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Effect of 2,4,5-Trichlorophenoxy Acetic Acid and Waxing on Quality and Storability of Lime Fruits

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Abstract: The effect of post-harvest treatment with 2,4,5-trichlorophenoxy acetic acid (2,4,5-T) and waxing on quality and storability of lime fruits at 18 ± 1°C and 85%-90% relative humidity was evaluated. Treatment with 2,4,5-T at 500 and 1000 ppm delayed senescence, maintained quality and extended storage life of lime fruits. The higher the concentration the more was the effect. Treatment with 2,4,5-T and waxing was more effective than 2,4,5-T alone. The effect of 2,4,5-T and waxing was manifested in decreased respiration rate and weight loss, total soluble solids (TSS) accumulation and delayed peel colour development.

Key words: Lime fruits; 2,4,5-T; waxing; quality; shelf-life

INTRODUCTION

Lime (*Citrus aurantifolia* L.) is an important citrus fruit. It originated in India and then spread to the Middle East and tropical and subtropical countries. It is used as a condiment, acidulant and beverage (Salunkhe and Desai 1984). Limes are grown in different parts of the Sudan for local consumption and for export. However, the availability in the local markets varies throughout the year. The seasonality of production, difficulty in storing the fruits and the instability of the juice, contribute to the wide fluctuation in prices and quality of limes (Al-Ashwah *et al*. 1981).

Limes should be picked while still green, but after the skin has become smooth and the fruit is mature and somewhat rounded (Hardenburg *et al.*1986). The market for fresh limes requires the fruit to be dark-green in

colour, with minimum yellowing and un-wilted (Stother 1970). It is essential that the fruit should remain firm and lose the minimum of water during storage and marketing (Blunden *et al*. 1979).

Plant-growth regulators are a potential means of regulating various aspects of fruit maturity, ripening and senescence (Coggins and Hield 1968). Gibberellic acid (GA_3), 2,4-dichlorophenoxy acetic acid (2,4-D) and 2,4,5-trichlorophenoxy acetic acid (2,4,5-T) delay loss of green rind pigments in many citrus fruits (Biasi and Zanette 2000; Camargo and Castro 2001; Coggins and Hield 1968). Most lemons (*Citrus limon*) in California are treated with 2,4-D before storage to delay senescence of the button (calyx plus disc) which is the usual point of attack by *Alternaria*. Oranges and grapefruits are similarly treated with 2,4-D in South Africa to reduce *Deplodia* and *Alternaria* stem-end rot during transportation and storage (DeWolfe *et al*. 1959). According to Coggins and Hield (1968), post-harvest treatment by 2,4,5-T on orange, grapefruit, mandarin and lime reduces black buttons and *Alternaria* decay, delays aging and improves storage life. Citrus fruits lose water, shrivel rapidly and lose consumer appeal during marketing and storage (Kader 2002). Waxing retards moisture loss, maintains turgidity and plumpness and covers injuries on surface of the commodity (Wills *et al*. 1998). Waxing delays fruit ripening and chlorophyll degradation, improves quality and extends shelf-life of lime (Abdallah 2008), orange (Martinez *et al*. 1991), grapefruit (Abu-Goukh and Elshiekh 2008), mango (Mohamed and Abu-Goukh 2003), guava (Mohamed-Nour 2007) and tomato (Ahmed and Abu-Goukh 2003).

This study was carried out to evaluate the effect of 2,4,5-T and waxing on quality and storability of lime fruits.

MATERIALS AND METHODS

Lime fruits of 'Balady' variety were harvested at the mature-green stage from a private orchard in Shambat ($15^{O}40^{'}$N, $32^{O}22^{'}$E). The fruits were selected for uniformity of size, colour and freedom from blemishes. They were transported to the experimental laboratory, washed with tap water to

remove dust and air dried. The fruits were distributed among six treatments in a randomized complete block design with four replications. The treatments were 0, 500 and 1000 ppm 2,4,5-T with or without waxing; and the fruits were dipped for three minutes in 2,4,5-T (BDH Chemicals Ltd.) solutions of 500 and 1000 ppm and air dried. The untreated fruits (control) were dipped in distilled water for three minutes and air dried. Food-grade wax (Flucka AG, CH-9470 Buchs) was used for wax treatment, and was applied in a thin layer by brushing over the surface of the fruits. The fruits were stored for 6 weeks at $18 \pm 1^{O}C$ and 85%-90% relative humidity.

Respiration rate was determined weekly, during the storage period, in 60 fruits from each treatment. The total absorption method of Charlimers (1956) was used, and respiration rate was expressed in mg CO_2 per kg-hr. Peel colour was determined weekly in the same 60 fruits. The following colour score was used: mature-green (= 0), light-green (= 1), 25% yellow (= 2), 50% yellow (= 3), 75% yellow (=4) and 100% yellow (= 5). Weight loss in the fruits was determined weekly in the same 60 fruits used for determination of respiration rate and colour changes according to the formula: $w_1 = [(w_o - w_t)/ w_o] \times 100\%$; where w_1 is the weight loss percentage at the designated time, w_o is the initial weight of the fruits and w_t is the weight of fruits at the designated time.

Total soluble solids (TSS) were determined at weekly intervals in ten fruits picked randomly from each replication, other than those used for respiration, colour changes and weight loss determinations. TSS were determined directly from the fruit juice using Kruss hand refractometer (model HRN-32). The mean values were calculated and corrected according to the refractometer chart.

Analysis of variance and Fisher's protected LSD test, with a significance level of $P \leq 0.05$, were performed on the data (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Treatment with 2,4,5-trichlorophenoxy acetic acid (2,4,5-T) significantly delayed senescence, maintained quality and extended shelf-life of lime fruits. Similar results were reported for orange, grapefruit, mandarin and lime (Coggins and Hield 1968). Waxing in addition to 2,4,5-T treatment resulted in more delay in senescence and extension of shelf-life of lime fruits. According to Abdallah (2008), waxing delays fruit ripening and senescence, reduce water loss, maintain quality and extend shelf-life of lime. Similar results were reported for orange (Salih and Thompson 1975), (Mohamed and Abu-Goukh 2003), (Ahmed and Abu-Goukh 2003). grapefruit (Mohamed-Nour 2007) (Abu-Goukh and Elshiekh 2008), mango guava and tomato

Effect on Respiration Rate

In all treatments, the respiration curves exhibited a typical non-climacteric pattern (Fig.1). This is in agreement with the findings of Aharoni (1968) who reported that citrus fruits harvested near horticultural maturity show a gradual decline in respiration rate and produce no ethylene.

Treatment with 2.4.5-T decreased respiration rate at all concentrations used, and the higher the concentration the more was the decrease. The respiration rate of the untreated fruits decreased from 18.5 to 7.7 mg CO_2/ kg – hr, after 6 weeks of storage. Respiration rate was 37.7 % and 63.6 % less in fruits treated with 500 and 1000 ppm 2,4,5-T , respectively, compared to the untreated ones, after 6 weeks of storage (Fig 1). It was reported by Coggins and Hield (1968) that post-harvest treatment with 2,4,5-T delays aging and improves storage of orange, grapefruit, mandarin and lime.

Treatment with 2,4,5-T and waxing was more effective in reducing respiration rate than 2,4,5 -T alone. The decrease was 51.4% and 72.2% in the waxed fruits treated with 500 and 1000 ppm 2,4,5-T, respectively, compared to the control (Fig.1). Waxing was reported to reduce respiration rate in orange (Martinez *et al*. 1991), mango (Mohamed and Abu-Goukh 2003) and tomato (Ahmed and Abu-Goukh 2003), and to influence respiration rate by decreasing oxygen and increasing carbon dioxide content in the internal atmosphere of the fruit (Irving and Warren 1960).

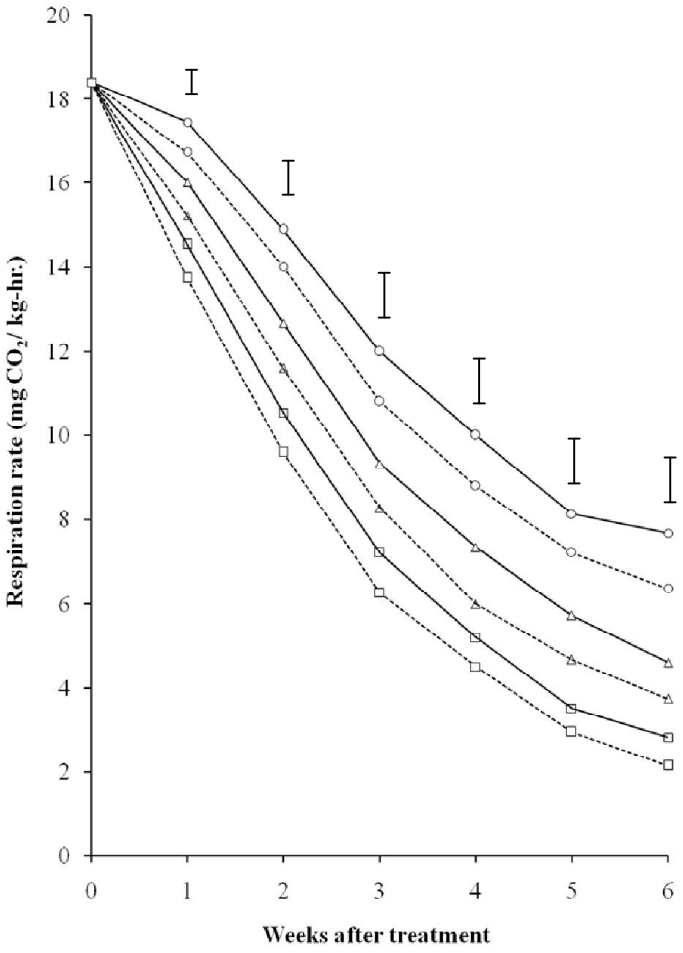

Fig. 1. Respiration rate during storage of lime fruits treated with 2,4,5-T at 0 (o), 500 (Δ) and 1000 ppm (□) without waxing (———) or with waxing (……) at 18◦C ± 1◦C and 85% - 90% relative humidity. Vertical bars represent LSD (5 %)

Effect on Peel Colour

Peel colour score progressively increased during storage of lime fruits, regardless of the treatment. Significant delay in peel colour development was obtained in fruits treated with 2,4,5-T (Fig. 2). At the end of the 6-weeks storage period, the untreated fruits reached the full yellow stage (colour score 5) in all fruits, while the fruits treated with 500 and 1000 ppm 2,4,5-T without waxing had only reached colour score of 3.9 and 3.1, respectively, at the end of the storage period. This is in agreement with the findings of many workers who reported that growth regulators delay senescence and loss of rind pigment in many fruits. It has been demonstrated that GA_3 delays loss of green rind pigment in lime (Biasi and Zanette 2000; Abdallah 2008), lemon and orange (Camargo and Castro 2001). The 2,4-D and 2,4,5-T were reported to delay yellow colour development in lemon fruits (Stewart *et al*. 1952; Erickson and Hass 1956); however, 2,4.5-T was more effective in retaining green peel colour in lemons (Stewart *el al*. 1952). A combined treatment of 2,4,-D and TBZ (Thiabendazole) delays stem-end rot and colour development in citruses (Eckert 1975).

The treatment with 2,4,5-T and waxing was more effective in delaying peel colour development in limes. After 6 weeks, the colour score was 4.6, 3.6 and 2.9 in the waxed fruits compared to 5.0, 3.9 and 3.1 in the unwaxed fruits treated with 2,4,5-T at 0, 500 and 1000 ppm, respectively (Fig.2). This agrees with earlier reports that waxing delays chlorophyll degradation and skin colour development in lime (Blunden *et al*. 1979; Abdallah 2008), orange (Martinez *et al*. 1991), tomato (Ahmed and Abu-Goukh 2003) and mango (Mohamed and Abu-Goukh 2003).

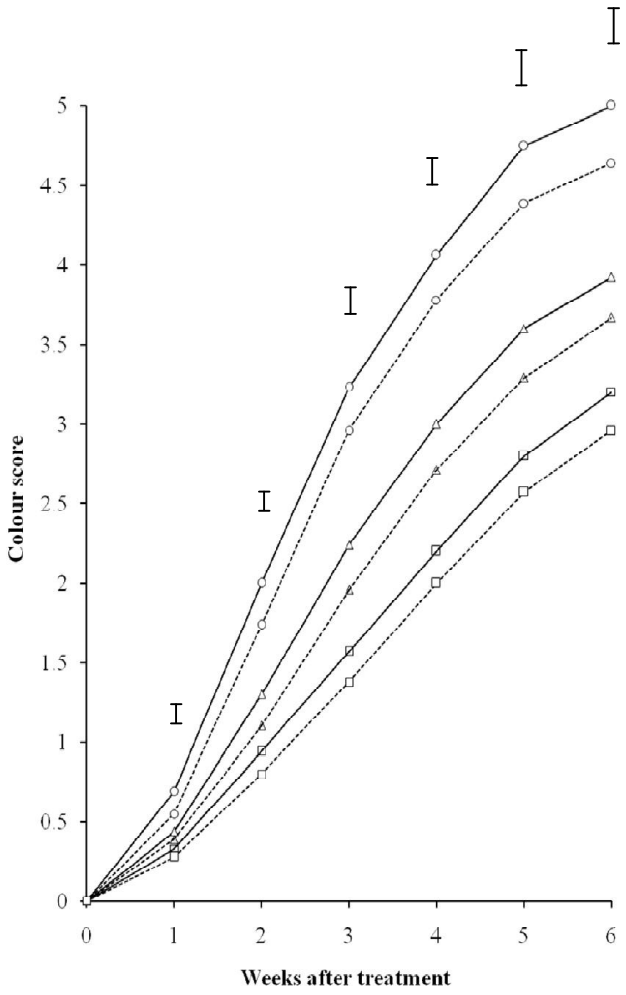

Fig. 2. Peel colour changes during storage of lime fruits treated with 2,4,5-T at 0 (o), 500 (Δ) and 1000 ppm (□) without waxing (_____) or with waxing (……) at 18◦C ± 1◦C and 85% - 90% relative humidity. Vertical bars represent LSD (5 %)

Effect on Weight Loss:

Weight loss progressively increased during storage of the lime fruits regardless of the treatment (Fig.3). The 2,4,5-T with or without waxing significantly reduced weight loss at all concentrations. The higher the concentration, the more was the reduction in weight loss. At the end of the storage period, weight loss was 24.1% in the untreated fruits. It was reduced by 6.6% and 12.5% in fruits treated with 500 and 1000 ppm 2,4,5-T without waxing, respectively, compared to the control (Fig.3). This is in line with previous reports that growth regulators reduce weight loss during storage of fruits. GA_3 was reported to reduce weight loss during storage of lime (Abdallah 2008) and guava (Mohamed-Nour 2007) and maleic hydrazide during storage of tomato (Ahmed and Abu- Goukh 2003).Treatment with 2,4,5-T and waxing was more effective in reducing weight loss than 2,4,5-T treatment alone. Weight loss was reduced by 24.5% and 30.3% in the waxed fruits compared to 6.6% and 12.5% in the unwaxed fruits treated with 500 and 1000 ppm 2,4,5-T, respectively (Fig.3). This is consistent with the reports that waxing decreases water loss in orange (Martinez *et al*. 1991), mango (Mohamed and Abu-Goukh 2003) and tomato (Ahmed and Abu-Goukh 2003).

Effect on Total Soluble Solids:

Total soluble solids (TSS) showed continuous increase during storage of lime fruits in all treatments (Fig.4). It increased in the untreated fruits from 8.5% to 10.2% during the 6-weeks storage period. An increase in TSS during storage was reported in limes (Abdallah 2008), grapefruits (Abu-Goukh and Elshiekh 2008) and oranges (Attia 1995). The increase in TSS was 2.0% and 3.5% less in the fruits treated with 500 and 1000 ppm 2,4,5-T without waxing and 6.3% and 8.1% in fruits treated with 500 and 1000 ppm 2,4,5-T with waxing, respectively, compared to the control (Fig.4). This increase in TSS seems to be due to water loss from the fruits during storage. The less increase in TSS during storage in fruits treated with 2,4,5-T and waxing, compared to the control was obvious, since both treatments decreased water loss compared to the control (Fig.3), and a positive correlation (r^2= 0.890) was found between the increase in TSS and weight loss during storage of limes. This is in agreement with the findings of Abu-Goukh *et al*. (2001) who reported a

positive correlation between TSS and weight loss during storage of onions.

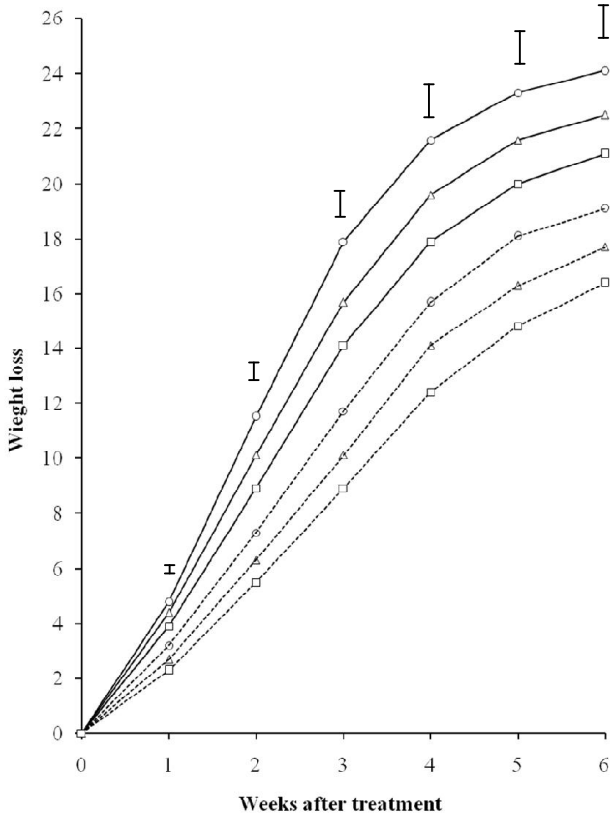

Fig. 3. Weight loss changes during storage of lime fruits treated with 2,4,5-T at 0 (o), (Δ) and 1000 ppm (□) without waxing (_____) or with waxing (……) at 18◦C ± 1◦C and 85% - 90% relative humidity. Vertical bars represent LSD (5 %)

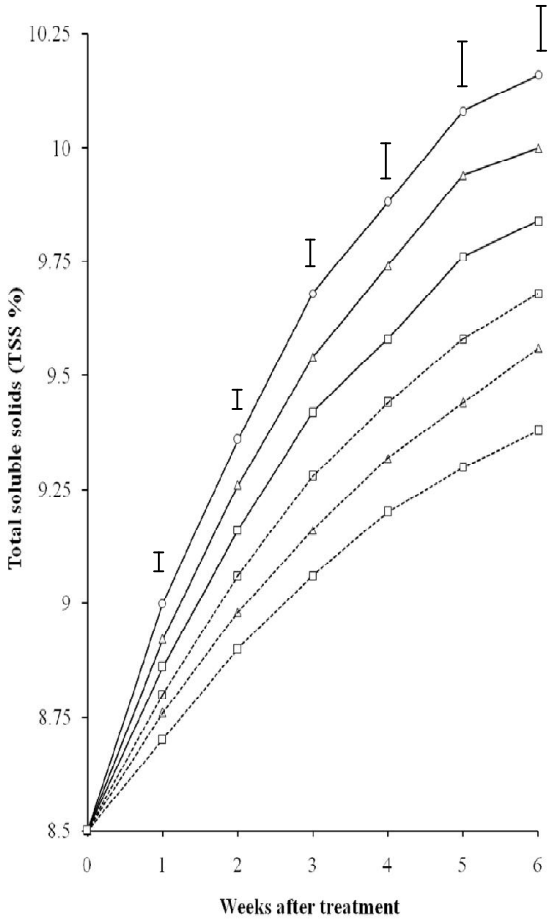

Fig. 4. Total soluble solids (TSS) changes during storage of lime fruits treated with 2,4,5-T at 0 (o), (Δ) and 1000 ppm (□) without waxing (_____) or with waxing (……) at 18◦C ± 1◦C and 85% - 90% relative humidity. Vertical bars represent LSD (5 %)

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تأثير المعاملة بمادة 2,4,5 –T والتشميع على جودة ثمار الليمون البلدى وطول فترة تخزينها

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موجز البحث : تم تقويم تأثير معاملة ثمار الليمون البلدي بعد الحصاد بمادة 2,4,5-T والتشميع على جودة وطول فترة تخزينها في درجة حرارة 18 ±1 درجة مئوية و 85%-90% رطوبة نسبية. أثبتت النتائج أن المعاملة بمادة 2,4,5-T بتركيز 500 و 1000 جزء في المليون قد اخرت الشيخوخة وحافظت على جودة ثمار الليمون البلدي وإطالة فترة تخزينها، وكان التركيز الأعلى أكثر فاعلية. كما أوضحت النتائج أن تشميع الثمار إضافة لمعاملتها بمادة 2,4,5-T قد كان أكثر فاعلية من معاملتها فقط بمادة 2,4,5-T. انعكس تأثير معاملة الثمار بمادة 2,4,5-T والتشميع في خفض معدل تنفسها وتقليل الفقد في وزنها وتركيز المواد الصلبة الذائبة فيها وتأخير تلوينها.