RESEARCH ARTICLE

Development of Integrated Disease Management on Tip Over Disease, *Pectobacterium carotovorum* subsp. *carotovorum* of Banana Under Field Conditions

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ABSTRACT

Recently, the tip over disease, Pectobacterium carotovorum subsp. carotovorum (Erwinia carotovora) is causing havoc in banana growth and development in Karnataka. The experiment was conducted to develop the integrated disease management on tip over disease of banana in two different farmers plots at Sokanadagi village using seven treatment and Sunaga village using twelve treatments. At Sokanadagi village plot, after four drenches of bronopol @ 500 ppm + copper hydroxide @ 2gm/lit has given maximum height of 157.48 cm followed by streptocycline @ 500 ppm, bronopol @ 500 ppm and bronopol @ 500 ppm + Copper oxy chloride @ 3 gm/ lit showed 147.32 cm height each. Maximum numbers of suckers were found in T4 (5.66) followed by T5 (5.33) and T2 (5.00) respectively. T6 (Bronopol @ 500 ppm + Copper hydroxide @ 2gm/lit) with the per cent reduction was to 34.78, 44.73, 76.67 and 95.89 this was followed by T4 (Streptocycline @ 500 ppm + Copper hydroxide @ 2gm/lit) and per cent reduction was 30.43, 39.47, 65.60 respectively. Similarly at Sunaga village, after four drenches, the maximum height was observed in T2 (Streptocycline @ 500 ppm + Copper hydroxide @ 2 gm/lt.), T4 (Botanicals (Garlic, Kokum, Prosopis) @ 1: 5 concentrations) and T7 (Streptocycline @ 500 ppm + Copper oxy chloride @ 3 gm) followed by Botanicals recording 254.00cm. Maximum numbers of suckers were found in T10 and T11 (4.33) followed by T1, T2, T3, T5, T6, T7 and T9 (4.00) respectively. The per cent leaf infected was 50.00 before spray in T9 (Streptocycline @ 500 ppm + Copper hydroxide @ 2 gm) followed by Botanicals and it reduced to 35.55, 26.19, 24.07 and 15.81, this was followed by T2 (Streptocycline @ 500 ppm + Copper hydroxide @ 2 gm/lt) which recorded 33.33 before spray and it decreased to 33.33, 27.77, 23.16 and 17.46 after 1st, 2nd, 3rd and 4th spray respectively. The highest yield was observed in T3 treatment with a yield of 13.43 ton per hectare with the cost benefit ratio of 2.18 followed by T2 treatment which gave 13.00 ton per hectare with the cost benefit ratio of 2.08. Hence, the study indicates that the harmonious adoption of the different management practices would boost the yield and reduce the disease load in banana.

Keywords: *Pectobacterium carotovorum subsp. carotovorum, banana, development, integrated disease management.*

INTRODUCTION

Banana is the most important fruit crop commercially grown in a number of countries worldwide for its utilization as dessert and staple food. Among the fruit crops, it is one of the most important crops in international trade for earning the foreign exchange in many African countries. The diseases caused by fungi, bacteria and viruses are the major limiting factors in successful quality production of this crop and almost all the commercial cultivars of banana are highly susceptible to certain deadly diseases. Among the bacterial diseases, tip-over or bacterial rhizome rot of banana is gaining importance in recent years in Karnataka, earlier the disease was considered as of minor importance. Tip over of banana pathogen which was identified as *Pectobacterium carotovorum* subsp. *carotovorum* (*Erwinia carotovora*) is becoming major constraint for successful production of the crop in

many countries including India. Tip rot disease of banana was reported by Wardlaw (1950) with very destructive effects in Gross Michel banana plantations in Aguan valley, Republic of Honduras. Again in 1959, Stover reported that rhizome rot of banana was incited by *Pectobacterium carotovorum* (Jones) Waldee (syn. *Erwinia carotovora*) Jones. In India this disease was first time reported by Seshadri *et al*., 1965 in Tamil Nadu on Monthan and Pachanadan cultivars with the causal pathogen as *Erwinia carotovora* pv. *carotovora*. Many studies were carried out to manage this disease in field conditions using streptocycline in combination with copper oxy chloride [1-2, 8-13], streptocycline plus copper sulphate [3, 14-17]. Most of time the management practices of tip over disease is conducting by adopting the chemical methods, but this method is not suitable in long run. Hence, by looking into the importance of the disease an endeavour made to manage this disease by practing integrated disease management at field conditions.

MATERIALS AND METHODS

The study was conducted at two different locations in farmers fields one at Sokanadagi village (Bagalkot taluk and district) and another at Sunaga village (Bilagi taluk, Bagalkot district), Karnataka, India to evaluate suitable and effective chemical, bioagents and botanical for management of tip over disease. The treatments were fixed based on the effectiveness of the treatments under *in vitro* conditions. There were two set of treatments with three replications imposed at different plots. The treatments with combination of bioagents and botanicals with chemicals were imposed at Sunaga village and treatments with chemicals alone at Sokanadagi village, spraying of water served as control.

Multiplication of bio agents

Two effective liquid mother cultures were taken out in separate test tubes and gently open the cotton plug of the sterilized conical flask containing the prepared nutrient agar broth. One loop of each liquid mother culture of all four isolates were dissolved carefully into the liquid medium from the test tubes and immediately closed with the cotton plug. Inoculated flasks were kept for multiplication in the orbital shaker at 28±2°C at 200 rpm for 72 hour. After 24 hours the clear medium turned turbid. It was used for field application after diluting with water (100 ml to 10 liter of water such that it reached a population of 10^8 cfu /ml) [4, 18-20].

Extraction of plant extracts

Using 200 gms of *Allium sativum, Garcinia indica* and *Prosopis juliflora* were taken and washed in tap water, later rinsed in distilled water then added to the mixy jar and grinded in the ratio of 1:1. This mixture is kept overnight for the release of metabolites in to the solution, next day this grinded mixture was filtered using muslin cloth. About 5 times the dilution *i.e.,* one litre of water is added to the obtained solution to make volume of 1:5 and this diluted solution was sprayed to the plants in field.

Evaluation of different agrochemicals in field conditions and Development of the integrated disease management schedule

The chemicals, antibiotics, botanicals and bioagents were sprayed accordingly to the dosages mentioned in the treatment details, given chemical/ antibiotic solutions (Table 1). The study *viz.,* evaluation of different agrochemicals in field conditions was conducted in farmer's field at Sokanadagi village (Bagalkot taluk) from June 2015 to May 2016 on Grand Naine (G-9) variety of banana with seven treatments (Table 1) and Development of the integrated disease management schedule was conducted in farmers field at Sunaga village (Bilagi taluk) from July 2016 to June 2017 on Rajapuri variety with 12 treatments. The investigation was done to study the effectiveness of the chemicals, bioagents and botanicals against tip over disease of banana in field conditions. The treatment was fixed based on the effectiveness of the treatments under *in vitro* conditions. The treatments included with combination of bioagents and botanicals with chemicals, sprayed for three plants in each treatment at 15 days interval around the pseudostem of the plant and the treatment details are mentioned in the below table 1.

Table 1. Details of the treatment followed in farmer's field at Sunaga village, Bagalkot

SI No.	Treatment Details
1	T_1- Streptocycline @ 500ppm

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2	T_2- Streptocycline @ 500ppm + Copper hydroxide @ 2 gm/lt
3	T_3- Streptocycline @ 500ppm + Copper oxy chloride @ 3gm/lt
4	T_4- Botanicals (Garlic, Kokum, Prosopis) @ 1: 5 concentrations
5	T_5- Streptocycline @ 500ppm followed by Botanicals
6	T_6- Streptocycline @ 500ppm followed by Bioagents (PM 2A, BK-8) (10^{-6} CFU)
7	T_7- Streptocycline @ 500ppm + Copper oxy chloride @ 3gm followed by Botanicals
8	T_8- Streptocycline @ 500ppm + Copper oxy chloride @ 3gm followed by Bioagents
9	T_9- Streptocycline @ 500ppm + Copper hydroxide @ 2 gm followed by Botanicals
10	T_{10}- Streptocycline @ 500ppm + Copper hydroxide @ 2 gm followed by Bioagents
11	T_{11}-Bioagents (PM-2A, BK-8) (10^{-6} CFU)
12	T_{12}-Control (Water drench)

RESULTS AND DISCUSSION

Evaluation of effective agrochemicals in management of tip over disease of banana in farmers field at Sokanadagi village, Bagalkot

The experiment were conducted in farmers field at Sokanadagi village, Bagalkot Karnataka, the details of the experimental treatments are mentioned in Materials and Methods.

Plant height

The observations on plant height were taken to notice whether there is difference in height of the infected plants after the treatments. There was significant difference with respect to height thus influenced by treatments imposed. Before drenching all the treatments showed no significant and even after first spray also the height of the plants in all the treatments was same. After second spray and third sprays significant difference was recorded. All the treatments have shown good height of the plants except in the control plants which were without drench of the chemicals. In the second spray, T_2 and T_5 treatments have given better growth of 116.84 cm respectively. After four drenches results indicated that, treatment T_6 has given maximum height of 157.48 cm followed by T_1, T_2 and T_5 which recorded 147.32 cm respectively. The least growth was observed in T_7 treatment and it was used as control and it recorded 96.52 cm. Hence, there was significant difference found among treatments with respect to height of plants (Table 2.).

Number of suckers

With respect to number of suckers, from before drench to second drench there was no significant difference among the treatments. But in third and fourth drenches the number of suckers differed significantly when compared with the control treatment. All the treatments gave good and

Table 2. Effect of drench of chemicals on plant parameters against tip over disease of banana in farmers field at Sokanadagi, Bagalkot

Treatments	Parameters									
	Plant height (cm)					Number of Suckers				
	Before drench	First drench	Second drench	Third drench	Fourth drench	Before drench	First drench	Second drench	Third drench	Fourth drench
T_1	60.96	71.12	91.44	127.00	147.32	1.67	2.66	3.33	3.33	4.66
T_2	55.88	91.44	116.8	132.08	147.32	1.67	2.33	3.00	4.00	5.00
T_3	60.96	66.04	81.28	116.84	137.16	1.67	2.00	2.33	3.33	4.33
T_4	66.04	81.28	96.52	132.08	152.40	1.67	2.66	2.66	4.33	5.66
T_5	71.12	91.44	116.84	127.00	147.32	1.33	2.00	3.33	4.33	5.33
T_6	50.80	71.12	101.60	132.08	157.48	1.67	1.66	3.00	4.00	4.66
T_7	50.79	50.80	76.20	86.36	96.52	1.67	2.00	2.66	2.00	2.33
SEm±	9.14	8.73	8.94	5.97	5.81	0.31	0.24	0.40	0.47	0.41
CD @ 5 %	NS	NS	27.84	18.59	18.11	NS	NS	NS	1.47	1.27

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Table 3: Effect of chemicals on per cent leaf infection against the tip over disease of banana in farmers field at Sokanadagi, Bagalkot

Treatment details	Per cent leaf infection								
	Before drench	1st	% reduction	2nd	% reduction	3rd	% reduction	4th	% reduction
T_1- Streptocycline @ 500ppm	66.66 (59.98)*	69.44 (56.46)	-8.70	53.33 (46.90)	15.79	35.12 (36.20)	49.82	13.09 (19.27)	82.26
T_2- Bronopol @ 500 ppm	55.55 (48.22)	58.33 (49.98)	8.68	46.66 (58.06)	26.32	27.38 (31.02)	60.88	13.77 (21.36)	81.34
T_3- Streptocycline @ 500ppm + Blitox at 3 gm/ lit	50.00 (44.98)	77.77 (71.75)	-21.74	55.00 (48.05)	13.15	33.33 (35.15)	52.38	14.07 (21.65)	80.93
T_4- Streptocycline @ 500ppm + Kocide at 2gm/lit	55.55 (53.50)	44.44 (41.73)	30.43	38.33 (38.06)	39.47	24.08 (26.61)	65.60	6.36 (11.99)	91.38
T_5- Bronopol at 500 ppm + COC @ 3 gm/ lit	50.00 (44.98)	53.33 (46.90)	16.51	31.66 (33.84)	50.00	24.20 (29.14)	65.42	9.81 (18.22)	86.70
T_6- Bronopol at 500 ppm + COH @ 2gm/lit	61.11 (56.74)	41.66 (39.98)	34.78	35.00 (36.14)	44.73	16.33 (23.67)	76.67	3.03 (5.84)	95.89
T_7- Control (Water drench)	52.77 (51.74)	63.88 (58.23)	-21.05	63.33 (53.05)	-20.01	70.00 (57.26)	-32.65	73.80 (59.41)	-39.85
SEm±	11.99	11.38		7.95		5.15		4.62	
CD @ 5 %	NS	NS		NS		16.05		14.39	

*Values in the parenthesis are angular transformed values

Table 4: Effect of treatments on plant parameters against tip over disease of banana in farmers field at Sunaga, Bagalkot

Treatments	Growth parameters									
	Plant height (cm)					Number of Suckers				
	Before drench	First drench	Second drench	Third drench	Fourth drench	Before drench	First drench	Second drench	Third drench	Fourth drench
T_1	106.68	152.40	193.04	202.28	248.92	2.33	4.00	6.00	5.33	4.00
T_2	111.76	152.40	182.88	218.44	254.00	2.00	4.33	5.33	5.33	4.00
T_3	101.60	142.24	182.88	213.36	243.84	2.33	4.33	5.00	4.67	4.00
T_4	101.60	147.32	182.88	218.44	254.00	2.33	4.33	5.33	4.67	3.67
T_5	101.60	132.08	167.64	203.20	243.84	2.00	3.67	5.00	5.67	4.00
T_6	101.60	142.24	172.72	198.12	248.92	2.33	4.33	4.33	5.00	4.00
T_7	101.60	142.24	182.88	213.36	254.00	2.33	4.33	4.00	5.00	4.00
T_8	111.76	152.40	177.80	195.07	243.84	2.33	4.67	4.33	5.00	3.67
T_9	121.92	167.64	198.12	208.28	248.92	2.00	3.67	5.67	4.33	4.00
T_{10}	111.76	147.32	182.88	198.12	238.76	2.00	4.33	5.33	4.67	4.33
T_{11}	101.60	152.40	187.96	193.04	228.76	2.33	5.00	5.33	5.00	4.33
T_{12}	111.76	132.08	147.32	167.64	187.96	2.33	4.33	3.33	3.33	3.00
SEm±	9.97	8.78	8.98	8.66	8.21	0.36	0.42	0.54	0.64	0.36
CD @ 5 %	NA	NA	NA	25.58	24.24	NS	1.69	2.71	2.58	1.44

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Table 5: Effect of the treatments on per cent leaf infection against the tip over disease of banana at farmers field Sunaga, Bagalkot

Treatment details	Per cent leaf infection								
	Before spray	1st	% reduction	2nd	% reduction	3rd	% reduction	4th	% reduction
T_1	50.00 (44.98)*	43.33 (41.13)	-21.88	41.07 (39.83)	9.19	37.77 (37.89)	24.46	31.62 (34.20)	45.36
T_2	33.33 (35.25)	33.33 (35.25)	6.24	27.77 (31.74)	38.60	23.16 (28.71)	53.68	17.46 (24.61)	69.82
T_3	44.44 (41.73)	40.00 (39.21)	-12.51	32.14 (34.38)	28.94	27.40 (31.50)	45.20	24.47 (29.62)	57.71
T_4	63.88 (58.23)	39.52 (38.83)	-11.16	34.19 (35.57)	24.40	30.20 (33.30)	39.60	23.80 (29.18)	58.87
T_5	41.66 (39.98)	35.71 (36.52)	-0.45	34.72 (36.08)	23.24	29.09 (32.62)	41.82	22.52 (28.32)	61.08
T_6	61.11 (56.74)	46.19 (42.67)	-29.92	40.21 (39.30)	11.09	34.24 (35.78)	31.52	27.47 (31.55)	52.53
T_7	50.00 (44.98)	42.06 (40.37)	-18.31	36.11 (36.91)	20.16	31.51 (34.05)	36.98	24.06 (29.26)	58.42
T_8	36.11 (36.74)	33.96 (35.58)	4.47	34.19 (35.57)	24.40	33.53 (35.31)	32.94	27.03 (31.28)	53.29
T_9	50.00 (44.98)	35.55 (36.09)	0.00	26.19 (30.24)	42.09	24.07 (29.28)	51.86	15.81 (23.41)	72.68
T_{10}	36.11 (36.74)	31.74 (34.26)	10.71	32.40 (34.53)	28.36	29.09 (32.62)	41.82	23.71 (29.12)	59.03
T_{11}	44.44 (41.73)	40.00 (39.21)	-12.51	36.90 (37.24)	18.41	33.33 (35.05)	33.34	31.51 (33.83)	45.55
T_{12}	30.55 (33.49)	35.55 (36.57)	-16.36	45.23 (42.24)	-48.05	50.00 (44.98)	-63.66	57.87 (49.52	-89.42
SEm±	8.49	3.19		2.99		1.74		1.73	
CD @ 5 %	N/A	N/A		N/A		5.13		5.11	

*Values in the parenthesis are angular transformed values

Table 6: Benefit Cost ratio and incremental cost benefit ratio of the experimental plot 2 of Sunaga village, Bagalkot district

Treatments	Yield/ha (ton)	Incremental yield over control	Returns per ha	Incremental return over control	Treatment cost	Cost of cultivation	Total cost /ha	B:C	ICBR	Net returns
T_1	12.22	9803.33	464486.54	372526.54	50200.00	170000.00	220200.00	2.11	7.42	244286.50
T_2	13.00	13000.00	494000.00	402040.00	66626.66	170000.00	236626.66	2.08	7.41	257373.30
T_3	13.43	13433.33	510466.67	418506.67	64200.00	170000.00	234200.00	2.18	7.60	276266.70
T_4	12.24	12236.67	464993.33	373033.33	49133.33	170000.00	219133.33	2.12	9.46	245860.00
T_5	10.58	10576.67	401913.33	309953.33	99133.33	170000.00	269133.33	1.53	4.05	132780.00
T_6	9.83	9833.33	373666.54	281706.54	97891.66	170000.00	267891.66	1.40	3.81	105774.90
T_7	11.92	11920.00	452960.00	361000.00	113133.33	170000.00	283133.33	1.60	4.00	169826.70
T_8	11.24	11236.67	426993.33	335033.33	111891.66	170000.00	281891.66	1.51	3.81	145101.70
T_9	12.16	12163.33	462206.67	370246.67	115559.99	170000.00	285559.99	1.62	4.00	176646.70
T_{10}	11.46	11456.67	435353.33	343393.33	114318.32	170000.00	284318.32	1.53	3.80	151035.00
T_{11}	10.29	10286.67	390893.33	298933.33	48091.66	170000.00	218091.66	1.80	8.12	172801.70
T_{12}	2.42	2420.00	91960.00	0.00	0.00	170000.00	170000.00	0.54	0.00	-78040.00

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healthy suckers except in the control. Maximum numbers of suckers were found in T_4 (5.66) followed by T_5 (5.33) and T_2 (5.00) respectively. The least number of suckers were observed in T_7 (2.33) followed by T_3 (4.33) (Table 2.).

Percentage of leaf infection

The data on per cent leaves infection is presented in table 3 and results revealed that the treatments are found significantly different. The per cent reduction was recorded in T_6 (Bronopol @ 500 ppm + Copper hydroxide @ 2gm/lit) and the per cent reduction was 34.78, 44.73, 76.67 and 95.89 this was followed by T_4 (Streptocycline @ 500 ppm + Copper hydroxide @ 2gm/lit) and per cent reduction was 30.43, 39.47, 65.60 and 91.38 after 1st, 2nd, 3rd and 4th spray respectively. Similarly, in T_5 (Bronopol @ 500 ppm + Copper oxy chloride @ 3 gm/ lit) with the per cent reduction of 16.51, 50.00, 65.42 and 86.70 after each spray schedule. The per cent leaf infected was 61.11 before spray in T_6 (Bronopol @ 500 ppm + Copper hydroxide @ 2gm/lit) and reduced to 41.66, 35.00, 16.33 and 3.03 this was followed by T_4 (Streptocycline @ 500 ppm + Copper hydroxide @ 2gm/lit) which recorded 55.55 before spray and decreased to 44.44, 38.33, 24.08 and 6.36 after 1st, 2nd, 3rd and 4th sprays respectively. Similarly, in T_5 (Bronopol @ 500 ppm + Copper oxy chloride @ 3 gm/ lit) the per cent leaf infection before initiation of spray was 50.00 and reduced to 53.33, 31.66, 24.20 and 9.81 respectively after each spray schedule (Table 3).

Evaluation of effective bioagents, botanicals and agro-chemicals in management of tip over disease of banana in farmers field at Sunaga village, Bagalkot

Plant height

Treatments before, first and second drenches were showing no significant difference. But in third and fourth drench the effect of treatments showed significant difference. The maximum height was observed in T_2 (Streptocycline @ 500 ppm + Copper hydroxide @ 2 gm/lt.), T_4 (Botanicals (Garlic, Kokum, Prosopis) @ 1: 5 concentrations) and T_7 (Streptocycline @ 500 ppm + Copper oxy chloride @ 3 gm followed by Botanicals) recording 254.00cm. Observations on plant height were taken to notice whether there is difference in height of the infected plants after the treatments. Considerable difference in the height of plants was observed. Before drenching all the treatments showed no significant and even after first spray also the height of the plants in all the treatments was same. After second spray and third spray significant difference with respect to plant height was observed. All the treatments have shown good height of the plants except in the control plants which were without drench of the chemicals**.** The least growth was observed in T_{12} (control) treatment which was used as control by recording 187.96 cm followed by T_{11} Bioagents (PM-2A, BK-8) (10^{-6} CFU) recording 228.76 cm. Hence, there was significant difference in the height of plants as influenced by treatments (Table 4).

Number of suckers

With respect to number of suckers, from before drench there was no significant difference among the treatments. But from first, second, third and fourth drenches the number of suckers differed significantly when compared to the control treatment. All the treatments gave good and healthy suckers except in the control. Results revealed that, maximum numbers of suckers were found in T_{10} and T_{11} (4.33) followed by T_1, T_2, T_3, T_5, T_6, T_7 and T_9 (4.00) respectively. The least number of suckers were observed in T_{12} (2.33) followed by T_4 and T_8 (3.67) (Table 4).

Percentage of leaf infection

The per cent leaf infected was 50.00 before spray in T_9 (Streptocycline @ 500 ppm + Copper hydroxide @ 2 gm followed by Botanicals) and it reduced to 35.55, 26.19, 24.07 and 15.81, this was followed by T_2 (Streptocycline @ 500 ppm + Copper hydroxide @ 2 gm/lt) which recorded 33.33 before spray and it decreased to 33.33, 27.77, 23.16 and 17.46 after 1st, 2nd, 3rd and 4th spray respectively. Similarly, in T_5 (Streptocycline @ 500 ppm followed by Botanicals) the per cent leaf infection before initiation of spray was 41.66 and it reduced to 35.71, 34.72, 29.09 and 22.52 after each spray schedule (Table 5).

The highest per cent reduction (72.68%) was recorded in T_9 (Streptocycline @ 500 ppm + Copper hydroxide @ 2 gm followed by Botanicals) followed by T_2 (Streptocycline @ 500 ppm + Copper

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hydroxide @ 2 gm/lt) which reduced the leaf infection to 69.82 per cent and T_5 (Streptocycline @ 500 ppm followed by Botanicals) recorded 61.08 per cent reduction. The untreated control recorded -89.42 per cent reduction in the leaf infection after four sprays. Results revealed that the treatments were found significantly different (Table 5).

The Benefit Cost ratio has shown maximum (2.18) in T_3- Streptocycline @ 500ppm + Copper oxy chloride @ 3gm/lt recording 13.43 t/ha followed by T_4- Botanicals (Garlic, Kokum, Prosopis) @ 1: 5 concentrations (2.12) recording 12.24 t/ha and T_1- Streptocycline @ 500ppm (2.11) recording 12.22 t/ha (Table 6).

A greener alternative to the conventional use of chemicals is an attempt to promote natural, economic and sociological farming methods through the most effective combination of farming techniques and judicious and limited use of agro-chemicals. In other words, integrating all the available disease management approaches including cultural, biological and chemical control with the main objective to keep the disease incidence below economic threshold level. Chemical control implies the judicious and need based use of pesticides (fungicides, insecticides and herbicides). Chemical control is essential in areas where diseases appear in the early stage of plant growth and environmental conditions are likely to spread them fast. In case of biological management pathogen activity is reduced through the use of other living organisms *e.g*., hyper-parasites, resulting in a reduction of disease incidence and severity. Hence, an experiment on management of tip rot or rhizome rot was undertaken in famer's field.

Observations were taken with respect to plant height, number of suckers and per cent leaf infection. Effects of all the treatments were significant and gave the good results with respect to reduction in leaf infection. Among the treatments T_9 (Streptocycline @ 500 ppm + Copper hydroxide @ 2 gm followed by botanicals has given good results. The per cent leaf infected was 50.00 before spray in T_9 and it reduced the per cent infection to 35.55, 26.19, 24.07 and 15.81, this was followed by T_2 (Streptocycline @ 500 ppm + Copper hydroxide @ 2 gm/lt) which recorded 33.33 before spray and decreased to 33.33, 27.77, 23.16 and 17.46 after 1st, 2nd, 3rd and 4th spray respectively. Similarly, in T_5 (Streptocycline @ 500 ppm followed by botanicals) the per cent leaf infection before initiation of spray was 41.66 and it reduced to 35.71, 34.72, 29.09 and 22.52 after each spray schedule. Some other parameters were also taken as in literature it is said that the tip over affected banana plants remain dwarf and the infection can affect the emerging rhizomes. In the plot sprayed with only agrochemicals, before drenching all the treatments showed no significant effect and even after first spray also the height of the plants in all the treatments was not altered. After second spray and third spray there was significant difference with respect to plant height. All the treatments have shown increased height of the plants except in the control plants**.** After four drenches the results indicated that, treatment T_6 has given maximum height of 157.48 cm followed by T_1, T_2 and T_5 which recorded 147.32 cm respectively. In case of treatment T_6 (Bronopol @ 500 ppm + Copper hydroxide @ 2gm/lit) and the per cent disease reduction was 34.78, 44.73, 76.67 and 95.89.

The results obtained in another plot where treatments included botanicals, bioagents and chemicals have shown that, treatment T_2 (Streptocycline @ 500 ppm + Copper hydroxide @ 2 gm/lt.), T_4 (Botanicals (Garlic, Kokum, Prosopis) @ 1: 5 concentrations) and T_7 (Streptocycline @ 500 ppm + Copper oxy chloride @ 3 gm followed by Botanicals) have given better growth. With respect to number of suckers were equal in all the treatments. T_9 (Streptocycline @ 500 ppm + Copper hydroxide @ 2 gm followed by Botanicals) has given maximum per cent reduction (72.68%) in the per cent leaf infection. Similarly, three times drenching with streptocycline either alone or in combination with copper sulphate completely suppressed the disease (100%) and increased the yield by 143.37 per cent [2, 20-22]. Kannan *et al.* [5] reported that soil drenching of sodium hypochorite (0.5 g) and streptomycin sulphate (500 ppm) performed well and reduced the rhizome rot incidence. Similarly, Vijayalaxmi [1], who reported that drenching of streptocycline 500 ppm + copper oxychloride 3000 ppm) gave 61.94 per cent disease reduction over the control.

REFERENCES

[1] Vijayalaxmi, S. T., 2012, Studies on tip over

 http://dx.doi.org/10.53709/CHE.2020.v01i01.032

disease of banana caused by *Erwinia carotovora* subsp. *carotovora* (Jones) Holland and its management. *M. Sc. Thesis submitted to University of Agricultural Sciences, Dharwad*, pp. 63.

[2] Thiyagarajan, V., 2016, Investigations on tip over disease of banana caused by *Erwinia carotovora* sub sp. *carotovora* (Jones) Holland. *M. Sc. Thesis submitted to College of Agriculture, Raichur, Uni. Hortl. Sci., Raichur*.

[3] Nagaraj, M. S., Khan, A. N. A., Ravikumar, M. R., and Amarnanjundeswara, H, 2002, Management of tip over disease of banana. *Global Conference on Banana and Plantain, Bangalore, India*, p. 28-31.

[4] Vijayan, A. K., Chhetri, P., Gudade, B.A., 2013, Mass multiplication and use of bio-agents for disease management in large cardamom in Sikkim. *Life Sci. Leaf.,* 9:75-85.

[5] Kannan, R., Uma Sankareswari, C., Gopalakrishnan and Balamohan, T. N., 2006, Management of *Erwinia* rot in banana. Abstracts published *In*: *Nation*. *Semi*. *on Int*. *Prod*. *and Post-Harvest Mgmt*. *Tropical Fruits*, April 11-12, p. 59.

[6] Basim, H., Basim, E., Bakİ, D., & Turgut, A. (2019). Wet rot disease of banana (Musa sp.) caused by Pectobacterium carotovorum subsp. carotovorum in Turkey. *Canadian Journal of Plant Pathology*, *41*(2), 174-187.

[7] Nagaraj, M. S., Umashankar, N., & Palanna, K. B. (2013). Ecology and transmission of Erwinia carotovora subsp. carotovora causing tip-over disease of banana. *Environment and Ecology*, *31*(2A), 647-650.

[8] Blomme, G., Dita, M., Jacobsen, K. S., Pérez Vicente, L., Molina, A., Ocimati, W., ... & Prior, P. (2017). Bacterial diseases of bananas and enset: current state of knowledge and integrated approaches toward sustainable management. *Frontiers in plant science*, 1290.

[9] Totagi, S., Reena, R., Roopa, R. S., & Shamarao, J. (2014). Studies on host-range of tip-over disease of banana caused by Erwinia carotovora subsp. carotovora. *International Journal of Plant Protection*, *7*(1), 270-271.

[10] Mansfield, J., Genin, S., Magori, S., Citovsky, V., Sriariyanum, M., Ronald, P., ... & Foster, G. D. (2012). Top 10 plant pathogenic bacteria in molecular plant pathology. *Molecular plant pathology*, *13*(6), 614-629.

[11] Cui, W., He, P., Munir, S., He, P., Li, X., Li, Y., ... & He, Y. (2019). Efficacy of plant growth promoting bacteria Bacillus amyloliquefaciens B9601-Y2 for biocontrol of southern corn leaf blight. *Biological Control*, *139*, 104080.

[12] Potrykus, M., Golanowska, M., Sledz, W., Zoledowska, S., Motyka, A., Kolodziejska, A., ... & Lojkowska, E. (2016). Biodiversity of Dickeya spp. isolated from potato plants and water sources in temperate climate. *Plant Disease*, *100*(2), 408-417.

[13] Fira, D., Dimkić, I., Berić, T., Lozo, J., & Stanković, S. (2018). Biological control of plant pathogens by Bacillus species. *Journal of biotechnology*, *285*, 44-55.

[14] Yishay, M., Burdman, S., Valverde, A., Luzzatto, T., Ophir, R., & Yedidia, I. (2008). Differential pathogenicity and genetic diversity among Pectobacterium carotovorum ssp. carotovorum isolates from monocot and dicot hosts support early genomic divergence within this taxon. *Environmental Microbiology*, *10*(10), 2746-2759.

[15] Solanki, M. K., Malviya, M. K., & Wang, Z. (2016). Actinomycetes bio-inoculants: A modern prospectus for plant disease management. In *Plant growth promoting actinobacteria* (pp. 63-81). Springer, Singapore.

[16] Tsror, L., Hélias, V., Mordechai-Lebiush, S., Erlich, O., Hazanovsky, M., Chalupowicz, L., ... & Manulis-Sasson, S. (2021). Characterization of Pectobacterium brasiliense strains from potato and vegetables in Israel. *Plant Pathology*, *70*(9), 2179-2187.

[17] Rodriguez, G. (2007). *Micropropagation of wasabi (Wasabia japonica) and identification of pathogens affecting plant growth and quality* (Doctoral dissertation, Dept. of Biological Sciences-Simon Fraser University).

[18] Latha, P., Karthikeyan, M., & Rajeswari, E. (2019). Endophytic bacteria: prospects and applications for the plant disease management. In *Plant health under biotic stress* (pp. 1-50). Springer, Singapore.

[19] Rizvi, A., Zaidi, A., Khan, M., Saif, S., Ahmed, B., & Shahid, M. (2017). Growth improvement and management of vegetable diseases by plant growth-promoting rhizobacteria. In *Microbial strategies for vegetable production* (pp. 99-123). Springer, Cham.

http://dx.doi.org/10.53709/CHE.2020.v01i01.032

[20] Köberl, M., Ramadan, E. M., Roßmann, B., Staver, C., Fürnkranz, M., Lukesch, B., ... & Berg, G. (2011). Using ecological knowledge and molecular tools to develop effective and safe biocontrol strategies. *Pesticides in the Modern World—Pests Control and Pesticides Exposure and Toxicity Assessment*, 3-26.

[21] Grenier, A. M., Duport, G., Pages, S., Condemine, G., & Rahbé, Y. (2006). The phytopathogen Dickeya dadantii (Erwinia chrysanthemi 3937) is a pathogen of the pea aphid. *Applied and Environmental Microbiology*, *72*(3), 1956-1965.

[22] Dayou, O., Mwangi, M., Egesa, A. O., Muteti, P. M., & Chumba, C. I. (2018). Application of molecular and biotechnological techniques in plant disease management: A review. *African Journal of Biotechnology*, *17*(31), 938-948.

http://dx.doi.org/10.53709/CHE.2020.v01i01.032