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IMPROVING FRUIT QUALITY IN LEMON THROUGH INM

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ABSTRACT : With a view to harvest superior quality lemon fruits, the experiment was carried out to study the impact of integrated use of inorganic fertilizer (N), organic manure (FYM) and biofertilizer (*Azotobacter*) on lemon cv. 'Baramasi' during 2009. The plant material was selected from Punjab Government Progeny Orchard & Nursery, Attari, Amritsar. There were nine nutrient management practices set in a Randomized Block Design replicated thrice. The present experiment showed that the substantial improvement in fruit quality could be achieved with the consortium of three classes of nutrient sources. FYM (75 Kg/tree), inorganic nitrogen (350g/tree) along with biofertilization (*Azotobacter* 18g/tree) proved to be the most judicious treatment in minimizing fruit cracking and maximizing fruit quality.

Keywords: *Inorganic fertilizer, farmyard manure, biofertilizer, cracking, quality, lemon.*

Citrus is one of the most important fruit crops grown in many tropical and subtropical countries. Of this lemon, a leading acid citrus fruit forms an integral part of citrus fruits for their utilization as refreshing cool drinks in summer having very appealing colour, odour and flavour. It is a medium sized abundantly juicy and little thick skinned fruit. Lemon has characterization of bearing fruits in many flushes making it available throughout the year, but simultaneously, the lemon is confronted with a serious problem of poor fruit quality in summers which causes considerable reduction in the marketable fruit. The adequate fertilization, regular application of nutrients or alternatively use of nutrient enriched organic manures and biofertilizers in integrated nutrient management results in quality citrus production (Srivastava, 17). Extensive use of chemicals and fertilizers with low doses of organic manures has resulted in deterioration of soil fertility and soil health as well. Biological routes of improving soil fertility and health for optimum crop production form vital component of integrated nutrient management. These routes are operated through the use of FYM and biofertilizer along chemical fertilizers. In the present experimentation, poor fruit quality was noticed when one or another source of nutrients was missing. This may be due to the reason that when one or another source was missing, it caused misbalancing in the nutrient uptake by the plants, hindering proper uptake of nutrients. The attractive fruit having superior quality, maintaining consumer appeal in taste, appearance and storability can be obtained only by following the concept of integrated nutrient management in lemon. Thus, the optimized standards of fertilizer application are of great importance to enhance fruit quality. The use of bio-fertilizers in enhancing fruit quality has gained momentum in recent years because of higher cost and hazardous effects of chemical fertilizers. Therefore, integrated application of inorganic fertilizers, organic and biological sources of nutrients in an efficient way would not only reduce the sole dependence on inorganic fertilizers but also reduce fruit cracking and enhance fruit quality as well as minimise environmental hazards.

MATERIALS AND METHODS

The present studies were conducted at Punjab Government Progeny Orchard & Nursery, Attari, Amritsar during the year 2009. In the trial, eight year old, uniform and disease free trees of lemon were selected to study the effect of organic manure, inorganic fertilizer and biofertilizer on fruit quality in lemon (*Citrus limon* (L.) Burm.) cv. 'Baramasi'. The data were analysed in Randomized Block Design. *Arc sine* transformation was applied on fruit cracking data. There were nine treatments and all the treatments were replicated three times having a treatment unit of single tree as per following treatment details.

T_1-Control (Standard dose), T_2-*Azotobacter* 18g/tree T_3-*Azotobacter* 18g/tree + FYM, T_4-*Azotobacter* + 100% N, T_5-*Azotobacter* 18g/tree + 75% N, T_6-*Azotobacter* 18g/tree + 50% N, T_7-*Azotobacter* 18g/tree + 100% N + FYM, T_8-*Azotobacter* 18g/tree + 75% N + FYM, and T_9-*Azotobacter* 18g/tree + 50% N + FYM

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In this experiment, the effect of FYM, inorganic nitrogen and biofertilizer on the fruit cracking and physico-chemical characters of lemon fruit were studied. The standard fertilizer dose as recommended by Punjab Agriculture University, Ludhiana for 8 years old citrus trees is 75 kg/tree FYM and 350 g/tree nitrogen. The whole quantity of farm yard manure was applied in December and nitrogen dose was given in two splits, the first part was given in February and the second in April after fruit set.

Biofertilizer used in this experiment was Azotobacter as the possible nitrogen biofertilizer for citrus is *Azotobacter* (Bhattacharyya, 6). The *Azotobacter* was procured from PAU, Ludhiana. The dose of biofertilizer used was 2 kg/acre (2 Kg of biofertilizer was mixed with 200 liters water) and it was drenched near the root zone of the plants (Indiamart, 10). It was also applied in December along FYM.

The percentage of cracked fruits was calculated on the basis of total number of fruits initially present on the tree. The observations on peel thickness were measured with Vernier's Calliper. To determine the moisture content, the fruits were peeled off. The fruit volume was calculated by water displacement method. The weight of peel and pulp of fruit was taken and then were kept in the oven at 65ºC till a constant dry weight was obtained. The moisture content was expressed as the per cent of fresh weight of the peel and pulp of fruit, respectively. The percentage of the juice was calculated on fresh weight basis. The chemical characters like ascorbic acid were measured as per standard procedures of A.O.A.C (1).

RESULTS AND DISCUSSION

A glance over the data in Table 1 divulged that T_7 (*Azotobacter* 18g/tree + 100% N+FYM) proved to be the most effective treatment which helped in controlling the fruit cracking per cent and increased the fruit volume of the lemon. The minimum fruit cracking (19.24 %) was registered in T_7 treatment where all the three sources of nutrients were applied together and maximum (36.22 %) in T_2 (*Azotobacter* 18g/tree) treatment consisting of only single source. There are many ports in the literature suggesting that any compound or nutrient with positive effect on reducing fruit cracking is expected to trigger plastic, elastic and peel strengthening properties to improve fruit skin. Irrespective of its origin, splitting develops as a consequence of disruption between peel and pulp growth. It was assessed by Augusti *et al.* (3) that during the phase of cell enlargement, if the peel does not restart its growth when the pulp extension takes place, the fruit cracks. They found the usefulness of mineral nutrition to reduce fruit cracking as it not only increase the peel thickness but also significantly increase peel resistance to puncturing. Hoffmann (9) explained citrus fruit cracking as one of the most exasperating problems experienced by the citrus fruit growers and to deal with this complex phenomena it is preferable to use compost and slow release fertilizers or bio-fertilizers to feed the trees. They replenish the

Table 1: Effect of integrated nutrient management on fruit cracking and quality of lemon (*Citrus limon* (L.) Burm.) cv. Baramasi.

Treatments	Fruit cracking (%)	Fruit volume (cc)	Peel thickness (mm)	Moisture content of peel (%)	Moisture content of pulp (%)	Juice (%)	Ascorbic acid (mg/100 ml of juice)
T_1	32.18 (34.54)	63.12	1.61	73.16	82.83	43.71	42.50
T_2	36.22 (36.97)	62.61	1.53	72.12	81.76	41.18	41.03
T_3	34.43 (35.87)	62.93	1.57	72.96	82.62	42.33	42.05
T_4	27.36 (31.52)	65.28	1.78	75.00	84.67	45.80	44.59
T_5	28.60 (32.27)	64.24	1.72	75.60	85.23	45.16	43.96
T_6	30.06 (33.22)	63.52	1.66	73.20	82.86	45.01	43.46
T_7	19.24 (25.98)	68.90	1.98	78.11	87.76	49.06	48.80
T_8	21.33 (27.47)	68.27	1.89	77.17	86.83	47.19	47.75
T_9	23.16 (28.72)	67.47	1.82	76.02	85.66	46.66	46.65
CD (P= 0.05)	3.55	3.90	0.05	3.23	3.22	1.62	2.06
CV %	6.45	3.46	1.81	2.50	2.21	2.08	2.68

nutrients, as time released fertilizers offer the convenience of supplying the nutrients at an even rate for a longer period for consistent growth of peel and pulp and thus helps in resisting fruit cracking.

The use of biofertilizer in combination with organic and inorganic fertilizer is always preferred because they contribute to better development of introduced organisms and at the same time inhibits proliferation of antagonists (Awasthi *et al.,* 4). *Azotobacter* is capable of elaborating small quantities of growth promoting substances like Vitamin B and phytohormones like IAA which along with inorganic N and FYM might have improved the physiology of the plants thereby reducing the fruit cracking. The increase in auxin status in plants could have increased peel thickness as the auxins have the tendency of faster and prolonged cell division in peel. Thus, optimized standards of fertilizer application might also have played role in keeping pace in cell wall growth with that of cortex leading to increase in elasticity of peel which inturn could have helped to reduce fruit cracking. Also, the growth hormones synthesized by *Azotobacter* increased the ability of absorption of nutrients like Ca. Deficiency of calcium causes severe cracking as calcium contributes to fruit cracking resistance mechanism through its structural role in the cell wall of the pericarp. The biofertilizers produces nitrate substances along with auxins and the presence of both promoted the deposition of the exogenous calcium in the cell walls of pericarp. Higher concentration of structural calcium in cell wall of pericarp provided cracking resistance. The higher capacity in binding exogenous calcium in the cell wall of pericarp suggests higher concentration of negatively charged structural component *i.e.* glacturonic acid residues which can be one of the material bases for cracking resistance (Zhong *et al.,* 18). It was further suggested that availability of such nutrients in the early stage of fruit ontogeny is important for cracking resistance.

The superior fruit quality with respect to physical parameters was encouraged in T_7 treatment where maximum fruit volume (68.90 cc) was recorded. However, the minimum value (62.61 cc) was recorded when only *Azotobacter* was applied. The better volume may probably be due to better growth and development of plants with the optimization of nutrients. The biofertilizer enhanced the cell division and cell enlargement as a resultant of induced growth hormones which helped in increasing the volume. In their opinion when inorganic N was added in combination with FYM and biofertilizer, it resulted in slow release of nitrogen for better nutrition throughout the growth of fruit resulting in increase in size which in turn increase the volume, as nitrogen is an important constituent of nucleo proteins and amino acids. Further it can be attributed that when all three nutrient sources viz. FYM, inorganic fertilizer and biofertilizer (*Azotobacter*) were applied, it resulted in improved nutrient and water availability leading to vital plant and fruit growth due to development of better root system along with increase in number of rootlets. Therefore, biofertilizers help in better proliferation of roots, which ultimately results in sturdy and healthy fruits showing resistance to biotic and abiotic stresses. The present findings are also in agreement with the results of Bhobia *et al.* (7) and Katiyar *et al.* (12).

The most effective fertilization treatment which decreased the peel thickness was found to be T_2, which was significantly lower than control (1.61 mm). The maximum peel thickness was observed in T7 treatment to the tune of 1.98 mm. The increase in peel thickness was however more striking when organic and inorganic nutrient sources were combined as it is an undesirable character. It was reported that organic matter plays an important role in retention of added nitrogen and greater uptake of K (Raychoudhuri, 14). This more uptake of K directly influences the thickness of peel as potassium decreases the putrecine content of peel and thus increases the thickness of peel (Bar-Akiva, 5). The organic matter also helps in more uptake of water in plant tissue and retention of moisture in soil. The application of biofertilizer might have lead to secretion of some organic acids such as acetic acid, formic acid, propionic acid, lactic acid, glycolic acid etc and converted insoluble form of minerals of soil into soluble forms. The acids lower the pH and bring about dissolution of bound forms of nutrients. Some of the hydroxy acids may chelate with Ca and Fe resulting in effective solubilization of crops (Asokan *et al.*, 2). Ca is directly involved in cell wall formation. Moreover, the biofertilization improve the root system resulting in increased availability of enzymes which lead to strengthening of cells and improve cell metabolism (Kumar *et al.*, 13). This might have also attributed to increase in peel thickness. This better supply of nutrients and water also results in prolonged peel growth. Although increase in peel thickness is considered undesirable character, however, increase in peel thickness decreases the splitting of fruits thus improving fruit quality creating logical basis.

The treatment T_7 proved to be most efficient, for increasing the moisture content both of peel and pulp significantly over control. The maximum peel and pulp moisture content was recorded to be 78.11 per cent and 87.76 per cent. The lowest moisture content of peel (72.12 per cent) and pulp (81.76 per cent) was recorded in control where standard fertilizer dose was applied. The moisture content of peel and pulp was influenced under application of organic and inorganic nutrient sources in lemon as compared to control. The maximum retention of moisture content in peel and pulp was evidenced when inorganic nitrogen was applied in combination with organic nutrient sources (FYM and *Azotobacter*) during both the years of study. Higher level of moisture content of peel and pulp may be attributed to higher retention of moisture content in soil by organic matter and higher uptake of moisture and nutrients like K by the plant tissue due to biofertilization. This ample availability of water in plant tissue might have resulted in higher moisture content in peel and pulp of lemon. Moreover, K also maintains the water status of cells.

The application under treatment T_7 helped to retain the highest level of juice content (49.06 %) whereas the minimum level (41.18 %) was found in the fruits obtained from the treatment T_2. The percentage of juice was influenced by various manurial, inorganic and biofertilizer doses as the beneficial effect of manuring and biofertilization seems to have resulted in the increased supply of nitrogen which forms the basis of many physiological reactions in the living cells. The ample increase in the juice content in case of combination of organic and inorganic sources of nitrogen appears to be due to the added benefits of organic matter which improves the soil structure, penetration, retention of moisture etc. and root proliferation by biofertilizer. Since water is the chief constituent of fruit juice, its increased availability within certain limits was apt to affect the juice percentage favourably. There is enough evidence in literature to support these findings. Seshadri and Madhavi (15) and Singh *et al.* (16) also elaborated similar results in sweet orange. The highest level of ascorbic acid (48.08 mg/100ml of juice) was attained with T_7 while the lowest level was evidenced in treatment T_2. The higher ascorbic acid content with increased N application in form of organic and inorganic nutrient sources under T_7 might be due to the catalytic activity of several enzymes, which participate in biosynthesis of ascorbic acid and its precursor. These results are in line with the findings of Dudi *et al.* (8) in Kinnow, Ingle *et al.* (11) in acid lime and Seshadri and Madhavi (15) in sweet orange.

The combination of nutrient sources proved to be far superior than their sole application due to optimization of nutrients. Hence, the nutrient requirement in lemon needs to be emphasized as inadequacy of one or other nutrients at critical stage of fruit development adversely affects the quality of lemon. Moreover, the enhancement and maintenance of soil fertility and conservation of the soil's health through INM will be a vital role and occupy significant concern for many of researcher in the future as a unique key for sustainable agriculture in developing countries.

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