EFFECT OF GREEN MANURE, ORGANIC MANURE AND CHEMICALS ON THE INCIDENCE OF BACTERIAL WILT (*Ralstonia (Pseudomonas) solanacearum*) IN POTATO

D.B.KELANIYANGODA, S.K.THARMARAJAH[1] AND L.G.HERAT[2]
Regional Agricultural Research and Development Centre, Bandarawela.

ABSTRACT

On-station and on-farm experiments were conducted at the Regional Agricultural Research and Development Centre, Bandarawela and a farmer's field at Bindunuwewa, during Yala 1993-Yala 1997 period to investigate the feasibility of environment-friendly integrated management of bacterial wilt [*Ralstonia (Pseudomonas) solanacearum*] disease in potato. Soil amendments such as Walsuriyakantha (*Tithonia diversifolia*) (10t/ha) + CaO (2t/ha)+ Urea (200 kg N/ha) or Walsuriyakantha (10t/ha) + Cowdung (10t/ha) or Walsuriyakantha (10t/ha) + Poultry manure (10t/ha) or Walsuriyakantha (10t/ha) alone could suppress bacterial wilt [*Ralstonia (Pseudomonas) solanacearum*] disease in potato cultivation.

KEY WORDS :- Amendments, Disease incidence, Integrated disease management

INTRODUCTION

Potato and tomato are major cash crops grown in the upcountry of Sri Lanka. The total extent cultivated is estimated at 9,500 ha and 4,500 ha, respectively. These two crops are popular among the farmers and are grown at least once in the cropping sequence in this region. The major problem confronted by the potato farmers is bacterial wilt caused by *Ralstonia (Pseudomonas) solanacearum*. This disease is widespread all over the upcountry region. The yield loss due to bacterial wilt varied from 5-25%, thus incurring heavy financial losses to the farmers. Bacterial wilt is an economically important disease affecting a wide range of hosts of high commercial value. The disease is particularly serious in tropical and subtropical environments.

Present address: [1] Regional Agricultural Research and Development Centre, Makandura
Present address: [2] Horticultural Research and Development Institute, Gannoruwa, Peradeniya

EFFECTS OF MANURE AND CHEMICALS ON BACTERIAL WILT OF POTATO

Ralstonia (Pseudomonas) solanacearum is a soil-borne pathogen which can persist for considerable periods of time in many different soil types around the world (Kelman, 1953; Buddenhagen and Kelman, 1964; Hayward, 1991). Control of bacterial wilt is difficult because the pathogen is soil-borne and has a wide host range covering 44 families of plants (Hayward, 1991).

The use of resistant varieties, sanitation, crop rotation, alternation of cultural practices, selection of disease-free planting materials, and more recently the use of microbial antagonists are some of the bacterial wilt management practices.

Bacterial wilt resistance in plants is controlled genetically. Trigalet and Demery (1990) reported the involvement of oligogenes which conferred resistance to *Ralstonia (Pseudomonas) solanacearum*. However, the genetic basis of resistance breaks down due to changes in the host or pathogen under conditions of high temperature (Mew and Ho, 1977). The effect of location as well as the location x variety interaction have been shown to be highly significant in a multiplication evaluation conducted in South Asia (Hanson and Wang, 1996).

The use of microbial antagonists has been noted as a promising control strategy. Biological control has an immense potential in management of bacterial wilt. The basic idea in biological control is to utilize a rhizosphere colonizer that would antagonize *Ralstonia (Pseudomonas) solanacearum* at the root infection site which would, result in reduced infection (Schroth and Hancock, 1982; Chen and Echandi, 1984; Weller, 1988; Trigalet *et al.*, 1994; Holloway, 1995). Avirulent mutants of *Ralstonia (Pseudomonas) solanacearum* have been used in the biological control of bacterial wilt (Kempe and Sequeira, 1983; Mclaughlin and Sequeira 1988; Trigalet and Demery, 1990; Hayward, 1991). Certain bacteria like *P. fluorescens, Bacillus polymyxa and Bacillus* spp. and Actinomycetes have been found to delay the development and reduce incidence of bacterial wilt (Nesmith and Jenkins, 1985; Aspira and Cruz, 1986; Liao 1989; Anuratha and Gnanamanikam, 1990; Hsu *et al,* 1992).

In addition to the above control measures, the use of soil amendments with organic matter has been adopted for controlling certain soil borne diseases, including bacterial wilt (Sun and Huang, 1985; Chang and Hsu, 1988; Hartman *et.al.*, 1993; French, 1994).

The primary objective of this study was to develop a suitable environment-friendly integrated management strategy for control of bacterial wilt in potato. In this context, on-station experiments and on-farm technology adaptation trials were conducted and are reported in this paper.

MATERIALS AND METHODS

A. On-station research

Experiment- 1 Yala 1993 and Yala 1994

The experiment was carried out at the Regional Agricultural Research and Development Centre, Bandarawela research field over two seasons viz. Yala 1993 and Yala 1994. The field was already infested with bacterial wilt at the commencement of the experiment. The treatments consisted of different green manure, organic manure and chemicals and their combinations (Table 1).

Table 1. Details of treatments – Yala 1993 and Yala 1994

Treatment	Application Rate
1. Walsuriyakantha (*Tithonia diversifolia*) (WS)	1kg/m^2
2. Walsuriyakantha + Cowdung (CD)	1kg +1kg/m^2
3. Sun hemp (*Crotalaria juncea* L.) (SH)	1kg/m^2
4. Sun hemp + Cowdung	1kg +1kg/m^2
5. Walsuriyakantha + CaO (CO) + Urea (U)	1kg +200 g + 20g/m^2
6. Sun hemp + CaO + Urea	1kg +200 g + 20g/m^2
7. Untreated control	-

Note: Method of application: Treatments 1-4 were applied to the furrows 7 days before planting and treatments 5 and 6 were applied to the furrows 14 days before planting whereas urea was incorporated at planting.

The experiment was done in a randomized complete block design with four replications. The plot size adopted was 3.0 x 2.5m. The recommended fertilizers @190kg/ha urea, 330kg/ha superphosphate and 190 kg/ha, mutriate of potash were applied as basal. Urea and Muriate of Potash were applied one month after planting as a top dressing mixture @ 190kg/ha and 196 kg/ha, respectively, one month after planting. Seed size (28-55mm) tubers of the potato variety 'Desiree' were planted at a spacing of 45 cm x 25 cm. All the plots were kept completely weed free. Hilling was done 4 weeks after planting. Supplementary irrigation was provided whenever necessary. The control of pests and diseases other than bacterial wilt was carried out as recommended by the Department of Agriculture.

Potato plants infected with bacterial wilt were counted at weekly intervals starting from emergence (two weeks after planting). Tuber weights of diseased and healthy plants were also recorded.

Experiment -2 Yala 1995, Yala 1996 and Yala 1997

Based on the findings from Experiment -1, Experiment-2 was designed with slight modification in the treatment structure as detailed in Table 2 and carried on a naturally bacterial wilt infested research field at the Regional Agricultural Research and Development Centre, Bandarawela during Yala 1995, Yala 1996 and Yala 1997 seasons. The other experimental details were the same as for Experiment-1.

Table 2. Details of treatments – Yala 1995, Yala 1996 and Yala 1997

Treatment	Application Rate
1. Walsuriyakantha (*Tithonia diversifolia*)	1kg/m^2
2. Walsuriyakantha + Cowdung	1kg +1kg/m^2
3. Walsuriyakantha + CaO+ Urea	1kg +200 g + 20g/m^2
4. Walsuriyakantha + Poultry manure (PM)	1kg +1kg/m^2
5. Untreated control	-

Note: Method of application: Treatments 1-2 and 4 were applied to the furrows 7 days before planting and treatment 3 was added to the furrows 14 days before planting whereas urea was incorporated at planting.

B. On-farm technology adaptation trials

An on-farm technology adaptation trial was conducted over two seasons (Yala 1995 and Yala 1996) in a naturally bacterial wilt infested farmer field at Binduunuwewa. The technology adaptation trial details were same as for Experiment-2.

RESULTS

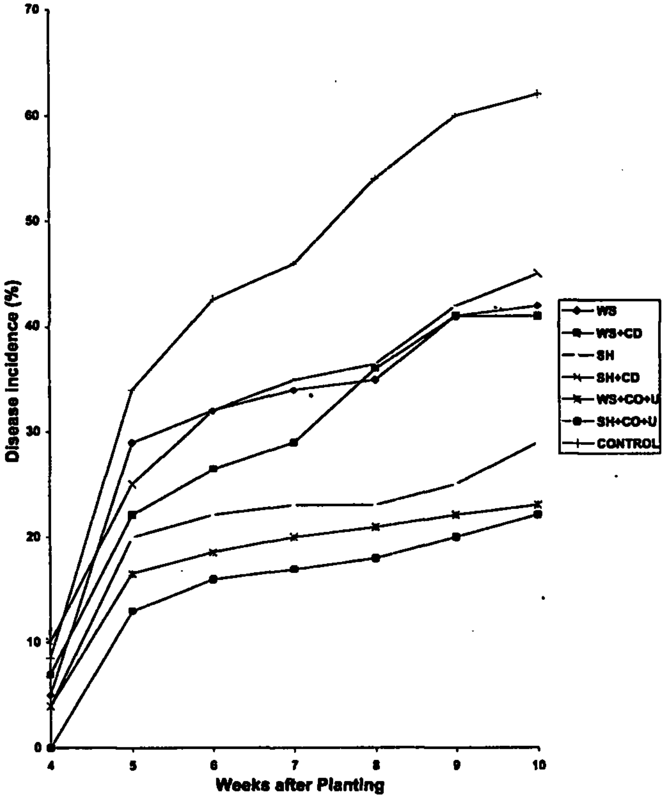
A. On-station research

Experiment- 1 Yala 1993 and Yala 1994

Untreated plants showed the highest percent wilting of 62% and 51% in 1993 Yala and 1994 Yala respectively. The disease incidence was drastically minimized by SH+CO+U treatment in 1993 Yala (22%) and 1994 Yala (18%) (Figs. 1 & 2). It was also evident that there was no significant difference in bacterial wilt suppression between the treatments WS+CO+U, SH and SH+CO+U in 1993 Yala. In 1994 Yala, treatment SH+CD showed a similar performance to the other three treatments WS+CO+U, SH and SH+CO+U. The treatments WS+CO+U, SH and SH+CO+U suppressed wilt incidence at 9 weeks after planting to 22-29% and 18-25% in 1993 Yala and 1994 Yala, respectively. It was evident that these treatments were more effective in bringing down the bacterial wilt disease incidence. Based on the above results, treatments that showed better bacterial wilt suppression were re-tested during Yala 1995, Yala 1996 and Yala 1997 in Experiment -2.

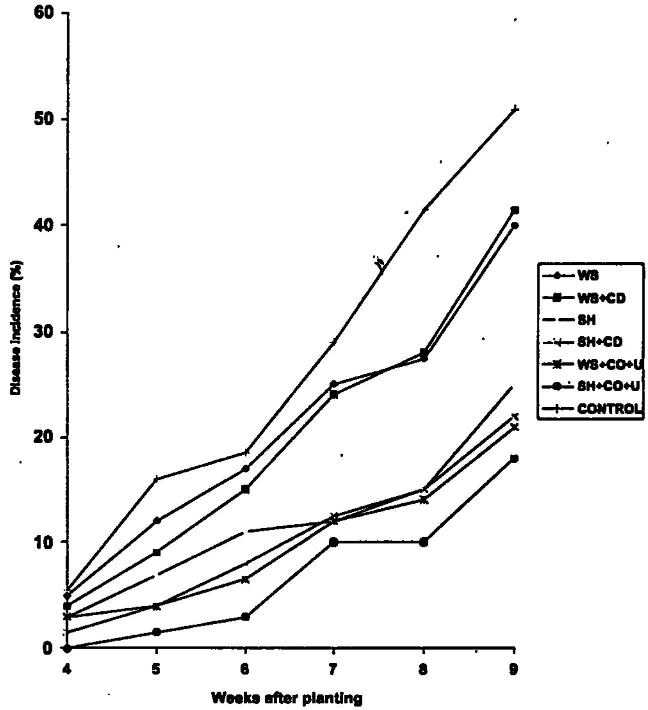
Experiment -2 Yala 1995, Yala 1996 and Yala 1997

Although results of Experiment -1 carried out in Yala 1993 and 1994 showed that combinations of SH+CO+U lowered the bacterial wilt incidence significantly, Sunhemp was not used in experiment -2 as the plant material was not readily available unlike Walsuriyakantha which is commonly available in this region. Untreated potato plants showed the highest wilt incidence of 38.5%, 35.7% and 40.5% in Yala 1995, Yala 1996 and Yala 1997 respectively (Table 3). Wilt incidence was very low under treatment WS+CO+U in Yala 1995 (10.3%), Yala 1996 (8.6%) and Yala 1997 (8.9%). There were no significant differences in bacterial wilt incidence among the other treatments (WS, WS+CD and WS+PM) the wilt incidence ranging from 10.3% to 15.2%, 8.6% to 12.6% and 8.9% to 13.5% in Yala 1995, Yala 1996 and Yala 1997 planting respectively. In all the seasons the treatments did not influence the tuber yield significantly (Table 3).



WS-Walsuriyakantha; CD-Cowdung; SH-Sunhemp; CO-Calcium Oxide; U-Urea

Fig. 1. The effect of green manure, organic manure and chemicals on the incidence of bacterial wilt (Yala, 1993) at Regional Agricultural Research & Development Centre, Bandarawela)



WS-Walsuriyakantha; CD-Cowdung; SH-Sunhemp; CO-Calcium Oxide; U-Urea

Fig. 2. The effect of green manure, organic manure and chemicals on the incidence of bacterial wilt (Yala, 1994) at Regional Agricultural Research & Development Centre, Bandarawela)

Table 3. Bacterial wilt disease incidence and tuber yield of different treatments at the Regional Agricultural Research & Development Centre, Bandarawela during Yala 1995, Yala 1996 and Yala 1997.

Treatment	Disease incidence (%)			Arc. Sin√ % transformation			Mean tuber yield (t/ha)		
	Yala 95	Yala 96	Yala 97	Yala 95	Yala 96	Yala 97	Yala 95	Yala 96	Yala 97
Walsuriyakantha	15.2	11.0	12.0	22.9	19.4	20.3	8.5	8.5	9.0
Walsuriyakantha + Cowdung	13.2	12.6	13.5	21.7	20.7	21.6	9.0	8.9	9.5
Walsuriyakantha + CaO + Urea	10.3	8.6	8.9	18.7	17.0	17.4	9.5	10.3	10.7
Walsuriyakantha + Walsuriyakantha + Poultry manure	12.5	9.3	10.5	20.7	17.8	18.9	9.2	10.5	10.3
Untreated control	38.8	35.7	40.5	38.4	36.7	39.5	7.3	7.5	7.0
LSD (P=0.05)				12.7	8.1	10.5	NS	NS	NS
CV(%)				13.2	14.5	12.5	12.7	13.5	13.0

B. On-farm technology adaptation trial

The treatments that showed better bacterial wilt suppression were tested over two seasons viz. 1995 Yala and 1996 Yala in the farmer fields which were naturally infested with bacterial wilt.

Untreated potato plants showed the highest wilt incidence of 30% and 35.5% in Yala 1995 and Yala 1996, respectively whereas WS+CO+U treated plants exhibited 9.2% and 8.7% in Yala 1995 and Yala 1996 , respectively (Table 4). There were no significant differences in bacterial wilt incidence among the other treatments tested (WS, WS+CD and WS+PM). The treatments did not significantly influence the tuber yields.

Table 4. Bacterial wilt disease incidence and tuber yields of different Treatments in farmer's field at Bindunuwewa-Yala 1995 and 1996

Treatment	Disease incidence (%)		Arc. Sin√ % transformation		Mean tuber yield (t/ha)	
	Yala 95	Yala 96	Yala 95	Yala 96	Yala 95	Yala 96
Walsuriyakantha	12.8	13.7	20.3	21.7	23.9	20.2
Walsuriyakantha + Cowdung	10.8	11.5	18.5	19.8	24.1	21.5
Walsuriyakantha + CaO + Urea	9.2	8.7	17.9	17.2	26.2	23.2
Walsuriyakantha + Poultry manure	10.5	10.0	18.4	18.9	24.3	22.2
Untreated control	30.0	35.5	31.2	36.5	14.5	16.3
LSD (P=0.05)			9.5	10.3	NS	NS
CV(%)			12.5	13.2	15.5	16.0

DISCUSSION

Sunhemp as a green manure reduced the bacterial population after 4 weeks of incubation at 2, 6 and 10% rates of incorporation. Inoculated plants wilted and died after the second week without amendment, but survival was 90% and 100% from 6% and 10% amendments (Hartman *et al.*, 1993).

CIP (1989 and 1990) also reported that amending with calcium oxide (2t/ha), urea (200kg/ha) and composted sugar cane bagasse (10t/ha) retarded the development of bacterial wilt in the field. Adding CaO or MgO at a rate of 5t/ha affected the survival of *Ralstonia solanacearum*, but decreased the pathogen population to an undetectable level only when combined with Urea (Michel *et al.*,1997). Urea alone did not reduce *Ralstonia solanacearum* in soil. A similar synergistic effect of CaO and urea was found by Elphinston and Aley (1993). The percentage of wilt of a susceptible potato line was lower when soil was amended with both components rather than with CaO or urea alone. Hsu and Chang (1989) reported that when different components of the S-H mixture were added to soil, only urea as a single component decreased the *Ralstonia solanacearum* population to an undetected level, but for this effect more time was needed than when the complete mixture was applied. When urea and mineral ash (with 44% CaO) were combined, the effect was the same as in the original S-H mixture. Based on all these statements, it appears that the most effective control of bacterial wilt is when urea and lime are applied together. The suppressive effect of the soil amendment on the *Ralstonia solanacearum* population was probably due to the generation of one or several toxic substances during the transformation of CaO in the presence of urea (Michel *et al.*, 1997).

The increase in total population of bacteria in green manure amended soil could be the contributing factor in suppressing *Ralstonia (Pseudomonas) solanacearum* (Schroth and Hancock, 1982; Bandara, 1984; Hsu and Chang, 1989, Kelaniyangoda 1992; French 1994).

Bacterial wilt disease could not be completely controlled by using green manure, organic manure and chemicals. However, from the on-station and on-farm research studies conducted during the period yala 1993 to Yala 1997, some green manure, organic manure and chemicals were identified as bacterial wilt *Ralstonia (Pseudomonas) solanacearum* suppressers. In particular, addition of Walsuriyakantha (*Tithonia diversiflola*) (10t/ha) + CaO (2t/ha)+ Urea (200 kg N/ha) or Walsuriyakantha (10t/ha) + Cowdung (10t/ha) or Walsuriyakantha (10t/ha) + Poultry manure (10t/ha) or Walsuriyakantha (10t/ha) alone could reduce the bacterial wilt [*Ralstonia (Pseudomonas) solanacearum*] incidence in the potato cultivation.

Although the tuber yield differences were not significant among the treatments which suppressed the bacterial wilt substantially in on-station and on-farm trials, the information generated in these studies is useful in seed potato programmes to produce disease-free seed materials under tropical environment.

CONCLUSIONS

Complete control of bacterial wilt [*Ralstonia (Pseudomonas) solanacearum*] disease in potato is difficult to achieve in the Bandarawela region (UCIZ). However, the results of the studies suggest that a substantial level of bacterial wilt suppression could be achieved through the soil amendments used in these studies.

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