ABSTRACT

Tomato (*Solanum lycopersicum* L; Synonym: *Lycopersicum esculentum* Mill.) is one of the most widely grown vegetable all over the world. With the worldwide production about 160 million tons in 2017, tomato is the seventh most important crop species after maize, rice, wheat, potatoes, soybeans and cassava and 2nd vegetable crops in the world after potato. Low yield of tomato production has been attributed to the various biotic and abiotic stresses. Susceptibility to several pathogenic fungi, bacteria, viruses and nematodes is major constraints to tomato cultivation. Fusarium wilt caused by the soil borne fungus, *Fusarium oxysporum* Schlectend.: Fr. f. sp. *lycopersici* (Sacc.) W.C. Snyder and H.N. Hansen, is one of the most devastating diseases of tomato. It affects greenhouse and field grown tomatoes in warm vegetable production areas. The *Fusarium oxysporum* is a soil borne pathogen which can persist many years in the soil without a host. The fungus is highly destructive both in greenhouses and field grown tomatoes causing 10-50% yield loss in many tomato production areas in India.

Vermicompost is the product of degradation of various organic substances in non-thermophilic manner by collective action of earthworms and associated microbes. Vermicompost has significant plant growth-promoting properties that attributed to the presence of nutrients such as nitrates, exchangeable calcium, phosphorus and soluble potassium in plant available form. Vermicompost has also been reported for disease suppressing potential on a wide range of phytopathogens. Over the past few years, experiments have been conducted that proved the efficacy of vermicompost products in suppression of various phytopathogens.

Keeping in the view the aforementioned issues the present research work was carried out with the following objectives:

1. To collect, identify and purify of pathogen causing fusarium wilt of tomato from different districts of Uttar Pradesh.

2. To evaluate the *in vitro* efficacy of vermicompost and vermi extract against *Fusarium oxysporum* f. sp. *lycopersici*. 
3. To isolate the beneficial microorganisms from vermicompost.

4. To determine the enzymatic activity in vermicompost and vermi extract inoculated plants.

5. To study the influence the vermicompost on antioxidant activities in tomato.

The present investigation entitled “Local and systemic resistance response in tomato against Fusarium wilt elicited by vermicompost and vermi-extract” was undertaken during the years 2014 to 2016. The details of the materials and methods used during the course of investigation have been described below. The in vitro experiments were conducted in the Bio control Laboratory and Plant Health Clinic of Department of Mycology and Plant Pathology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India. The in vivo experiments were carried out in the polyhouse and agricultural field of the same department, where tomato crop was raised in pots (15 x 10 cm) and field.

A roving survey was conducted during January, 2015 in 10 districts of Eastern Uttar Pradesh to analyze the status of fusarium wilt incidence and to collect diseased samples infected by *F. oxysporum* under field conditions. The areas having maximum wilt incidence were selected and infected samples were collected from those areas. After isolation and purification of *F. oxysporum* from the collected samples, they were subjected to the pathogenicity tests on susceptible genotype of tomato cultivar ‘Kashi Amrit’ through soil inoculation method. Out of 20 isolates of *F. oxysporum* tested for pathogenicity, 10 isolates showed typical wilt symptoms like drooping and wilting of lower leaves. 10 isolates showed positive result for Koch’s postulate while the remaining 10 isolates failed to prove Koch’s postulate indicating their non-pathogenicity to tomato. Variability in the cultural and morphological characters of ten isolates of *F. oxysporum* was studied by growing on PDA medium. The studies of per cent disease incidence (PDI) of 10 selected isolates of *F. oxysporum* were studied by soil inoculation methods in pots under greenhouse conditions. It is evident from data none of the isolate showed PDI up to 30 DAI while four isolates i.e. Fol 2, Fol 8, Fol 16 and Fol 17 recorded PDI of 19.52%, 16.43%, 16.21% and 18.55%, respectively at 60 DAI. All the ten isolates recorded different levels of PDI at 90 DAI. Maximum PDI i.e 35.55% was recorded in treatment with Fol 2.
The bacteria were isolated from vermicompost samples through serial dilution method. The bacteria having distinct colony characteristics were selected and grown in individual NA plates. Ten bacteria were isolated having different morphology and colony characters and were designated serially from VC1 to VC10. Out of the 10 isolates, VC1 and VC2 showed maximum antagonistic activity against *F. oxysporum* with 83 and 69.66% inhibition. The 10 selected bacterial isolates i.e VC1, VC2, VC3, VC4, VC5, VC6, VC7, VC8, VC9 and VC10 were grown in different media for their qualitative assay. Biochemical characterization of all the isolates for plant growth promotion traits and biocontrol potential were carried out. The isolates VC1, VC2, VC4, VC6, VC8, VC9 and VC10 showed positive pectolytic activity. All the isolates showed negative results for cellulolytic activity. Different concentrations of vermicompost extract were evaluated against the test pathogen by poison plate technique. 10, 15, 20, 30 and 40% solution of vermicompost and PDA were prepared. Maximum inhibition (91.75%) was recorded at 40% concentration.

The three BCAs viz. *T. harzianum, P. fluorescens* and *B. subtilis* used in this study were chosen because of their compatibility and ascertained ability to reduce the soilborne diseases in various crops (Singh et al., 2013). All these selected BCAs were used to fortify the vermicompost individually. The influence of different microbes used for fortification of vermicompost on the growth characters was clearly observed after 15 days of transplanting. All treated plants showed significant improvement in root length in comparison to the control. Tomato plants treated with vermicompost fortified with *Trichoderma* showed maximum root length (14.95 cm) after 15 days of sowing followed by T-2 (11.25 cm) and T-3 (9.85 cm). Similar trends were observed after 45, 60 and 90 days after sowing. Shoot length was recorded at 15, 45, 60 and 90 days after sowing. Tomato plants treated with vermicompost fortified with *Trichoderma* showed maximum shoot length at every interval. Maximum shoot length 57.5 cm was observed in T-1.

PAL levels increased significantly in all treatments up to 48 h, followed by a decline in its activity. Maximum PAL activity was recorded in leaves from plant grown in vermicompost fortified with *T. harzianum* (T1) at 48 h. PO levels increased significantly in all treatments up to 72 h, followed by a decline in its activity.
Maximum PO activity was recorded in leaves from plant grown in vermicompost fortified with _T. harzianum_ (T1) at 72 h. Maximum PO activity was recorded in leaves from plant grown in vermicompost fortified with _T. harzianum_ (T1) at 72 h followed by T2, T3 and T4.

Maximum ascorbic acid content in tomato leaves were found in plant treated with vermicompost + _P. fluorescens_ which was 0.44 mg g⁻¹. All the plants treated with biofortified vermicompost showed higher ascorbic acid content in leaves in comparison to control. Maximum carotenoid content in tomato leaves were recorded in leaves from plant treated with vermicompost + _P. fluorescens_ (T3). 0.19 µg g⁻¹ plant tissues carotenoid was estimated in tomato leaves treated with vermicompost + _P. fluorescens_. Tomato fruit harvested from the plants treated with vermicompost + _P. fluorescens_ (T3) showed maximum lycopene content which was 5.26 µg g⁻¹. Minimum lycopene content (3.26 µg g⁻¹) was estimated in control. TPC in all treatment was ranges from 4.28 to 11.32 mg g⁻¹. Maximum TPC was recorded in T3 followed by T2 (Vermicompost + _B. subtilis_), T1 (Vermicompost + _T. harzianum_) and T4 (only vermicompost). Like TPC, protein content was recorded highest in T3 (vermicompost + _P. fluorescens_) which was 5.1 mg g⁻¹ followed by T2 (4.74 mg g⁻¹), T1 (3.56 mg g⁻¹) and T4 (3.1 mg g⁻¹).

During present study a rapid method of decomposition of floral offerings using vermicompost was validated. From the results obtained in this study it is concluded that the application of vermicompost fortified with selected BCAs was found to be most effective in biological management of fugal wilt in tomato caused by _F. oxysporum_ f. sp. _lycopersici_. Tomato plants sown in soil mixture with fortified vermicompost showed significant augmentation in defense related enzymes. Biofortified vermicompost has significant effect on plant morphology and growth parameters. Liquid extract of vermicompost has significantly inhibited the growth of wilt pathogen (_F. oxysporum_ f. sp. _lycopersici_). As vermicompost harbor plant beneficial microorganisms, it may also be used as stimulants and for plant disease control.