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INTEGRATED MANAGEMENT OF WILT COMPLEX INVOLVING *MELOIDOGYNE INCOGNITA* AND *RALSTONIA SOLANACEARUM* ON BRINJAL (*SOLANUM MELONGENA* L.)

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ABSTRACT
An experiment was conducted in the farm of the Department of Plant Pathology, GKVK, Bangalore to test the effect of different treatments on management of wilt complex of brinjal under local conditions. Among different treatments tested Integration of mustard as an intercrop, streptocycline and COC were found superior against *Meloidogyne incognita* and *Ralstonia solanacearum* wilt complex in brinjal under field conditions. Among the treatments tested to manage wilt complex under field condition, mustard intercrop + streptocycline @ 0.5 g/lit + COC 50% WP (1g/lit) reduced bacterial wilt incidence (23.35%). It recorded 63.33 galls/root system which accounted to 72.54 per cent reduction over control and recorded an yield of 1.92 kg/25 m^2 followed by mustard intercrop + *P. fluorescens* @ 20g/m^2 (1×10^8) which was effective in reducing wilt by 28.35 per cent. It recorded 51.66 galls/root systems which accounted to 77.60 per cent reduction over control and recorded yield of 1.78 kg/ 25 m^2.

INTRODUCTION

Brinjal (*Solanum melongena* L.; 2n = 24) belong to the Solanaceae family, are native to the South East Asian region and were first domesticated there over 4000 years ago. It is one of the most important vegetables worldwide, with a global production 431.74 lakh tones and 17.28 lakh ha area harvested, in 2010-11. India ranked second in brinjal production. In India Brinjal ranked third in vegetable crops in terms of production (118.96 lakh tones) and area harvested (6.8 lakh ha), respectively in the year 2010-11 (Anonymous 2011). Brinjal is rich in antioxidant compounds and have hepatoprotective properties (Bhat *et al.*, 2013).

Bacterial wilt of brinjal caused by *Ralstonia solanacearum* is prominent diseases and could cause yield loss up to 80 per cent (Rao *et al.*, 1975). It has been proved that root knot nematode facilitates entry and establishment of pathogenic fungi and bacteria (Powell, 1971). In recent years, the disease complex due to *M. incognita* and *R. solanacearum* has been gaining economic importance in brinjal cultivation (Ravichandra *et al.*, 1990). The main aim of this study was to identify the efficacy of different treatments on wilt complex under field condition.

MATERIALS AND METHODS

The experiment was conducted at *M. incognita* and *R. solanacearum* infested sick plot of AICRP (N), ZARS, University of Agricultural Sciences, GKVK, Bengaluru. Initial population of second stage juvenile (J2) of *M. incognita* and population of *R. solanacearum* in the experimental field were determined from six random soil samples. This experimental plot was divided into microplots of 2×2 m^2 size. Seedlings of brinjal cultivar Arka Shirish (susceptible to both pathogen) were raised separately in healthy plot. Following treatments were imposed. Mustard seeds were sown in between furrows one week before transplanting of seedlings, neem cake was applied 15 days before transplanting. *P. fluorscens* and *T. viride* were applied before one week of transplanting. 16.6 g of carbofuran was applied to 1 m^2 of designated microplots in furrows and mixed well with the soil before one week after transplanting of brinjal seedlings. Streptocycline 0.5g/L, COC 50%WP (1g/L) were drenched in the standing crop one week after transplanting. The plot without any component was designated as control. Carbofuran 3G was maintained as standard check. Ranomized complete block design was employed with three replications for each treatment (Hussain and Bora, 2008).

Treatments

T_1 = Mustard as an intercrop

T_2 = *Pseudomonas fluorescens* @ 20g/m^2 (1×10^8 cfu/ g of soil)

T_3 = *Trichoderma viridae* @ 20g/m^2 (2×10^6 cfu/g of soil)

T_4 = Neem cake (100 g/ m^2)

T_5 = Streptocycline (0.5 g/ L)

T_6 = Mustard intercrop + *Pseudomonas fluorescens* @ 20g/ m^2 (1×10^8 cfu/g of soil)

T_7 = Mustard intercrop + *Trichoderma viridae* @ 20g/m^2

(2×10^6 cfu/g of soil)

T_8 = *Trichoderma viridae* @ 20g/m² (2×10^6 cfu/g of soil) + Neem cake in seed bed @ 100 g/m²

T_9 = Mustard intercrop + Streptocycline 0.5 g/ liter + COC 50%WP (1g/L)

T_{10} = Carbofuran 16.6 g/m²

T_{11} = Streptocycline 0.5g/L + COC 50%WP (1g/L

T_{12} = Control

RESULTS AND DISCUSSION

Data on Table 1 revealed that Integrated management of *M. incognita* and *R. solanacearum* complex in brinjal under field condition revealed that all the treatments were effective in managing wilt complex in brinjal. However, Mustard intercrop + streptocycline @ 0.5 g/lit + COC 50% WP (1g/L) recorded minimum wilt (23.35 %) and bacterial population in soil (0.20×10^3) followed by mustard + *P. fluorescens* @ 20g/m² recorded 28.35 per cent wilt and 0.6×10^3 bacterial population in soil. Maximum wilt was recorded in control plot (88.35 %) which recorded 2.81×10^6 bacterial population. This might be due to the combined action of the treatments applied to manage the disease complex as noticed by Dutta and Verma by 1969. Vanita *et al.* (2009) reported that seed treatment with *P. fluorscens* controlled bacterial wilt incidence in tomato under green house condition. *P. fluorescens* might be inducing systemic resistance or antagonism against *R. solanacearum*.

Effect of treatment on nematode

The number of galls and egg masses were reduced significantly in all the treatments over control (Table 1). Carbofuran recorded least galls per root system (22.66) followed by mustard intercrop + *Pseudomonas fluorscens* (51.66) and mustard intercrop + *Trichoderma viride* (61.00). Similar results were also reported by Rangaswamy *et al.* (2000), who observed highest egg parasitisation of *M. incognita* when neem cake was integrated with *T. harzianum*.

Final nematode population of *M. incognita* both in soil and roots decreased in all the treatments over control. The maximum reduction was observed in carbofuran in 200 cc of soil (110.33) and in 5 g of root (49.33) followed by mustard + *P. fluorscens* in 200 cc of soil (160) and 87.33 in 5 g of root (Table 1). Liza Barua and Bora, (2009) reported that the highest reduction of *Meloidogyne incognita* and *Ralstonia solanacearum* population in soil was observed in combined application of *T. harzianum* and *P. fluorescens* when applied against the complex. *P. fluorescens* was proved to be more promising followed by *T. harzinum* in suppressing the population of *R. solanacearum*. *P. fluorscens* was capable of producing HCN and antibiotics with antibacterial and antifungal activities. *T. harzianum* could inhibit the growth of *R. solanacearum* by production of some diffusible substances and overcrowding the pathogen.

Effect of treatment on plant growth and yield

Plant height, shoot and root weight (Fresh and Dry) and yield data are presented in Table 2. All the individual treatments recorded better height than the control. However, in all the

Table 1: Effect of various treatments on wilt incidence, *M. incognita* and *R. solanacearum* populations in brinjal cv. Arka Shirish infested by *M. incognita* and *R. solanacearum* under field condition

Sl No.	Treatments	% wilt incidence	% decrease over control	No. of galls/ root system	Root-knot index	% decrease over control	Final nematode population				Final bacterial population (cfu/ g soil)
							200 cc soil	% reduction over control	5 g of roots	% reduction over control	
1	Mustard	85.00	3.79	120.66(11.00)*	5	47.69	184.33(13.57)	54.49	96.00(9.79)	71.40	2.63×10^6
2	*P. fluorescens*	38.25	56.71	160.33(12.68)	5	30.49	176.67(13.29)	56.38	115.67(10.75)	65.54	0.66×10^3
3	*T. viride*	45.00	49.07	83.00(9.13)	4	64.02	198.33(14.08)	51.03	131.33(11.45)	60.88	1.20×10^4
4	Neem cake	80.00	9.45	177.00(13.32)	5	23.27	221.00(14.8)	45.43	180.33(13.42)	46.28	0.33×10^5
5	Streptocycline	36.65	58.52	192.66(13.89)	5	16.48	376.33(19.39)	7.08	234.33(15.30)	30.20	0.30×10^3
6	Mustard + *P. fluorscens*	28.35	67.91	51.66(7.22)	4	77.60	160.00(12.64)	60.49	87.33(9.34)	73.98	0.6×10^3
7	Mustard + *T. viride*	35.00	60.38	61.00(7.84)	4	73.56	167.67(12.94)	58.60	90.00(9.48)	73.19	1.29×10^4
8	*T. viride* + Neem cake	41.65	52.86	70.33(8.41)	4	69.51	171.33(13.08)	57.70	143.67(11.98)	57.20	2×10^3
9	Mustard + Streptocycline + COC	23.35	73.57	63.33(7.98)	4	72.54	168.33(12.97)	58.44	106.66(10.29)	68.24	0.20×10^3
10	Carbofuran	76.65	13.24	22.66(4.81)	3	90.17	110.33(10.50)	72.76	49.33(7.02)	85.30	2.42×10^6
11	Streptocycline +COC	26.65	69.84	170.33(13.05)	5	26.16	359.33(18.95)	11.28	286.33(16.92)	14.71	0.24×10^3
12	Control	88.35	0.00	230.66(15.18)	5	0.00	405.00(20.12)	0.00	335.67(18.32)	0.00	2.81×10^6
	SEM±	0.345		2.131		2.390		1.923			
	CD@ 5%	1.014		6.252		7.012		5.642			
	CV%	5.16		33.786		0.202		0.276			

*Square root transformed value; Initial population of *M. incognita* : 380/200 cc soil; Initial population of *R. solanacearum* : 2×10^6 cfu/g soil

Table 2: Effect of various treatments on growth, development and yield of brinjal cv. Arka Shirish infested by *M. incognita* and *R. solanacearum* under field condition

Treatments	Plant height (cm)			Shoot weight (g)		Root weight (g)		Yield(Kg/ plot)(25 m²)	Yield(Kg/ ha)	% increase over control
	30 days	60 days	90 days	Fresh	Dry	Fresh	Dry			
1.Mustard	22.47(4.74)*	28.77(5.36)	34.23(5.85)	25.66(5.06)	12.37(3.51	9.13(3.02)	4.24(2.05)	0.81	342	10.96
2. *Pseudomonas fluorescens*	24.76(4.97)	30.73(5.54)	38.37(6.19)	30.20(5.49)	14.49(3.80)	11.58(3.40)	5.57(1.60)	1.23	492	68.95
3. *Trichoderma viride*	26.47(5.11)	33.57(5.79)	39.97(6.32)	33.47(5.58)	15.73(3.90)	12.67(3.55)	6.06(2.46)	1.31	524	79.91
4. Neem cake	21.87(4.67)	27.27(5.22)	32.73(5.72)	24.57(4.95)	12.31(3.50)	8.51(2.91)	4.95(2.22)	0.99	396	36.07
5.Streptocycline	28.33(5.32)	35.57(5.96)	42.80(6.54)	36.10(6.00)	17.32(4.16)	13.27(3.64)	6.25(2.5)	1.33	532	82.65
6. Mustard + *P.fluorscens*	42.25(6.50)	49.33(7.02)	55.70(7.46)	45.40(6.73)	20.15(4.48)	19.07(4.36)	8.66(2.94)	1.78	712	144.29
7. Mustard + *T. viride*	32.53(5.70)	39.87(6.31)	47.67(6.90)	39.57(6.29)	18.74(4.30)	14.68(3.83)	6.91(2.63)	1.67	668	128.77
8. *T. viride* + Neem cake	39.40(6.27)	46.13(6.79)	50.23(7.08)	41.93(6.47)	19.59(4.42)	17.56(4.19)	7.95(2.81)	1.41	564	93.61
9. Mustard+ Streptocycline + COC	41.38(6.42)	48.30(6.94)	54.57(7.38)	44.20(6.64)	21.32(4.61)	18.91(4.34)	8.41(2.90)	1.92	768	163.47
10. Carbofuran	31.87(5.64)	38.50(6.20)	43.43(6.59)	35.37(5.97)	16.23(4.02)	13.10(3.61)	6.10(2.46)	1.10	440	50.68
11.Streptocycline +COC	35.83(5.98)	42.47(6.51)	47.63(6.90)	38.60(6.21)	18.21(4.26)	15.31(3.91)	7.24(2.69)	1.50	600	105.48
12. Control	21.90(4.67)	25.47(5.04)	29.13(5.39)	24.03(4.90)	11.00(3.31)	8.49(2.91)	3.94(1.98)	0.73	292	0.46
SEM±	0.147	0.233	0.291	0.121	0.123	0.079	0.032	0.014	0.488	
CD@ 5%	0.432	0.685	0.854	0.355	0.361	0.233	0.095	0.041	1.667	
CV%	1.830	1.089	1.171	0.600	1.296	1.017	0.888	0.235	0.166	

Initial population of *M. incognita* : 380/200 cc soil; Initial population of *R. solanacearum* : 2 × 10^6 cfu/g soil; *values in parenthesis are square root transformed

cases mustard intercrop and *P. fluorscens* recorded maximum plant height (55.70 cm) followed by mustard intercrop + streptocycline + COC (54.57) and mustard intercrop + *T. viride* (47.67 cm) which is on par with streptocycline + COC (47.63 cm).

In general, it was observed that the plants receiving mustard intercrop and *P. fluorscens* recorded highest fresh shoot and dry weight of 45.40, 20.15 g followed by mustard intercrop + streptocycline + COC (44.20 g, 21.32 g) and *T. viride* + neem cake (41.93 g, 19.59 g). The least shoot weights were noticed in neem cake (24.57, 11.0 g) and control recorded fresh and dry weight of 24.03, 12.31 g respectively.

It was observed that the plot receiving mustard intercrop and *P. fluorscens* recorded highest fresh root (19.07 g) and dry (8.66 g) weight followed by mustard intercrop + streptocycline + COC (18.91, 8.41g) and *T. viride* + neem cake (17.56, 7.95 g). However least fresh and dry root weight was recorded in neem cake (8.51, 4.95g) which is on par with control (8.49, 3.94 g).

All the treatments increased yield (Table 2) significantly compared to the control. Mustard intercrop + streptocycline + COC recorded highest fruits yield (1.92 kg/plant) and yield was 163.47 per cent increase over control (0.73 kg/plant). The treatment mustard intercrop and *P. fluorscens* recorded 1.78 kg/plant followed by mustard + *T. viride* (1.67 kg/plant) (Table 2). Whereas least yield was recorded in mustard (0.81 kg/plant). The present results are supported by the work done by Zakir Hussain and Bora, 2008, who reported that integration of summer ploughing, half recommended dose each of carbofuran 3G, neem cake, streptocycline and full dose of *Trichoderma harzianum* were found superior treatments against *Meloidogyne incognita* and *Ralstonia solanacearum* complex in brinjal under field conditions The treatment effectively improved all the plant growth parameters and yield of the crop with corresponding decrease in the nematode reproductive rate. The treatment also produced minimum final bacterial population in the soil along with less percent wilt incidence. This might be due to the multiple actions of all these components.

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