacterial leaf spot disease of chilli *in vitro.* In standard blotter method *Tabernaemontana divericata* and *Parthenium hysterophorus* found most effective at 100% concentration. The treatment also improved seed germination and control of pathogen as compared to check.

## 5. ACKNOWLEDGEMENT

Author is also grateful to Prof. Ashok Sharma, vice-chancellor, VMOU, Kota; Prof Kailash Agrawal, department of botany, university of rajasthan, jaipur for their valuable guidance and faculty members of P.G. Department of Botany, Agrawal PG College, Jaipur for valuable support. The author is also thankful to all the scientists whom work is cited and could not acknowledge unknowingly and persons that directly or indirectly engaged in writing in this paper and during practical work.

## 6. REFERENCES

1. Anonymous. Data sheets on quarantine organisms, no. 45. *Xanthomonas campestris* pv. *vesicatoria*. EPPO Bulletin 1992; 22: 247±52.
2. Black R, Seal S, Zakia A, Nono-Womdium R and Swai I. Bacterial spot (*Xanthomonas campestris* pv. *vesicatoria*) of tomato and sweet pepper in Tanzania. Plant Pathology 2001; 50(6): 810.
3. McGuire RG, Jones JB, Sasser M. Tween media for semiselective isolation of *Xanthomonas campestris* pv. *vesicatoria* from soil and plant material. Plant Disease, 1986; 70: 887±91.
4. Shekhawat PS and Chakravarti BP. Assessment of loss, symptomology and occurrence of bacterial leaf spot of chillies caused by *Xanthomonas vesicatoria* in Rajasthan. Indian J. Mycol. Plant Pathol., 1977; 7: 11-14.
5. Shekhawat PS and Chakravarti BP. Factors affecting development of bacterial leaf spot of chilli caused by *Xanthomonas vesicatoria.* Indian Phytopath., 1976; 29: 392-397.

6. Anonymous. EPPO quarantine pest. 1996. Data Sheets on Quarantine Pests-*Xanthomonas vesicatoria*. Prepared by CABI and EPPO for the EU under contract 90/399003.
7. Thieme, Frank et al. Insights into Genome Plasticity and Pathogenicity of the Plant Pathogenic Bacterium *Xanthomonas campestris* pv. *vesicatoria* revealed by the complete genome sequence. J Bacteriol., 2005; 187(21): 7254–7266.
8. Anonymous. University of connecticut-integrated pest management. 2012. Managing bacterial leaf spot in pepper. Archived from the original on January 1, 1970. Retrieved October 24, 2012.
9. Anonymous. Cornell university-vegetable md online. Managing bacterial leaf spot in Pepper. http://vegetablemdonline.ppath.cornell.edu/NewsArticles/PepperLeaf Spot.htm.
10. Anonymous. 2016. Bacterial leaf spot (*Xanthomonas campestris*). UMass Extension Center for Agriculture. 2012. Retrieved 19 July 2016. B.V., North Carolina, USA., 2009, 317-330.
11. Pohronezny K, Hewitt M, Infante J and Datnoff L. Wind and wind generented sand injury as factors in infection of pepper by *Xanthomonas campestris* pv. *vesicatoria.* Plant Dis., 1992; 76: 1037-1039.
12. Jones JB, Pohronezny K, Stall RE and Jones JP . Survival of *Xanthomonas campestris* pv. *vesicatoria* in Florida on tomato crops residue, weeds, seeds and volunteer tomato plants. Phytopathology, 1986; 76: 430-434.
13. Ravnikar M, Demsar T and Dreo T. Laboratory diagnosis of bacterial spot on tomato and pepper. In proceedings of the 5th Slovenian conference on plant protection, Catez of Savi, Slovenia, 6-8 March, 2001.
14. Neergaard P. Seed Pathology. The MacMillan Press Ltd., London pp. 1977: 1187.
15. Bradbury JF. Guide to Plant Pathogenic Bacteria. CAB International Mycological Institute (CMI), UK, 1986: 332.
16. Richardson MJ. An annotated list of seed-borne diseases (4th edn). Proceedings International Seed Testing Association Zurich, Switzerland 1990.
17. Anonymous. International seed rules for seed testing International Seed Testing Association (ISTA). Seed Science & Technology, 1985; 4(3-49):50-177.
18. Murray PR, Baron EJ, Pfaller MA, Tenover FC, Yolke RH. Manual of clinical microbiology. 6th ed. Washington, DC: ASM, 1995.
19. Verma, AK and Kailash Agrawal. bio-efficacy of some medicinal plant extracts against *Pseudomonas syringae* pv. *pisi* causing bacterial blight of pea. International Journal of Pharmacology & Toxicology, 2015; 5(1): 67-70.
20. Verma, AK and Kailash Agrawal. *In vitro* evaluation of antibacterial activity of some medicinal plants against *Xanthomonas pisi* causing leaf spot of pea. Int. J. Pharm. Sci. Rev. Res., 2017; 45(2): 156-159.
21. Bahadauria S and Kumar P. Anti-bacterial activity of some extracts of *Lowsonia alba, Solanum dulcamara* and *Allium sativum* against four pathogenic bacteria. Journal Phytol. Res., 2004; **17(2)**: 191-193.
22. Schaad NW. Laboratory guide for identification of plant pathogenic bacteria (2nd edn). APS Press (The American Phytopathological Society) St. Paul, Minnesota, 1988: 164.
23. Agarwal PC, Mortensen CN and Mathur SB. Seed-borne diseases and seed health testing of rice. Technical Bull. No. 3, Phytopath. Papers No. 30. Danish government institute of seed pathology for developing countries (DGISP), Copenhagen & CAB International Mycological Institute, (CMI) UK, 1989: 106.
24. Mortensen CN. Seed health testing for bacterial pathogens. Danish. government institute of seed pathology for developing countries (DGISP), Copenhagen, Denmark, 1994: 68.
25. Mortensen CN. Seed bacteriology laboratory guide. Danish government institute of seed pathology for developing countries (DGISP), Copenhagen, Denmark, 1994: 102.
26. Agrios GN. Plant pathology 5 th edition. Elsevier, Academic press. 2005: 952.
27. Jeyaseelan E, Pathmanathan M and Jeyadevan J. Inhibitory effect of different solvent extracts of *Vitex negundo* L. and *Allium sativum* L. on phytopathogenic bacteria. Arch Appl Sci Res 2010; 2: 325-331.
28. Ranjit PM, Santhipriya T, Nagasri S, Chowdary Y, Pasumarthy N and Gopal V. Preliminary phytochemical screening and antibacterial activities of ethanolic extract of viron. Biotech., 2012; 54: 266-271.
29. Balandrin MF, Klocke JA, Wurtele ES and Bollinger WH. Natural plant chemicals: Sources of Industrial and Medicinal Materials, Sci., 1985; 228: 1154-1160.
30. Hostettmann K and Wolfender J. The search for biological active secondary metabolites. *Pesticides Sci.*, 1997; 51: 471-482.
31. Biruma M, Pillay M, Tripathi L, Blomme G, Abele S, Mwangi M, Bandyopadhyay R, Muchunguzi P, Kassim S, Nyine M, Turyagyenda L and Eden-Green S. Banana Xanthomonas wilt: of the disease, management strategies and future research directions. African J. Biotechnol., 2007; 6: 953-962.
32. Charjan, SKU 1995. Studies on antifungal activity of some medicinal plant product on jowar grains during storage. In: Proc.82nd Science Congress Part-III.
33. Abd-Aziz ZA, Darah I, Leong HY, Ibrahim CO, Noraini I and Prencen LH (1994-1996). Jojoba leaf extract; potential as antimicrobial and antinematode agents. In: Procedings of 9th International Conference on Jojoba and its uses and of the 3rd International Conference on New Industrial Crops and Products, Argentina.

34. Suhaila Mohamed, Sizama Saka, El Sharkawy SH, Ali AM and Sepial Muid. Antimycotic screening of 58 Malasian plants against plant pathogens. *Pesticides Sci*., 43(3): 1996: 259- 264.
35. Yemata G and Fetene M. In vitro evaluation of the antibacterial activity of some medicinal plant extracts against *Xanthomonas campestris* pv. *musacearum*. Ethiop. J. Sci. & Technol., 2016; 10(1):17-32.
36. Kagale S, Marimuthu T, Thayumanavan B, Nandakumar R and Samiyappan R. Antibacterial activity and induction of systemic resistance in rice by leaf extract of *Datura metel* against *Rhizoctonia solani* and *Xanthomonas oryzae* pv. *oryzae*. Physiological and Molecular Plant Pathology. 2004; 65(2): 91-100.
37. Guleria S and Tiku AK. Botanicals in Pest Management: Current Status and Future Perspectives. In: Integrated Pest Management: Innovation-Development Process, (Peshin, R. and Dhawan, A. K. (eds.).Springer Science Business Media
38. Agrawal M, Bhagat N, Agrawal K and Jain R. Microbial quality of ready to eat products of groundnut. J. Phytological Res., 2010; 23(1): 105-107.
39. Agrawal K, Sharma DK, Jain R, Sharma VK. Seed borne bacterial diseases of tomato (*Lycopersicon esculentum* Mill) and their control measures: A review. J. Food Agricult. Vat. Sci., 2012; 2:173-182.
40. Singh T and Agrawal K. (Eds.). Eco-friendly and nonhazardous management of crop diseases. Pointer Publishers, Jaipur, 2010.
41. Bag A, Bhattacharyya SK and Chattopadhyay RR. The development of *Terminalia chebula* Retz. (Combretaceae) in clinical research. Asian Pac J. Trop Biomed., 2013; 3(3): 244-252.
42. Aneja KR and Radhika Joshi R. Evaluation of antimicrobial properties of fruit extracts of *Terminalia chebula* against dental caries pathogens. Jundishapur J. of Microbiol., 2009; 2(3): 105-111.
43. Hogade MG, Jalalpure S and Kuthar S. Antibacterial activity of fruit extract of *Terminalia chebula* Retz. against some Gram positive and Gram negative bacteria. Int. J. of Pharmacy and Pharma Sci Res., 2011; 1(1): 26-29.
44. Singh G and Kumar P. Evaluation of antimicrobial activity of alkaloids of *Terminalia chebula* Retz. Against some multi drug resistant microorganisms. Int. J. of Green Pharm., 2012; 6: 57-62.
45. Osborn EM. On the occurrence of antibacterial substances in green plants. *British. J. Exp. Path.,* 1943; 24: 227-231.
46. Pawar BG. Studies on the utilization of plant extracts for the management of Phytopathogenic bacteria. Ph.D. Thesis, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad (M.S.) 1999.
47. Meher B and Das DK. Antioxidant and antimicrobial properties of *Tamarindus indica* L. Int. J. Phytomedicine, 2013; 5 :322-329.
48. Nwodo UU, Obiiyeke GE and Okoh AI. Assessment of *Tamarindus indica* extracts for antibacterial activity. Int. J. Mol. Sci., 2011; 12(10): 6385-6396.
49. Deshmukh KP and Deshmukh YD. Antibacterial Analysis of (*Syzygium Aromaticum*) Clove, (*Zingiber Officinale*) Ginger, (*Allium Cepa*) Onion, (*Allium Sativum*) Garlic against three human and two plant pathogens. Int. J. of Green and Herbal Chem., 2014; 3(1): 204-210.
50. Nisha S, Revathi K, Chandrasekaran R, Arunachalam SK, Sathish-Narayanan SN, Stout MJ, Senthil-Nathan S. Effect of plant compounds on induced activities of defense-related enzymes and pathogenesis related protein in bacterial blight disease susceptible rice plant. Physiol. and Mol. Pl. Pathol., 2012; 80: 1-9.
51. Mahesh B and Satish S. Antimicrobial activity of some important medicinal plant against plant and human pathogens. World J. of Agri. Sci., 2008; 4(5): 839-843.
52. Ratore BS. Efficacy of streptocycline and plant extracts against bacterial leaf spot disease caused by *Xanthomonas axonopodis* pv. *vignaradiatae* of greengram. Indian Phytopath., 2010; 63(4): 384-386.
53. Didwania N, Sadana D and Trivedi PC. Antibacterial activity of a few medicinal plants against *Xanthomonas campestris* pv. *campestris*. Int. J. Res. Pharm. Sci., 2013; 4(2): 177-182.
54. Saettler AW, Schaad NW and Roth DA. Detection of bacteria in seed (edt.). APS Press St. Paul, Minnesota, 1989: 122.

**Conflict of Interest: None**

**Source of Funding: Nil**