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# Field Management of Fungal Wilt (*Fusarium solani*) and Root-knot Nematode (*Meloidogyne incognita*) Complex in Crossandra (*Crossandra undulaefolia L.*)

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## Abstract

The root-knot nematode (*Meloidogyne incognita)* and fungus (*Fusarium solani*) independently could damage and cause considerable loss crossandra. However, the effect on plant growth and wilt incidence is more when both pathogens were present together. A field experiment was conducted to study the effect of various chemicals on this devastating disease complex in crossandra. Carbendazim (0.1%) and carbofuran 3G (0.3 a.i./$m^2$) were found superior in increasing growth and yield of crossandra which also increased shoot length, shoot weight, root length and root weight. Carbofuran greatly reduced the root-knot index (2.00) compared to other treatments, which accounted for 57.08% reduction over control and on par with new nematicides, phosphonothioate (2.33) and cartaphydrochloride (2.66), which accounted for 50.00 and 42.91% reduction respectively. Least wilt incidence (13.33%) was also recorded with carbofuran which accounted for 69.23% reduction followed by phosphonothioate (15.00%) and cartaphydrochloride (18.33%) that were on par in reducing wilt and accounted for 65.38 and 57.69% reduction respectively.

**Keywords:** *Fusarium solani*; *Meloidogyne incognita*; Crossandra; Complex; Wilt; Field management

## Introduction

Crossandra (*Crossandra undulaefolia Salisb*.) is an important commercial flower crop mainly grown in tropical countries like India and Madagascar. The flowers are popular because of their attractive bright colour, light weight and good keeping quality. Crossandra is susceptible to various fungal diseases such as leaf spots caused by *Alternaria amaranthi var*. *crossandrae*, and *Cercospora crossandrae*, blight due to *Colletotrichum crossandrae* stem rot due to *Rhizoctonia solani* and, collar rot, wilt due to *Fusarium solani* [1,2].

Besides fungal pathogens, several parasitic nematodes have also been reported on crossandra such as root-knot nematode (*Meloidogyne incognita*), lesion nematode (*Pratylenchus delattrei*), needle nematode (*Longidorus africanus*), spiral nematode (*Helicotylenchus dihystera*), reniform nematode (*Rotylenchulus sp*.), lance nematode (*Hoplolaimus sp*.), stunt nematode (*Tylenchorhynchus sp*.) and dagger nematode (*Xiphinema sp*.) [3,4]. Among different plant parasitic nematodes, infestation of crossandra by *M. incognita* is wide spread in crossandra growing fields with high soil population. The infested crossandra roots developed severe root galling and root-knots [3].

Reports are available on increased wilt incidence in presence of nematode on crossandra [5-8]. However, detailed studies have not been conducted on the complex involving both root-knot nematode (*M. incognia*) and fungus (*F. solani*). Also information is lacking with regard to management of this important disease complex in crossandra. Hence, an attempt was made to study the effect of various chemicals on this important disease complex in crossandra.

## Materials and Methods

The field experiment was conducted at the farmland of GKVK Campus, University of Agricultural Sciences, Bangalore. Tomato and Bhendi crops were raised in the main field, which served as host for the nematode. Ninety days was allowed for multiplication of nematodes so as to achieve the nematode population above economic threshold level. Then, the plants were harvested leaving the roots in the soil. At the time of transplanting, the field had initial population of 3.12 *M. incognita* larvae per gram of soil. Thirty days old seedlings (Cv. Local Orange) from the treated nursery seedbeds were transplanted to the infested main field after preparing 2.5 × 2.5 $m^2$ plots. The treatments were allotted following RCBD. Three seedlings were transplanted per hill with a spacing of 1' × 1'. Individual plots were irrigated separately. Normal package of practices were followed in taking of the crop. Cartaphydrochloride (10 g/$m^2$), phosphonothioate 10G (10 g/$m^2$), carbofuran 3G (0.3 a.i./$m^2$) and carbendazim (0.1%) were applied near the root region of crossandra plants by making lines and then it was covered with the soil. Plants were grown for the period of 6 months. Observations on population levels of *M. incognita* were recorded at 30, 60, 90, 120, 150 and 180 days

after imposition of treatments. Population levels of *F. solani* were recorded at every 60, 120 and 180 days after imposition of treatments. During the termination of experiment, final nematode population of soil and root, root-knot index (RKI), population of *F. solani*, wilt incidence and yield of flowers were recorded.

## Results and Discussion

### Effect of chemicals on various parameters

**a. Shoot length:** Observations on the effect of various treatments on the shoot length of crossandra plants were recorded at 30, 60, 90, 120, 150 and 180 days after imposition of treatments is presented in **Table 1**. At 90 and 120 days after imposition of treatments with carbendazim recorded maximum height of 55.61 cm and 59.35 cm followed by 49.30 and 57.12 cm in carbofuran. It was seen that control showed the least of 36.05 and 37.12 cm at 90 and 120 days respectively. Similar trend was noticed at 150 and 180 days with carbendazim recorded maximum height of 64.94 and 69.78 cm followed by 58.92 and 65.75 cm in carbofuran.

**b. Fresh and dry weight of shoot:** With respect to the shoot (fresh and dry) weights the plants receiving carbendazim showed highest shoot fresh weight of 62.35 and 36.01 g followed by carbofuran (60.27 and 35.21 g) and cartaphydrochloride (59.71 and 33.07 g) and were on par with each other **(Table 2)**.

**c. Root length:** With regards to the root length carbendazim applied plants recorded longest roots of 39.60 cm than the other treatments and accounted for about 83.33% increase over control **(Table 2)**. However, the treatments cartaphydrochloride (34.2 cm), phosphonothioate (32.20 cm) and carbofuran (36.60 cm) were on par with the carbendazim.

**d. Fresh and dry root weights:** Among fresh and dry root weights all the treated plants recorded significant increase in both fresh and dry root weights compared to control **(Table 2)**. Among the different treatments, highest fresh and dry root weights were found in carbendazim applied plants (31.21 and 15.28 g) with 83.91 and 84.31% increase over control (16.97 and 8.29 g).

**Table 1:** Effect of various chemicals on growth and development of crossandra in *M. incognita* and *F. solani* infected field at 30 days interval.

| Treatments | Shoot length (cm) | | | | | |
|---|---|---|---|---|---|---|
| | 30 days | 60 days | 90 days | 120 days | 150 days | 180 days |
| Cartaphydrochloride | 33.42 | 41.96 | 43.55 | 49.05 | 54.21 | 57.71 |
| Phosphonothioate | 31.35 | 35.44 | 39.40 | 47.28 | 48.57 | 52.69 |
| Carbofuran | 36.41 | 44.23 | 49.80 | 57.12 | 58.92 | 65.75 |
| Control | 24.96 | 33.06 | 36.05 | 37.12 | 38.85 | 42.79 |
| Carbendazim | 38.47 | 52.89 | 55.61 | 59.35 | 64.94 | 69.78 |
| SEM ± | 1.09 | 1.63 | 1.34 | 2.39 | 0.67 | 0.62 |
| CD at 5% | 3.27 | 4.91 | 4.02 | 7.17 | 2.01 | 1.86 |
| Initial population of *M. incognita*: 514.60/200 cc soil<br>Initial population of *F. solani* : 30.00 × $10^3$ cfu/g soil | | | | | | |

**Table 2:** Effect of various chemicals on growth and development of crossandra in *M. incognita* and *F. solani* infected field.

| Treatments | Shoot fresh weight (g) | Shoot dry weight (g) | Root fresh weight (g) | Root dry weight (g) | Root length (cm) | Yield (kg /ha) |
|---|---|---|---|---|---|---|
| Cartaphydrochloride | 59.71 | 33.07 | 28.30 | 14.10 | 34.20 | 551.70 |
| Phosphonothioate | 57.98 | 25.19 | 27.33 | 13.98 | 32.00 | 586.20 |
| Carbofuran | 60.27 | 35.21 | 28.97 | 14.61 | 36.60 | 615.50 |
| Control | 34.57 | 19.81 | 16.97 | 8.29 | 21.60 | 351.00 |
| Carbendazim | 62.35 | 36.01 | 31.21 | 15.28 | 39.60 | 561.60 |
| SEM + | 0.57 | 0.60 | 0.38 | 0.004 | 0.57 | -- |
| CD at 5% | 1.73 | 1.82 | 1.15 | 0.01 | 1.73 | -- |

Initial population of *M. incognita*: 514.60/200 cc soil
Initial population of *F. solani*: 30.00 × $10^3$ cfu/g soil

With respect to the yield, carbofuran recorded highest flower yield (615.50 kg/ha) and the yield increase was 75.35% over control (351.00 kg/ha) **(Table 2)**. The treatments phosphonothioate (67.00%), carbendazim (60.00%) and cartaphydrochloride (57.17%) were on par with each other.

The above results are in accordance with several workers who have tried Carbendazim on several crops like crossandra [9] and carbofuran on crops like banana [10]. From these results it was concluded that among the chemicals Carbendazim and Carbofuran were found superior in increasing growth and yield of crossandra and both were increased shoot length, shoot weight, root length, root weight, and yield.

## Effect of nematicides on population of *M. incognita*

At 30 days, all the treatments differed significantly superior over control with respect to the reduction of nematode population **(Table 3)**. Least nematode population (380.00) was recorded in carbofuran applied plots. At 60 days, the treatment that received carbofuran was recorded highest reduction of nematode population (293.33) followed by phosphonothioate (306.66). Highest populations were recorded in carbendazim applied plots (586.66), which is on par with control. At 90 days even though there is an increased growth of nematode population because of their repeating life cycle, the carbofuran and the newly introduced chemical phosphonothioate (RIL 028) recorded lowest nematode population of 320.00 and 320.00 respectively while the cartaphydrochloride rated as second in its efficiency in reducing nematode population.

Similar trend was noticed at 120, 150 and 180 days, wherein least nematode population was recorded in the treatment that received carbofuran (280, 260 and 220 respectively) followed by phosphonothioate (320.00, 306.66 and 280.00 respectively). In general highest population was noticed in control followed by carbendazim, which were on par with each other.

**Table 3:** Effect of various chemicals on population of *M. incognita* in *M. incognita* and *F. solani* infected crossandra field at 30 days interval.

| Treatments | Nematode population per 200 cc soil | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 30 days | 60 days | 90 days | 120 days | 150 days | 180 days | 210 days | 5 g of roots at harvest |
| Cartaphydrochloride | 400.00 | 393.33 | 400.00 | 368.88 | 330.00 | 326.99 | 260.00 | 193.33 |
| Phosphonothioate | 413.13 | 306.66 | 320.00 | 320.00 | 306.66 | 280.00 | 233.55 | 186.00 |
| Carbofuran | 380.00 | 293.33 | 320.00 | 280.00 | 260.00 | 220.00 | 260.66 | 120.00 |
| Control | 573.33 | 640.00 | 680.00 | 686.66 | 646.66 | 686.66 | 673.33 | 540.00 |
| Carbendazim | 566.66 | 586.66 | 620.00 | 580.00 | 586.66 | 540.00 | 506.66 | 433.33 |
| SEM ± | 8.90 | 10.31 | 13.72 | 9.15 | 7.96 | 8.83 | 8.55 | 8.22 |
| CD at 5% | 26.71 | 30.91 | 41.13 | 27.44 | 23.89 | 26.48 | 25.64 | 24.66 |

Initial population of *M. incognita*: 514.60/200 cc soil
Initial population of *F. solani*: 30.00 × $10^3$ cfu/g soil

Maximum reduction (69.30% and 77.77%) was recorded with the treatment that received carbofuran both in soil and root. This reduction was significantly superior over other all treatments. Phosphonothioate (65.31% and 65.43%) followed by cartaphydrochloride (61.38% and 64.19%) were in the next order of their efficacy and on par in reducing the final nematode population of both soil and roots.

## Effect of chemicals on population of *Fusarium solani*

At 60 days, all the treatments differed significantly over control with respect to the reduction of *Fusarium solani* population **(Table 4)**. Least propagules (4.46 × $10^3$ cfu/g soil) were recorded in carbendazim applied plots. Even though there is significant reduction in *Fusarium* propagules, however, the treatments cartaphydrochloride (5.80 × $10^3$ cfu/g soil) and phosphonothioate were on par with carbofuran (5.33 × $10^3$ cfu/g soil).

Similar trend was noticed at 120, 180 days and at termination of experiment where least propagules were recorded in carbendazim (2.86 and 1.60 × $10^3$ cfu/g soil respectively) followed by carbofuran (3.06 and 2.80 × $10^3$ cfu/g soil). Phosphonothioate (3.80 and 3.26 × $10^3$ cfu/g soil) and cartaphydrochloride (3.26 and 3.33 × $10^3$ cfu/g soil) were on par with each other. Carbendazim retained its supremacy in soil when applied as drenching and mean for the superiority over other treatments in controlling mycelial growth of *Fusarium solani* [9] reported that the combined application of neem cake (250 $gm^{-2}$) and carbendazim (0.1%) followed by introduction of native *Trichoderma sp*. (150 $gm^{-2}$ containing 2.2 × $10^{-1}$ spores/g

culture) to the rhizosphere of naturally infected *Fusarium* sick soil remarkably reduced the wilt disease in crossandra, caused by *F. solani*.

## Root-knot index and wilt incidence

The host infestation by *M. incognita* as represented by root-knot index was recorded and results are presented in **Table 4**.

The treatments differed in their efficacy in reducing the host infestation by the nematode. Carbofuran greatly reduced the root-knot index (2.00) when compared to other treatments, which accounted for 57.08% reduction over control and at par with phosphonothioate (2.33) and cartaphydrochloride (2.66), which accounted for 50.00 and 42.91% reduction respectively.

**Table 4:** Effect of various chemicals on population of *F. solani* , root-knot index and wilt incidence in *M. incognita* and *F. solani* infected crossandra field at 60 days interval.

| Treatments | Cfu/g soil | | | | | | |
|---|---|---|---|---|---|---|---|
| | 60 days | 120 days | 180 days | 210 days | No. of galls/ root system | Root - Knot Index | % Wilt incidence |
| Cartaphydrochloride | 5.80 | 3.26 | 3.33 | 3.13 | 18.50 | 2.66 | 18.33 (25.30) |
| Phosphonothioate | 5.46 | 3.80 | 3.26 | 2.93 | 12.08 | 2.33 | 15.00 (22.59) |
| Carbofuran | 5.33 | 3.06 | 2.86 | 2.20 | 8.91 | 2.00 | 13.33 (21.33) |
| Control | 8.06 | 8.26 | 8.66 | 5.26 | 100.83 | 4.66 | 43.33 (41.15) |
| Carbendazim | 4.46 | 2.86 | 1.60 | 0.93 | 86.91 | 4.00 | 26.66 (30.99) |
| SEM ± | 0.20 | 0.19 | 0.20 | 0.19 | 11.75 | - | 1.93 |
| CD at 5% | 0.61 | 0.58 | 0.61 | 0.58 | 35.23 | - | 5.79 |
| Initial population of *M. incognita*: 514.60/200 cc soil<br>Initial population of *F. solani*: 30.00 × $10^3$ cfu/g soil | | | | | | | |

The effect of different treatments on wilt incidence revealed that when compared to control (43.33% incidence) least wilt incidence (13.33%) was recorded in the treatment that received carbofuran which accounted for 69.23% reduction followed by phosphonothioate (15.00%) and cartaphydrochloride (18.33%) and both were on par in reducing wilt and accounted for 65.38 and 57.69% reduction respectively.

The results are in accordance with [11] who observed that, soil application with carbofuran 3G at 3 kg a.i/ha significantly reduced the nematode population, root-knot index and root rot incidence in disease complex of sunflower caused by *M. incognita* and *Macrophomina phaseolina* and also similar findings are reported on banana reduced the soil and root population of nematode by 78.88 and 72.22% respectively [12].

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