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*Short communication*

# Improving lemon [*Citrus limon* (L.) Burm.] quality using growth regulators

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## ABSTRACT

**Lemon [*Citrus limon* (L.) Burm.] is a leading acidic citrus fruit. However, poor fruit quality causes considerable reduction in marketable yield leading to heavy financial loss to the grower. To combat poor fruit quality, an experiment was laid out during the fruiting year 2009 with a view to obtain excellent quality lemon at harvest. Plant material for this investigation was selected from Punjab Government Progeny Orchard & Nursery, Attari, Amritsar. Foliar spray of NAA (10, 20 and 40ppm) and $GA_3$ (5, 10 and 20ppm) was applied twice at an interval of 15 days during the month of May. Substantial improvement in fruit quality could be achieved with growth regulator treatment. NAA at 40ppm proved to be the best treatment for managing fruit cracking and improving fruit quality.**

**Key words:** Lemon, Baramasi, fruit cracking, quality, NAA, $GA_3$

Lemon cultivation is becoming exceedingly popular because of wider utilization of this fruit than any other citrus fruit. Lemon is popularly seen in kitchen gardens. In India, fresh lemons are primarily consumed for a cooling effect in summers. Lemon is widely used in preparation of soft drinks and possesses special dietary and medicinal value associated with its high vitamin C content. Lemon oil is among the most important citrus oils used for flavouring soft drinks, baked foods, confectioneries, etc. Lemon is also used for preparing pickles, squashes, jams, jellies, and marmalades. The plant is free from citrus canker and is endowed with the trait of bearing fruits in several flushes, thus making it available throughout the year. Unfortunately, it suffers from a very serious problem of fruit cracking in summers causing considerable reduction in marketable yield, leading to a heavy financial loss to the grower every year. However, application of growth regulators can help in improvement of quality in lemon by controlling the intensity of fruit cracking.

In a report on citrus fruit quality, physiological basis and techniques of improvement, Augusti *et al* (2002) concluded that citrus fruit quality was influenced largely by physiological disorders like cracking, puffing and creasing. Cracking manifests as a meridian fissure in the peel, usually developing from the stylar end and reaching the equatorial zone or, even, extending beyond that. Irrespective of its origin, the crack develops as a consequence of disruption between peel and pulp growth. It was found that during the phase of cell enlargement, if the peel does not restart its growth when the pulp expansion takes place, the fruit splits. They found growth regulators to be useful in reducing fruit cracking as these not only increase peel thickness but also significantly increase peel resistance to puncturing. They also observed that repetition of sprays improved this response. Growth regulator sprays are of utmost importance when targeting quality in lemon fruits. Therefore, this study is an attempt to work out the most suitable hormone spray for improving fruit quality and controlling rind splitting in lemon.

The plant material for investigation was selected from Punjab Government Progeny Orchard & Nursery, Attari (Amritsar), during the year 2009. In the trial, eight year old lemon trees of uniform size and vigor, free from diseases and pests, were selected. The experiment was conducted in Randomized Block Design. All the treatments were replicated four times taking a treatment unit as two trees. Percentage data was analyzed using arcsine transformation. The experiment consisted of foliar sprays of NAA and $GA_3$ at various concentrations as shown below:

## Treatment details

$T_1$ - Untreated (Control)
$T_2$ - NAA (10ppm)
$T_3$ - NAA (20ppm)
$T_4$ - NAA (40ppm)

$T_5$ - $GA_3$ (5ppm)

$T_6$ - $GA_3$ (10ppm)

$T_7$ - $GA_3$ (20ppm)

Two sprays were applied during May at an interval of 15 days (first spray on 10th May and the second on 25th May). The plants received standard fertilizer dose of 75kg FYM /tree and 350g N/tree) and irrigation at intervals of 10-15 days, as recommended by PAU, Ludhiana. Percentage of cracked fruits was calculated on the basis of total number of fruits initially present on the tree. Fruit length and breadth was measured using Vernier's Callipers. Percentage of juice was calculated on fresh weight basis. Chemical characters like TSS, acidity and ascorbic acid were measured as per standard procedures of A.O.A.C. (1990).

Data in Table 1 indicate $T_4$ (NAA @ 40ppm) to be the most effective treatment for minimizing fruit cracking in lemon (to 13.35%). However, Control treatment registered maximum fruit cracking (37.62%). Reduction in fruit cracking may be due to the auxin causing enlargement of cells by increasing elasticity and plasticity of the cell wall (Yasuda, 1969). Thus, peripheral tissues of the fruit would have kept pace with growth of cortex resulting in the reduction of fruit cracking, since, one reason for cracking in fruits is differential growth rates of the peripheral and cortex tissues. Peripheral tissues, being senescent and weak, are highly prone to mechanical stress and cracking. Therefore reduction in cracking by $GA_3$ spray may well be due to suppression of certain aging processes leading to increased viability of the peel (Coggins and Lewis, 1965). Richards *et al* (2001) reported that growth regulators improve cell wall flexibility by stimulating synthesis of new cellulose polymers. Singh *et al* (2006) also opined that systematic spray of growth regulators before rind splitting helps control cracking as growth regulators influence rind thickness. Garcia-Luis *et al* (2001) found that application of growth regulators markedly influenced rind structure, affecting both cell size and thickness of flavedo, as it is relevant to cracking. Moreover, growth regulators play a significant role in peel resistance and plasticity that determine intensity of cracking.

$T_4$ (NAA @ 40ppm) also proved to be the best treatment for maximizing fruit size (5.5cm length and 5.3cm breadth) and weight (65.46g) in lemon. On the other hand, fruits from untreated plants registered minimum fruit size and weight. A generally accepted opinion is that increase in fruit size is due to enlargement of the already existing cells, and auxins are presumed to be responsible for this enlargement. Hence, application of NAA caused fruit enlargement by increase in cell size. Fruit elongation and increase in fruit breadth may be due to cell division initially, and cell enlargement in the later stages. Similar findings have been documented by Singh *et al* (2007) and Bhatia and Yadav (2005). Fruit weight also exhibited the same pattern as in fruit size, with treatment $T_4$ maintaining its superiority over other treatments. Singh *et al* (2007) in aonla, Kumar *et al* (2004) in litchi and Josan *et al* (1995) in lemon elucidated similar results. There are many reports in literature suggesting that application of NAA may raise endogenous auxin levels in the fruit, which favours development of various parts of the fruit. Thus, increase in fruit size and juice percentage due to auxin application perhaps led to increase in fruit weight due to cell expansion. It is also possible that a developing fruit is an important metabolic sink, into which nutrients and organic substances from leaves and other plant parts flow, thereby accumulating in the fruit. This accumulation of metabolites and water in fruit increases fruit weight. A direct relationship between endogenous gibberellin content in developing fruits of orange with their growth rate was established by Krishnamoorthy (1981).

**Table 1. Effect of spraying various growth regulators on fruit cracking and quality in lemon [*Citrus limon* (L.) Burm.] cv. Baramasi**

| Treatment | Fruit trait | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Fruit cracking (%) | Fruit length (cm) | Fruit breadth (cm) | Fruit weight (g) | Juice (%) | TSS (%) | Acidity (%) | Ascorbic acid (mg/100ml of juice) |
| $T_1$ | 37.62 (37.78) | 4.70 | 4.43 | 53.67 | 41.20 | 7.15 | 5.05 | 45.43 |
| $T_2$ | 18.22 (25.14) | 5.10 | 4.80 | 57.30 | 45.28 | 7.33 | 5.70 | 49.36 |
| $T_3$ | 15.30 (22.88) | 5.35 | 5.15 | 62.20 | 47.20 | 7.47 | 5.70 | 50.30 |
| $T_4$ | 13.35 (21.30) | 5.50 | 5.30 | 65.46 | 48.82 | 7.53 | 5.56 | 53.44 |
| $T_5$ | 23.45 (28.87) | 4.90 | 4.75 | 57.13 | 42.38 | 7.28 | 5.40 | 48.13 |
| $T_6$ | 17.58 (24.64) | 5.00 | 4.90 | 59.06 | 44.40 | 7.40 | 5.50 | 49.41 |
| $T_7$ | 20.55 (26.85) | 5.15 | 4.95 | 66.20 | 46.98 | 7.60 | 5.62 | 51.53 |
| CD (*P=0.05*) | 5.85 | 0.14 | 0.20 | 6.60 | 2.48 | 0.07 | 0.05 | 2.71 |
| CV % | 12.29 | 1.64 | 2.40 | 6.17 | 3.09 | 0.58 | 0.54 | 3.08 |

Figures in parantheses indicate arcsine transformed values

All chemical treatments applied in our experiment produced significant effect on juice content in lemon fruits compared to the Control. Data clearly depict that fruits harvested from trees sprayed with 40ppm NAA showed maximum juice content (48.82%). Higher moisture content in fruits resulted in higher juice content. Significant increase in TSS and acidity was recorded with increasing concentration in the foliar spray. Maximum values for these parameters were recorded in treatment $T_4$, and, the minimum in trees with no foliar sprays. TSS increased with every increase in concentration of growth regulators in the foliar spray. Auxins have been known to be involved in synthesis of α-amylase which converts starch in sugars and, consequently, increasing osmotic pressure of the cell which results in accumulation of water and other solutes. Another reason may be that sugars get accumulated, or, some insoluble substances like starch are rendered soluble by hydrolysis, and thus increase total soluble solids (Krishnamoorthy, 1981). Increase in acidity could be attributed to increased osmotic pressure by cell expansion due to auxins, which lead to accumulation of organic acids. Work of Josan *et al* (1995) and Mostafa *et al* (2005) also lends support to the present findings. Treatment $T_4$ resulted in maximum ascorbic acid content (53.44%) in fruits. Minimum ascorbic acid content was recorded in fruits from untreated trees. Increase in ascorbic acid content may also be due to the growth regulators increasing osmotic pressure by cell expansion, thus leading to accumulation of this organic acid.

Results indicated that foliar spray of NAA @ 40ppm in lemon substantially reduced cracking losses and resulted in better fruit quality. Thus, to overcome this serious problem, a good preventive spray programme is necessary at critical stage of fruit development.

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