



Original Research Article

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Influence of Foliar Application of Bio-Regulators and Nutrients on the Fruit Quality of Lemon (*Citrus limon* Burma.) Cv. Pant Lemon-1

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An experiment was conducted to study the Influence of foliar application of Bio-Regulators and Nutrients on the fruit Quality of Lemon (*Citrus Limon* Burma.) Cv. Pant Lemon-1 during 2009-10 at HRC (Horticultural Research Centre), Chauras Campus. H.N.B. Garhwal University Srinagar, Garhwal Uttarakhand, India. The experiment was conducted in Randomized Block Design with sixteen treatments and replicated in three, considering one plant as a unit. On the basis of overall performance of treatments on quality characters of fruits, it can be concluded that the values for fruit length, fruit juice, total soluble solids, total sugars, shelf-life of fruits, have been obtained maximum, while the maximum fruit weight, fruit volume, acidity were recorded with NAA (50 ppm).

Introduction

India is the sixth largest citrus producing country in the world. Citrus fruits claim to be at third place in area and production after mango and banana with an area of 1042 thousand hectares with a total production of 10090 thousand MT and productivity of about 9.7 MT/ha. These fruits contribute 12.4% share in total production of fruits in India (NHB, 2012-13). Most of the cultivated species of the citrus fruits are believed to be native of tropical and subtropical regions of South-East Asia stretching from India and China in the North-East up to Australia and New Caledonia in the South-East.

Vitamin-C content of these fruits increases the body resistance to diseases, aids the healing of wounds and prevents damage to the

eyes, but deficiency of it causes scurvy disease. These fruits also contain vitamin-P, which keeps the small blood vessels in healthy condition in our bodies and helps in the assimilation of vitamin-C. Because of high nutritive value, medicinal properties and suitability to processing, the consumption of citrus fruits has gone up several folds but the area and production have not increased in same proportion. Therefore, citrus fruits deserve special attention and management for raising the quality production to fulfill the demand of masses.

Among the various practices, the use of bio-regulators have been identified to play an important role in modern crop husbandry for increased production of quality fruits through

improving flowering, fruit set, fruit drop control, fruit shape and size etc. These organic chemical compounds modify the physiological processes of fruit plants when applied in small concentrations. Therefore, there is a need to study the effect of bio-regulators along with varied concentrations for above quantitative and qualitative characters of lemon fruits. Nutrition is another important factor affecting the health of the plants. The optimum requirement of nutrition of a particular species or variety greatly varies with soil and agro-climatic conditions. Thus, there is a need to standardize the nutritional requirements for lemons under different agro-climatic conditions. Foliar application of nutrients is an ideal way of evading the problems of nutrient availability and supplementing the fertilizers to the soil. In the semi-arid areas of Garhwal region, the foliar application is the alternative and safe way of applying nutrients for quick absorption and maximum availability.

In view of the above facts, it is clear that the foliar application of bio-regulators and nutrients is very important not only for increasing yield but also to improve the quality of fruits.

Therefore, the present investigation entitled Effect of Foliar Application of Bio-regulators and Nutrients on Yield and Quality of Lemon (*C. limon* Burma.) cv. Pant Lemon-1 under Subtropical Conditions of Garhwal Region was carried out at Horticultural Research Centre, Chauras, HNB Garhwal University, Srinagar (Garhwal) Uttarakhand with the following objectives to find out the efficacy of different nutrients on yield and quality of lemon fruits through foliar application. And to study the effects of bio-regulators on yield and quality of lemon fruits. Also to standardize the concentrations of bio-regulators and nutrients for enhancing yield and quality of lemon fruits.

Materials and Methods

Geographically, the Department of Horticulture and Horticultural Research Centre, Chauras Campus, H.N.B. Garhwal University, Srinagar (Garhwal), Uttarakhand, is situated at Alaknanda Valley between $78^{\circ}46'7''$ N latitude, right in the heart of Garhwal region, 132 km away from Haridwar on Haridwar Badrinath Dham Highway at an elevation of 540 m above MSL, in the lesser Himalayan region. The average minimum and maximum temperature, relative humidity and rainfall vary from 6.44°C to 34.7° , 65.24% and 2.60 to 245.46 mm respectively. Six-year-old bearing lemon trees of cultivar Pant Lemon-1 of uniform vigour and size were selected for the present study. All the trees were maintained under uniform cultural schedule during the course of investigation. The experiment consisted of sixteen treatments of two bio-regulators and three nutrients, and each one was applied singly and a spray of plain tap water as control. These were, NAA (10 ppm), NAA (25 ppm), NAA (50 ppm), GA3 (10 ppm), GA3 (15 ppm), GA3 (20 ppm), Urea (0.5%), Urea (1.0%), Urea (2.0%), Zinc Sulphate (0.2%), Zinc Sulphate (0.3%), Zinc Sulphate (0.4%), Borax (0.2%), Borax (0.3%), Borax (0.4%) and Control. Forty eight plants of Pant Lemon-1 were selected for the present study and each tree formed as a unit of treatment. All the treatments were replicated thrice. All the plants selected for the experiment were labelled as per layout of experiment and the sprays of treatment solutions were done on experimental pants of Pant Lemon-1 at full bloom stage (when about 75% flowers had opened on the selected shoots) during the spring season. The spray was done in morning around 10 AM with the help of hand sprayer at the rate of three liters per plant to ensure the maximum absorption of bio-regulators and nutrients through the leaves. Each tree was sprayed thoroughly in such a way as to

completely drench it with the spray solution. The experimental data were subjected to 'F' test as per procedure of Randomized Block Design (RBD) as described by Snedecar and Cochran (1987). The critical difference (C.D.) for each parameter was calculated to compare treatment means at 5 per cent level of significance.

Results and Discussion

Significant the maximum fruit length (5.55 cm) was also recorded under treatment GA_3 (20 ppm), while second position was earned by Borax spray (0.3%) with 5.42 cm fruit length. The minimum fruit length (4.62 cm) was recorded under control. However, the highest breadth of fruit (5.39 cm) was observed with borax (0.4%) and the lowest value (4.46 cm) under control. Application of NAA (200 ppm) 30 days after full bloom to Unshiu orange trees greatly increased fruit size and the proportion of larger fruits (Nakajima *et al.*, 1969). Babu and Lavania (1985) reported that the maximum length of lemon fruits was recorded with NAA (10 ppm) treatment, followed by (5 ppm and 20 ppm) 2,4-D. Except for the higher concentrations each of NAA and GA_3 , all other treatments increased the diameter of the fruits. As the concentrations of these three growth regulators increased the fruit length and diameter also increased proportionally. In the present investigations GA_3 and borax in higher concentrations increased the fruit length and diameter significantly. Earlier findings of scientists on fruit length and diameter supported the results for this character under present study. The fruit weight was observed highest (110.01 g) with NAA (50 ppm). While, the lowest value for fruit weight (77.23 g) was exhibited by control. Sprays of 40 ppm 2,4-D to Washington Navel orange increased the fruit weight by 62% (Keleg and Minessy, 1965). Similarly, Coorg mandarin fruits treated with 25 and 50 ppm 2,4,5-T had

34% and 35% more weight, respectively, over the untreated fruits (Rodrigues and Subramanyam, 1966). An increase in fruit weight with 250-500 ppm NAA was reported by Ali *et al.*, (1973) in kinnow mandarin, when sprayed two weeks after fruit set. Singh and Singh (1981) reported that GA_3 (15 ppm) applied once in August, September and October to Kaula mandarin trees increased fruit weight by 30% over control. All above scientists have reported that NAA and GA_3 were found to increase fruit weight in different fruit crops which also encourage the results of the present investigation for these quality parameters. The maximum fruit volume (108.11 ml) was observed with treatment NAA (50 ppm) While, the minimum fruit volume (76.68 ml) was found under control. Reddy and Prasad (2012) reported that the fruit volume was found superior with the application of 2,4-D (40 ppm), followed by GA_3 (75 ppm) and NAA (40 ppm) in pomegranate cv. Ganesh. The results obtained for fruit volume under present study are in conformity with the results of earlier workers as mentioned above. Similar observations were recorded by Babu and Lavania (1985) in Pant Lemon-1. The maximum specific gravity (0.98) was observed with control and the minimum specific gravity (0.96) was found under urea (1.0%) treatment. The minimum specific gravity of fruits was obtained under urea treatment presumably, because of the effect of urea on the internal quality of the fruits, which affects the weight and volume of the fruits. Guava fruits showed minimum specific gravity when trees were sprayed with zinc sulphate at the rate of 0.4% concentration (Rawat *et al.*, 2010). The maximum values for fruit juice (47.33%) was recorded with treatment GA_3 (20 ppm) treatments. However, the minimum value for fruit juice percentage (38.69) was found under control. Babu *et al.*, (1982) investigated the effects of zinc, 2,4-D and GA_3 alone or in combination on the fruit

quality of kagzi lime fruits. Zinc and 2,4-D treatments were found to increase the physical traits and chemical composition of juice. GA₃ treatments increased the fresh weight and percentage of juice. Sharma *et al.*, (2003) reported that maximum juice content was

obtained with 0.5% zinc sulphate + 50 ppm gibberellic acid in kagzi lime. Similar observations were findings of Singh and Singh (1981) with the spray of GA₃ (15 ppm) of Kaula mandarin.

Table.1 Effect of Foliar application of bio-regulators and nutrients on physical characters of lemon (*Citrus limon* Burma.) cv. Pant Lemon-1

Treatments	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (gm)	Fruit volume (ml)	Specific gravity of fruits	Peel thickness (mm)
NAA (10 ppm)	5.13	4.91	96.95	97.12	0.972	2.26
NAA (25 ppm)	5.20	5.03	106.75	106.98	0.969	2.29
NAA (50 ppm)	5.27	5.16	110.01	108.11	0.969	2.28
GA ₃ (10 ppm)	5.29	5.13	95.89	97.27	0.969	2.19
GA ₃ (15 ppm)	5.33	5.12	101.39	100.31	0.974	2.16
GA ₃ (20 ppm)	5.55	5.24	102.78	101.91	0.971	2.19
Urea (0.5%)	4.95	4.71	93.57	94.43	0.968	2.35
Urea (1.0%)	5.17	5.03	93.78	94.81	0.967	2.33
Urea (2.0%)	5.02	4.72	94.89	95.37	0.973	2.59
Zinc Sulphate (0.2%)	5.15	4.95	84.88	87.41	0.977	2.66
Zinc Sulphate (0.3%)	5.21	5.03	85.92	84.14	0.972	2.54
Zinc Sulphate (0.4%)	5.39	5.06	92.58	92.98	0.968	2.49
Borax (0.2%)	5.13	5.89	79.84	81.11	0.969	2.38
Borax (0.3%)	5.42	5.11	82.74	83.13	0.972	2.41
Borax (0.4%)	5.21	5.92	83.76	82.67	0.969	2.36
Control	4.62	4.45	77.23	76.68	0.981	2.72
S.Em. \pm	0.105	0.161	4.48	4.51	0.005	0.123
CD at 5%	0.305	0.466	12.95	13.04	0.015	0.356

Table.2 Effect of Foliar application of bio-regulators and nutrients on chemical characters of lemon (*Citrus limon* Burma.) cv. Pant Lemon-1

Treatments	Fruit juice (%)	Total soluble solids (%)	Acidity (%)	Vitamin C (mg/100gm)	Total Sugars (%)	Shelf-life of fruits (Days)
NAA (10 ppm)	42.53 (40.70)	6.37	5.22 (13.20)	21.58	0.171 (2.356)	25.03
NAA (25 ppm)	42.89 (40.90)	6.45	5.49 (13.55)	19.69	0.173 (2.380)	25.34
NAA (50 ppm)	46.21 (42.82)	6.47	6.68 (14.97)	19.54	0.269 (2.972)	25.89
GA ₃ (10 ppm)	45.22 (42.25)	6.46	5.71 (13.80)	20.11	0.167 (2.338)	26.02
GA ₃ (15 ppm)	46.51 (42.99)	6.54	5.35 (13.37)	20.37	0.281 (3.037)	26.59
GA ₃ (20 ppm)	47.33 (43.46)	6.59	5.37 (13.39)	19.43	0.299 (3.134)	26.75
Urea (0.5%)	43.51 (41.26)	6.51	5.71 (13.82)	21.50	0.119 (1.969)	23.45
Urea (1.0%)	42.87 (40.89)	6.38	5.74 (13.85)	21.07	0.124 (2.007)	23.67
Urea (2.0%)	42.86 (40.89)	6.19	5.74 (13.86)	20.58	0.151 (2.206)	23.92
Zinc Sulphate (0.2%)	43.49 (41.25)	6.34	5.32 (13.33)	19.53	0.141 (2.135)	24.02
Zinc Sulphate (0.3%)	42.87 (40.89)	5.97	5.69 (13.79)	19.40	0.159 (2.269)	24.28
Zinc Sulphate (0.4%)	41.88 (40.32)	5.76	5.62 (13.71)	19.17	0.179 (2.407)	24.53
Borax (0.2%)	43.87 (41.47)	6.06	5.59 (13.67)	19.67	0.134 (2.088)	23.24
Borax (0.3%)	41.67 (40.18)	5.57	5.73 (13.84)	19.98	0.146 (2.184)	23.67
Borax (0.4%)	44.36 (41.75)	5.69	5.52 (13.57)	19.54	0.149 (2.204)	23.68
Control	38.69 (38.42)	5.21	4.96 (13.83)	18.93	0.117 (1.958)	19.37
S.Em. \pm	0.80 (0.47)	0.153	0.144 (0.185)	0.509	0.012 (0.091)	0.70
CD at 5%	2.31 (1.36)	0.443	0.416 (0.534)	1.472	0.036 (0.264)	2.03

The maximum peel thickness (2.72 mm) was observed with control, while the minimum peel thickness (2.16 mm) was obtained with GA₃ (15 ppm), Sharma *et al.*, (2003) reported that the maximum juice content and the minimum peel thickness was obtained with 0.5% zinc sulphate + 50 ppm gibberellic acid in kagzi lime. Bhat *et al.*, (2006) also observed the maximum juice content and the minimum peel thickness in Eureka lemon when sprayed with GA₃ in different concentrations. These findings of above scientists with respect to peel thickness match with the results of present study (Table.1).

The highest total soluble solid (6.59%) was found with treatment GA₃ (20 ppm). The second highest value 6.54% was recorded under GA₃ (15 ppm). Significant increase in TSS over control was recorded with the sprays of GA₃ (250-1000 ppm) at full bloom stage in Sweet lime Kumar *et al.*, (1975), and sprays of GA₃ (50-100 ppm) in Washington Naval orange (Deidda, 1971). Similarly, sprays of 2,4-D or 2,4,5-T have been reported to increase the TSS in Lahore local (Singh and Randhawa, 1961) and Kinnow mandarins (Chundawat *et al.*, 1975). Malik *et al.*, (2000) found the significant increase in total soluble solids with receiving 1% urea spray and 0.8% zinc sulphate separately or in combination in mandarin hybrid trees. All these findings of different workers and scientist are justifying the results obtained for total soluble solids under present investigation. The maximum acidity percentage (6.68%) was also observed with treatment NAA (50 ppm). The second highest value for acidity (5.74%) was shown by spray of urea at 1.0%. Phillips and Meagher (1967) observed an increase in acidity with sprays of 20 ppm 2,4-D or 2,4,5-T in pineapple orange, when sprayed three months before harvest. Similarly, in Unshiu orange, an application of NAA (200 ppm), 30 days after full bloom has been reported to increase the acidity of the juice (Nakajima *et*

al., 1969). Joshan *et al.*, (1995) also reported that the acid content was maximum under 6% and 8% K₂SO₄ treatments in lemon. The maximum vitamin C content (21.06 mg/100g of fruit juice) was recorded under treatment NAA (10 ppm), followed by 20.93 mg/100g of fruit juice with urea (0.5%). Kumar *et al.*, (1975) also reported that the ascorbic acid content was increased significantly in all the sprayed fruits. However, the maximum increase was obtained in fruits treated with PCPA at 100 ppm and 2,4-D at 7.5 ppm in Sweet lime. The ascorbic acid content in fruits was estimated to be highest in fruits treated with NAA (20 ppm), which was closely followed by Mumaur and the lowest under control in aonla cv. NA-10 (Ghosh *et al.*, 2009). Findings of earlier works carried out by various scientists with respect to vitamin C completely match with the results of the present study. The results are in closed conformity with the findings of Singh *et al.*, (2007) in aonla. The total sugar content (0.29%) was observed to be the highest under treatment GA₃ (20 ppm), followed by 0.28% with GA₃ (15 ppm), while the minimum total sugar content (0.11%) was recorded under control. Ram and Bose (1994) reported that the mandarin orange treated with 600 g urea as soil application + 1.5% foliar application and spray of ZnSO₄ (0.5%) contained more total sugars as compared to control plants. All these findings of different scientists are justifying the results of present investigation with regard to total sugars. Similar observations were recorded by Singh and Singh (1981) in Kaula mandarin.

The data related to shelf-life of fruits indicated that the maximum shelf- life (26.39 days) of fruits was observed with treatment GA₃ (20 ppm), However, the minimum shelf-life (19.34 days) of fruits was found under control. Brahmachari *et al.*, (1999) reported that the spray of GA₃ (50 and 100 ppm), Kinetin (20 and 40 ppm), CCC (500 and 1000 ppm) MH (500 and 1000 ppm), calcium

nitrate (1 and 2%) and borax (0.4 and 0.8%) 15 days before harvest extended the shelf-life of Purbi litchi fruits as compared to control. Choudhary and Dhaka (2005) reported that gibberellic acid and their combinations were found to prolong the shelf-life of kinnow fruits. All above earlier findings reported by different scientists are almost similar to the results obtained under present study with regards the shelf-life of fruits of Pant Lemon-1(Table.2).

It is concluded on the basis of overall performance of treatments on quality characters of fruits, it can be concluded that the values for fruit length, fruit juice, total soluble solids, total sugars, shelf-life of fruits, have been obtained maximum, while the maximum fruit weight, fruit volume, acidity were recorded with NAA (50 ppm). However, the maximum vitamin C was recorded under NAA (10 ppm) foliar application.

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