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COMPARATIVE EFFICACY OF DIFFERENT FUNGICIDES AGAINST DAMPING OFF DISEASE IN CITRUS NURSERY PLANTS

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ABSTRACT

Background Damping off is considered to be one of the most destructive diseases of citrus nursery plants, characterized by leaf yellowing, stem girdling, base rotting, discoloration of vascular tissues and wilting. This disease is favored by cool and wet conditions, and caused by different pathogens which kill or weaken the seeds or seedlings at pre- or post-emergence stage. Damping off can, however, be managed or controlled in several ways. Among these, application of fungicides is a widely used method to control this disease, worldwide. The present experiment is aimed to evaluate the efficiency of different chemicals/fungicides for the management of damping off disease of citrus under the prevailing climatic conditions of Sargodha.

Methodology In this experiment, eight commercial fungicides, Topsin-M, Ridomil gold, Antracol, Copper oxychloride, Acrobat, Alliette, Mancozeb and Formalin at their respective doses of 1.5 g kg^{-1} seed, 2.5 g L^{-1}, 3 g L^{-1}, 3 g L^{-1}, 3 g L^{-1}, 3 g L^{-1}, 3 g L^{-1} and 1000 mL in 100 L water, were evaluated for the management of damping off disease in Rough Lemon rootstock (*Citrus jambheri* lush). The experiment was planned in accordance with randomized complete block design with four replications.

Results The performance of different fungicides to control damping off disease in Rough Lemon rootstock was evaluated in term of germination percentage, survival percentage and plant height. Results revealed that among eight tested fungicides, Formalin was found to be most effective to control the damping off disease as compared to untreated control followed by Copper oxychloride and Topsin-M, respectively. While, other tested fungicides (Ridomil gold, Antracol, Acrobat, Alliette and Mancozeb) exhibited poor control on damping off disease that were non-significant ($p \leq 0.05$) when compared to untreated control treatment.

Conclusion It is concluded that soil must be fumigated with the Formalin, and seeds be treated with recommended dose of Copper oxychloride and Topsin-M fungicides for the production of disease free citrus nursery and the establishment of a healthy orchard.

INTRODUCTION

Citrus is one of the leading fruit crops of the world with global availability and popularity contributing to human diets (Liu et al. 2012). In Pakistan, it is grown on an area of about 0.2 million hectares with a production of 2.1 million tons and a productivity of 9.2 tons per hectare (FAO 2016). It is the largest fruit in Pakistan and its production plays an important role in economic development and poverty alleviation. Although, citrus is grown in all the five provinces, however, it is primarily adaptable and grown in Punjab which produces over 95% of the crop (Altaf et al. 2009). The major citrus varieties grown in Punjab are mandarins with two varieties viz. Kinnow and Feutrell, covering 80% of the total citrus growing area (Altaf 2006).

Pakistan stands at sixth position among the citrus

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growing countries in the world, but the citrus production in general is almost static, or even declining (Ahmed and Saleem 2006). The reasons for this decline may be numerous but non-availability of disease free nursery plants has been considered the major factor responsible for poor establishment of citrus orchards (Helal 2017). It has been observed that demand of citrus nursery plants is increasing day by day, however, on account of the incidence of soil borne pathogens, large number of seedlings undergo serious mortality before or just after their germination (Altaf et al. 2009). According to Kean et al. (2010), one factor associated with poor citrus production is the citrus nursery diseases which resulting in deteriorating the seedling health or even death of the young seedlings. Helal et al. (2017) also reported that among different problems pertains to citrus nursery, damping off disease has been identified as a most serious issue. This disease is not only damaging to the citrus nursery both at pre- and post-emergence of seedlings but also acts as a source of infestation during raising of citrus orchards. Impacts of initial infestation is on the healthy survival of nursery but it is the potential threat to the vigorous establishment of citrus orchards as well.

Among various factors which cause damping off disease, the presence of different soil borne fungi (i.e. *Pythium*, *Phytophthora*, *Corticium* and *Fusarium*) are the major contributing factors of the problem. Substantiating the fact, various scientists have conducted studies on seedling mortality at nursery level. For example, evaluating effect of phytophthora disease on nursery, Naqvi (1994) reported that more than 20% nursery plants were damaged due to phytophthora disease and all nurseries were infected with this damaging fungus. Moreover, *Fusarium* spp. was attributed as pathogenic for citrus roots as reported by Nemec (1975) and Nemec et al. (1989). Labuschagne et al. (1989) found that *Fusarium* alone or in combination with nematodes were dangerous for citrus roots to cause the seedling mortality. It was also reported by Duncan and Cohn (1990), Abd-Elgawad et al. (2010) that among many problems in the citrus nursery production, plant parasitic nematodes ranked high for aggravating conditions towards various soil borne diseases.

Different management strategies adopted to control damping off disease include sowing the seeds in a sterilized growing medium, removing and discarding the diseased plants, and sterilizing the containers to remove dust, planting medium, and soil particles in which spores can survive, maintaining the drier conditions with better air circulation and spraying or drenching the soil or seed treatment with a recommended anti-fungal chemicals (Kazempour 2004; Sangeetha et al. 2013; Helal et al. 2017). In the light of the research studies, different fungicides/or chemicals were selected for assessing their efficacy against damping off disease of citrus nursery. Various scientists used the tool of chemical control in different citrus growing regions for pathological diseases (Farih et al. 1981; Timmer and Castle 1985). Gade et al. (2000) used Ridomil solution at 0.25% in rough lemon seedlings to control the phytophthora root rot disease. For the control of soil borne pathogens, many scientists also used fumigants as a tool to overcome these pathogens. Soil may be fumigated with melthyl bromide (390-500 kg ha^{-1}) or with Vapam (111 L ha^{-1}) to eliminate phytophthora from nursery/orchard (Ajwe 2004).

Keeping in view the above discussion, the present study was conducted to evaluate the efficacy of different recommended chemicals/fungicides to control damping off disease of citrus nursery under the prevailing conditions of Sargodha.

MATERIALS AND METHODS

A three year study was carried out in the research area of Citrus Research Institute (CRI), Sargodha to evaluate the efficiency of different fungicides against damping off disease of citrus nursery plants. The study was comprised of the following treatments including T_1: Topsin-M (1.5 g kg^{-1} seed), T_2: Ridomil gold (2.5 g L^{-1}), T_3: Antracol (3.0 g L^{-1}), T_4: Copper oxychloride (3.0 g L^{-1}), T_5: Acrobat (3.0 g L^{-1}), T_6: Aliette (3.0 g L^{-1}), T_7: Mancozeb (3.0 g L^{-1}), T_8: Formalin (1000 mL 100 L^{-1}) and T_9: Control (untreated). The seeds of the rough lemon (*Citrus jambheri* lush) root stock were treated with the candidate fungicides except of Formalin that was applied directly in the seed beds as a fumigant and then the seeds were sown in the trial site. The untreated seeds raised in plots were considered as control in this experiment.

The experiment was laid out according to randomized complete block design (RCBD) with 4 replications. Total number of plants/seed bed as per experiment plan were thirty six. Root stock seeds were extracted from fully mature, fresh rough lemon fruits, washed with water, dried and treated with selected fungicides according to treatment plan. Thereafter, the seeds were sown on the seed beds already treated with individual fungicide/ chemicals under study. The research trial was appropriately managed by adopting recommended cultural practices. After germination, the citrus seedlings were sprayed with same fungicides/ chemicals that were used as seed treatment at one month interval till the seedlings were transplanted. The observations were recorded for each treatment after twenty days of every spray. Efficacy of all applied fungicides was determined on the basis of survival rate of root stock seedlings in response to the candidate treatments. The parameters studied were

number of seedling germinated, plant height and survival rate of the seedlings. The data were analyzed using Statistix Software (version 8.1).

RESULTS AND DISCUSSION

The results mentioned in the Table 1 indicated that seed bed treated/fumigated with the Formalin solution showed maximum survival rate of seedlings (i.e. 155.83 seedlings plot^{-1}) as compared to untreated control treatment (77.25 seedlings plot^{-1}). Similarly, other fungicides such as Copper oxychloride, Topsin-M and Aliette also controlled the disease depicting the survival rate many times more than control. However, there was no statistically significant ($p \leq 0.05$) difference among these treatments. These results were matched with past studies (Vaartaja 1964; Gade et al. 2000; Safdar et al. 2013) which declared that damping off disease of citrus seedling could effectively be controlled by chemical treatment.

Results about number of seedlings germinated plot^{-1} in three different years as affected by different fungicides are mentioned in Figure 1. In 1st year, the maximum number of germinated seedlings were observed in the plots treated with Formalin as compared to untreated control treatment. In 2nd year, application of Formalin and Copper oxychloride resulted in maximum germination of seedlings as compared to control treatment. However, in 3rd year, the results were somewhat different, application of Copper oxychloride and Ridomil gold produced higher number of seedlings germinated over other treatments. Kazempour (2004) reported that seed treatment, soil application and foliar spray with systemic chemical fungicides provide an effective management strategy for the control of different plant diseases. Gade et al. (2000) also reported that the use of Ridomil solution @ 0.25% provided effective control of phytophthora root rot disease in rough lemon seedlings. Data presented in Figure 2 showed the effects of different fungicide treatments on survival rate of rough lemon seedlings against damping off disease. In 1st and 2nd years, the statistically maximum survival rate was observed in seedlings treated with Formalin in comparison to untreated control and all other treatments. However, in 3rd year, treatment of seedlings with Topsin-M resulted in maximum survival rate as compared to untreated control but all the treatments did not show any significant ($p \leq 0.05$) difference among themselves. Thind (2017) reported that application of chemicals is still a principal method of managing a number of plant diseases because these chemicals reduced the mortality rate and thus improved the plant survival percentage.

Data presented in Figure 3 depicted the effect of different fungicide treatments on the plant height of seedlings over the period of three years. In 1st year, the maximum plant height was attained by the application of Formalin and Antracol as compared to control and all other treatments while, in 2nd year, application of Mancozeb and Antracol resulted in seedlings with maximum height as compared to all other treatments. In 3rd year, maximum plant height was recorded in plants treated with Topsin-M than untreated control and all other treatments. The results corroborate with the findings of various researchers, for example, Vaartaja (1964) who described the control of nursery diseases by applying pre-planting application of Mefenoxam, (Metalaxyl), Fosetyl-Al (Aliette) and Thiophanate-methyl (Topsin-M). Similarly, the application of fumigants has been described by the scientists to reduce the soil borne pathogens associated with damping off. Hansen et al. (1990) used Chloropicrin (100%) and Dazomet as soil fumigant in conifers nursery to control damping off disease. Vaartaja (1964) applied Methyl bromide (67%), Chloropicrin (33%) and Meta sodium (33%) on seed

Table 1 Effect of different fungicide treatments on the management of damping-off disease of citrus seedlings

Treatments	Dose rate (kg^{-1} seed)	Average value after three years		
		Seedlings survived plot^{-1}	Seedlings germinated plot^{-1}	Plant height (cm)
TM	1.5 g L^{-1}	117.67 ± 10.11	208 ± 12.56	48 ± 2.78
RG	2.5 g L^{-1}	82.08 ± 7.42	192 ± 10.87	46 ± 2.08
AC	3.0 g L^{-1}	89.17 ± 9.91	185 ± 11.43	48 ± 2.39
COL	3.0 g L^{-1}	120.25 ± 11.90	239 ± 14.90	37 ± 1.80
ARB	3.0 g L^{-1}	98.17 ± 9.89	155 ± 9.78	37 ± 1.56
AE	3.0 g L^{-1}	100.33 ± 10.04	187 ± 10.80	49 ± 2.92
MZ	3.0 g L^{-1}	87.33 ± 7.32	173 ± 9.84	46 ± 2.19
FAD	1000 mL 100 L^{-1}	155.83 ± 12.56	254 ± 15.34	51 ± 3.45
CTL	–	77.25 ± 7.38	218 ± 13.22	37 ± 1.87

TM: Topsin−M (Thiophanate−Methyl), RG: Ridomil gold (Met al.axyl + Mancozeb), AC: Antracol (Propineb), COL: Copper Oxychloride, ARB: Acrobat (Dimethomorph + Mancozeb), AE: Aliette (Fosetyl−Al), MZ: Mancozeb, FAD: Formalin (Formaldehyde), CTL: Control

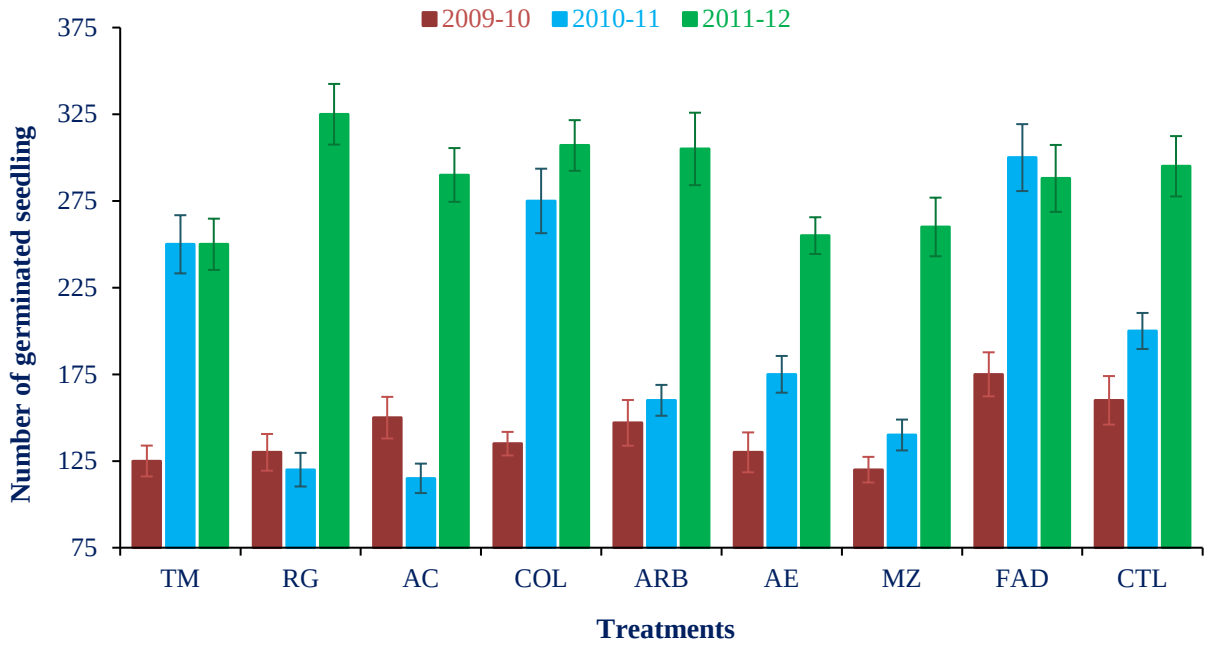

Figure 1 Effect of different fungicide treatments on number of germinated seedlings of citrus "rough lemon" during the period of three years. TM: Topsin-M (Thiophanate - Methyl), RG: Ridomil gold (Metalaxyl + Mancozeb), AC: Antracol (Propineb), COL: Copper Oxychloride, ARB: Acrobat (Dimethomorph + Mancozeb), AE: Aliette (Fosetyl-Al), MZ: Mancozeb, FAD: Formalin (Formaldehyde), CTL: Control

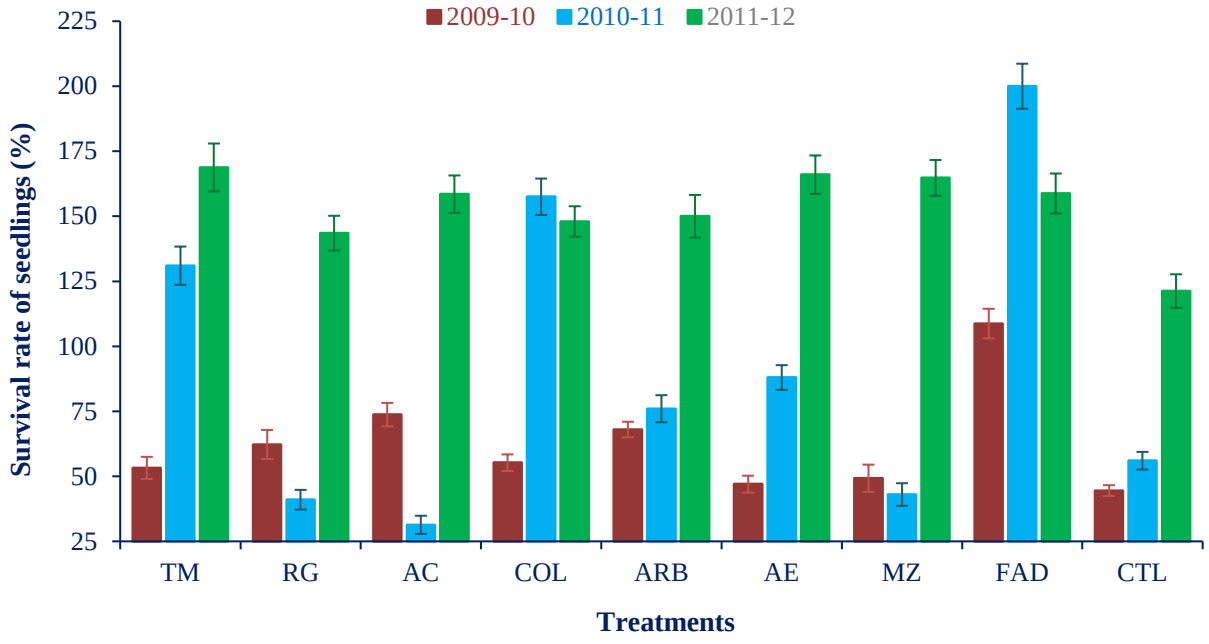

Figure 2 Effect of different fungicide treatments on the survival rate of citrus "rough lemon" seedlings during the period of three years. TM: Topsin-M (Thiophanate - Methyl), RG: Ridomil gold (Metalaxyl + Mancozeb), AC: Antracol (Propineb), COL: Copper Oxychloride, ARB: Acrobat (Dimethomorph + Mancozeb), AE: Aliette (Fosetyl-Al), MZ: Mancozeb, FAD: Formalin (Formaldehyde), CTL: Control

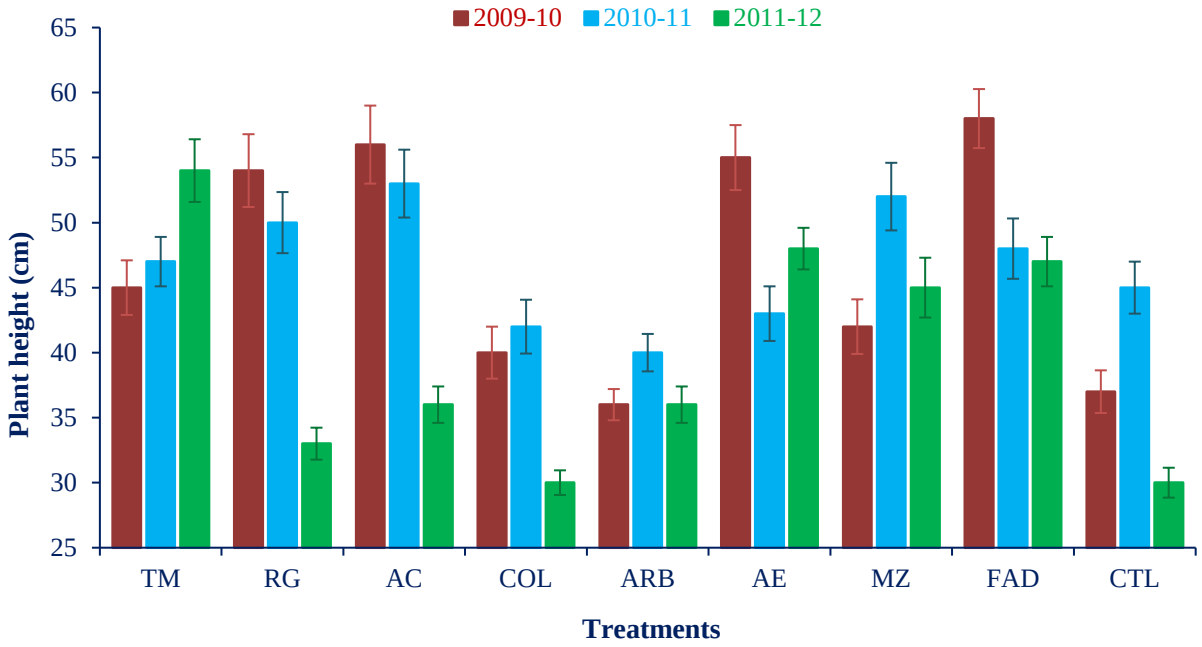

Figure 3 Effect of different fungicide treatments on plant height of citrus "rough lemon" seedlings during the period of three years. TM: Topsin-M (Thiophanate - Methyl), RG: Ridomil gold (Metalaxyl + Mancozeb), AC: Antracol (Propineb), COL: Copper Oxychloride, ARB: Acrobat (Dimethomorph + Mancozeb), AE: Aliette (Fosetyl-Al), MZ: Mancozeb, FAD: Formalin (Formaldehyde), CTL: Control

to control nursery disease. Klotz and Calavan (1978); Bailey and Morse (1990); Naqvi (2002) used Methyl bromide @ 390-500 kg ha^{-1} or Chloropicrin @ 484-968 kg ha^{-1} for fumigation to eliminate the phytophthora as well as nematode. Seed bed treatment of Formalin was also reported by Srivastava and Singh (1954) where application of Formalin @ 30-40 g ft^2 seed bed against damping off proved more effective.

CONCLUSION

The tested chemicals/ fungicides showed remarkable differences in controlling the damping off disease of citrus nursery. Formalin showed its superiority over others in eliminating the damping off of citrus nursery plants due to its double action in controlling the citrus soil borne pathogens as well as nematodes. Among other fungicides, Copper oxychloride, Topsin-M and Aliette also proved their worth for controlling the disease. It is suggested that better management and wise cultural practices of citrus nursery might be effective in controlling the other contributing factors which facilitate the infestation and multiplication of the soil borne pathogens and diseases. It is important not to rely entirely on the chemical control in the best interest of environmental quality and to avoid resistance against the pathogens.

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