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MANAGEMENT OF CITRUS GUMMOSIS CAUSED BY *Phytophthora* SPP.

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ABSTRACT
Citrus is the most extensively produced tree fruit crop in the world. Citrus species are essentially diploid and were domesticated in Southeast Asia several thousand years ago and then spread throughout the world. Citrus sp. are susceptible to a number of destructive diseases that are continuously emerging and which can severely limit production or totally decimate the industries of the country. Among these citrus gummosis is one of the most important biotic constraints in the country. This study was conducted with the objective for management of citrus gummosis (.). The study of two year trial suggested that pasting the stem with metalaxyl MZ 68% WP (50 g/litre) followed by drenching of fenamidone 10% + mancozeb 50% WG, 0.2% (10 litre/ tree) twice *i.e.* first at onset of monsoon and second at one month after first application found effective for management of citrus gummosis.

INTRODUCTION

Citrus is one of the most important tropical fruit crops of the world with a very wide production area. Most of the cultivated citrus species are part of the Citrus genus containing, depending on the taxonomist, between 16 and 156 species. It is generally grown under both tropical and subtropical climatic conditions in the plains and up to 1200 MSL. In India, it is commercially cultivated in the states of Maharastra, Andra Pradesh, Karnataka, Tamil Nadu, Gujarat and Bihar. In Tamil Nadu, it is widely cultivated under rainfed and irrigated conditions in the districts of Dindigul, Trichy, Tirunelveli, Virudhunagar, Ramanathapuram, Madurai, Theni *etc.*, in anarea about 1,060 ha with a production of about 4,400 tonnesper annumAmong its pathogens, the Oomycete Phytophthora represents one of the most serious threats to production. Although 10 species have been reported from diseased trees around the world, three species cause the most serious disease, stem gummosis, as well as root and fruit rot: Phytophthora citrophthora, P. nicotianae (syn P. parasitica) and P. palmivora (Erwin and Ribeiro, 1996; Graham and Menge, 1999). Gummosis has a worldwide distribution and is responsible for 10% to 30% of losses in citrus cultured around the world (Timmer *et al.*, 1998). In Central India, 20 per cent yield losses to the citrus industry were recorded by Naqvi (2003). The prevalence of gummosis to a tune of 9.3-45.3% was noticed in Punjab (Thind and Sharma, 1996). Phytophthora root rot, foot rot, and gummosis may cause tree decline and in severe cases even tree are wilted and their death takes place (Graham and Menge, 1999). The general practices to manage this disease are bud union 30-45 cm above the base and soil level at the time of planting, stem painting with Bordeaux paste up to 70 cm and spray with Fosetyl-Al or metalaxyl (Javed *et al.*, 2007).The disease can also be managed by use of resistant rootstocks (Matheron *et al.*, 1998). Several formulations of metalaxyl based fungicides (Ridomil MZ, Matco M-8) are used by citrus growers to control foot rot and gummosis which is a serious disease throughout India. Gade (2012) tested three rootstocks against foot rot and found that Cleopatra and Rough lemon more susceptible than Rangpur lime. Phytophthora spp. are known to develop resistance to metalaxyl after its repeated use (Gisi *et al.*, 1997; Timmer *et al.*, 1998).The present paper deals with the management of citrus gummosis caused by phytophthora spp.

MATERIALS AND METHODS

The experiment was conducted at Horticulture Farm, AAU, Anandduring year 2016 to 2018. One plant of 20 years old age selected as a replication following plant-to-plant spacing of 6m × 6m by adopting completely randomized design with four replication. First application of treatments were given at the onset of monsoon, *i.e.* second fortnight of June, second application was after one month of first application.

Method of application

Bordeaux paste (1 Kg copper sulphate +1 Kg lime +10 lit water) and metalaxyl MZ 68 WP (Metalaxyl-M 4% + Mancozeb 64%) (50 g/lit) were pasted on Phytophthora infected trunk up to 90 cm from ground level. Drenching of respective fungicide was given up to 10 lit/tree. Talc based formulation of 1% WP of (2 x 108 cfu/gm) of Trichoderma viride enriched FYM (10 gm T. viride/kg FYM) @ 10 kg/plant applied in feeder root zone. Untreated infected trees were

maintained as control/check. Phytophthora lesion size was recorded before and after the application of the fungicides up to two months with 15 days interval. Two assessment were made for each stem and these values were averaged Lesion area (Length X Width) was determined by measurement of discoloured tissue on stem and value were obtained from each plant.

RESULTS AND DISCUSSION

The result of first year-2016 suggested that all the treatments (Table 1) recorded significantly minimum size of lesion as compared to control. During first application of treatments, minimum lesion size (110.04 cm2) found in treatment T8 i.e. stem pasting with metalaxyl MZ 68 WP + drenching of fenamidone 10% + mancozeb 50% WG and was at par with treatment T6 *i.e.* stem pasting with metalaxyl MZ 68 WP + drenching of metalaxyl MZ 68 WP. After 2nd application, the minimum lesion size 67.57cm2 was found in treatment T8 i.e. stem pasting with metalaxyl MZ 68 WP + drenching with fenamidone 10% + mancozeb 50% WG than the rest of other treatments. Pooled data over period and fungicidal application revealed the minimum lesion size of (87.61 cm2) found in treatment T8 *i.e.* stem pasting with metalaxyl MZ 68 WP + drenching of fenamidone 10% + mancozeb 50% WG. The next best treatment in order of merit was treatment T6 *i.e.* stem pasting with metalaxyl MZ 68 WP + drenching of metalaxyl MZ 68 WP, (99.40 cm2) lesion size.

The result of second year-2017 suggested that the data on lesion size (cm2) (Table 2) revealed that all the treatments recorded significantly decresed in size of lesion as compare to control. The data of pooled over periods revealed the minimum lesion size (145.43 cm2) in treatment T8 *i.e.* stem pasting with metalaxyl MZ 68 WP + drenching of fenamidone 10% + mancozeb 50% WG in comparison to rest of treatments and was at par with treatment T6 *i.e.* Stem pasting with metalaxyl MZ 68 WP + drenching of metalaxyl MZ 68 WP (154.50 cm2) and treatment T7 *i.e.* stem pasting with metalaxyl MZ 68 WP + drenching of fosetyl A-L (161.81 cm2) after the first application. Durind the second application, data of pooled over period found that the minimum lesion size (101.91cm2) was found in treatment T8 *i.e.* stem pasting with

Table1: Effect of fungicide on lesion size due to citrus gummosis during first year.

Treatments	Lesion size (cm2) 1st application				2nd application			Pooled overperiod and appli cation	Recovery in lesion size comp are to bef ore appli cation
	Before Spray	15 DAA	30 DAA	Pooled	15 DAA	30 DAA	Pooled		
T1	11.92a	11.54ab	11.34bcd	11.44bc	10.70cd	9.73c	10.21cd	10.82cd	17.6
	-142.09	-133.17	-128.6	-130.87	-114.49	-94.67	-104.24	-117.07	
T2	11.67a	11.57ab	11.46bc	11.51bc	10.84cd	9.87c	10.35cd	10.93cd	12.4
	-136.19	-133.86	-131.33	-132.48	-117.51	-97.42	-107.12	-119.46	
T3	11.67a	11.76ab	11.56abc	11.65bc	11.16bc	10.12c	10.64c	11.15c	8.82
	-136.19	-138.3	-133.65	-135.72	-124.55	-102.41	-113.21	-124.32	
T4	11.77a	11.52 ab	10.97bcde	11.24bcd	10.45cde	9.31cd	9.88de	10.56de	19.56
	-138.53	-132.71	-120.34	-126.34	-109.2	-86.68	-97.61	-111.51	
T5	11.80a	11.74 ab	11.89ab	11.81ab	11.88b	12.01b	11.95b	11.88b	0
	-139.24	-137.83	-141.37	-139.48	-141.13	-144.24	-142.8	-141.13	
T6	11.92a	11.25bc	10.46de	10.85de	9.83ef	8.32e	9.08f	9.97f	30.04
	-142.09	-126.56	-109.41	-117.72	-96.63	-69.22	-82.45	-99.4	
T7	11.75a	11.46abc	10.82cde	11.13cd	10.07de	8.62de	9.35ef	10.24ef	24.04
	-138.06	-131.33	-117.07	-123.88	-101.4	-74.3	-87.42	-104.86	
T8	11.58a	10.78c	10.23e	10.49e	9.19f	7.25f	8.22g	9.36g	34.62
	-134.01	-116.21	-104.65	-110.04	-84.46	-52.56	-67.57	-87.61	
T9	11.83a	12.11a	12.49a	12.30a	12.89a	13.39a	13.15a	12.73a	—
	-139.95	-146.65	-156	-151.29	-166.15	-179.29	-172.92	-162.05	
S. Em.± Treatment (T)	0.91	0.23	0.28	0.18	0.26	0.25	0.18	0.12	
Period (P)	—	—	—	0.86	—	—	0.08	0.06	
Spray (S)	—	—	—	—	—	—		0.06	
T x P	—	—	—	0.25	—	—	0.25	0.18	
T x S	—	—	—	—	—	—	—	0.18	
P x S	—	—	—	—	—	—	—	0.08	
T x P x S	—	—	—	—	—	—		0.25	
C.D. at 5% T	NS	0.67	0.85	0.52	0.79	0.74	0.52	0.36	
P	—	—	—	0.24	—	—	0.24	0.17	
S	—	—	—	—	—	—	—	0.17	
T x P	—	—	—	NS	—	—	0.73	0.36	
T x S	—	—	—	—	—	—	—	0.51	
P x S	—	—	—	—	—	—	—	0.24	
T x P x S	—	—	—	—	—	—	—	NS	
C. V. %	13.5	3.41	4.41	3.93	4.27	4.37	4.32	4.11	

Notes:DAA: Days After Application; NS: Non significant:Figures in parentheses are retransformed values; those outside square root transformed values;Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance

Table2: Effect of fungicide on lesion size due to citrus gummosis during second year.

Treatments	Lesion size (cm2) 1st application				2nd application			Pooled over period and appli cation	Recovery in lesion size com pare to before application
	Before Spray	15 DAA	30 DAA	Pooled	15 DAA	30 DAA	Pooled		
T1	13.99a	13.50ab	12.91bc	13.21bcd	12.68bcd	12.07cd	12.37c	12.79cd	16.46
	-195.22	-181.75	-166.17	-174	-160.28	-145.18	-152.52	-163.08	
T2	13.98a	13.63ab	13.27b	13.45bc	12.58cde	12.13bcd	12.35c	12.91bc	14.75
	-194.94	-185.28	-175.59	-180.4	-157.76	-146.64	-152.02	-166.17	
T3	14.01a	13.79ab	13.32b	13.56b	13.11bc	12.86b	12.99b	13.27bc	10.31
	-195.78	-189.66	-176.92	-183.37	-171.37	-164.88	-168.24	-175.59	
T4	14.00a	13.35ab	12.68bcd	13.02bcd	12.14de	11.52d	11.83d	12.42de	21.35
	-195.5	-177.72	-160.28	-169.08	-146.88	-132.21	-139.45	-153.76	
T5	13.92a	13.74ab	13.40b	13.57b	13.24b	12.84bc	13.04b	13.31b	8.59
	-193.27	-188.29	-179.06	-183.64	-174.8	-164.37	-169.54	-176.66	
T6	13.89a	12.83b	12.07de	12.45de	11.25f	10.54e	10.88e	11.68f	29.36
	-192.43	-164.11	-145.18	-154.5	-126.06	-110.59	-117.87	-135.92	
T7	13.99a	13.10ab	12.39cd	12.74cde	12.00e	11.39d	11.69d	12.22e	23.76
	-195.22	-171.11	-153.01	-161.81	-143.5	-129.37	-136.16	-148.83	
T8	13.96a	12.53b	11.62e	12.08e	10.54g	9.68f	10.12f	11.10g	36.87
	-194.38	-156.6	-134.52	-145.43	-110.59	-93.2	-101.91	-122.71	
T9	14.04a	14.4a	14.87a	14.67a	15.42a	15.90a	15.66a	15.17a	—
	-196.62	-206.86	-220.62	-214.71	-237.28	-252.31	-244.74	-229.63	
S. Em.± Treatment (T)		0.66	0.44	0.22	0.24	0.19	0.23	0.15	0.15
Period (P)	—	—	—	0.11	—	—	0.07	0.73	
Spray (S)	—	—	—	—	—	—		0.73	
T x P	—	—	—	0.35	—	—	0.21	0.2	
T x S	—	—	—	—	—	—	—	0.2	
P x S	—	—	—	—	—	—	—	0.52	
T x P x S	—	—	—	—	—	—		0.29	
C.D. at 5% T	NS	NS	0.66	0.7	0.53	0.69	0.42	0.4	
P	—	—	—	0.12	—	—	0.2	0.19	
S	—	—	—	—	—	—	—	0.19	
T x P	—	—	—	NS	—	—	NS	NS	
T x S	—	—	—	—	—	—	—	0.57	
P x S	—	—	—	—	—	—	—	NS	
T x P x S	—	—	—	—	—	—	—	NS	
C. V. %	8.27	5.65	3.01	4.56	2.45	3.16	2.9	3.88	

Notes: DAA: Days After Application; NS: Non significant:Figures in parentheses are retransformed values; those outside square root transformed values;Treatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance

Treated

Untreated

Table3: Effect of fungicide on lesion size due to citrus gummosis (Pooled).

Sr. No.	Treatments	Recovery in lesion size (cm2) -2016	-2017	Pooled over period, appli cation and Years
1	T1	10.82cd	12.79cd	11.83cd
		-117.07	-163.08	-139.45
2	T2	10.93cd	12.91bc	11.93cd
		-119.46	-166.17	-141.82
3	T3	11.15c	13.27bc	12.22bc
		-124.32	-175.59	-148.83
4	T4	10.56de	12.42de	11.50de
		-111.51	-153.76	-131.75
5	T5	11.88b	13.31b	12.60b
		-141.13	-176.66	-158.26
6	T6	9.97f	11.68f	10.83f
		-99.4	-135.92	-116.79
7	T7	10.24ef	12.22e	11.24e
		-104.86	-148.83	-125.84
8	T8	9.36g	11.10g	10.24g
		-87.61	-122.71	-104.36
9	T9	12.73a	15.17a	13.98a
		-162.05	-229.63	-194.94
	S.Em.+ T	0.12	0.15	0.14
	P	0.06	0.73	0.05
	Y	—	—	0.05
	S	0.06	0.73	0.05
	P x Y	—	—	0.07
	P x S	0.08	0.52	0.17
	P x T	0.18	0.2	0.14
	Y x S	—	—	0.06
	Y x T	—	—	0.14
	S x T	0.18	0.2	0.14
	P x Y x S	—	—	0.09
	P x Y x T	—	—	0.19
	P x S x T	0.25	0.29	0.19
	Y x S x T	—	—	0.19
	P x Y x S x T	—	—	0.27
	C. D. at 5% T	0.36	0.4	0.45
	P	0.17	0.19	0.13
	Y	—	—	0.05
	S	0.17	0.19	0.05
	P x Y	—	—	NS
	P x S	0.24	NS	NS
	P x T	0.36	NS	0.38
	Y x S	—	—	NS
	Y x T	—	—	0.38
	S x T	0.51	0.57	0.98
	P x Y x S	—	—	0.25
	P x Y x T	—	—	NS
	P x S x T	NS	NS	NS
	Y x S x T	—	—	NS
	P x Y x S x T	—	—	NS
	C. V. (%)	4.11	3.88	3.98

Notes: DAA: Days After Application; NS: Non significant :Figures in parentheses are retransformed values; those outside square root transformed valuesTreatment means with the letter(s) in common are not significant by DNMRT at 5% level of significance

metalaxyl MZ 68 WP + drenching with fenamidone 10% + mancozeb 50% WG than the rest of treatments followed by treatment T6. The pooled data over period and application reveled the minimum lesion size of (122.71 cm2) in treatment T8 *i.e* stem pasting with metalaxyl MZ 68 WP + drenching of fenamidone 10% + mancozeb 50% WG as compared to rest of treatments. The next best treatment in order of merit was found in treatment T6 *i.e.* stem pasting with metalaxyl MZ 68 WP + drenching of metalaxyl MZ 68 WP (135.92 cm2) in effective on recover in lesion size.

The pooled data over period and years (Table 3) indicated treatment T8 *i.e.* stem pasting with metalaxyl MZ 68 WP + drenching of fenamidone 10% + mancozeb 50% WG having significantly lower incidence of lesion size (104.36 cm2) than rest of the treatments, followed by treatment T6 *i.e.* stem pasting with metalaxyl MZ 68 WP + drenching of metalaxyl MZ 68 WP (2.5g/l) (116.79 cm2).

Singh *et al*. (2015) recorded maximum lesion size recovery of foot rot/ gummosis (88.9%), fruit yield (58.5 kg/plant) and canopy volume (16.9 m3) was obtained by application of metalaxyl M paste (25g/l water), metalaxyl M soil application (2.5g/l water) and Fosetyl Al (0.1%) spray in mid of February, March and August. Bairwa *et al*. (2015) reported that Phytophthora root rot and gummosis were significantly recovered by application of bioagents based treatment of stem painting with Bordeaux paste (copper sulphate, lime and water in a 3:3:30 ratio), followed by application of Trichoderma viride (2 × 107 cfu/gm) at 100g + Pseudomonas fluorescens (2 × 108 cfu/gm) at 100g/ tree with carrier material FYM. Somani and Patel (1970) got good control of gummosis incited by P. nicotianae var. nicotianae by aureofungin as soil drench and spraying of foliage twice at an interval of one month. Drenching of Ridomil MZ (0.2%) has also been found effective against gummosis.

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