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EFFECT OF CALCIUM ON JUJUBE *Ziziphus* sp. FRUIT GROWTH AND THEIR RESISTANCE TO JUJUBE FRUIT FLY *Carpomyia incompleta*

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Abstract

Calcium chloride was sprayed during winter growing season 2005-2006 to jujube trees cultivars Bambawi *Ziziphus spina-christi* and Zaitooni *Z. mauritiana* to test its effect on jujube fruit fly *Carpomyia incompleta* (*Tephritidae:Diptera*). The percentage of jujube fruit fly infestation on both cultivars of jujube were reduced and continued decreasing down during the growing season, that resulted from increasing of some jujube fruit quality characteristics, at a high concentration of calcium salt. A negative correlation was found among the percentage of fruit fly infestation and weight, size, water content, vitamin C, protein content and calcium content percentage of Bambawi and Zaitooni fruits, while positive correlation was found between the percentage infestation of fruit fly and dry matter percentage rate of both cultivars fruits .The present result concluded that there are a synergistic effect of jujube fruit quality characteristics on jujube fruit fly infestation, when spraying with calcium salt.

ملخص

رشت اشجار السدر صنفي بمباوي *Zizphus spina- Christi* وزيتوني *Z. mauritiana* بكلوريد الكالسيوم خلال موسم النمو الشتوي 2005-2006 ، لمعرفة تأثير الكالسيوم في ذبابة ثمار السدر (*Tephritidae: Carpomyia incomplete Diptera*) ، وقد بينت النتائج إن النسبة المئوية للإصابة بذبابة ثمار السدر اختزلت في كلا صنفي السدر ، وقد استمرت بالانخفاض خلال موسم النمو ، نتج ذلك من زيادة بعض صفات ثمار السدر النوعية باستخدام التركيز العالي من الكالسيوم ، إذ وجد إن هناك علاقة ارتباط عكسية بين نسبة الإصابة المئوية لذبابة الثمار مع الوزن والحجم وفيتامين جـ والنسبة المئوية للمحتوى المائي وللمحتوى البروتيني ولمحتوى الكالسيوم في ثمار الصنفين بمباوي وزيتوني ، بينما وجد ارتباط موجب بين نسبة الإصابة لذبابة الثمار والنسبة المئوية للمادة الجافة في كلا صنفي السدر.ونستنتج من ذلك أن هناك تأثير تآزري للصفات النوعية لثمار السدر عند رش الثمار بالكالسيوم في نسبة إصابة ذبابة ثمار السدر .

Introduction

Larvae of jujube fruit fly *Carpomyia incompleta* (*Tephritidae: Diptera*) are important pests of jujube *Ziziphus* spp. Soon after hatching, the jujube fruit fly bores into the fruit and feeds there until larval development is completed (Jebbar, 1996). Pesticides target adults, eggs and neonate larvae are used for controlling insect population. The use of fertilization is an alternative strategy for the control of insect and improving plant quality (Davies *et al.,* 2003). Application of macronutrient calcium salts has been shown to prolong storage life and improve various measures of quality in several fruit and vegetable crop (Shear, 1975; Conway *et al*., 1992 and 1994). Beyond the effect on fruit quality, excess calcium may have an effect on susceptibility of trees to the attack by pathogens (Blodgett *et al.*, 2002).Spraying jujube fruit with high calcium concentration had an effect on quality characteristics changes during fruit development (Al-Maihy, 2004). However, no data are available on the effect of calcium on insect. The aim of conducting experiments on jujube fruit orchard is to test the effect of calcium salt applied during the growing season on :(i) plant quality characteristic and (ii) jujube fruit fly infestation.

Materials and Methods

Trials were conducted during winter growing season 2005-2006 in a jujube orchard, at Abu Al-khasieb region, Basrah . Calcium salt (CaCl2.7H2O) at concentrations of 0 , 1000 and 2000 mg/l were prepared and diluted with 0.1% Tween 20 solution as a surfactant. Jujube cultivars Bambawi and Zaitooni trees were sprayed with calcium (3 trees as replicates for each concentration) on 1st Nov.2005and 1st Jan.2005. Randomly, fifteen fruits samples were collected from each tree at different times, starting from 6th to 19th week after fruit set (7th Des. 2005-1st May 2006) and then transferred to the laboratory for recording infestation percentage rates of jujube fly *Carpomyia incompleta* on each cultivars Bambawi and Zaitooni .

The correlation between the infestation rate and the following fruit quality characteristics was calculated at each replicate of concentration of calcium: size and weight, water content and dry matter percentage of jujube fruit were measured according to Howrtiz (1975). Vitamin C content was determined according to procedure of A.O.A.C. (1980) . Protein content was determined according to Cresser and Parson (1979) by using Micro-kjldhal method to measure nitrogen . Calcium content of fruit was measured by Atomic absorption spectrophotometer (Cresser and Parsons, 1979). Data were statistically analyzed according to the Complete Randomized Design and means were separated using Revised Least Significant difference (R.L.S.d.) test (Al-Rawi and Khalaf-Allah ,1980).

Results

Results indicated that calcium reduced significantly the infestation rates of Jujube fruit fly *C. incompleta* on Jujube fruit cultivars Bambawi and Zaitooni . It reached 18.66% and 13.33% at concentrations of 1000 and 2000 mg/l calcium respectively, compared with 24% at control treatment on the 6th week after Bambawi fruit set, thereafter during the growing season, the rate reduced to 3.33%, 1.33% and 1.33% at concentration (0-2000)mg/l calcium on the 19th week after fruit set (Table 1).

Table(1) Effect of Calcium on Jujube fruit fly infestation percentage at different stages of cultivar Bambawi fruit growth .

Fruit growth stages (week after fruit set)	Mean of infestation %		
	Concentration Ca (mg / l)		
	0	1000	2000
6	24.00	18.66	13.33
9	23.33	21.33	14.00
12	14.66	16.66	8.66
14	18.66	12.00	6.66
15	15.33	4.66	6.00
16	8.66	5.33	5.33
17	6.66	3.33	2.00
18	4.00	2.00	2.00
19	3.33	1.33	1.33
R.L.S.d values 0.05	1.79		

It was also shown that infestation rates of Zaitooni fruit influenced by calcium (Table 2), it ranged from 28%, 20% and 18.66% at concentrations 0, 1000 and 2000 mg/l calcium respectively on the 6th week after fruit set. It continued decreasing down during the growing season, until the 19th week after fruit set for the cultivar, with average 0% at both concentrations of calcium, compared with 0.66 % at control.

Table(2) Effect of Calcium on Jujube fruit fly infestation percentage at different stages of cultivar Zaitooni fruit growth .

Fruit growth stages (week after fruit set)	Mean of infestation %		
	Concentration Ca (mg / l)		
	0	1000	2000
6	28.00	20.00	18.66
9	22.66	12.00	15.32
12	16.66	8.00	7.32
14	6.66	4.00	4.66
15	7.32	4.00	2.00
16	3.32	2.00	2.00
17	2.00	2.00	1.33
18	1.32	0.00	0.00
19	0.66	0.00	0.00
R.L.S.d values 0.05	1.46		

The results elucidated that weight and size of fruit cultivars Bambawi and Zaitooni (Fig. 1 and 2) was positively proportional to calcium concentration. Weight of both cultivars reached 3.444 g and 3.24 g respectively at the concentration 2000 mg/l calcium, compared with 3.345 g and 2.473 g respectively at 0 mg/l calcium . Size of both cultivars had increased at concentration 2000 mg/l calcium, reaching 3.469 cm^3 and 3.17 cm^3 respectively, compared with 3.254 cm^3 and 2.709 cm^3 at control concentration.

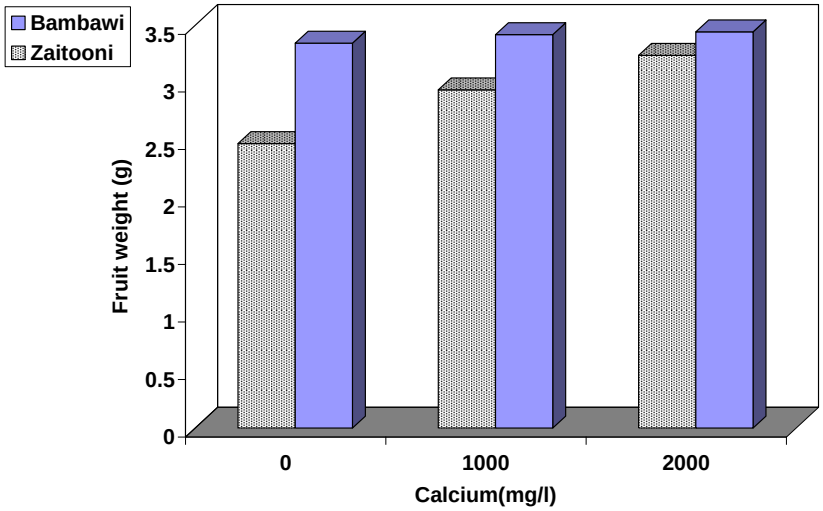

Fig.(1) Effect of Calcium on weight of Jujube fruit of cultivars Bambawi ($R.L.S.d._{0.05}$ =0.002) and Zaitooni ($R.L.S.d._{0.05}$ = 0.188)

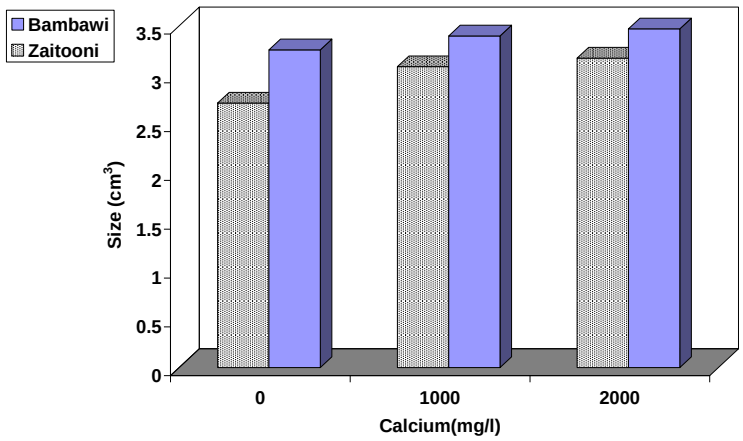

Fig.(2) Effect of Calcium on size of Jujube fruit of cultivars Bambawi ($R.L.S.d._{0.05}$ =0.077) and Zaitooni ($R.L.S.d._{0.05}$ = 0.030)

Infestation rate of *C. incompleta* on both cultivars negatively correlated with weight of Bambawi and Zaitooni fruit (r=-0.36 and -0.92 respectively), also with size (r=-0.41 and -0.97 respectively) (Table 3).

Table(3) Simple correlation coefficient of Jujube fruit fly infestation percentage and Jujube fruit quality characteristics .

Fruit quality characteristics	Jujube cultivars	
	Bambaw	Zaitooni
Weight	-0.36	-0.92
Size	-0.41	-0.97
Water Content %	-0.98	-0.084
Drymatter	0.85	0.185
Vitamin C	-0.96	-0.93
Protein Content %	-0.49	-0.82
Calcium Content %	-0.98	-0.957

Water content of Bambawi fruit increased as seen in Fig. 3, reaching 77.084%, 78.207% and 78.424% at calcium concentrations of 0, 1000 and 2000 mg/l , whereas no significant difference was observed in cultivars Zaitooni . In contrast, dry matter percentage of both cultivars showed inverse relationship with calcium , they varied from 22.896%, 22.576% to 21.573% in cultivar Bambawi fruit, and from 22.472%, 21.997% to 21.467% in cultivar Zaitooni fruit at concentration 0, 1000 and 2000 mg/l calcium respectively(Fig. 4).

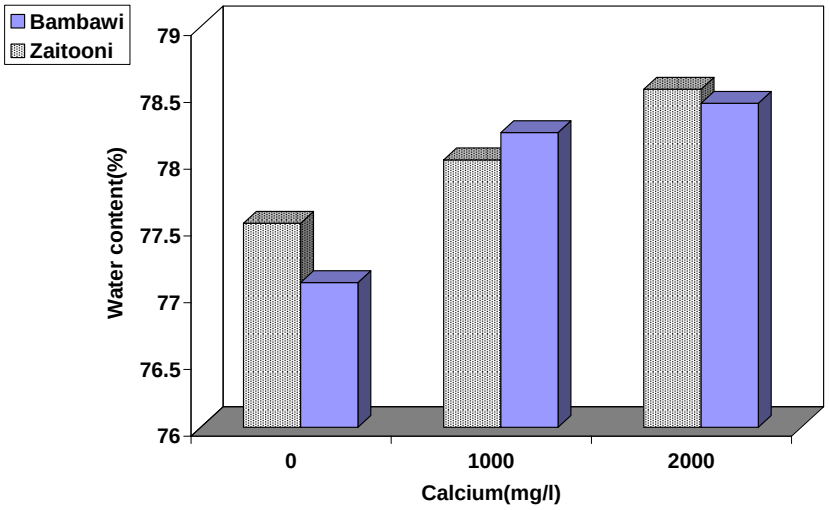

Fig.(3) Effect of Calcium on water content of Jujube fruit of cultivars Bambawi (R.L.S.d.$_{0.05}$ =0.696) and Zaitooni (R.L.S.d.$_{0.05}$ = N.S.)

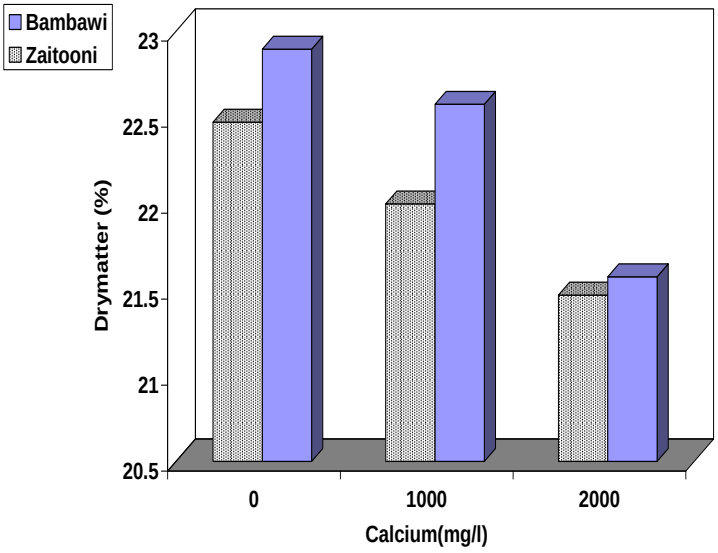

Fig.(4) Effect of Calcium on dry matter of Jujube fruit of cultivars Bambawi (R.L.S.d.$_{0.05}$ =1.096) and Zaitooni (R.L.S.d.$_{0.05}$ = .696)

Negative correlations were noticed between infestation rate and water content of cultivars Bambawi fruit (r=-0.98) and cultivar Zaitooni fruit (r=-0.84) while positively correlated with dry matter percentage rates for cultivars Bambawi and Zaitooni fruits (r=+0.85 and +0.185) respectively.

Spraying with calcium had significantly affected vitamin C content of cultivars Bambawi and Zaitooni, with an average of 77.85 and 54.922 mg/100g respectively at concentration 0 mg/l calcium, continued increasing to 85.917 and 59.667 mg/100g respectively at concentration 2000 mg/l calcium (Fig. 5).An inverse correlations werefound between vitamin C content and *C. incomplete* infestation rates in cultivars Bambawi and Zaitooni (r=-0.96 and -0.93 respectively).

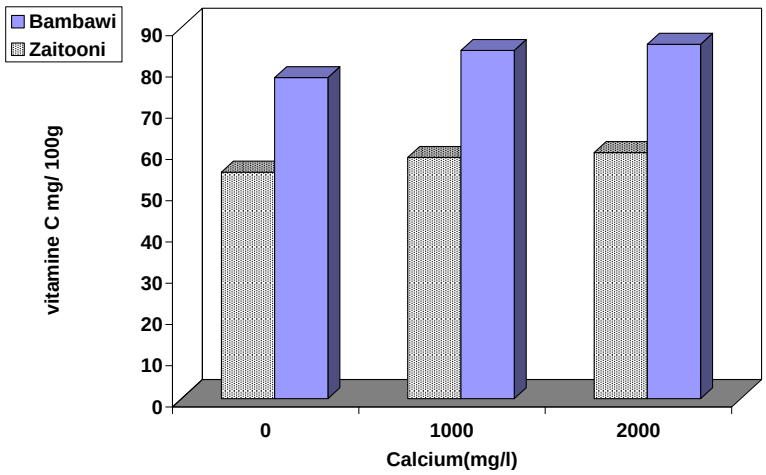

Fig.(5) Effect of Calcium on Vitamin C of Jujube fruit of cultivars Bambawi (R.L.S.d.$_{0.05}$ = 0.747) and Zaitooni (R.L.S.d.$_{0.05}$ = 1.115)

The highest percentage of protein content in both cultivars reached 25.965% and 10.244% respectively , at concentration 1000 mg/l calcium , while the lowest were 11.155% and 8.846% at 0 gm/l calcium (Fig. 6). Inverse relationships were recorded between protein content and jujube fruit fly infestation in both cultivars of jujube (r=-0.49 and -0.82 respectively).

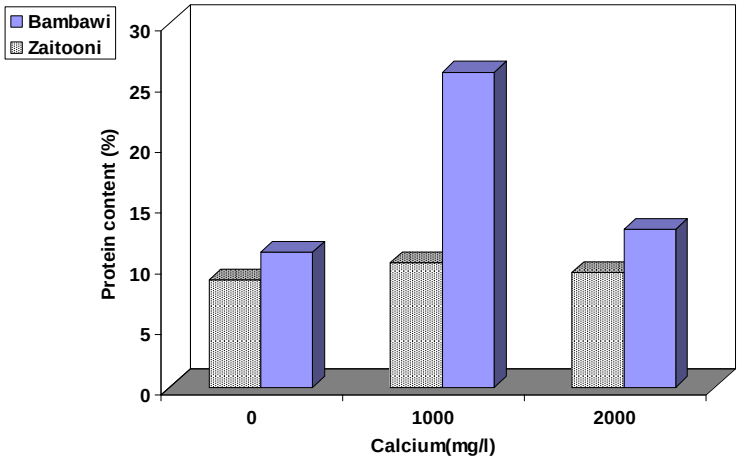

Fig.(6) Effect of Calcium on protein content of Jujube fruit of cultivars Bambawi (R.L.S.d.$_{0.05}$ = 0.16) and Zaitooni (R.L.S.d.$_{0.05}$ = 0.182)

Calcium salt increased fruit content of calcium (Fig. 7) which reached 0.169% and 0.151% for cultivars Bambawi and Zaitooni at concentration 2000 mg/l calcium, compared with 0.137% and 0.127% at concentration 0 mg /l calcium. An inverse correlation was found between *C. incompleta* infestation and calcium content percentage (r=-0.98 and -0.907) of Bambawi and Zaitooni respectively.

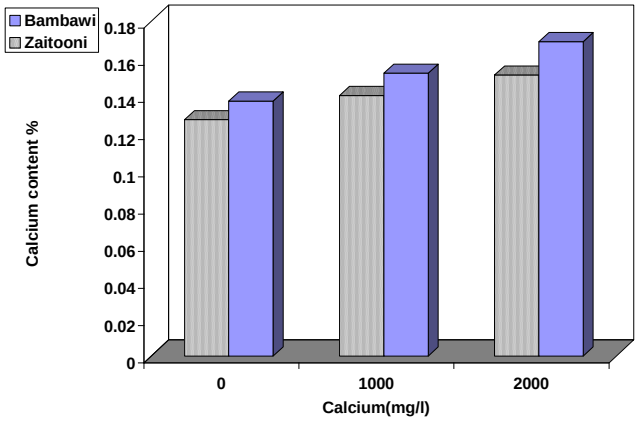

Fig.(7) Effect of Calcium on calcium content of Jujube fruit of cultivars Bambawi ($R.L.S.d._{0.05}$ =0.011) and Zaitooni ($R.L.S.d._{0.05}$ = 0.011)

Discussion

The percentage of jujube fruit fly infestation in jujube fruit trees cultivars Bambawi and Zaitooni have been reduced with increasing calcium concentration (Tables 1,2). The change in fruit fly infestation on fruits in this study, is an indication of feeding deterrent of pest on fruit at higher calcium concentration.

Differences in fruit fly infestation at different calcium concentrations might be resulted from changes in host plant characteristics, such as weight, size, water content, dry matter, vitamin C, protein content and calcium content percentages (Fig. 1-7). Such host plant quality changes might have direct effects on pest infestation. For example, increasing weight and size of Bambawi and Zaitooni fruits has reduced infestation by fruit fly. In this respect Sivinski *et al.* (1999) mentioned that fruit fly *Anasterpha suspensa* infested Guara fruits which had lighter weight fruit than those did not, and the females of Papaya fruit fly *Toxotrypana curvicauda* prefer to lay eggs, or larvae are better able to survive in smaller fruits (Landolt, 1985). Averages of water and dry matter contents of both cultivars increased with increasing calcium concentration. Jimenez *et al.* (1989) suggested that tolerance index of Alfalfa to the spotted Alfalfa aphid was correlated with plant dry matter. In the present experiment, high calcium concentration increased protein content. The coefficient presented in table (3) suggested that the higher protein content of fruit decreased the infestation of jujube fruit fly. The higher content fruit protein may inhibit feeding of fruit fly and influenced its performance that proposed by Srirastava *et al.* (1983) in their bioassay with *Acyrthosiphon pisum.* Lee *et al.* (2003) reported that nitrogen (protein) content of *Spodoptera exempta* body reduced when reared on higher concentration of protein, resulting from reduced conversion efficiency of ingested nitrogen into body nitrogen.

Calcium concentrations increased vitamin C content of both cultivars ,in turn , increased resistance to jujube fruit fly .No reports on the effect of vitamin C on any insect was found , therefore , additional studies are needed to explain the mechanisms of negative vitamin C effect on jujube fruit fly infestation on jujube fruit.

The application of calcium at concentrations of 1000 to 2000 mg/l to jujube trees during different developmental stages, increased calcium content of both cultivars fruit which, in turn, reduced insect infestation compared with untreated control . Feeding on calcium treated jujube fruit may create an osmotic imbalance to the fly between hemolymph and water , compared with untreated fruits, (Stanley, 1997). In addition to the binding affinity of calcium ions to protein in plant cell wall (Demarty *et al.*, 1984), thereby protecting them from insect feeding and oviposition (Kunvear , 1984).

The present result indicated that there are synergistic affects of jujube fruit quality characteristics on jujube fruit fly infestation and supported the hypothesis that insect infestation is closely tied to chemical host plant. Krokos *et al.* (2002) suggested that plant chemistry is probably the most important source of information contributing to the final decision by a herbivore insect to select a host .

Finally we recommend that use of calcium must be included in IPM programs of jujube fruit fly on Bambawi and Zaitooni cultivar.

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