Control of the Citrus Disease Complex in Iraq

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Authors’ contributions

This work was carried out in collaboration between all authors, Author IIA designed the study, wrote the protocol and managed the final manuscript, authors BGA and SAA-R were carried out the field and laboratory studies, wrote the first draft of the manuscript, performed the stastical analysis and managed literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This study was conducted in a citrus orchard in Baghdad province, Iraq. Roots were severely infected with citrus-root nematode *Tylenchulus semipenetrans* and the fungus *Phytophthora citrophthora*, die back symptoms were highly observed on the vegetative growth, and the yield of these trees were very poor. The experiment included 16 treatments using three nematicides Rugby (Cadusafos), Mocap and Garland, and three fungicides Previcure, Agrífos and Nando, and the control (untreated) with three replicates/treatments. Each treatment was about 50 m² and consists of ten citrus trees using complete randomized block design (CRBD). Soil and root samples were taken a week before treatment and six months after treatment for nematode extraction (250 g soil and 1 g roots) and for fungus using potato dextrose agar media (PDA) for germination. Results indicated that all the fungicides applied had no effect on citrus root nematode, but when they were applied with nematicides simultaneously there was a sharp decline in nematode population. All the nematicides applied in this experiment were highly effective against the nematode and significantly reduced their number compared to the untreated (control) plot. Rugby (Cadusafos) was significantly effective than the other nematicides, where the number of nematodes
in 250 g soil and 1 g root reduced from 3833.3 and 1876 juvenile before treatment to 333.3 and 124 juveniles after treatment respectively. Similar effect was found when these nematicides were applied with the fungicides for controlling the disease complex and it was found that Rugby again was highly effective than the other applied nematicides.

Keywords: Citrus disease complex; nematicides; fungicides.

1. INTRODUCTION

Citrus plantation is considered as one of the most important economic crop concentrated in the central and southern regions of Iraq. The average production is about half a million ton/year [1]. Citrus root nematode *Tylenchulus semipenetrans* Cobb was first recorded in Iraq in 1965 as a cause of citrus decline [2]. The nematode has been found in almost every citrus grove and nurseries in the country with high population in many areas [3]. An association between citrus root nematode and some soil fungi such as *Fusarium*, *Pythium*, *Phytophthora* and *Rhizoctonia* has been previously reported [4-7] causing more deterioration in both root and vegetative citrus growth. Similar interaction effect was observed with other plant parasitic nematodes and some soil fungi [8]. Several control measures were applied to control this disease complex such as using mycorrhizal fungus [9], biological control [10,11] and chemical control [12,13,14].

The present study was conducted to determine the efficacy of some nematicides and fungicides in control the pathogens, the nematode *Tylenchulus semipenetrans* and the fungus *Phytophthora citrophthora* (complex disease), to achieve satisfactory control in Iraqi soils.

2. MATERIALS AND METHODS

Citrus orchard was selected at Doura in Baghdad Province/Iraq, because citrus growth was very poor and roots were severely infected with citrus root nematode *Tylenchulus semipenetrans* Cobb and the fungus *Phytophthora citrophthora* (R.B.Sm & E.H.Sm) L. Nematode juveniles and males and the fungus were estimated from composite soil samples at 10-30 cm depth. The experiment was consisted of 16 treatments using 3 nematicides as follows:

1- Rugby (Cadusafus) at rate 6 cm³/m² added with irrigation water.
2- Mocap 20EC at rate 5 cm³/m² added with irrigation water.
3- Garland at rate 5 cm³/m² added with the irrigation water.

Also 2 fungicides were used in this experiment as follows:

1- Agrifos at rate 1 cm³/m² added with irrigation water.
2- Nando at rate 1 cm³/m² added with irrigation water.

Other treatments consist of the mixture of each nematicide with either fungicide at same rate of application when they were applied alone. Therefore, we had 16 treatments including the control (untreated). Each treatment consists 3 replicates. Each treatment was about 50 m² and consists 10 citrus trees using complete randomized block design (CRBD), statistical analysis was done according to Duncan’s multiple limits at (P=0.005). For counted the nematode soil and root samples were taken (250 g soil and 1 g roots) a week before treatment and 6 months after treatment for nematode extraction, and root samples for the fungus was germinated by potato dextrose agar media (PDA).

3. RESULTS AND DISCUSSION

The effect of complex of citrus root-nematode and the fungus caused severe damage to the root growth which reflected on citrus growth and yield production. The number of nematodes in control (untreated) was higher in the soil (5166) and roots (2333) juvenile per 250 g soil and 1 g root. Similar results have been reported previously about the interaction between citrus root nematode and some soil fungi in Iraqi citrus orchards [15,10,14], and around the world [16,17].

Other results showed that all the fungicides applied alone had no effect on citrus root nematode, but when they were applied as a mixture with either nematicide simultaneously there was a sharp decline in nematode population (Table 1).
Table 1. Average numbers of citrus root nematodes in 250 g soil and 1 g root of citrus trees, before and after treatment

| Treatments         | Number of nematodes/1g. root Before treatment | Number of nematodes/1g. root After treatment | Number of nematodes/250g. soil Before treatment | Number of nematodes/250g. soil After treatment |
|--------------------|-----------------------------------------------|----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| Control            | 2333.3<sup>a</sup>                           | 2125<sup>b</sup>                             | *5166.7                                       | 4583.3<sup>m</sup>                             |
| Garland            | 1250<sup>b</sup>                             | 166.7<sup>b</sup>                            | 2750                                          | 333.3<sup>a</sup>                             |
| Rugby              | 1875<sup>i</sup>                             | 125<sup>a</sup>                              | 3833.3                                        | 333.3<sup>a</sup>                             |
| Mocap              | 1833.3<sup>i</sup>                           | 458.3<sup>h</sup>                            | 4666.7                                        | 1000<sup>g</sup>                              |
| Previcure          | 1166.7<sup>a</sup>                           | 1666.7<sup>m</sup>                           | 3000                                          | 2416.7<sup>i</sup>                            |
| Agrifos            | 1541.6<sup>d</sup>                           | 1875<sup>i</sup>                             | 4000                                          | 4166.7<sup>i</sup>                            |
| Nando              | 2458.3<sup>i</sup>                           | 1416.7<sup>i</sup>                           | 3166.7                                        | 4000<sup>h</sup>                              |
| Previcure + Garland| 1708.3<sup>j</sup>                           | 375<sup>j</sup>                              | 3666.7                                        | 833.3<sup>f</sup>                             |
| Previcure + Rugby  | 1333.3<sup>e</sup>                           | 416.7<sup>g</sup>                            | 4583.3                                        | 833.3<sup>f</sup>                             |
| Previcure + Mocap  | 1541.6<sup>d</sup>                           | 719.7<sup>i</sup>                            | 2666.7                                        | 750<sup>e</sup>                               |
| Agrifos + Garland  | 1541.6<sup>d</sup>                           | 291.7<sup>d</sup>                            | 3416.7                                        | 583.3<sup>c</sup>                             |
| Agrifos + Rugby    | 1541.6<sup>d</sup>                           | 250<sup>c</sup>                              | 3750                                          | 833.3<sup>f</sup>                             |
| Agrifos + Mocap    | 1875<sup>i</sup>                             | 250<sup>c</sup>                              | 6500                                          | 500<sup>b</sup>                               |
| Nando + Garland    | 1583.3<sup>d</sup>                           | 333.3<sup>e</sup>                            | 4500                                          | 666.7<sup>d</sup>                             |
| Nando + Rugby      | 1250<sup>b</sup>                             | 875<sup>k</sup>                              | 3083.3                                        | 2083.3<sup>i</sup>                            |
| Nando + Mocap      | 2208<sup>i</sup>                             | 541.7<sup>i</sup>                            | 4500                                          | 1250<sup>n</sup>                              |

* Numbers represents average of 3 replicates/treatment.

Values with similar letters within same column are not significantly different between them according to Duncan’s Multiple limits.

The fungicides sharply reduced the fungi population including the fungus *Phytophthora citrophthora* between 80-90% when spores numbers were counted under the microscope from soil or citrus roots after the soil was treated with these 2 fungicides (Agrifos or Nando). These results reflects positively by reducing the effect of fungi on citrus root growth and their interaction with the nematodes. These results agrees with previous results that Agrifos highly effective against fungi mortality and improve the growth of both citrus roots and vegetative growth [11]. All the nematicides applied in this experiment were highly effective against the nematode and significantly reduced their number compared to the untreated (control) plot (Table 1). But Rugby (Cadusafos) was significantly effective than the other nematicide. Number of nematodes in 250 g soil and 1 g root reduced from 3833.3 and 1876 juvenile before treatment to 333.3 and 124 juvenile after treatment respectively.

Similar effect was found when these nematicides were applied with the fungicides for controlling the disease complex and it was found again that Rugby was significantly highly effective than the other applied nematicides (Table 1). Similar results were found when Rugby used as alone or as a mixture with fungicide was highly effective against citrus root nematode or root-knot nematode [11,14]. Results showed that both Garland and Mocap were also alone or with combination with either fungicide were significantly effective in controlling citrus nematode. Therefore, both nematicide can be applied against nematodes if rugby is not available.

4. CONCLUSION AND RECOMMENDATION

Citrus orchards in the middle of Iraq highly infested with the nematode *Tylenchulus semipenetrans* and the fungus *Phytophthora citrophthora*, farmers may be need to implementation of the control program for the purpose of avoiding damage and losses to their orchards, which requires to the use of nematicides and fungicides to reduce the density of pathogens. Studies must conduct for the selection of resistance varieties of citrus, especially there are many peasant families live on these orchards in many provinces. As well as highly productive varieties must be choose, and get rid of the bad varieties that are still grown in most orchards.
COMPETING INTERESTS

Authors have declared that no competing interests exist.

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