STUDIES ON THE CONTROL OF BACTERIAL WILT OF TOMATO WITH REFERENCE TO ORGANIC SOIL AMENDMENTS AND CHEMICALS

BY

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THESIS

SUBMITTED IN PARTIAL FULFILMENT OF THE

REQUIREMENT FOR THE DEGREE

MASTER OF SCIENCE IN AGRICULTURE

FACULTY OF AGRICULTURE

KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF PLANT PATHOLOGY

COLLEGE OF AGRICULTURE

VELLAYANI-TRIVANDRUM

1977

DECLARATION

I hereby declare that, the thesis entitled "STUDIES ON THE CONTROL OF BACTERIAL WILT OF TOMATO WITH REFERENCE TO ORGANIC SOIL AMENDMENTS AND CHEMICALS" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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Certified that, this thesis entitled "STUDIES ON THE CONTROL OF BACTERIAL WILT OF TOMATO WITH REFERENCE TO ORGANIC SOIL AMENDMENTS AND CHEMICALS" is a record of research work done independantly by Sri.M.G. JAYAPRAKASH, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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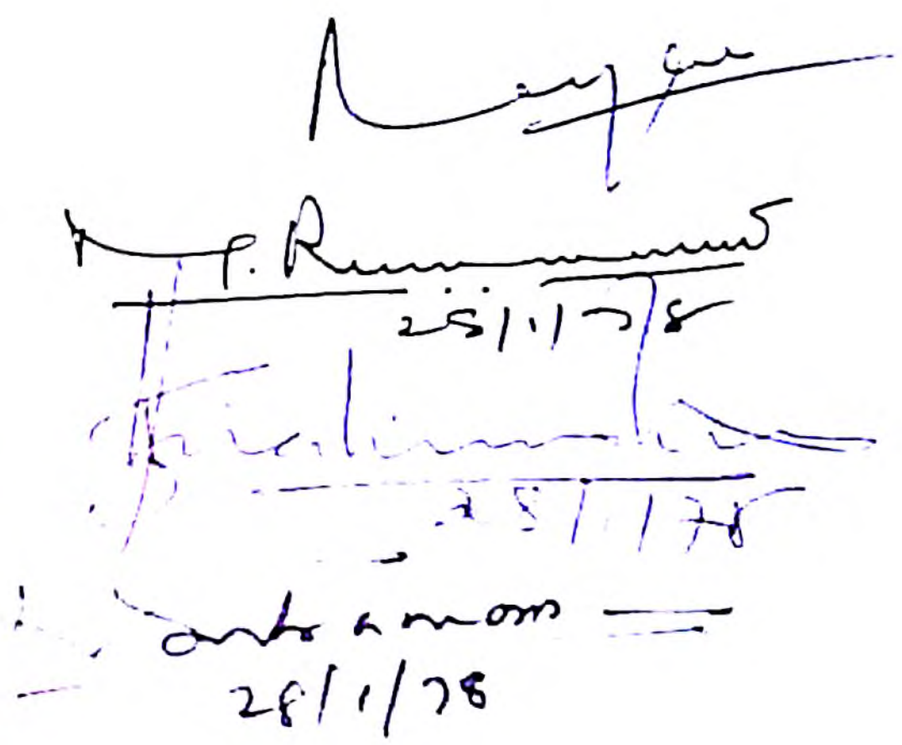

ACKNOWLEDGEMENT

But for the inspiring patronage and guidance of my most beloved and respected teacher Dr.K.M. Rajan, this thesis would not have come out.

It is the critical comments of Dr.M. Ramanatha Menon, Professor, Department of Plant Pathology, that has given me courage to present this humble attempt of mine.

I acknowledge with thanks the very valuable help rendered by Dri. .V. Sally, Associate Professor, Department of Plant Pathology; Dr.R. Subramonia Iyer, Associate Professor, Department of Agricultural Chemistry; Dri.E.J. Thomas, Professor, Department of Agricultural Statistics and, Dri. .V. Prabhakaran, Assistant Professor, Department of Statistics, College of Horticulture.

I should thank Dri.R. Vasudevan Illai, who has burnt the mid-night oil with me to type the manuscript.

My thanks are due to all others also, who have aided and guided me with affection.

-- M.J. JAYAPRAKASH.

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INTRODUCTION

INTRODUCTION

From time immemorial, vegetables are recognised to be the panacea for many evil effects on health. They are rich sources of vitamins, minerals and hormones which are quite essential for the normal maintenance of human health. Amongst the several vegetables which are grown as annuals, solanaceous vegetables like brinjal, tomato and chillies are the most important in South India. These vegetables are very popular with the rich as well as the poor alike and they are invariably consumed in some form or other daily by all. Since these vegetables are highly perishable and because the demand is continuous, they are being cultivated throughout the year. The fact that all these vegetables are cultivated with maximum care and expenditure, disease hazard affects the economy of the grower and thereby the health and wealth of the nation as a whole.

All the solanaceous vegetables are subject to a number of diseases caused by fungi, bacteria, viruses, nematodes and unfavourable environmental factors. Among them, two distinct types of wilt diseases: the fungal wilt caused by Fusarium oxysporum. f. lycopersici and the bacterial wilt incited by Pseudomonas solanacearum (E.F.Smith) E.F.Smith are important. The bacterial wilt is quite destructive in Kerala and is characterised by the sudden wilting of the plants. The plants collapse completely within a day

or two, the most susceptible stage being one to three weeks after transplanting.

Breeding trials conducted to evolve varieties resistant to this dreaded disease have not been completely successful so far. A wide range of chemical substances have been employed for the control of this disease. But, the amount of success achieved so far remains far from satisfactory. Some workers have observed that the severity of bacterial wilt of solanaceous crops is slightly reduced by a heavy application of organic nitrogenous fertilizers to soil (Kelman,1950; Kumar,1970).

The effect of various organic amendments in the severity of diseases caused by soil-borne plant pathogens has been widely observed. Although several organic materials have been found useful in controlling diseases caused by fungi and nematodes, much work has not been carried out against soil-borne diseases of bacterial origin.

With due consideration to the above facts, an investigation was undertaken to study the effect of various agricultural and industrial waste products, green and mature crop residues and major plant nutrients on the severity of bacterial wilt of tomato, population dynamics of *Pseudomonas solanacearum*, the causal organism of the disease and the total population of fungi, bacteria and actinomycetes in soil.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Bacterial wilt of solanaceous plants was first reported by Burril (1890). The causal organism was identified by Smith (1896) as Pseudomonas solanacearum. The occurence of bacterial wilt in tomato and egg plant was observed by Smith (1906). In India bacterial wilt of tomato was first reported by Hedayathulla and Saha (1941). Later the organism has been recorded on other crops such as potato, brinjal, and chillies (Das and Chathopadhyay, 1955).

Morphology and Physiology

Colonies of the organism in nutrient medium are dirty white at first, later on turning into a brown colouration. They are gram negative, short rods and motile by means of a single polar flagellum. The formation of a water soluble pigment brown in colour is also noticed (Smith,1896). Quinon et al (1964) suggested that the organism may be identified by its brown coloured pigmentation in culture medium. Kelman (1954) used tetrazolium medium (containing 2,3-5 triphenyl tetrazolium chloride) to test the virulence of the organism. The virulent strains possessed fluidal white colonies with pink centres on tetrazolium containing medium.

Control of Bacterial wilt

(i) Crop rotation and other cultural practices.

Rotation for several years with crops immune to the disease would probably aid in the control of bacterial wilt. Experiments conducted in North Carolina showed that five year rotation with corn was very effective in checking tobacco wilt (Garner et al., 1917; Moss and Wolf, 1917). The percentage of wilting in the continuous tobacco plot was 81.3 while 3.77 percentage was noticed in fields rotated with corn. Ashby (1928) suggested that growing Mimosa invisa as a cover crop for several years is a practical measure to control tobacco wilt. Smith (1944) pointed out the efficiency of maize rotation in the control of tobacco wilt disease. He believed that 'starving out' of the pathogen due to the presence of an immune crop in the rotation is responsible for the reduction in wilt incidence (Smith, 1896). In India brown rot of potatoes was significantly reduced by growing soybean crop prior to the cultivation of potatoes (Dey, 1947). Kumar (1970) observed that the bacterial wilt of potatoes did not appear in the fields in which a summer crop was grown.

(ii) Adjusting soil pH

Earle and Orr (1898) observed a reduction in tomato wilt disease by the application of lime. Chemicals such as potassium carbonate, basic slag, sodium acid sulphate, acid phosphate and ammonium sulphate which caused a substantial

change in the soil pH did not significantly influence the wilt disease (Garner et al., 1917). Poole (1939) obtained control of bacterial wilt through lime application for one season, but the results were not consistent. Eddins (1936; 1937; 1939) suggested that diseases such as brown rot of potato and wilt of tobacco, tomato and brinjal could be successfully controlled by application of sulphur and lime in succession. Initially the pH is made to extreme acidic range. After keeping the soil in that condition for a reasonable period, the acidity was corrected by the application of limestone. Due to extreme acidity the pathogen disappeared from soil. He also further observed that the pathogen did not reappear even after a long period. Jochems (1934) suggested that only neutral soils favour the disease.

(iii) Application of fertilizers

Stevens (1906) did not get success in controlling the disease by fertilizing tobacco with high levels of nitrogen, phosphorus and potassium. However, reports from North Carolina Agricultural Experimental Station (Anon., 1941) revealed that, blood meal, ammonium sulphate, sodium nitrate and urea at the rate of 100 lb. per acre significantly reduced tobacco wilt. Better results were obtained when fertilizer application was followed by crop rotation. Another experiment in which varying levels of nitrogen was tried, the wilt incidence was reduced with increased levels of nitrogen (Anon., 1943; Kincaid, 1950). Smith and Clayton (1943) obtained similar results in wilt diseases of tomato, potato, egg plant, chillies castor, beans and petunia. Van der Meer Mohr (1935; 1936; 1937) and Van der Feel (1937; 1938) reported that, in general, nitrogen and potassium reduced, while phosphorus enhanced the

disease. The different forms of nitrogen showed variation in disease incidence. Kelman (1950) noticed that a very high dose of nitrogen, above the optimum for plant growth suppressed the wilt disease in tobacco and tomato. Sequeira (1958) obtained excellent control of bacterial wilt of banana through urea application to soil. Kumar (1970) recommended the application of urea at the rate of 1000 lb./acre followed by a maize crop in the next season for the control of brown rot of potato caused by _. solanacearum.

(iv) Organic materials

The effect of various organic amendments on the severity of soil diseases caused by soil-borne plant pathogens has been observed widely in the past. Although several organic materials have been tried in controlling plant diseases caused by fungi and nematodes, much work has not been carried out against soil-borne diseases of bacterial origin. Green manuring has been demonstrated by several workers as a means of controlling soil-borne diseases. This may be due to the supply of nutrients of the decomposition products resulting in host improvement and/or due to the decomposition products acting as inhibitory substances to the pathogen population in soil. Successful control of Rhizoctonia disease of snap beans and Aphanomyces root rot of peas (apaviseae and Davey, 1955; 1960; 1961) and root-knot nematode of bhendi and tomato (Singh and Sitaramaiah, 1967; Johnson,1962) has been resulted by amending the soil with various crop residues such as mature cereal straws, leguminous crops, and foliage

of several trees. Basu Chaudhary (1967) reported that the application of rye-meal, corn-meal & oat-meal at the rate of 20 gms/Kg. soil have reduced the incidence of potato scab considerably.

(v) Agricultural and industrial waste materials

Saw dust mulch is known to be a good soil management practice (Kender and Baggert, 1966). Turk and Patridge (1947) observed that saw dust mulching conserved moisture by decreasing run off, increasing intake, reducing evaporation and inducing storage of water in deeper layers of soil. Instances where saw dust have been useful for plant disease control are few. Singh and Sitaramaiah (1970) observed that root-knot of bhendi and tomato (Meloidogyne javanica) was significantly reduced by incorporation of saw dust into soil. Satisfactory control of root rot of wheat caused by Pythium graminicolum (Kaurav, 1970), black scurf of potatoes caused by Rhizoctonia solani (Singh, 1971) and soft rot of ginger (Rajan, 1971; Rajan and Singh, 1972) has been reported by amending the soil with saw dust in combination with a nitrogen source.

(vi) Oil cakes

The annual production of oil cakes in India is well above two millions tonnes. In general, these products contain larger quantities of organic matter, fair amounts of nitrogen, small amounts of phosphorus and potassium. The oil percentage of cakes varies from 2 to 15 per cent depending

on the method of extraction. Many of these oil cakes are used as manure. Attempts to control plant diseases by amending soil with oil cakes are few. Control of sclerotial wilt of betelvine, caused by Sclerotium rolfsii (Chaudhary, 1946) pigeon pea wilt caused by Fusarium oxysporum f. udum (Vasudeva et al., 1962; Mahamood, 1964), black scurf of potatoes caused by Rhizoctonia solani (Singh, 1968) and root knot of bhendi and tomato caused by Meloidogyne javanica (Singh and Sitaramaiah, 1966) by amending the soil with oil cakes of margosa, groundnut, sesamum and castor has been reported.

Van Beek and Chung (1950) observed that the development of brown rot of potato (Pseudomonas solanacearum) was more rapid in the untreated plots than those amended with oil cakes of groundnut or cocoanut. However, the results were not significant at the time of final disease reading. Sidhanathan (1973) obtained good control of citrus canker by treating with 5% solution of neem cake. Changes in the population dynamics of plant pathogens have been observed as a result of host nutrition and organic and inorganic soil amendment. Oil cake amendment and saw dust with supplemental nitrogen have been observed to reduce the population of Pythium (Kaurav, 1970; Rajan, 1971) and Fusarium (Bhalla, 1966; Singh and Singh, 1970; Khanna, 1970). These workers suggested that control of diseases caused by the above pathogens might have been achieved through a reduction in the population of

the pathogens through microbial antagonism. The increase in the total saprophytic soil microflora following soil amendments has been observed by several workers. (Maloy and Burkholder, 1959; Papavizas et al.; 1962; Smith and Ashworth, 1965; Reddi and Rao, 1965).

(vii) Antibiotics and other chemicals

The control of bacterial diseases of citrus, plum, pear, rice, beans, potatoes, chillies, bhendi and tomato by spraying antibiotics such as streptomycin, streptocycline, terramycin, chloromycetin and aureomycin has been reported by several workers. (Brown and Heon, 1946; Zaumeyer et al., 1953; Ark, 1955; Ranganswami et al.,1959; Desai et al., 1967). Treating seeds with antibiotic solution has been recommended as a control measure against bacterial blight of rice caused by Xanthomonas oryzae (Srivastava and Rao, 1964; Sulaiman and Ahamed, 1965) and wilt of brinjal caused by Pseudomonas solanacearum (Dutta and Verma, 1969). Hou and Han(1970) obtained good control of tobacco wild fire by spraying the crop with phytomycin two to three times and treating the soil with chloropicrin. Inhibitary effects of streptomycin and streptocycline on Pseudomonas and Xanthomonas have been observed by Ranganwami (1957), Desai et al. (1967), Nath and Devadath (1969), Rangarajan and Chakravarti (1969) and Shivappashetty and Ranganwami (1971). Rahim (1972) and George (1973)

obtained excellent field control of bacterial wilt of chillies by spraying the foliage with streptomycin and streptocycline. According to Conover(1954) and Crossan and Krupka (1955) three to five sprays of streptomycin at the rate of 250-500 ppm has controlled the bacterial leaf spot incited by Xanthomonas vesicatoriae in tomato and chillies. Thind and Dayak (1973) reported that bacterial stalk-rot of maize caused by Erwinia carotovora var. zeae can be controlled by streptocycline.

Mingorani et al.(1956) reported soil treatment with chloropicrin and sulphur-lime to be effective in controlling brown rot of potato. Drenching 5 per cent formalin has been found to reduce black rot of crucifers (Antol et al., 1949). Narov (1960) observed that thiram, ziram, ferbam, maneb, bordeaux mixture, and copper oxychloride inhibit the growth of Fusarium sp. in vitro. Rahim (1972) found that chemical compound was much superior to bordeaux mixture in its efficiency to control wilt of chillies. Seerge (1973) showed that drenching the soil with chemical compound controlled wilt of chillies better than sprays of streptomycin. However, the antibiotic spray was better than drenching with ceresan and ziram.

MATERIALS AND METHODS

MATERIALS AND METHODS

Experiments were conducted in pots and also in the field. The tomato seeds (variety CO-1) obtained from Tamil Nadu Agricultural University were used in the study. The seedlings used in the experiments were raised in pots and transplanted after twenty five days.

A. Organic Amendments in pots:-

(i) Industrial and Agricultural waste products:-

In pots the following organic amendments of soils were given using the following industrial and agricultural waste products. The experiment was laid out in Completely Randomised Design and two pots were considered as a single replication.

1. Coconut oil cake
   (Cocos nucifera L.) - 10g./plant
2. Groundnut cake
   (Arachis hypogea L.) - "
3. Gingelly cake
   (Sesamum indicum L.) - "
4. Mahuva cake
   (Bassia longifolia L.) - "
5. Margosa cake
   (Azadirachta indica L.) - "
6. Illupa cake
   (Bassia Latifolia Roxb) - "
7. Rubber cake
   (Hevea braseliensis Muell.) - "

8. Pumpkin cake
(Calopbyllum inopbyllum Juss.) - 10 g/plant

9. Margetti cake
(Hydnocarpus wightiana Caus.) - "

10. N.P.K. - 100 mg., 60mg., 60mg./plant

11. Saw dust - 20 g/plant

12. Cashew shell powder - "

13. Coconut husk pith - "

14. Oil palm seed waste - "

15. Saw dust + N. P. K. - Trt. 10 + 11

16. Cashew shell powder + N. P. K. - " 10 + 12

17. Coconut husk pith + N. P. K. - " 10 + 13

18. Oil palm seed waste + N. P. K. - " 10 + 14

19. Control (no amendments) -

Pots of uniform size (25cm. diameter) were used in the experiment. The potting mixture consisted of 3 soil, 3 cowdung and 3 sand. The organic amendment were well powdered and thoroughly mixed with potting mixture. Each pot was filled with 4kg. of the potting mixture. The required quantity of the amendments were thoroughly incorporated with the potting mixture in each pot. After filling watering was done to completely soak the soil in the pots. Thereafter, light irrigation using a rose can was given twice daily. Tomato seedlings were planted in the pots two weeks after the application of organic amendments. Before planting, soil samples were taken from each replication and kept separately in polythene bags. Small quantities of the soil were taken from different parts of the pot to a depth of 15cm and they

were thoroughly mixed together. The soil samples were kept open in the laboratory for air drying. Microbial population was estimated from the soil thus collected. Similarly, another sample was collected for estimation of microbial population after two weeks. The percentage of disease incidence in the pots were also noted.

(ii) Effect of green leaves and straw:-

The experiments were conducted in pots and the procedure described above was used excepting that the green leaves and straw were finely chopped into pieces and incorporated in the potting mixture. The following were the treatments.

1. Glyricidia leaves
(*Glyricidia maculata* (Heud.) - 200 g/plant
2. Pongamia leaves
(*Pongamia glabera* Roxb.) - "
3. Sesbanea leaves
(*Sesbanea aculeata* Pers.) - "
4. Neem leaves
(*Azadirachta indica* L.) - "
5. Paddy straw
(*Oryza sativa* L.) - "
6. Control (no amendments)

The experiment was laid out in completely randomised design and two pots were considered as a single replication. The procedure for collection of soil samples and microbial estimation was the same as described earlier.

(iii) Major nutrients

The experiment was conducted in a 3^3 factorial lay out in pots with varying levels of nitrogen, phosphorus and potassium. The treatment combinations were as follows:

N_0 P_0 K_0	N_1 P_0 K_0	N_2 P_0 K_0
N_0 P_0 K_1	N_1 P_0 K_1	N_2 P_0 K_1
N_0 P_0 K_2	N_1 P_0 K_2	N_2 P_0 K_2
N_0 P_1 K_0	N_1 P_1 K_0	N_2 P_1 K_0
N_0 P_1 K_1	N_1 P_1 K_1	N_2 P_1 K_1
N_0 P_1 K_2	N_1 P_1 K_2	N_2 P_1 K_2
N_0 P_2 K_0	N_1 P_2 K_0	N_2 P_2 K_0
N_0 P_2 K_1	N_1 P_2 K_1	N_2 P_2 K_1
N_0 P_2 K_2	N_1 P_2 K_2	N_2 P_2 K_2

N_0 = 0 ppm nitrogen
N_1 = 500 ppm nitrogen
N_2 = 1000 ppm nitrogen
P_0 = 0 ppm phosphorus
P_1 = 125 ppm phosphorus
P_2 = 250 ppm phosphorus
K_0 = 0 ppm potassium
K_1 = 250 ppm potassium
K_2 = 500 ppm potassium.

Nitrogen was given as urea, phosphorus in the form of superphosphate and potassium as muriate of potash.

The fertilisers were given as per the doses, just before transplanting. Other procedures remained the same as in the previous pot experiments.

B. Field experiment

The crop was grown in a field in which tomato was grown previously. In addition to this, the soil which was severely infested with the pathogen was spread uniformly to ensure the occurance of the disease in the field. Soil was brought to a very fine tilth and plots of size 2m.X1.8m. were prepared. Twentyfive days old seedlings were transplanted with a spacing of 50 cm. in between rows and 30 cm. in between plants. Each plot consisted of twenty plants.

The experiment was laid out in a split plot design with six major treatments and eight minor treatments and three replications. The major treatments consisted of urea, groundnut cake, neem cake, gliricidia leaves, pongamia leaves and control (no treatment). The quantities of different amendments were equated on the basis of their nitrogen contents. Thus each plant was receiving nitrogen, phosphorus and potassium at the rate of 100 mg., 40 mg., 30 mg. per plant respectively. The balance phosphorus and potassic requirements were met by supplying them through superphosphate and muriate of potash, respectively. As in pot experiments, in the field also, the organic materials were applied two weeks before planting.

The minor treatments were Bordeaux mixture, cheshunt compound, streptomycin, streptocycline, dithane-Z 78, captan, F.M. Spray and control (no treatment).

Streptomycin and streptocycline were given as foliar spray at 1000 ppm (15ml. per plant) five days after transplanting. Others were applied to soil at the rate of one litre per plant just before transplanting. The plants were observed for disease incidence.

(i) Microbial estimation

(a) Fungi:- The medium used was Peptone-Dextrose Agar with Rose Bengal and streptomycin (Martin, 1950).

Dextrose	10 g
Peptone	5 g
Dipotassium monohydrogen phosphate	1 g
Magnesium sulphate	0.5 g
Agar Agar	15 g
Distilled water	1000 ml.
Rose Bengal	1 part in 30,000 parts
Streptomycin	30 μ g/ml

Streptomycin was added only at the time of plating.

(b) **Bacteria**

Soil Extract Agar (Taylor and Lochhead, 1938)

Soil extract	- 1000 ml.
Monopotassium dihydrogen phosphate	- 0.2 g
Agar Agar	- 15 g

The soil extract was prepared in the following manner. One kilogram soil was autoclaved in 1000 ml. water in a one litre flask at 15 lb. pressure for 15 minutes. Before sedimentation a small quantity of calcium sulphate was added to obtain a clear filtrate. The clear supernatant liquid was then filtered through Whatman No. 41 filter paper. The volume was made upto 1000 ml. In order to hasten the appearance of bacterial colonies 1 g. glucose was also added. Before sterilisation, the pH was adjusted to 6.8

(c) Actinomycetes

Kuster's Agar

Glycerol	10.00 g
Casein	0.30 g
Potassium nitrate	2.00 g
Sodium chloride	2.00 g
Dipotassium monohydrogen orthophosphate	0.05 g
Ferrous sulphate	0.01 g
Calcium carbonate	0.20 g
Agar Agar	20.00 g
Distilled water	1000 ml.

The pH of the medium was adjusted to 6.8

ml. of the required dilution (10^{-3} for fungi and actinomycetes and 10^{-6} for bacteria) was transferred to sterile petriplates using a sterile pipette. The plates were rotated gently in order to get a uniform spread. The concerned agar medium was melted and cooled to a temperature of 45°C and uniform quantities were poured out to each petriplate. For each group of micro-organisms, the dilutions were plated in triplicates. The plates were kept in room temperature (28° +/- 1°C). Counts of fungal colonies were taken seven days after plating and those of bacteria and actinomycetes after ten days. The colonies of bacteria and actinomycetes were counted with the help of Sponcers dark field quebec colony counter. The population of bacteria was expressed in millions, while those of fungi and actinomycetes were expressed in ten thousands per gram of soil.

(d) Isoudomonas solanacearum

The medium developed b Kelgmilla and Luddenhagen (1972) with slight modifications were used to selectively isolate I.solanacearum from soil. It consisted of the following composition.

Mannitol	-	2.5 g
L-glutamic acid	-	1.0 g
Magnesium sulphate	-	0.16g
Tetrazolium chloride solution 1%	-	5 ml.
Metal stock solution	-	0.05 ml.

(metal stock solution consisted the following compounds:

Manganese sulphate	- 0.616%
Zinc sulphate	- 0 1.1%
Ferrous ammonium sulphate	- 0.176%
Cobalt sulphate	- 0.0286%
Boric acid	- 0.01144%
Potassium iodide	- 0.0000128%)

The pH was adjusted to 7.2 with KOH and buffered with one millilitre dipotassium monohydrogen orthophosphate (0.0002 M) and 1 ml. of 0.0002 M monopotassium dihydrogen orthophosphate.

Before soil dilution plating, the following antibiotics and fungicide were also added.

Chloromycetin	- 5 g/ml
Penicillin -G	- 1 g/ml
Captan	-10 g/ml

The plates were incubated at room temperature for 10 days. Colonies were counted using colony counter.

RESULTS

RESULTS

A. Organic amendments in pots

(I) Industrial and agricultural waste materials

i) Disease incidence:- Though the results of the experiment were not found to be statistically significant, the trend indicated that groundnut cake, neem cake and NPK slightly reduced the infection while mahuva cake, rubber seed cake, cashew shell and oil palm seed waste have enhanced the disease severity (Table 1). When cocconut pith was used along with NPK the disease was found to increase, whereas NPK alone have reduced the disease incidence.

ii) Population of total fungi, bacteria and actinomycetes:-

Two weeks after amendment, a significant increase in the population of total fungi was observed in pots treated with neem cake, aluva cake, punnakka cake, saw dust and cashew shell with NPK over others. Oil palm seed waste with NPK, saw dust with NPK and mahuva cake, did not increase fungi to the level of the earlier group, but higher than the remaining treatments and the untreated control (Table 2, Appendix I). The estimation of fungal population four weeks after amendment has revealed that neem cake amended pots contain a significantly higher population than all other pots. Pots treated with aluva cake, punnakka cake or saw dust contained population less than the above, but greater than all other treatments. Though the remaining treatments had significantly lower fungal population than the above, all the treatments except

TABLE 1

Incidence of bacterial wilt of tomato in pots amended with different agricultural and industrial waste materials.

	Treatment	Per cent disease incidence	Transformed value
T1	Coconut cake	75.0	60
T2	Sesamum cake	75.0	60
T3	Groundnut cake	50.0	45
T4	Mahua cake	93.3	75
T5	Eluppa cake	75.0	60
T6	Punnakka cake	75.0	60
T7	Rubber cake	93.3	75
T8	Neem cake	50.0	45
T9	Karotti cake	75.0	60
T10	NPK	50.0	45
T11	Saw dust	75.0	60
T12	Cashew shell	93.3	75
T13	Coconut pith	75.0	60
T14	Oil palm seed waste	93.3	75
T15	Saw dust + NPK	93.3	75
T16	Cashew shell + NPK	93.3	75
T17	Coconut pith + NPK	93.3	75
T18	Oil palm seed waste + NPK	75.0	60
T19	Control	75.0	60
	$C.D_{(.05)}$		43.8

TABLE 2

Population of total fungi, bacteria and actinomycetes in soil collected from pots of different agricultural and industrial waste materials.

(Square root transformations)

Treatment	Fungi in ten thousands		Bacteria in millions		Actinomycetes in ten thousands	
	1*	2*	1*	2*	1*	2*
1. Coconut cake	6.00	5.70	4.43	5.10	2.20	2.53
2. Sesamum cake	5.50	5.06	5.86	6.03	2.06	2.33
3. Groundnut cake	5.96	7.43	3.60	4.20	1.60	1.90
4. Mahuva cake	6.26	5.83	5.46	6.90	2.03	2.66
5. Mlupa cake	9.30	9.43	4.36	4.80	2.20	1.70
6. Punnakka cake	8.70	9.23	4.86	5.70	2.33	2.43
7. Rubber cake	5.66	5.70	4.76	5.16	2.33	1.80
8. Neem cake	10.03	11.03	4.20	4.70	1.60	1.90
9. Karetti cake	5.36	5.02	4.70	4.93	1.90	2.33
10. N.P.K	5.80	5.90	4.63	5.63	2.10	2.16
11. Saw dust	8.53	8.90	4.63	4.43	1.90	2.33
12. Cashew shell	5.60	5.90	4.20	4.73	1.36	2.20
13. Coconut pith	5.73	6.30	4.26	3.80	1.60	1.80
14. Oil palm seed waste	6.67	6.76	4.23	4.33	1.90	2.53
15. Saw dust + N.P.K	6.63	6.80	4.13	4.43	2.16	1.90
16. Cashew shell+N.P.K	7.60	8.03	2.46	4.46	2.26	2.66
17. Coconut pith+N.P.K	5.00	5.10	4.10	4.03	2.06	1.50
18. Oil palm seed waste + N.P.K	3.46	3.43	4.46	5.33	1.60	1.70
19. Control	3.46	3.30	5.03	3.06	2.06	1.90
C.D.(0.05)	2.60	1.05	1.24	1.24	0.49	0.62

1* - Two weeks after amendment.

2* - Four weeks after amendment.

oil palm seed waste plus NPK had significantly higher population than untreated control.

Groundnut cake and cashew shell with NPK have significantly reduced the population of bacteria two weeks after amendment. But, after four weeks the bacterial population has significantly increased in all the treatments except in pots containing cocconut pith alone or in combination with NPK and in groundnut cake. Among those treatments which increased bacterial population, pots of sesamum, mahuva and punnakka cakes had significantly higher number than others.

After two weeks the population of actinomycetes did not differ from the untreated control in most of the treatments. In pots treated with cashew shell powder, a significant reduction in the population of actinomycetes was observed. At the end of four weeks, significant increase in the population of actinomycetes was observed in pots treated with mahuva cake, cashew shell with NPK, oil palm seed waste and cocconut cake.

iii) <u>The relationship between disease incidence and population of microflora</u>:-

The relationship between disease incidence and the population of total fungi was of negative nature, though, it was not significant.(Table 3)

TABLE 3

Correlation coefficients between disease incidence, total population of fungi, bacteria and actinomycetes.

	DF	DB	DA	FB	FA	BA
Two weeks after amendment	-0.32	0.07	0.15	0.04	0.11	0.41
Four weeks after amendment	-0.25	0.02	0.18	0.03	0.12	0.44

DF - Between disease incidence and fungi

DB - Between disease incidence and bacteria

DA - Between disease incidence and actinomycetes

FB - Between fungi and bacteria

FA - Between fungi and actinomycetes.

BA - Between bacteria and actinomycetes.

II. Effect of neem leaves and paddy straw

i) Disease incidence

Significant reduction in the disease incidence was observed in pots treated with neem, glyricidia and sesbania leaves among the three least disease incidence was observed in pots containing neem leaves. (Table 4, Appendix II)

ii) Population of total fungi, bacteria and actinomycetes

Plating of soil from different pots two weeks after amendment, has revealed that in all the treatments the population of total fungi has increased. Maximum population was recorded in soils treated with sesbania or neem leaves.

Four weeks after amendment also all treatments significantly enhanced the fungal population over that of untreated control. The maximum fungal population after four weeks was observed in pots treated with sesbania leaves. Neem leaves amended pots recorded considerably less population than the above, but higher than that of glyricidia or sesamia leaves. Paddy straw amended pots were having the least population among all the treatments.

As in the case of fungi, bacterial population also increased considerably two weeks after amendment. Pots amended with neem leaves had the maximum population. In all other treatments, the population of bacteria was significantly less than the above. At the end of fourth week also, significant reduction in the total bacterial population has

TABLE 4

Incidence of bacterial wilt and population of fungi, bacteria and actinomycetes in pots amended with different green leaves and paddy straw.

(Transformed data)

Treatment	Percent disease incidence	Fungi in ten thousands		Bacteria in millions		Actinomycetes in ten thousands	
		1*	2*	1*	2*	1*	2*
Glyricidia leaves	30.00	5.12	5.92	5.14	6.90	2.22	2.30
Pongamia leaves	60.00	4.85	6.05	4.88	6.02	1.81	1.91
Neem leaves	15.00	7.27	8.25	6.29	8.05	2.29	2.30
Paddy straw	60.00	4.79	5.12	4.85	4.71	1.71	1.89
Jasbanea leaves	30.00	7.43	9.08	5.04	6.42	2.17	2.13
Control	90.00	4.19	4.01	4.03	4.19	1.70	1.51
C.D.(.05)	42.10	0.42	0.61	0.69	0.72	0.47	0.51

1* - Two weeks after amendment

2* - Four weeks after amendment.

been noticed in those amended with paddy straw. But all others significantly increased bacteria. Pots receiving neem leaves had the highest population of bacteria. Next in order was pots receiving glyricidia or sesbanea leaves.

In general, the actinomycetes population was found to be stimulated by application of different green manures. However, the increase was significant with respect to glyricidia and neem leaves (both after two and four weeks after amendment) and with sesbanea leaves (only after four weeks of amendment).

iii) <u>The relationship between disease incidence and microbial population</u>

The correlation coefficients worked out between disease intensity, population of fungi, bacteria and actinomycetes have shown that all of them are negative and significant. (Table 5) The fact that disease incidence and population of fungi, disease and bacteria and disease and actinomycetes are significant and negative indicate that saprophytic microflora existing in the soil exercise a profound influence on the severity of this disease.

III. <u>Effect of N,P,K</u>

1) <u>Disease incidence</u>

Among the different combinations of N, P and K only the main effects due to nitrogen influence the disease incidence. (Table 6, Appendix III). The trend indicates that, as the level of nitrogen increases there is a corresponding decrease in the intensity of the disease. However, only the higher

TABLE 5

Correlation coefficients between disease incidence and total population of fungi, bacteria and actinomycetes.

	DF	DB	DA	FB	FA	BA
Two weeks after amendment	-0.82*	-0.94*	-0.97*	0.59	0.68	0.82*
Four weeks after amendment	-0.94*	-0.93*	-0.99*	0.77	0.73	0.92*

* - Significant at 5% level.

DF - Between disease and fungi

DB - Between disease and bacteria

DA - Between disease and actinomycetes

FB - Between fungi and bacteria

FA - Between fungi and actinomycetes

BA - Between bacteria and actinomycetes.

TABLE 6

Incidence of bacterial wilt and population of total fungi, bacteria and actinomycetes in pots amended with major nutrients.

(Transformed data)

Treatment	Percent disease incidence	Fungi in ten thousands		Bacteria in millions		Actinomycetes in ten thousands	
		1*	2*	1*	2*	1*	2*
N_0 (0 ppm)	63.33	3.93	4.15	3.35	3.95	1.98	2.21
N_1 (500 ppm)	50.00	4.13	4.41	4.14	4.63	2.10	2.14
N_2 (1000 ppm)	38.33	4.28	4.58	3.96	4.30	2.00	2.16
P_0 (0 ppm)	61.66	4.04	4.33	3.71	4.39	2.02	2.14
P_1 (125 ppm)	45.00	4.04	4.39	3.57	4.14	2.12	2.12
P_2 (250 ppm)	45.00	4.24	4.42	3.86	4.37	1.94	2.12
K_0 (0 ppm)	58.33	3.92	4.31	3.51	4.23	2.14	2.20
K_1 (250 ppm)	45.00	4.14	4.41	3.85	4.51	1.91	2.16
K_2 (500 ppm)	48.33	4.28	4.42	3.78	4.13	2.04	2.15
C.D.(.05)	16.80	0.27	0.33	0.20	0.36	0.30	0.11

1* - Two weeks after amendment
2* - Four weeks after amendment.

level of nitrogen (1000 ppm) had a statistically significant effect on disease incidence. In the case of P and K nutrition, pots receiving P and K showed slight and non-significant difference in disease intensity than those receiving no phosphorus and potassium.

ii) Total population of fungi, bacteria and actinomycetes

Population of total fungi was found to be stimulated by application of 1000 ppm nitrogen while bacteria were found to be stimulated both at lower (500 ppm) and higher (1000 ppm) levels of nitrogen (after two weeks) whereas bacterial population was found to be stimulated only at 500 ppm four weeks after amendment. The population of actinomycetes was not influenced by nitrogen application. The other two elements viz. phosphorus and potassium showed only very little influence on the change in the population of microflora in the soil. After two weeks of amendment both the levels of potassium have increased bacterial population while the higher level alone has increased fungal population.

iii) Relationship between disease incidence and soil microflora

The correlation coefficients between disease incidence and fungi were negative and significant. (Table 7) This indicates that the population of total fungi in soil influence the severity of disease.

TABLE 7

Correlation coefficients between disease incidence total population of fungi, bacteria and actinomycetes.

	DF	DB	DA	FB	FA	BA
Two weeks after amendment	-0.91*	-0.27	0.32	0.42	-0.41	-0.59
Four weeks after amendment	-0.89*	-0.31	0.27	0.48	-0.47	-0.67*

* - Significant at 5% level

DF - Between disease and fungi.

DB - Between disease and bacteria

DA - Between disease and actinomycetes

FB - Between fungi and bacteria

FA - Between fungi and actinomycetes

BA - Between bacteria and actinomycetes.

B. Field experiment

The main effects of organic amendments on disease incidence and population of P. solanacearum, total fungi, bacteria and actinomycetes are presented. (Table 8, Appendix IV)

i) Disease incidence

Significant reduction in disease incidence was observed in all amended plots over unamended control except with glyricidia leaves after two weeks of amendment. The least per cent of wilting was noticed after four weeks in plots amended with neem cake, urea or groundnut cake. The number of plants wilted in lots amended with cowpea leaves or gl ricidia leaves was also significantly less than the control. However, more number of plants were wilted in plots amended with leaves than those of urea or oil cakes.

All the chemicals tried, reduced the incidence of disease significantly. (Table 9, Appendix V). Among them plots amended with streptomycin and oxytetracycline had the least number of wilted plants. This was followed by plots drenched with chechunt compound or Bordeaux mixture. In plots drenched with ditheane Z-78 or captan also, the disease incidence was low, eventhough not to the extent of the earlier treatments. Higher number of plants was found to be wilted in plots drenched with F.D. spray. It was observed that the combination of urea, groundnut cake, or neem cake with streptomycin was quite effective in reducing the wilt incidence. Other combinations such as those between urea, groundnut cake or neem cake with streptocycline also

TABLE 8

Main effects of organic amendments on disease incidence and population of Pseudomonas solanacearum, total fungi, bacteria and actinomycetes. (Transformed data)

Treatment	Percent disease incidence			P. solanacearum in millions			Fungi in ten thousands			Bacteria in millions			Actinomycetes in ten thousands		
	1*	2*	3*	1*	2*	3*	1*	2*	3*	1*	2*	3*	1*	2*	3*
Urea	0	22.60	25.72	4.90	4.39	4.29	4.10	4.39	4.91	4.64	5.22	5.42	1.06	1.34	1.41
Groundnut cake	0	23.89	27.27	4.76	4.37	4.23	5.00	5.80	6.14	4.75	5.34	5.53	1.27	1.68	1.69
Neem cake	0	21.56	24.87	4.71	4.32	4.19	4.84	5.70	6.15	4.86	5.53	5.72	1.30	1.69	1.99
Glyricidia leaves	0	30.12	32.42	5.03	4.80	4.47	4.30	4.81	5.25	4.51	5.06	5.24	1.34	1.55	1.65
Sesbania leaves	0	29.59	31.96	5.42	5.31	5.11	4.54	5.08	5.54	4.54	5.16	5.57	1.28	1.78	1.76
Control	0	34.78	43.20	6.99	6.96	6.90	3.83	4.01	3.97	3.13	3.58	3.86	1.03	1.20	1.05
C.D.(.05)		4.59	2.76	0.14	0.18	0.18	0.19	0.23	0.26	0.12	0.19	0.19	0.16	0.13	0.12

1*- Two weeks after amendment. 2* - Four weeks after amendment.
3* - Six weeks after amendment.

TABLE 9

Main effects of chemicals on disease incidence and population of Pseudomonas solanacearum, total fungi, bacteria and actinomycetes. (Transformed data)

Treatment	Percent disease incidence			Pseudomonas solanacearum in millions			Fungi in ten thousands			Bacteria in millions			Actinomycetes in ten thousands		
	1*	2*	3*	1*	2*	3*	1*	2*	3*	1*	2*	3*	1*	2*	3*
Bordeaux mixture	0	20.76	24.68	5.15	4.81	4.42	4.33	4.77	5.05	4.37	4.76	4.97	1.11	1.45	1.49
Cheshunt compound	0	21.24	24.13	5.05	4.55	4.33	4.57	4.80	5.19	4.15	4.57	4.79	1.09	1.30	1.36
Streptomycin	0	14.46	17.93	5.09	4.32	4.01	4.18	4.56	4.93	4.01	4.39	4.61	1.04	1.18	1.29
Strepto-cycline	0	16.39	19.69	5.02	4.36	4.09	4.18	4.37	4.77	4.22	4.71	4.97	1.09	1.38	1.44
Dithane Z-78	0	29.44	31.92	5.34	5.16	4.96	4.40	4.93	5.35	4.46	4.92	5.18	1.20	1.55	1.45
Captan	0	31.88	33.98	5.53	5.44	5.20	4.46	5.04	5.44	4.55	5.12	5.32	1.30	1.62	1.59
F.M. spray	0	35.31	37.96	5.58	5.66	5.46	4.69	5.23	5.63	4.70	5.48	5.66	1.42	1.78	1.69
Control	0	47.25	57.03	5.65	6.09	6.35	4.72	5.90	6.31	4.81	5.91	6.08	1.47	2.05	1.90
C.D.(.05)		2.8	2.65	0.15	0.19	0.17	0.21	0.30	0.35	0.14	0.20	0.17	0.12	0.09	0.13

1* - Two weeks after amendment. 2* - Four weeks after amendment. 3* - Six weeks after amendment.

exerted some influence in reducing wilt incidence. Neem cake and Bordeaux mixture or cheshunt compound also reduced the wilt incidence considerably.

ii) Population of Pseudomonas solanacearum

A significant reduction in the population of P. solanacearum was observed in all the amended plots. (Table 8, Appendix IV). Among them plots amended with neem or groundnut cake contained the least number of the organism. This was closely followed by plots amended with urea or glyricidea leaves. Pot amended with cassava leaves contained higher population of the bacteria than the earlier mentioned ones, but significantly less than untreated control.

The application of chemicals has significantly reduced the population of the bacterium. Among the different chemicals streptomycin and streptocycline had the least population. This was followed by cheshunt compound and Bordeaux mixture. Pots drenched with dithane Z-78 contained the bacteria significantly less than the e of captan, while la tor had significantly less population of the bacteria than plots treated with F.H. spray except at the time of planting wherein captan and F.H. spray did not differ significantly than the control.

The population of P. solanacearum in the various treatment combinations was also compared. It was found that the combination of neem cake and streptomycin was most effective in reducing the bacterium. This was followed by

plots of treatment combination of urea and streptomycin or groundnut cake and streptomycin.

iii) Population of fungi

A very great stimulation of the total fungal population was observed in amended plots. Maximum population was noticed in plots amended with groundnut cake or neem cake. This was followed by plots amended with seshania leaves. Plots amended with glyricidia leaves contained greater population than those amended with urea.

A significant reduction in the fungal population was observed in plots treated with one or other of the chemicals tried. Maximum reduction in fungal population was observed in those plots sprayed with streptomycin or streptocycline. This was followed by plots drenched with chenhunt compound or Bordeaux mixture. However, during first observation chenhunt compound did not reduce the fungal population. Plots drenched with dithane Z-78, captan or F.M. spray had higher fungal population than the above, but were significantly less than the control. The only exception was noticed during the first observation when F.M. spray did not reduce the fungal population.

The effect of interaction between amendments and chemicals was not significant for the population of total fungi in soil, except at the time of planting.

iv) Population of bacteria

As in the case of fungi, bacteria was also found to be stimulated significantly in the amended plots. Maximum

total bacterial population was noticed in plots amended with neem cake. This was followed by those amended with groundnut cake. Plots amended with urea or sesbania leaves were having less bacterial population than the above, but significantly greater than those amended with glyricidia leaves or the unamended control plots.

A significant reduction in the total bacterial population was observed in all the plots treated with chemicals. The only exception was in the case of F.M. spray during first observation. The lowest population was noticed in plots treated with streptomycin. This was closely followed by those of cheshunt compound. There was no statistical difference between the population of bacteria in plots treated with cheshunt compound and streptocycline. Plots treated with Bordeaux mixture was having higher population than those of streptocycline treated plots. Plots treated with dithane Z-78 contained higher bacterial population than the above mentioned treatments but less than control, F.M. spray or untreated control. The bacterial population differed significant among plots treated with captan and F.M. spray. The plots treated with captan were having significantly less population than the e plots treated with F.M. spray.

The effect of interaction between amendments and chemicals was not significant for bacterial population.

v) <u>Population of actinomycetes</u>

The population of actinomycetes was found to be increased significantly in all the amended plots than in

the unamended control. But, in the case of urea amended soil, after two weeks, the increase was slight and non-significant. Among the different treatments, not much difference was observed in stimulating the actinomycetes, except that the stimulation offered by urea was of a lower magnitude than the rest of the treatments.

The application of chemicals was found to reduce the population of actinomycetes significantly. The only exception was in the case of F.M. spray during first observation. Maximum inhibition was noticed in plots sprayed with streptomycin. This was followed by plots of cheshunt compound or streptocycline. Next in order of merit was Bordeaux mixture. This was followed by plots receiving dithane Z-78. Plots containing captan had population of actinomycetes less than the above but more than those receiving F.M. spray.

The effect of combination of amendments and chemicals was not significant for the population of actinomycetes.

vi) <u>Relationship between disease incidence, the pathogen and the soil microflora</u>

Strong positive correlations exist between the severity of disease incidence and the population dynamics of the pathogen and between the different members of soil microflora (Table 10).

TABLE 10

Correlation coefficients between disease incidence, population of the pathogen, total fungi, bacteria and actinomycetes.

	DF	DF	DB	DA	F	FB	FA	FB	FA	BA
Two weeks after amendment	0.78*	0.27	0.31	0.32	-0.17	-0.15	0.04	0.85*	0.89*	0.79*
Four weeks after amendment	0.89*	0.25	0.28	0.37	-0.11	-0.11	0.01	0.90*	0.87*	0.91*

* - Significant at 5 percent level.

DF- Between disease incidence and fungi
DB- Between disease incidence and bacteria
DA- Between disease incidence and actinomycetes
FF- Between pathogen and fungi
FB- Between pathogen and bacteria
FA- Between pathogen and actinomycetes
FB- Between fungi and bacteria
FA- Between fungi and actinomycetes
BA- Between bacteria and actinomycetes.

DISCUSSION

DISCUSSION

Pseudomonas solanacearum (E.F.Smith) E.F. Smith is one of the most important plant pathogenic bacterium. The diseases caused by the bacterium are widespread in India and elsewhere. More than two hundred species of different plants are found to be attacked by this pathogen. Among them, the bacterial wilts of tomato, brinjal, tobacco, chillies and brown rot of potato are quite common and serious in our country. The bacteria are short rods, measuring 1.5 x 0. 5μ in size. They are motile by means of a single polar flagellum and gram negative in reaction.

During the past, a number of antibiotics and other chemicals have been tried in the control of bacterial wilts. But, the results achieved are far from satisfaction. The wilt pathogens are generally soil-borne in origin and therefore, to a great extent, the severity of these diseases will largely depend upon the inoculum levels present in soils at a particular time.

The utility of various organic materials in plant disease control by biological means is found to be promising in several soil-borne diseases caused by fungi and nematodes. (Johnson, 1959; 1962; 1963; Weinke, 1962). Garrett (1965) defined biological control as "any condition under which or practice whereby survival or activity of a pathogen is reduced, through the agency of any living organism (except man himself),

with the result that, there is reduction in the incidence of the disease caused by the pathogen". This consists of a group of methods, designed in full accordance with the ecological principles that the soil population at any time will be determined by habitat conditions and that the population, therefore, can be changed in any desired direction by making an appropriate change in soil condition, such as organic amendments. The concept of biological control is thus mainly based on the assumption that suitable modifications in soil condition can stimulate the activity of such soil microbial population that may be antagonistic to a given pathogen.

Recent investigation using various industrial and agricultural organic waste materials as tools of biological control, revealed that some of the materials were not substantially effective in checking the disease. The degree of disease suppression also observed in pots amended with groundnut or neem cake or N P K alone was slight and non-significant. Similar failure in the control of soil-borne disease of fungal origin has been observed in the past also. (Kaurav, 1970; Rajan, 1971). It has been postulated that the amendments were not useful in disease control wherein the initial pathogen population was high and the disease occured immediately after amendment.

The suppression or stimulation of soil-borne plant pathogenic fungi by organic amendments in soil has been

discussed in many recent reviews (Park, 1963; Stover, 1962; Patrick and Toussoun, 1965). Singh and Pandey (1967) noticed that the inhibitary and stimulatory effects of various oil-cakes depend upon factors such as chemical nature, quality and quantity of oil cake, degree of decomposition and fluctuations in soil pH. These workers have observed higher population of Pythium aphanidermatum in soil amended with oil-cakes, the increase being generally proportional to the quantity of the cake. The failure in the present investigation that the oil cakes did not satisfactorily control the wilt disease can be attributed to the aforesaid reasons.

Green manuring is a conventional practice whereby green plants are ploughed into soil to rot and to provide nutrients for the succeeding crop. These materials undergo the process of decomposition and bring about, physical, chemical and microbial changes in microsites where microflora and fauna are active. Results of the present investigation indicate that green leaves of neem, glyricidia, and sesbania suppressed the severity of wilt disease. It is well known that organic materials in undecomposed form, when introduced into soil influence the survival and growth of pathogen in soil. The fact that the suppression of the disease in pots supplied with pongamia leaves or paddy straw was slight and non-significant, may be attributed to the difference in their nutrient value or the differences in their decomposition products. Tyner(1940) noticed that wheat, barley and oat straw have reduced the severity of

diseases in wheat caused by Ophiobolus graminis, Helminthosporium sativum and Fusarium culmorum. Similar results have been reported by Kommedhal and Young (1956) in controlling diseases of potato caused by Rhizoctonia solani and Fusarium spp. Singh and Pandey (1967) observed that a reduction in the population of a fungal pathogen (Pythium aphanidermatum) has occurred in soil amended with neem and other green leaves. Basu Choudhury (1967) obtained partial control of common scab of potato caused by Streptomyces scabies by organic soil amendments.

The estimation of total microflora (fungi, bacteria and actinomycetes) under the various organic amendments has shown that saprophytes are greatly stimulated. Among them the stimulus shown by fungi was greater than the others. Patrick and Toussoun(1965), Huber and Watson (1970), and Lindeman (1970) have comprehensively reviewed the influence of decomposition products of organic matter. Watanabe (1946) suggested that addition of organic matter to soil suppress root pathogens. Mahmood (1964) observed that groundnut cake enhanced the growth of soil organisms antagonistic to pigeon pea wilt organism, Fusarium oxysporum f udum. Khanna (1970) and Rajan (1971) obtained increase in population of soil microflora by addition of oil-cakes. Korah and Shinde (1960) reported that the quantity of carbon-di-oxide evolved from soil treated with non-edible cakes was more than five to eight times that of

untreated, showing that these oil-cakes have increased the microbial activity of soil.

The observation in the present investigation that highest stimulation occured with regard to fungal population is in agreement with the observations made by several workers in the past (Maloy and Burkholder,1959; Papavizas et al., 1962; Smith and Ashworth, 1965; Mennis et al., 1967). Reddi and Rao (1965) and Khanna (1970) observed that either increase or decrease of fungal population may occur depending upon the type of amendment.

Clark (1939), Abd-El-Malek et al. (1961), Papavizas(1963), Smith and Ashworth (1965), Reddi and Rao (1965) and Mennis et al. (1967) have observed increased bacterial population after amendment of soil with different organic materials. The finding of the above workers is supported by the present work. As in the case of bacteria, stimulation in the population of actinomycetes has also been observed following organic amendment (Davey and Papavizas, 1960; Papavizas et al., 1962; Mitchell and Alexander, 1962; Smith and Ashworth, 1965; Mennis et al., 1967; Khanna, 1970).

Garrett (1956) has suggested that the members of the sugar fungi use simple organic compounds for food and are adapted to utilise the food supply ahead of their competitors. Members of this group grow very rapidly, immediately after addition of such substances to soil and thus their population occupy a dominant position in the ecological succession. This explains the greater stimulation of fungal flora than bacteria or actinomycetes.

In a separate pot culture trial of assessing the disease severity and population of total saprophytes under different levels of major plant nutrients, nitrogen was found to possess a stronger influence than phosphorus or potassium. According to the report of North Carolina Agricultural Experiment Station (Anon., 1943), the wilt disease of tobacco caused by Pseudomonas tabacina was reduced with increasing levels of nitrogen. Kelman (1950) observed that a high dose of nitrogen above optimum for plant growth suppressed wilt incidence in tobacco and tomato. Sequeira (1958) has recorded a high degree of control of bacterial wilt (moko disease of banana) by application of urea to soil. Kumar (1970) recommended the application of urea at the rate of two pounds per acre as a control measure against brown rot of potato caused by Pseudomonas solanacearum.

Van der Pool (1940), Garrett (1949; 1956) and Huber et al., (1968) have noticed that nitrogen fertilization controls certain soil-borne diseases due to the reduction in pathogen population, which may either be due to the direct toxicity of the chemicals to the pathogen or by favouring indirectly soil microflora antagonistic to the pathogen. Agnihotri and Vaartaja (1967) working on the root rot of wheat have observed the formation of nitrite during nitrogen transformations. The low concentration and its rapid oxidation into non-toxic nitrate might have helped in selectively killing the pathogen, without affecting plant roots.

Rajan and Singh (1974) also have suggested that the above may be applicable, at least in part, in the case of post emergent damping-off of tomato caused by Pythium arhanidermatum.

Increased population of saprophytes leading to increased antibiosis or competition following fertiliser application is widely known (Kaufman, 1963; Kaufman and Williams, 1964; Sadasivan, 1965). Thankam (1949) noticed that application of ammonium sulphate and sodium nitrate to soil has resulted in remarkable changes in population of soil microflora. Rajan (1971) obtained sharp and consistent increase in the population of total fungi and bacteria in pots receiving 60 ppm nitrogen. The present work is in full support of the above mentioned works as the increase in total fungi, bacteria and actinomycetes was highly significant. In addition to the above increased plant growth due to higher amount of plant nutrients received may compensate the damage due to the disease to some extent. Further, the application of fertilisers may bring about an increase in host resistance also. Thus, it can be seen that the success achieved may be a combination of the nutrients being directly toxic to pathogen, stimulate certain specific soil microflora, help in increased crop growth and render greater resistance against the disease.

Antibiotics are the most potent systemic agents of bacterial plant disease control. The utility of antibiotics in the control of bacterial diseases of foliar nature has been found to be very promising. However, many workers have failed to get a satisfactory control in bacterial diseases of

soil-borne nature by using different antibiotics.

Under the present investigation, an attempt was made for an integrated method of control through chemical and biological means. The basis for the above was that the success achieved through chemical means as well as through biological means as evidenced by some of the trials under the present investigation was only partial. It is well known that chemical control and biological control are never mutually exclusive. In circumstances, where inoculam potential of the pathogen is quite high, biological control may not operate. The observed relatively little success through chemical control by several workers may be due to the fact, that only a partial destruction of the pathogen has been achieved. In course of time, the remaining population of the pathogen might have been multiplied and succeeded in causing significant damage to the crop.

This particular disease is not fully amenable to biological control due to various reasons. Baker and Maurer (1967) have stipulated certain conditions in assessing the efficiency of biological control. According to them, if the pathogen can infect anywhere in the root system (moving type of infection court) the control through biological means will be difficult. Further, the mobility of the pathogen will also reduce the success, which can occur through biological means. Since the

infection of tomato wilt occur anywhere in the root system and the pathogen can move in the environment it is natural that the control of the disease achieved through biological means can never be perfect.

The fact that the organic amendments gave a better degree of control when used along with chemicals than alone, indicates that once the inoculum level is reduced to a level at which significant disease may not occur, the further multiplication leading to increased inoculum can well be prevented by organic amendments. All the amendments have reduced the disease as well as the population of the pathogen considerably and increased the total population of soil actinophytes. When groundnut or neem cake was used in combination with chemicals like streptomycin or streptocycline the efficiency of control became twice than without chemicals. The lack of significant control through groundnut or neem cake alone may be explained on that the initial population of the pathogen might have been high.

The success of combining chemicals with amendments can be explained as follows. The high inoculum potential of the pathogen in soil might have been reduced to a low level in plots treated with chemicals. Ramadevi and Samraj (1969) observed that streptomycin when applied as a foliar spray was readily absorbed and translocated to various tissues of the tomato plant. A marked decrease in the bacterial population of the rhizosphere was also noted as a result of

the antibiotics spray. Under the present investigation, streptomycin, streptocycline, cheshunt compound and Bordeaux mixture had reduced disease incidence and the population of the pathogen significantly. Rahim (1972), George (1973) and various other workers in the field have reported disease suppression in field plots treated with streptomycin, Bordeaux mixture and cheshunt compound.

The general trend in relationships between disease incidence, population of fungi, bacteria and actinomycetes in the field as well as in pot culture experiments indicate that the severity of disease increases with the population of the pathogen and decreases with the population of total fungi, bacteria and actinomycetes. The fact that negative relationships between disease incidence and fungal population and that between the population of pathogen and total fungi are much more stronger than between disease incidence and population of bacteria or actinomycetes indicate that it is the fungal population which decides, to a great extent, the population of pathogen and thereby the severity of the disease. Similar studies conducted by Rajan (1971) have revealed that during the first few weeks after rhizome population of fungi was highly stimulated. Thereafter, the bacteria have taken the lead. He also reported very strong negative correlation between severity of soft rot disease of ginger and population of total fungi in soil. Kaufman and Williams (1963) have noticed that saprophytic fungi like Trichoderma and

Penicillium produce antibiotics in the soil. In the light of the above, it may be presumed that in the present context, fungi act as better antogonistic organisms than bacteria or actinomycetes. It is to be taken into account that the plate counts were taken only for a period of six weeks after amendment. It isgwidely reported that during the first phase of decomposition, sugar fungi will be most active in decomposing the simple fractions of the carbohydrates. The increase in population of bacteria occur only later, while that of actinomycetes occur only very late.

Several workers have tried to explain the mechanism of biological control. Of course, the mechanism may differ with the host, the pathogen and the environment. It is generally accepted that antibiosis followed by lysis and competition followed by death of cells are the chief mechanismsof biological control. The results in the present investigation show that within a short period of six weeks, significant control in disease as well as substantial reduction in the population of the pathogen have occured. This observation in favour of antibiosis, being the principal mechanism of control of the disease. The significant negative correlation between population of pathogen and fungi adds further proof that antibiosis is the major phenomenon of control which is active. However, the lack of perfect correlation between the two indicates that competition is also active, though at a lower

magnitude than antibiosis. Rangaswami and Ethiraj (1962) observed that antibiotic activity was more in amended soils than in unamended soils. However, Subbarao and Baily(1961) have observed a lack of correlation between antibiosis and disease suppression. Raja (1971) have reported that the control of soft rot of ginger obtained through organic amendments is due to both antibiosis and competition.

Garrett (1960) has stated that "root disease investigators have before them the elusive lure of biological control, but this is likely to remain elusive until microbial ecology of the soil is better understood - a prospect possibly remote". This 'lure' has been made attractively challenging by the demonstration that biological control can, at times, operate in the field. The organic materials have shown to be effective in reducing the severity of several soil-borne disease. The benefit gained by the practice may not only be due to the starvation of the pathogen (competition), but also due to the stimulation of antagonistic proportion of the soil microflora, (antibiosis). The reduction in disease incidence is, therefore, linked with the concept of inoculum potential, a product of the quantity of inoculum present (intensity factor) and capacity of the environment to produce the disease (capacity factor).

Though biological control has been widely adopted, in controlling soil-borne diseases caused by fungi and nema-

nematodes, such attempts to control soil-borne diseases of bacterial origin are quite meagre. The results of the present investigation indicate that such studies are highly provocative and throw light on this important topic. Future studies on this line will definitely yield useful information with regards to control of soil-borne bacterial plant diseases.

SUMMARY

SUMMARY

Pot culture and field experiments were conducted to assess the utility of various organic soil amendments and chemicals on the incidence of bacterial wilt of tomato. The population dynamics in relation to the causal organism, total fungi, bacteria and actinomycetes were also studied.

The results of the investigation revealed the following:

1. Organic amendments alone did not satisfactorily check the incidence of bacterial wilt.

2. A satisfactory control of the disease was observed on application of chemicals to amended plots.

3. A general stimulation in the population of soil microflora was the resultant of organic amendment. The degree of stimulation varied with the kind of organic material.

4. Among the different chemicals tried, streptomycin and streptocycline were most effective in suppressing the population of the pathogen in soil and in reducing the disease severity.

5. The relationship between disease incidence, population of the pathogen and the total population of soil microflora such as fungi, bacteria and actinomycetes were worked out for different periods. It was found that negative correlations exist between:

   a) disease incidence and total population of soil microflora

   and

   b) pathogen population and total population of soil microflora.

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* - Originals not seen.

APPENDICES

APPENDIX-I

(Table - 2)

Treatments	Fungi in ten thousands		Bacteria in millions		Actinomycetes in ten thousands	
	1	2	1	2	1	2
Coconut cake	36.00	32.49	19.62	26.01	4.84	6.40
Sesamum cake	30.25	25.60	34.33	36.36	4.24	5.42
Groundnut cake	35.42	55.20	12.96	17.64	2.56	3.61
Mahuva cake	39.18	33.98	29.81	47.61	4.12	7.08
Illupa cake	86.49	89.92	19.00	23.04	4.84	2.89
Punnakka cake	75.69	85.19	23.61	32.49	5.42	5.90
Rubber cake	32.03	32.49	22.65	26.62	5.42	3.24
Neem cake	100.60	121.60	17.64	22.09	2.56	3.61
Karotti cake	23.72	25.20	22.09	23.32	3.61	5.42
N K	33.64	34.81	21.43	31.69	4.40	4.66
Saw dust	72.76	79.21	21.43	19.62	3.61	5.42
Cashew shell	31.36	33.64	17.64	22.37	1.55	4.84
Coconut pith	32.83	39.69	17.14	14.44	2.56	3.24
Oilpalm seed waste	44.48	45.69	17.79	19.74	3.61	6.40
Saw dust + N K	43.95	46.24	17.05	19.62	4.66	3.61
Cashew shell + N K	57.76	64.43	6.05	19.99	5.10	7.07
Coconut pith + N K	25.00	26.01	16.31	16.24	4.24	2.25
Oil palm seed waste + N K	11.97	11.76	19.99	20.40	2.56	2.89
Control	11.97	10.09	25.30	9.36	4.24	3.61

1 - Total population two weeks after amendment.
2 - " " four weeks after amendment.

APPENDIX - I (a)

Analysis of variance table
(Disease incidence)

Source	Sum of squares	d.f.	variance	F. value
Total	33820.2	56		
Amendments	6181.6	18	343.42	0.48
Error	27638.6	38	720.23	

APPENDIX - I (b)
(Fungi-1)

Source	Sum of squares	d.f	variance	F. value
Total	299.10	56		
Amendments	254.84	18	14.15	15.72**
Error	44.25	38	1.16	

** Significance at P = 0.01.

APPENDIX - I (c)
(Fungi-2)

Source	Sum of squares	d.f.	variance	F.value
Total	227.53	56		
Amendments	220.61	18	12.25	68.0**
Error	6.92	38	0.18	

** Significance at P = 0.01.

APPENDIX - I (d)
(Bacteria -1)

Analysis of variance table

Source	Sum of squares	d.f	Variance	F. value
Total	65.78	56		
Amendments	44.54	18	2.47	4.41*
Error	21.24	38	0.56	

* Significance at P = 0.05

APPENDIX - I (e)
(Bacteria -2)

Source	Sum of squares	d.f.	Variance	F. value
Total	61.21	56		
Amendments	40.29	18	2.25	4.09*
Error	20.72	38	0.55	

* Significance at P = 0.05

APPENDIX - I (f)
(Actinomycetes-1)

Source	Sum of squares	d.f.	Variance	F.value
Total	9.25	56		
Amendments	6.69	18	0.36	6.00**
Error	2.56	38	0.06	

** Significance at P = 0.01

APPENDIX - I (g)

Analysis of variance table (Actinomycetes-2)

Source	Sum of squares	d.f.	Variance	F.value
Total	6.46	56		
Amendments	4.83	18	0.27	6.7**
Error	1.63	38	0.04	

** Significance at P = 0.01

APPENDIX - II (Table 4)

Treatment	Percent disease incidence	Fungi in ton thousands		Bacteria in millions		Actinomycetes in ton thousands	
	1	1	2	1	2	1	2
Glyricidia leaves	25.0	26.21	35.05	26.42	47.61	4.93	5.29
Pongamia leaves	75.0	23.52	36.60	23.81	36.24	3.29	3.65
Neem leaves	6.7	52.85	68.06	39.56	64.20	5.24	5.29
Paddy straw	75.0	22.94	26.21	23.52	22.18	2.92	3.46
Mesbanea leaves	25.0	55.20	82.44	25.40	41.21	4.71	4.54
Control	100.0	17.55	16.07	16.24	17.56	2.89	2.28

1 - Total population two weeks after amendment

2 - Total population four weeks after amendment.

APPENDIX -II (a)

Analysis of variance Table
(Disease incidence)

Source	Sum of squares	d.f.	Variance	F.value
Total	18112.5	17		
Amendments	11365.8	5	2273.2	4.0*
Error	6746.7	12	562.2	

* Significance at P = 0.05

APPENDIX - II(b)
(Fungi - 1)

Total Source	Sum of square	d.f.	Variance	F. value
Total	30.67	17		
Amendments	28.69	5	5.74	33.7**
Error	1.98	12	0.17	

** Significance at = 0.01

APPENDIX - II (c)
(Fungi - 2)

Source	Sum of squares	d.f.	Variance	F. Value
Total	44.68	17		
Amendments	43.26	5	8.65	72.1**
Error	1.42	12	0.12	

** Significance at P = 0.01

APPENDIX - II (d)
(Bacteria - 1)

Analysis of variance table

Source	Sum of squares	d.f.	Variance	F. Value
Total	9.91	17		
Amendments	7.94	5	1.58	9.9**
Error	1.97	12	0.16	

** Significance at P = 0.01

APPENDIX - II (e)
(Bacteria - 2)

Source	Sum of squares	d.f.	Variance	F.Value
Total	32.19	17		
Amendments	30.36	5	6.07	40.4**
Error	1.83	12	0.15	

** Significance at P = 0.01

APPENDIX - II (f)
(Actinomycetes-1)

Source	Sum of squares	d.f.	Variance	F.Value
Total	1.94	17		
Amendments	1.04	5	0.21	2.63
Error	0.90	12	0.08	

APPENDIX -II(g)

Analysis of variance table (Actinomycetes-2)

Source	Sum of squares	d.f.	Variance	F. Value
Total	2.16	17		
Amendments	1.36	5	0.27	4.03*
Error	0.80	12	0.06	

* Significance at P = 0.05

APPENDIX - III(Table 6)

Treatment	Percent disease incidence	Fungi in ten thousands		Bacteria in millions		Actinomycetes in ten thousands	
		1	2	1	2	1	2
N_0	79.8	15.44	17.22	11.22	15.60	3.92	4.88
N_1	58.7	17.06	19.45	17.14	21.44	4.41	4.58
N_2	38.4	18.32	20.97	15.68	18.49	4.00	4.67
P_0	77.4	16.32	18.75	13.76	19.27	4.08	4.58
P_1	50.0	16.32	19.27	14.98	17.14	4.49	4.93
P_2	50.0	17.98	19.54	14.90	19.09	3.76	4.49
K_0	72.4	15.36	18.58	14.52	17.89	4.58	4.84
K_1	50.0	17.14	19.45	14.82	20.34	3.65	4.67
K_2	55.8	18.32	19.54	14.29	17.06	4.16	4.62

1 - Total population two weeks after amendment

2 - Total population four weeks after amendment.

APPENDIX - III (a)
Analysis of variance table
(Disease incidence)

Source	Sum of squares	d.f.	variance	F.Value
Total	74450.0	80		
Amendments	23150.0	26	890.3	0.93
N	8450.0	2	4225.0	4.45*
P	5000.0	2	2500.0	2.63
K	2600.0	2	1300.0	1.36
N x P	3400.0	4	850.0	0.89
N x K	400.0	4	100.0	0.10
P x K	1150.0	4	287.5	0.30
N x P x K	2000.0	8	250.0	0.26
Error	51300.0	54	950.0	

* Significance at = 0.05

APPENDIX - III (b)
(Fungi - 1)

Source	Sum of squares	d.f.	variance	F.Value
Total	30.09	80		
Amendments	14.92	26	0.49	1.86*
N	1.81	2	0.90	3.45*
P	0.60	2	0.30	1.15
K	1.67	2	0.83	3.19*
N x P	1.23	4	0.31	1.19
N x K	5.96	4	1.49	4.32*
P x K	0.98	4	0.26	1.00
N x P x K	2.67	8	0.33	1.26
Error	15.17	54	0.26	

* Significance at P = 0.05.

APPENDIX -XI (c)
(Fungi - 2)

Source	Sum of squares	d.f.	Variance	F. value
Total	28.95	80		
Amendments	8.66	26	0.33	0.92
N	2.57	2	1.28	3.46*
P	0.14	2	0.07	0.01
K	0.24	2	0.12	0.03
N x P	0.94	4	0.23	0.79
N x K	2.78	4	0.69	1.80
P x K	0.63	4	0.16	0.56
N x P x K	1.36	8	0.17	0.54
Error	20.29	54	0.37	

* Significance at = 0.05

APPENDIX - III (d)
(Bacteria - 1)

Source	Sum of squares	d.f.	Variance	F. Value
Total	31.97	80		
Amendments	22.32	26	0.86	4.77*
N	9.11	2	4.55	25.27**
P	0.43	2	0.22	1.22
K	0.08	2	0.04	0.02
N x P	6.79	4	1.69	9.38*
N x K	0.90	4	0.23	1.25
P x K	0.70	4	0.17	0.95
N x P x K	4.31	8	0.54	3.00*
Error	9.65	54	0.18	

** Significance at P = 0.01
* Significance at P = 0.05

APPENDIX - XII (e)
(Bacteria - 2)

Source	Sum of Squares	d.f.	Variance	F. Value
Total	49.11	80		
Amendments	20.82	26	0.80	1.42
N	6.20	2	3.10	5.96*
P	1.34	2	0.67	1.28
K	2.09	2	1.04	2.00
N x P	5.21	4	1.30	2.50
N x K	2.05	4	0.51	0.97
N x P x K	2.28	8	0.28	0.42
P x K	1.68	4	0.42	0.93
Error	28.29	54	0.52	

* Significance at P = 0.05

APPENDIX - III (f)
(Actinomycetes -1)

Source	Sum of squares	d.f.	Variance	F. Value
Total	25.07	80		
Amendments	9.53	26	0.33	1.06
N	1.24	2	0.62	2.00
P	1.10	2	0.55	1.75
K	0.88	2	0.44	1.45
N x P	2.00	4	0.50	1.62
N x K	1.08	4	0.27	0.90
P x K	1.97	4	0.49	1.60
N x P x K	0.26	8	0.03	0.01
Error	16.55	54	0.31	

APPENDIX - III (g)
(Actinomycetes-2)

Source	Sum of squares	d.f.	Variance	C F.Value
Total	27.52	80		
Amendments	7.18	26	0.27	0.67
N	0.58	2	0.29	0.65
P	0.49	2	0.25	0.63
K	0.42	2	0.21	0.31
N x P	1.02	4	0.25	0.63
N x K	0.99	4	0.24	0.64
P x K	1.12	4	0.28	0.66
N x P x K	2.59	8	0.32	0.80
Error	20.34	54	0.41	

APPENDIX -IV (Table 8)

Treatment	Disease incidence			*F. solanacearum* in millions			Fungi in ten thousands			Bacteria in millions			Actinomycetes in ten thousands		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Urea	0	14.7	18.8	24.0	19.3	18.4	16.8	19.3	24.1	21.5	27.3	29.4	1.1	1.8	2.0
Groundnut cake	0	16.4	21.0	22.7	19.1	17.9	25.0	33.6	37.7	22.6	29.5	30.6	1.6	2.8	2.9
Neem cake	0	13.5	17.7	22.2	18.9	17.6	23.4	32.5	37.8	23.6	30.6	32.7	1.7	2.9	2.5
Glyricidia leaves	0	25.2	29.7	25.3	23.0	20.0	18.5	23.1	27.6	20.3	25.6	27.5	1.8	2.5	2.7
Sesbanes leaves	0	24.4	28.0	29.4	28.2	26.1	20.6	25.8	30.7	20.6	27.6	29.8	1.6	3.2	3.1
Control	0	32.5	46.9	48.9	48.4	47.6	14.7	16.1	15.8	9.8	12.8	14.9	1.1	1.4	1.1

1 - Two weeks after amendment

2 - Four weeks after amendment

3 - Six weeks after amendment

APPENDIX - V (Table 9)

Treatment	Disease incidence			*C.gloeosporioides* in millions			Fungi in ten thousands			Bacteria in millions			Actinomycetes in ten thousands		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Bordeaux mixture	0	12.5	17.4	26.5	23.1	19.5	18.7	22.8	25.5	19.1	22.7	24.7	1.2	2.1	2.2
Cheshunt compound	0	13.1	16.7	25.5	20.7	18.9	20.9	23.8	27.0	17.2	20.9	23.0	1.2	1.7	1.9
Streptomycin	0	6.3	9.5	25.9	18.7	16.5	17.5	20.8	23.8	16.1	19.3	21.3	1.1	1.4	1.7
Strepto-cycline	0	7.9	11.4	25.2	19.0	16.7	17.0	19.1	22.8	17.8	22.2	23.7	1.2	1.9	2.1
Dithane	0	23.5	28.0	27.5	26.6	24.6	19.4	24.3	27.6	19.9	24.2	26.8	1.4	2.4	2.1
Captan	0	27.0	31.2	30.6	29.6	27.0	19.9	25.4	29.6	20.7	26.2	28.3	1.7	2.6	2.5
F.M.Spray	0	33.4	37.8	31.1	32.0	29.8	22.0	27.9	31.7	22.1	30.0	32.0	2.0	3.2	2.9
Control	0	54.0	7044	31.9	37.1	40.3	22.3	34.8	39.8	23.1	35.0	37.0	2.2	4.2	3.6

1 - Two weeks after treatment
2 - Four weeks after treatment
3 - Six weeks after treatment

APPENDIX -V (a)

Analysis of variance table
(Disease incidence-2)

Source	Sum of squares	d.f.	Variance	F. Value
Total	22700.3	143		
Blocks	58.7	2	29.4	0.58
Amendments	3247.8	5	649.6	12.75**
Error - 1	509.4	10	50.9	
Chemicals	15310.6	7	2187.2	122.19**
Amendments X Chemicals	2070.3	35	59.2	3.30**
Error - 2	1503.6	84	17.9	

** Significance at P = 0.01

A... ... I... - V(b)
(Disease incidence 3)

ource	Sum of squares	d.f.	Variance	F. Value
Total	30422.9	143		
Blocks	61.22	2	30.6	1.67
Amendments	5611.6	5	1122.3	61.03**
Error - 1	193.9	10	18.4	
Chemicals	20167.1	7	2881.0	179.61**
Amendments X Chemicals	3051.9	35	87.2	5.44**
Error - 2	1347.3	84	16.0	

** Significance at P = 0.01

APPENDIX - V (c)

(F. solanacearum -1)

Source	Sum of squares	d.f.	Variance	F. Value
Total	110.44	143		
Blocks	0.48	2	0.24	4.8*
Amendments	89.49	5	17.89	357.8**
Error -1	0.52	10	0.05	
Chemicals	8.32	7	1.18	23.6**
Amendments X Chemicals	7.20	35	0.21	4.2**
Error - 2	4.43	84	0.05	

** Significance at P = 0.01
* Significance at P = 0.05

APPENDIX -V (d)

(F. solanacearum -2)

Source	Sum of squares	d.f.	Variance	F. Value
Total	193.76	143		
Blocks	0.42	2	0.21	2.63
Amendments	125.20	5	25.04	313.00**
Error -1	0.83	10	0.08	
Chemicals	54.38	7	7.79	86.56**
Amendments X Chemicals	5.45	35	0.16	1.78*
Error - 2	7.48	84	0.09	

** Significance at P = 0.01
* Significance at P = 0.05

APPENDIX - V (e)
(*P. Solanacearum* -3)

Source	Sum of Squares	d.f.	Variance	F. Value
Total	227.14	143		
Blocks	0.46	2	0.23	2.67
Amendments	133.14	5	26.63	309.65**
Error -1	0.86	10	0.09	
Chemicals	79.13	7	11.30	166.73**
Amendments X chemicals	7.85	35	0.22	3.24**
Error - 2	5.70	84	0.07	

** Significance at α = 0.01

APPENDIX - V (f)

Source	Sum of squares	d.f.	Variance	F.Value
Total	47.28	143		
Blocks	0.64	2	0.32	3.56
Amendments	23.76	5	4.75	52.78**
Error -1	0.92	10	0.07	
Chemicals	6.62	7	0.89	8.9**
Amendments X Chemicals	7.21	35	0.21	2.1**
Error - 2	8.53	84	0.10	

** - Significance at P = 0.01.

APPENDIX - V (g)

(Fungi - 2)

Source	Sum of squares	d.f	Variance	F. Value
Total	121.64	143		
Blocks	1.52	2	0.76	5.85*
Amendments	60.23	5	12.05	92.69**
Error - 1	1.29	10	0.13	
Chemicals	27.71	7	3.96	18.86**
Amendments X Chemicals	12.71	35	0.36	1.71
Error - 2	18.18	84	0.21	

** Significance at α = 0.01

* Significance at α = 0.05

APPENDIX - V (h)

(Fungi -3)

Source	Sum of squares	d.f	Variance	F. Value
Total	169.02	143		
Blocks	0.51	2	0.25	1.47
Amendments	91.90	5	16.39	96.35**
Error - 1	1.71	10	0.17	
Chemicals	30.31	7	4.33	9.02**
Amendments X chemicals	13.81	35	0.39	0.82
Error - 2	40.78	84	0.48	

** Significance at α = 0.01

APPENDIX -V(i)
(Bacteria - 1)

Source	Sum of squares	d.f	Variance	F. value
Total	64.73	143		
Blocks	0.15	2	0.07	2.01
Amendments	48.76	5	9.75	296.76**
Error -1	0.34	10	0.03	
Chemicals	10.39	7	1.48	31.29**
Amendments X chemicals	1.11	35	0.03	0.60
Error - 2	3.98	84	0.05	

** Significance at a P = 0.01

APPENDIX - V (j)
(Bacteria - 2)

Source	Sum of squares	d.f.	Variance	F. Value
Total	103.81	143		
Block	1.58	2	0.79	8.98**
Amendments	59.47	5	11.89	135.11**
Error - 1	0.88	10	0.08	
Chemicals	31.80	7	4.54	47.14**
Amendments X Chemicals	1.99	35	0.06	0.62
Error - 2	8.09	84	0.09	

** Significance at P = 0.01

APPENDIX - V (k)
(Bacteria - 3)

Source	Sum of Squares	d.f	Variance	F. Value
Total	95.52	143		
Blocks	1.55	2	0.78	8.86**
Amendments	53.88	5	10.78	122.50**
Error - 1	0.98	10	0.08	
Chemicals	30.19	7	4.31	61.57**
Amendments X Chemicals	2.45	35	0.07	1.00
Error - 2	6.57	84	0.07	

** Significance at P = 0.01

APPENDIX - V (l)
(Actinomycetes -1)

Source	Sum of squares	d.f.	Variance	F. value
Total	10.47	143		
ABlocks	0.18	2	0.09	1.32
Amendments	2.10	5	0.42	6.18**
Error -1	0.69	10	0.07	
Chemicals	3.44	7	0.49	14.58**
Amendments X Chemicals	1.24	35	0.04	1.05
Error -2	2.93	84	0.03	

** Significance at P = 0.01

APPENDIX - V (m)
(Actinomycetes-2)

Source	Sum of Squares	d.f.	Variance	F. Value
Total	18.43	143		
Blocks	0.04	2	0.02	0.50
Amendments	6.13	5	1.23	30.00**
Error -1	0.41	10	0.04	
Chemicals	9.70	7	1.39	77.22**
Amendments X Chemicals	0.63	35	0.02	1.00
Error -2	1.52	84	0.02	

**Significance at P = 0.01.

APPENDIX - V (n)
(Actinomycetes - 3)

Source	Sum of Squares	d.f.	Variance	F. Value
Total	17.14	143		
Blocks	0.11	2	0.06	1.59
Amendments	3.29	5	1.66	43.68**
Error - 1	0.39	10	0.04	
Chemicals	5.06	7	0.69	17.25**
Amendments X Chemicals	1.11	35	0.03	0.75
Error-2	3.39	84	0.04	

** Significance at = 00.01.

STUDIES ON THE CONTROL OF BACTERIAL WILT OF TOMATO WITH REFERENCE TO ORGANIC SOIL AMENDMENTS AND CHEMICALS

BY

M. G. JAYAPRAKASH

ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILMENT OF THE

REQUIREMENT FOR THE DEGREE

MASTER OF SCIENCE IN AGRICULTURE

DEPARTMENT OF PLANT PATHOLOGY

COLLEGE OF AGRICULTURE

VELLAYANI-TRIVANDRUM

1977

ABSTRACT

The pot culture and field experiments were conducted to assess the effect of organic soil amendments and chemicals on the incidence of bacterial wilt of tomato. The population dynamics in relation to the causal organism, total fungi, bacteria and actinomycetes were also studied.

The result of the investigation revealed that organic matrials alone did not check the disease incidence to a satisfactory level. However, the application of organic material followed by the treatment with oxytetracycln and streptocycline gave a satisfactory control of the disease.