

Foot rot incidence in Kinnow orchards and its management through biorational paint formulations

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ABSTRACT

The prevalence of citrus *Phytophthora* in Kinnow orchards varied from 3.7-21.4% in Sriganganagar district situated in North-West part of Rajasthan. Old Kinnow orchards in high cropping intensity area with heavy soils exhibited comparatively high incidence of foot rot disease. Field studies were conducted to find out environmentally accepted paint formulation, alternate to metalaxyl for the control of foot rot disease in Kinnow. Stem painting with metalaxyl (Ridomil MZ 72 WP) @ 20 g/l linseed oil, talc based *Pseudomonas fluorescence* (2×10^9 cfu/g) or *Trichoderma harzianum* (2×10^7 cfu/g) @ 100 g/l water subsequently painting with linseed oil after 5 days each during February and August was found significantly superior over check and other paint formulations in giving maximum per cent recovery in trunk lesion size of *Phytophthora* rot of Kinnow. The per cent increase in yield under these treatments ranged between 98.73 - 87.93 per cent. Paint formulations involving *tulsi* (*Ocimum sanctum* L.) leaf powder and bulb extract of garlic (*Allium sativum* L.) @ 100 g/l linseed oil and *T. harzianum* formulation @ 100 g/l rice starch solution were found at par in controlling *Phytophthora* disease. The Kinnow plants painted with turmeric powder (*Curcuma longa* L.) @ 100 g/l linseed oil and untreated plants (control) enhanced trunk lesion size and yield under these treatments decreased to the extent of 29.26 and 78.54 per cent, respectively.

Key words: *Phytophthora*, foot rot, Kinnow, paint formulation, *Pseudomonas*, *Trichoderma*.

INTRODUCTION

Citrus occupies an important place in the horticultural wealth and economy of India as the third largest fruit industry after mango and banana. It is grown in 0.48 million ha area producing approximately 4.25 mt per annum with average yield 7-8 t/ha (Singh, 7). Kinnow is mostly grown in northern states of India, covering area of 45,101 ha and producing 32,4208 mt with productivity of 7.18 mt/ha (Singh and Thakur, 8). The area under Kinnow in Rajasthan is 10,382 ha with production and productivity of 85,700 mt and 250-300 q/ha respectively during 2007-08 (Anon., 1). Sriganganagar district situated in North-West part of Rajasthan occupies a pivotal role in Kinnow cultivation.

Foot rot/ gummosis is the most serious limitation to profitable production of citrus in Rajasthan and its adjoining states. The incidence of foot rot in commercial citrus plantation has assumed an alarming proportions and it is reported to be 6.5 to 38.2% in Kinnow and 8.3 to 38.9% in sweet orange cv. Jaffa (Thind and Sharma, 9). The most common and important *Phytophthora* spp. attacking citrus in the region are *P. parasitica* and *P. citrophthora* causing gummosis, foot rot and root rot (Gaur *et al.* 2). Infected tree turns pale in colour with less foliage, restricted leaf size and inward leaf curling.

Profuse gummosis occurs as foot rot, attacking the base of trunk under the soil leading to trunk girdling, twig die back and gradual plant death (Timmer *et al.*, 14). This disease proves fatal to the plants if they are not properly diagnosed and timely treated.

Attempts have been made in past to control the disease through chemicals (Sandler *et al.*, 6; Naqvi, 5; Thind *et al.*, 12). However looking to the pollution hazards, development of drug resistant strains and non-target inhibition of beneficial microflora by the use of chemicals, there is need for development of environmentally acceptable methods. Gaur *et al.* (2) reported soil application of *Trichoderma harzianum* in association with metalaxyl painting to be an economically viable management technology for *Phytophthora* of Kinnow. This technology restricts use of metalaxyl to painting only and reduces the pesticidal load and helps to avoid the development of resistant strains and non-target inhibition of soil microflora. In continuation to these studies, an effort has further been made to find out effective environmentally acceptable paint formulation, alternative to metalaxyl for the control of this malady.

MATERIALS AND METHODS

The surveillance of various Kinnow orchards of Sriganganagar belt was conducted during 2004-05 to work out the foot rot disease/gummosis incidence. The orchards with in the age group of 15-20 years were

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selected for this investigation. The plants showing typical trunk girdling and gummosis symptoms were rated as infected with the disease. The per cent incidence of infected plants was calculated on the basis of total plants observed in orchard.

A trial was conducted for three successive years (2004-05 to 2006-07) on 15-years-old Kinnow plants selected at a private orchard at Layalpur Farm, Sriganganagar. The Kinnow trees showing mild to moderate decline and apparent typical trunk lesions and gummosis symptoms (Fig. 2A & B) were selected and given surgical treatment before applying paint formulations. The infected portions of the tree bark were removed along with some healthy bark with the help of sharp knife (Fig. 2C). The scraped portions were disinfected with 0.1% mercuric chloride and painted with different paint formulations using painting brush (Fig. 2D). Two fungicides (Ridomil and Aureofungin), four botanicals {turmeric (*Curcuma longa* L.), neem (*Azadirachta indica* Juss) seed kernel extract powder, garlic (*Allium sativum* L.), tulsi (*Ocimum sanctum* L.)} and two bioagents (*Trichoderma* and *Pseudomonas*) were used as base for paint formulations during February and again in August in every year. Each treatment was replicated three times in RBD with three trees per replication. An equal number of unscraped untreated trees were maintained as control. The initial area (length x breadth) of the trunk lesions and fruit yield (kg/plant) were recorded before applying the treatments. The subsequent observations on the trunk lesions were recorded after six months of treatment application given during July-August period in each year and converted in to per cent recovery over initial

infection. The final fruit yield was recorded in the last season of the crop during the investigation and finally per cent increase over initial yield was calculated.

RESULTS AND DISCUSSION

The prevalence of foot rot disease varied between 3.7 to 21.4% among Kinnow orchards of different locations. Kinnow planted in Khanuja Farm in 10 Z area of Sriganganagar exhibited maximum fruit rot incidence of 21.4%, whereas minimum disease incidence of 3.7% was recorded in orchard of Agricultural Research Station, Sriganganagar, which is maintained scientifically. Kinnow plants in orchards of Srikaranpur area (11-FF, 60-B, 19-Q, 26-H) suffered less due to foot rot. Disease incidence in different orchards in this locality (*Tehsil*) ranged between 5.3 to 15.7 per cent. However, over all *Phytophthora* incidence in different orchards in Sriganganagar *tehsil* was comparatively higher. Foot rot incidence in different orchards in this *tehsil* (11 Q, 8 Z, 5 Z, 10 Z, 2 E Choti, ARS farm) varied from 3.7 to 21.4% (Fig. 1).

The Kinnow orchards situated in Sriganganagar area are much older compared to adjoining *tehsils* beside heavy soils and high cropping intensity in the area. This may be the reason for higher disease incidence in the area. Thind *et al.* (13) have also reported maximum soil infestation (54.4%) in Sriganganagar orchards, which confirm the present findings. Prevalence of disease in citrus orchards of adjoining state have also been reported by Thind and Sharma (9), and Thind *et al.* (10) as 38.9 and 67.5%, respectively.

The results presented in Table 1 revealed that paint formulation involving metalaxyl (Ridomil MZ 72 WP)

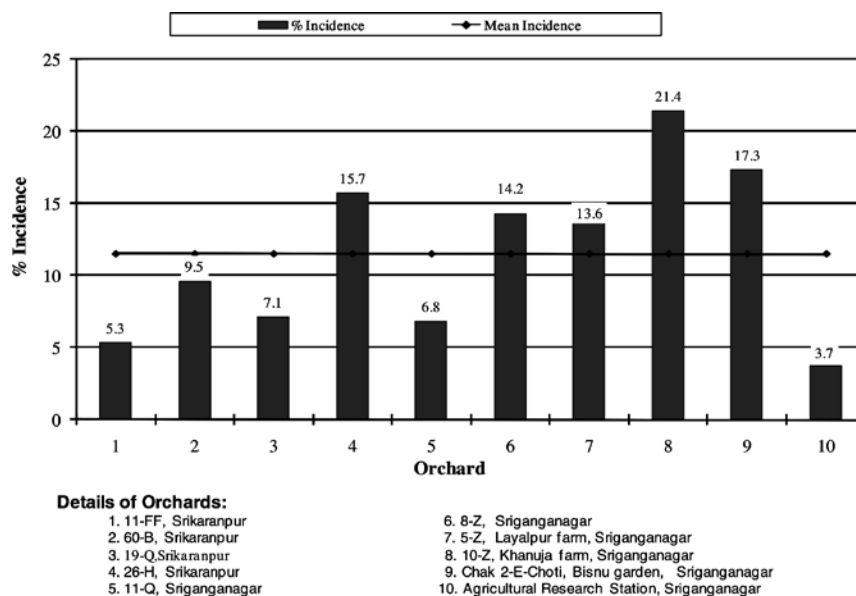


Fig. 1. Per cent incidence of foot rot disease (*Phytophthora* spp.) in Kinnow orchards of Sriganganagar belt of Rajasthan.

@ 20 g/l of linseed oil and talc based *Pseudomonas fluorescens* @ 100 g/l water followed by painting with linseed oil proved most effective against the foot rot of Kinnow, providing maximum per cent recovery (100.00 and 97.33%) in trunk lesion size of *Phytophthora*. These formulations though provided at par results but were found significantly superior to rest paint formulations. Paint with talc based *Trichoderma harzianum* @ 100 g/l water followed by painting with linseed oil was next in order of superiority which differed significantly with metalaxyl painting but gave at par results with *Pseudomonas* (Fig. 2E). Paint formulations involving bulb extract of garlic @ 100 g/l linseed oil, *tulsi* leaf powder @ 100 g/l linseed oil and talc based *Trichoderma* formulation @ 100 g/l rice starch solution were found at par in controlling the disease.

The next group of paint formulations which indicated recovery in trunk lesion size were: Painting with Aureofungin @ 20 g/l linseed oil, painting with neem seed kernel powder @ 100 g/l linseed oil and painting with talc based *Trichoderma* formulation @

100 g/l of water. Minimum recovery in trunk lesion size was recorded in case of DC-Tron Plus. The plants, painted with turmeric powder @ 100 g/l linseed oil and of control showed enhanced trunk lesion size. The high effectiveness of metalaxyl under present investigation is attributed to its systemic nature and ability to inhibit the persistence of inoculum and production of chlamydospores and oospores on the treated portions. Efficacy of metalaxyl either in the form of a drenching or as a paint against the pathogen has been documented (Timmer and Menga, 15; Thind *et al.*, 11; Jadeja *et al.*, 3). Menge (4) reported antagonistic effect of biocontrol agents such as *Pseudomonas* spp. and *Trichoderma* spp. against the *Phytophthora*. Gaur *et al.* (2) suggested ecofriendly integrated approach of using *T. harzianum* as soil application and painting with metalaxyl for the control of *Phytophthora* in Kinnow.

The maximum per cent increase (98.73%) over initial fruit yield was obtained in the plants painted with metalaxyl @ 20 g/l linseed oil closely followed by the painting with talc based *P. fluorescens* @ 100 g/l water subsequently painted with linseed oil after

Table 1. Efficacy of different paint formulations against the foot rot disease of Kinnow.

Treatment	Trunk lesion recovery* (%)		
	2004-05	2005-06	2006-07
Painting with Ridomil @ 20 g/l linseed oil	78.28 (62.23)	99.25 (87.17)	100.00 (90.00)
Painting with Aureofungin @ 20 g/l linseed oil	39.19 (38.7)	59.72 (50.63)	65.34 (54.11)
Painting with turmeric powder @ 100 g/l linseed oil	{-} 28.32(4.1)	-21.50 (4.10)	{-} 41.75 (4.1)
Painting with neem seed kernal powder @ 100 g/l linseed oil	40.82 (39.7)	49.92 (44.93)	55.44 (48.12)
Painting with garlic bulb extract @ 100 g/l linseed oil	17.11 (24.33)	29.61 (32.90)	77.12 (61.47)
Painting with <i>tulsi</i> leaf powder @ 100 g/l linseed oil	68.38 (57.83)	75.52 (60.43)	75.52 (60.41)
Application of aqueous spore suspension of <i>Trichoderma harzianum</i> (5×10^9 conidia/ml) followed by painting with linseed oil after 5 days	10.14 (18.47)	31.82 (34.33)	55.21 (48.0)
Painting with talc based <i>Trichoderma harzianum</i> formulation (2×10^7 cfu/g) @ 100 g/l water followed by painting with linseed oil after 5 days	77.44 (61.67)	93.27 (75.30)	97.33 (80.73)
Painting with talc based <i>Trichoderma harzianum</i> formulation (2×10^7 cfu/g) @ 100 g/l water	24.08 (29.37)	41.15 (39.87)	58.21 (49.74)
Painting with talc based <i>Trichoderma harzianum</i> formulation (2×10^7 cfu/g) @ 100 g/l rice starch solution	58.41 (49.83)	75.17 (60.20)	75.48 (60.87)
Painting with talc based <i>Pseudomonas fluorescens</i> formulation (2×10^9 cfu/g) @ 100 g/l water followed by painting with linseed oil after 5 days	74.74 (59.93)	95.43 (80.03)	98.67 (84.58)
Painting with DC-Tron Plus @ 50 ml/l of water	32.13 (34.5)	39.65 (39.03)	41.84 (40.29)
Control (Untreated)	{-}63.59 (4.1)	-108.57 (4.1)	{-}128.10 (4.1)
CD at 5%	3.73	6.64	6.47
CV (%)	5.94	8.36	7.30

*Average of three replications, Figures in parenthesis are angular transformed values

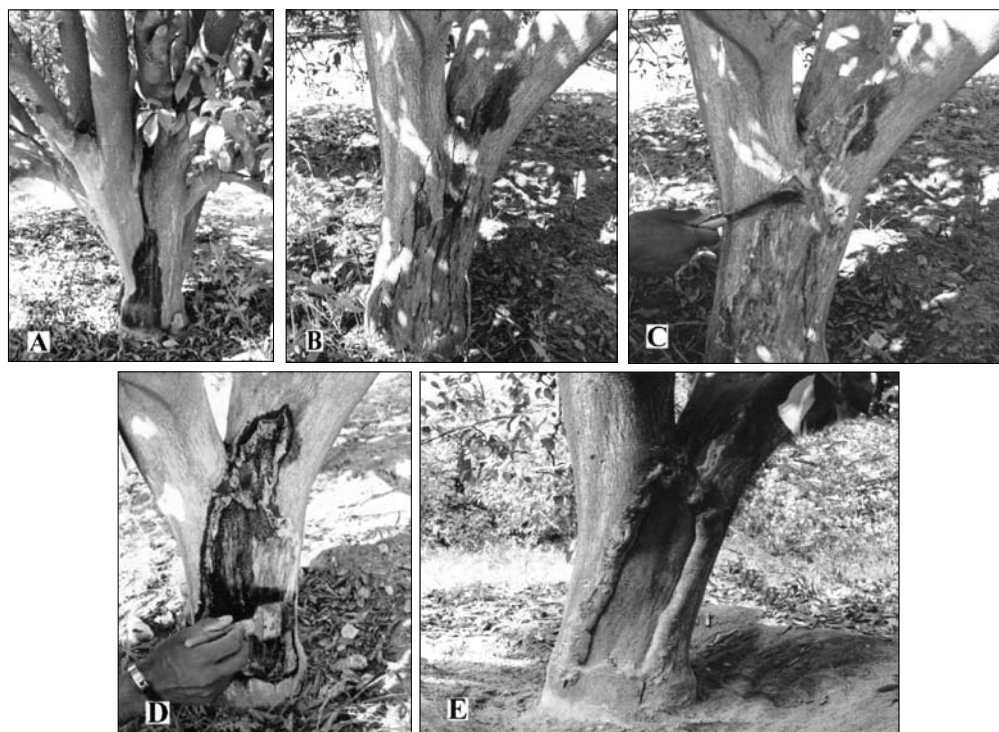


Fig. 2. Foot rot (*Phytophthora*) of Kinnow plant (a). Gummosis symptoms; (b) Bark splitting; (c) Scraping of infected portion with some health bark. (d) Paining of trunk lesion; (e) Recovered trunk lesion with fresh bark growth after three years of painting.

Table 2. Effect of different chemical and biorational painting treatments on fruit yield of Kinnow.

Treatment	Fruit yield (kg/plant)*		
	Initial	Final	% increase over initial
Painting with Ridomil @ 20 g/l linseed oil	96.61	191.99	98.73
Painting with Aureofungin @ 20 g/l linseed oil	88.93	139.74	57.14
Painting with turmeric powder @ 100 g/l linseed oil	79.85	23.36	(-) 29.26
Painting with neem seed kernal powder @ 100 g/l linseed oil	95.37	137.09	43.75
Painting with garlic bulb extract @ 100 g/l linseed oil	113.52	197.32	73.82
Painting with <i>tulsi</i> leaf powder @ 100 g/l linseed oil	104.77	177.55	69.47
Application of aqueous spore suspension of <i>Trichoderma harzianum</i> (5×10^9 conidia/ml) followed by painting with linseed oil after 5 days	81.05	115.76	42.83
Painting with talc based <i>Trichoderma</i> formulation @ 100 g/l water followed by painting with linseed oil after 5 days	102.62	192.85	87.93
Painting with talc based <i>Trichoderma</i> formulation @ 100 g/l water	109.82	163.24	48.64
Painting with talc based <i>Trichoderma</i> formulation @ 100 g/l rice starch solution	98.16	165.21	68.31
Painting with talc based <i>Pseudomonas fluorescens</i> @ 100 g/l water followed by painting with linseed oil after 5 days	107.28	207.68	93.59
Painting with DC-Tron Plus @ 50 ml/l of water	73.84	99.52	34.78
Control (Untreated)	93.89	20.15	(-) 78.54

*Average of three replications

5 days (93.59%). Painting of talc based *Trichoderma* formulation @ 100 g/l water and subsequently painting with linseed oil after 5 days was the next in order efficacy indicating increase of 87.93% over initial fruit yield. DC-Tron Plus @ 50 ml/l water was least effective as a paint, providing only 34.78% increase over initial fruit yield. In case of painting with turmeric powder @ 100 g/l linseed oil and untreated plants (control) the fruit yield decreased to the extent of 29.26 and 78.54% respectively. Thind *et al.* (10 & 13) reported higher yields in citrus plants treated with metalaxyl.

Higher yield obtained under treated plants is attributed due to the fact that after recovery from foot rot such plants received proper nutrients and salts from the roots which were subsequently transported to all aerial parts through trunk bark. This was not the case with untreated and turmeric painted plants where supply line through trunk bark get disturbed and ultimately decline symptoms appeared which provided decrease in fruit yield.

Outcome of present investigation further strengthen ecofriendly bioagent approach of *Phytophthora* management in Kinnow through soil application of *T. harzianum* (Gaur *et al.*, 2) and trunk painting with either *P. fluorescens* or *T. harzianum*. These findings provided not only an alternative paint formulation but completely avoided use of metalaxyl and thus reduced chances of development of resistant strains and non-target inhibition of beneficial microflora.

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