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2,4-D the Appropriate Composition for Controlling Citrus Postharvest Decay.

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ABSTRACT

In order to assess the influence of chemical treatments on controlling postharvest decay of Lisbon lemon (*Citrus lemon*) in two storage conditions including ambient (25 °C) and cool storage (5 °C) was conducted an experiment as factorial arrangement in completely randomized design with three replicates. For this purpose, the fruits of Lisbon lemon were harvested in full ripening stage and after treating by different concentrations of sodium carbonate, sodium bicarbonate, Thiabendazol, Benomyl, 2,4-D and sodium hypochlorite were packaged into two groups in plastic bags. One of the packaged fruit s group was kept in ambient storage and another in cool storage for 105 days. The results showed that storage and treatment type had influence on safe fruit percent. Between treatments, 2,4-D in ambient storage and then sodium bicarbonate in cool storage significantly were better than other treatments. The influence of storage type was various depending on treatment type, but generally fruit decay percent in the cool storage significantly were less than ambient storage.

Keywords: 2,4-D, Citrus decay percent, Fungicides.

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INTRODUCTION

The Citrus fruits in the postharvest time and during transportation, in the shop or storage are damaging due to several fungal agents attack. Hence, controlling postharvest diseases of Citrus is necessary to quality survival and staying fresh fruit. Gutter [1] evaluated the effect of Benomyl and Thiabendazol on controlling green mold of Shamouti and Valencia sweet oranges. He dipped the fruits in fungal solutions (450, 900 and 1350 mgL^{-1}) for 2 minutes in the room temperature conditions. He observed that the Thiabendazol concentrations had no significant difference together and the best results obtained from Benomyl 900 mgL^{-1}. Cohen and Shuadi [2] used Thiabendazol and 2,4-D for controlling *Alternaria* decay in the Citrus fruits and obtained good results. Snowdon [3] in his book, has been mentioned *Alternaria* species as the most important decay agents in Citrus fruits and the best chemical controlling of this fungi recommended using of 2,4-D, Thiabendazol and Befran. Wild [4] in the experiment evaluated the sensitivity of various strains of *P. digitatum* separated from Lime and Sweet orange from different regions of America and Australia. Laboratory evaluations showed that four American strains had more than 13 times less sensitivity than four Australian strains. Also similar results were obtained in the field experiments. All American strains were resistant to Benzimidazols.

Aharoni *et al*. [5] reported that performance of bicarbonate salts for controlling postharvest pathogens have been confirmed in Citrus, Carrot and Sweet pepper. They examined the effect of bicarbonate on fungal decays of Melon. They filtered salt solutions by Millipore filter before adding to autoclaved PDA medium. After cooling the medium in 55°C temperature, were added salt solutions by different concentrations. Effect of salts bicarbonates on mycelium growth of *Alternaria alternate*, *Fusarium* species and *Rhizopus stolonifer* was evaluated by placing one 4-cm-diameter disk from 10-days culture of fungi in center of 9-mm petri dishes containing PDA medium having different concentrations of sodium bicarbonate salt. The experiments were done three times with three replications and the grown colonies diameter was measured every day until seven days. These experiments were done on Melon. Each treatment was consisting 30 Melon fruits that were divided into five groups. The Melon fruits were sprayed by Zivdar wax so that the wax covered total surface of the fruits. The wax had 1.0, 2.0 or 3.0% sodium bicarbonate or 2000 μlL^{-1} Imazalil fungicide. The treated fruits were kept in 3 °C for 14 days and additional 4 days in shop condition in 20 °C. The field experiment showed that fruit decay in the control treatment was high after 14 days (10%). Waxing decreased fruit decay up to 40% while sodium bicarbonate decreased fruit decay up to 50%. Sodium bicarbonate 2-3% completely stopped decay percent. Anyhow sodium bicarbonate 3% caused to damage to the fruits.

Mari *et al*. [6] evaluated integrate biological and chemical control for postharvest diseases. They explained that anti-fungal effect of antagonists can be increase by adding calcium salts or sugar analogs. In their experiment application of yeast in conjunction with low doses of fungicides well controlled blue mold in citrus fruit. Karabulut *et al*. [7] examined the effect of sodium bicarbonate, potassium sorbate and two yeast bio-control agents for preventing postharvest decay of Sweet cherry. Sodium bicarbonate 2% decreased fruit decay after 30 days fruit keeping in 0 °C and 4 days keeping in shop conditions compared with untreated fruits up to one-eighth. Potassium sorbate was effective on reduction of decay less than sodium bicarbonate. Smilanick and Sorenson [8] in the

experiment by dipping Lime and Sweet orange in calcium poly sulfide 0.75% solution decreased green mold up to 80% and sour rot due to *Geotrichum citri-auranti* up to 35-70%. Its influence on Lime was more than Sweet orange. Kobiler [9] evaluated the effect of 2,4-D on Mango fruit end rot due to *Alternaria alternate* and found that 75-175 mgL^{-1} had significant influence on disease controlling. Ritenour *et al*. [10] explained that *Alternaria citri* is one of the postharvest damaging agents of Citrus in Florida and for its control recommended Benomyl and Thiabendazol. They recommended Thiabendazol 1000 mgL^{-1} as suspension in water. Meanwhile, they recommended Imazalil for controlling this pathogen and explained that Imazalil has relative control on this disease.

Timmer *et al*. [11] demonstrated that *Alternaria* species make four diseases in Citrus, which fruit rot, is the most important. Captafol is a fungicide that is widely used in Florida and it is effective. Iprodion also is very effective in disease controlling. Cupper fungicides also are used and they are very effective. In occupation Palestine in addition to above fungicides, are used Dithiocarbamates, Triazoles and Famoxadone. Peever *et al*. [12] also reported that *Alternaria* diseases of Citrus are four types. Mohamad and Zhand [13] also mentioned that *A. citri* is one of the damaging agents in Citrus fruit, which addition to fruit rot is a problem in Industrial process and is causing to contamination of fruit juice. They identified Thiphanate-methyl, Scular, Azoxistrobin and 2,4-D for controlling this disease.

MATERIALS AND METHODS

In order to evaluate the effects of sodium carbonate, sodium bicarbonate, Thiabendazol, Benomyl, 2,4-D and Sodium hypochlorite on decay controlling of Lisbon lemon in ambient and cool storage, was performed this study in Jahrom city, Fars, Iran.

Lisbon lemon fruit harvesting

Lisbon lemon fruits were harvested from one of the Jahrom city's garden placed in Mohamad-abad region from 5-years-olds tree that had been cultured 5×5 m distance and nutritional condition of all trees was equal. Harvest operation was done by using scissors from all sides of tree. The harvested fruits were transferred to the laboratory for operating the treatments.

Fruit preparation and treating

The harvested fruits were washed by water and completely randomized were divided into below groups based on treatment type:

Control; Sodium carbonate (SC) 500, 1000 and 1500 mgL^{-1}; Sodium bicarbonate (SBC) 500, 1000 and 1500 mgL^{-1}; Thiabendazol (TBZ) 500, 1000 and 1500 mgL^{-1}; Benomyl (B) 500, 1000 and 1500 mgL^{-1}; 2,4-D 100, 150 and 200 mgL^{-1} and Sodium hypochlorite (SHC) 1000, 2000 and 3000 mgL^{-1}. This experiment was conducted in completely randomized design (CRD). Each treatment has 3 replications and 25 fruits in each replicate. The fruits were dipped into above chemical solutions for 5 minuets. Control samples were dipped in common water. After drying the fruit surface in free air, each fruit was packaged into a plastic bag individually.

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Fruits weighing

Before storing, the treated fruits were weighed until after storing can be calculated weight losing.

Fruits keeping in the storages

The treated fruits were kept in the storage for 105 days (3.5 months). The ambient storage was dark, 12-25 °C and 53-68% RH. The cool storage (refrigerator) was dark, 5-10 °C and 65-75% RH.

Determination safe fruits percent

To determine safe fruit percent, the rotted fruit in each replication was counted and based on total number of fruits, safe fruit percent was calculated.

Determination total weight losing

To determine total weight losing, after removing the decayed fruits, the remained fruits were weighing and based on primary weight, weight loss percent was calculated.

Statistical analysis

The obtained data was analyzed by MSTAT-C software and the means were compared by Duncan's multiple range test (DMRT).

RESULTS AND DISCUSSION

Analysis of variance

Analysis of variance results showed that storage and treatments type had significant influence ($p<0.01$) on safe fruit percent and weight loss. Also there was significant interaction between factors. In fact, reaction of different treatments in both storages was not equal and showed various trend (Table 1). Whereas because of high coefficient of variation (CV) in weight loss, the obtained results in this characteristic is not discussed and in the following the results of safe fruit percent is explained.

Table 1- Analysis of variance in relation to the soft fruit percent

Source of variation	df	Sums of square	Mean square	Fs	CV
Storage (A)	1	9414.88	9414.88	243.9**	13.9 %
Treatment (B)	18	30502.46	1694.58	43.9**	
Interaction AB	18	11313.12	628.51	16.3**	
Error	76	2933.33	38.60		
Total	113	54163.79			

** Significant in $p<0.01$.

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Influence of treatment type on the safe fruit percent

The highest safe fruit percent was observed in application different concentrations of 2,4-D (84.7, 76.0 and 85.3%), which had significant difference to other treatments.

Table 2-Mean comparison of the soft fruit percent

Storage type / Treatments	Ambient storage	Cool storage	Treatment means
Control	$^{\dagger}8.7^{q}$	49.3^{hijkl}	$^{\dagger\dagger}33.3^{EF}$
Benomyl 500 mgL^{-1}	44.0^{jklmn}	60.0^{defghi}	52.0^{BC}
Benomyl 1000 mgL^{-1}	24.0^{p}	73.3^{bcde}	48.7^{C}
Benomyl 1500 mgL^{-1}	28.0^{op}	60.0^{defghi}	44.0^{CD}
SBC 500 mgL^{-1}	23.3^{p}	57.3^{fghijk}	45.3^{CD}
SBC 1000 mgL^{-1}	46.7^{ijklm}	70.7^{cdef}	58.7^{B}
SBC 1500 mgL^{-1}	54.7^{ghijk}	66.7^{defg}	60.7^{B}
2,4-D 100 mgL^{-1}	86.7^{ab}	84.0^{abc}	85.3^{A}
2,4-D 150 mgL^{-1}	88.0^{ab}	64.0^{defgh}	76.0^{A}
2,4-D 200 mgL^{-1}	94.7^{a}	74.7^{bcd}	84.7^{A}
TBZ 500 mgL^{-1}	25.3^{p}	66.7^{defg}	46.0^{CD}
TBZ 1000 mgL^{-1}	29.3^{nop}	42.7^{klmno}	36.0^{DEF}
TBZ 1500 mgL^{-1}	36.0^{lmnop}	48.0^{ijkl}	42.0^{CDE}
SC 500 mgL^{-1}	29.3^{nop}	25.3^{p}	27.3^{F}
SC 1000 mgL^{-1}	6.7^{q}	56.0^{fghijk}	31.3^{F}
SC 1500 mgL^{-1}	42.7^{klmno}	53.3^{ghijk}	48.0^{C}
SHC 1000 mgL^{-1}	25.3^{p}	46.7^{ijklm}	36.0^{DEF}
SHC 2000 mgL^{-1}	25.3^{p}	58.7^{efghij}	42.0^{CDE}
SHC 3000 mgL^{-1}	32.0^{mnop}	57.3^{fghijk}	44.7^{CD}
Storage means	$^{\dagger\dagger}40.5^{B}$	58.7^{A}	

The means having same letter, have not significant difference according to DMRT ($p<0.01$).
††Uppercase and †lowercase letters are relative to main effect of factors and their interaction respectively.

Application 500 and 1000 mgL^{-1} Sodium carbonate (SC) not only did not prevent to fruit decay (27.3 and 31.3% safe fruit respectively) but had less the safe fruit percent than untreated fruits (control) Although was not observed any significant difference between them and control treatment. In this relation, Sodium hypochlorite (SHC) 1000 and 2000 mgL^{-1} and TBZ 1000 and 1500 mgL^{-1} had no significant difference to control treatment.

After 2,4-D the concentrations of 1500 and 1000 mgL^{-1} of SBC and 500 mgL^{-1} Benomyl respectively had the greatest safe fruit percent. By increasing Benomyl concentration from 500 to 1500 mgL^{-1}, the safe fruit percent decreased. It seems high concentrations of Benomyl had negative effect on controlling fruit decay of Lisbon lemon. In

contrast, increasing concentration of SC and ABC as well as SHC from 500 to 1500 mgL^{-1} caused to reduction of decay percent. In truth, high concentrations of these materials had more inhibitory effect on decay of Lisbon lemon in the storage (right Table 2).

Interaction between storage and treatment

The highest safe fruit percent was observed in application 200 mgL^{-1} 2,4-D in ambient storage (94.7%), which had no significant difference to 100 mgL^{-1} 2,4-D in both storages and 150 mgL^{-1} 2,4-D in ambient storage but indicated significant difference to other treatments. It seems 2,4-D is not able to controlling decay in low temperature and/or low temperature is preventing to 2,4-D activity against decay agents on the fruits, because of in the all 2,4-D concentrations, the safe fruit percent in the cool storage has been less than ambient storage. In the all applied treatments, except different concentrations of 2,4-D and SC 500 mgL^{-1}, the safe fruit percent in the cool storage was more than ambient storage (Table 2).

CONCLUSION

Generally, according to the above results can be concluded that 2,4-D was the best treatment on controlling diseases. After 2,4-D, SBC could be controlled fruit decay. Benomyl, Sodium carbonate, Thiabendazol and Sodium hypochlorite, especially in low concentrations, had no influence on disease controlling but in high concentrations had significant difference to control treatment.

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