The Journal of Animal & Plant Sciences, 23(5): 2013, Page: 1385-1390
ISSN: 1018-7081

FOLIAR APPLICATION OF CALCIUM CHLORIDE AND BORAX ENHANCE THE FRUIT QUALITY OF LITCHI CULTIVARS

I. Haq[*], A. Rab[**] and M. Sajid[**]

[*]Hazara Agriculture Research Station, Abbotabad, Pakistan
[**]Department of Horticulture, KP Agricultural University, Peshawar, Pakistan.
Corresponding Author E-Mail: abdurrabaup@gmail.com

ABSTRACT

The influence of foliar application of calcium chloride and borax on the fruit quality of litchi cultivars was investigated by applying1-3% Calcium either alone or in combination with 0.5 to 1.5 Borax. The litchi cultivars varied significantly for quality traits. Cultivar Gola had the highest fruit weight (23.54 g), pulp weight (17.16 g), TSS (22.54%), total sugars (21.45%), reducing sugars (17.96%) and specific gravity (1.1051), while cultivar Bedana had the highest non-reducing sugars (9.72%). Foliar application of calcium chloride ($CaCl_2$) alone had no significant effect on most of the quality variables, however, $CaCl_2$ + Borax ($Na_2B_4O_7 \cdot 10H_2O$) application increased the fruit weight (19.87 g), pulp weight (14.88 g) and pulp dry weight (13.76%) in control fruits to the maximum of 20.79, 15.69 g and 15.40% respectively with $CaCl_2$ (3%) + Borax (1.5%). No variations were observed in total sugars, reducing sugars and non-reducing sugars of litchi fruit with application of $CaCl_2$ alone, which increased significantly with foliar application of $CaCl_2$ 3% + Borax. The planned paired means comparison showed that the least fruit weight (19.87 g), pulp weight (14.88 g) and pulp dry weight % (13.76%) of control fruits increased significantly to 20.10 g, 14.94 g and 13.93% with $CaCl_2$ application and further to 20.54 g, 15.38 g and 15.08% with $CaCl_2$ + Borax treatments. The fruit weight, pulp weight and pulp dry weight % was significantly higher with $CaCl_2$ + Borax foliar application as compared to $CaCl_2$ alone. The total sugars, reducing sugars and non-reducing sugars were not significantly affected by $CaCl_2$ application but were significantly higher in Control vs. Rest, Control vs. $CaCl_2$ + Borax and Ca vs. $CaCl_2$ + Borax treatments means.

Key words: Boron, Calcium, Litchi Fruit, Quality, TSS, Sugars.

INTRODUCTION

Litchi (*Litchi chinensis* Sonn.) is a popular fruit of family *Sapindaceae* (Haq and Rab, 2012). It is an arillate fruit with sweet, translucent and juicy flesh. The fruit is high in sugars, minerals and vitamins (Marisa, 2006) and can be processed into juice, wine, pickles, jam, jelly, ice cream and yoghurt (Huang *et al*., 2005). In Pakistan, litchi is grown over a small area with a production of 9250 tons (Shah, 2003), thus is in high demand and captures good price in markets (Rajwana *et al*., 2010). The cultivation of litchi could not be extended due its high sensitivity to soil and climatic conditions. For good production, litchi requires cool dry winters and warm wet summers (Menzel, 1987). Fluctuation in temperature (Crane and Schaffer, 2004) and poor nutrition result in yield losses and poor fruit quality (Waseem *et al*., 2002). In Pakistan, a small number of litchi cultivars such as Bedana, Calcutti, Gola, Bombay, Chinese, Lychee Siah and Madrasi are grown for commercial production (Rajwana *et al*., 2010), which have considerable genetic variations (Khurshid *et al*., 2004), resulting in marked differences in fruit color, shape, size and quality (Waseem *et al*., 2002; Sivakumara *et al*., 2010).

Nutrient management is essential for maximum yield (Menzel and Simpson, 1987), good quality and profitability (Ganeshamurthy *et al*., 2011). In Pakistan, most of the soils are deficient in macro and micronutrients and some nutrients are not available to plants due to high soil pH (Yaseen and Ahmad, 2010). Calcium is structural component of cell wall (Li *et al*., 2001), however, its movement to fruits is generally low even when sufficient in soil (Kadir, 2005). Boron is another important micronutrient which is deficient in our soils and adversely affects the yield and quality (Imtiaz *et al*., 2010). Application of boron increases fruit setting and yield as well as quality by increasing total soluble solids (TSS) and total sugars (Ruby *et al*., 2001). Therefore, the present study was designed to evaluate fruit quality of commonly grown litchi cultivars in Pakistan and determine the influence of foliar application of calcium and boron on fruit quality.

MATERIALS AND METHODS

The study on influence of foliar application of calcium ($CaCl_2$) and boron (Borax) on fruit quality of four litchi cultivars i.e. China, Gola, Surahi and Bedana was conducted under agro-climatic conditions of Haripur Hazara, Khyber Pakhtunkhwa, Pakistan during 2007 and

2008. The randomized complete block (RCB) design was used with factorial arrangement having litchi cultivars in main blocks while 13 treatments comprising of different doses of $CaCl_2$ and Borax ($Na_2B_4O_7 \cdot 10H_2O$) including control in subplots. Each treatment comprised of three trees. All the nutrient solutions were prepared from AnalaR Grade chemicals. Since Calcium chloride dihydrate ($CaCl_2.2H_2O$) was being used, therefore, the molecular weight of $2H_2O$ was subtracted from the total molecular weight of $CaCl_2.2H_2O$ (147 g) to weight of $CaCl_2$ only (111 g). A power sprayer was used to carry out foliar sprays. After each treatment, the pump was washed thoroughly. A teaspoon of a commercial washing powder was added as wetting agent. Plain water was sprayed on plants in controlled treatment. All foliar sprays were carried out early in the morning starting immediately after fruit set with 21 days interval till harvest, so that each cultivar received 4 applications. Data was recorded on the following parameters of fruit quality.

The fruit weight was recorded for 10 randomly taken fruits from each treatment and replication and weighed with the help of an electronic balance. The average weight of 10 fruits was calculated and presented as fruit weight. The pulp weight was estimated by removing the peel and taking the fresh weight of pulp. Pulp dry weight was recorded by exposing the peeled pulp to 45°C for 48 hours in an oven. The pulp dry weight was averaged and presented as percentage of fresh weight.

For chemical analysis, the fruit juice was extracted from mature fruits. The TSS was measured with a hand held refractometer (KROSS HRN-16). The refractometer was first calibrated by using distilled water to have a zero reading. One drop per sample was poured onto the refractometer prism plate. The readings on prism plate were noted to one decimal place. After each test, the prism plate was cleaned with distilled water and wiped with a soft tissue. The data was averaged and recorded in percent TSS.

Total and reducing sugars in the litchi fruit juice were determined as described in A.O.A.C. (1995). For this purpose 10 fruits from each treatment and replication were taken at random. The juice was extracted from fruits with the help of locally made juice extractor, and 25 grams of filtered (whattman-4) juice was transferred to 250 ml volumetric flask. The 100 ml of water was added and neutralized with 1N NaOH. The 2 ml of lead acetate solution was added, solution shaken and let to stand for 10 minutes. The necessary amount of potassium oxalate was also added to remove excess lead and volume made with water. Sugars were calculated as:

$$\%\ \text{Reducing sugars} = \frac{\text{Factor} \times \text{dilution} \times 100}{\text{titre} \times \text{Wt or volume of the sample}}$$

Non reducing sugars = (% total sugars - % reducing sugars) x 0.95

Total Sugars = (% reducing sugars + % non reducing sugars)

Care was taken to prepare fresh Fehling A and B solutions each time the sugars determinations were made. The specific gravity of fruit was recorded from selected fruits by measuring their weight (g) in air and water with following formula:

$$\text{Specific gravity} = \frac{\text{weight in air}}{(\text{weight in air} - \text{weight in water})}$$

The data were recorded on different parameters and subjected to analysis of variance (Steel and Torrie, 1997). Paired means analysis was conducted to compare the influence of calcium and boron. The treatment means as well as their interactions were separated by LSD test.

RESULTS AND DISCUSSION

Fruit weight: The highest fruit weight (23.54 g) was recorded in cultivar Gola followed by China and Surahi with 21.92 and 20.89 g respectively, while lowest fruit weight of 15.20 g was obtained in cultivar Bedana (Table 1). The fruit weight did not increase significantly with $CaCl_2$ or $CaCl_2$ (1-2%) + Borax (0.5-1.0%) treatments but increased to maximum of 20.79 g with combination of $CaCl_2$ 3% + Borax 1.5% . However, the difference at 3% $CaCl_2$ with Borax at 0.5 to 1.5% was non-significant (Table 1). In litchi, the fruit size is a cultivar specific character (Li *et al*., 2001) but foliar application of micronutrients increased fruit size, weight and eventually yield of litchi (Brahamchari *et al*., 1997; Stino *et al*., 2011). Application of Calcium chloride and Borax increased the fruit weight by 1.34 and 4.43% with 3% $CaCl_2$ and $CaCl_2$ 3% + Borax 1.5% respectively.

Pulp weight: The pulp weight was highest (17.16 g) in litchi cultivar Gola followed by cultivars Surahi and China with 16.37 and 16.27 g pulp weight, respectively. However, pulp weight of cultivar Bedana (11.17 g) was the least among all the cultivars (Table 1). The pulp weight was not significantly affected by application of 1 and 2% $CaCl_2$ alone or its combination with Borax but higher dose of $CaCl_2$ (3%) + Borax (1.5%) increased pulp weight from minimum (14.88 g) in control to maximum of 15.69 g (Table 1). The pulp weight of litchi fruit varies significantly among cultivars (Waseem *et al*., 2002). The pulp weight depends on fruit and seed size and varies in different cultivars (Li *et al*., 2001) but is affected by plant nutrition (Wojvik *et al*., 1999; Kazuhiro *et al*., 2004). The pulp weight increased by 5.16% with CaCl2 (3%) + Borax (1.5%) as compared to control (Table 1). It seems that relatively higher calcium concentration (3%) is required to increase pulp weight significantly in litchi genotypes.

Pulp Dry weight: The dry weight of pulp ranged from 14.63 to 14.73% of the pulp fresh weight and was at par in various litchi cultivars but increased significantly with combine foliar application of $CaCl_2$ and Borax. The pulp dry weight in control (14.69%) nonsignificantly increased with calcium chloride application alone, however, it increased significantly to 14.77% with 1% of $CaCl_2$ and 0.5% Borax. It increased further to 15.03% with $CaCl_2$ + Borax @ 2% and 0.5%, respectively. The pulp dry weight was the maximum with 3% $CaCl_2$ and 0.5% Borax. At each calcium chloride level, the Borax concentration had no significant effect on dry weight (Table 1). There were nonsignificant differences in dry weight of pulp within different litchi cultivars but it increased significantly with combined foliar application of $CaCl_2$ + Borax. Calcium is involved in the cell walls structure and helps nitrogen assimilation by plants. Similarly, born is involved in metabolism of nitrogen and phosphorus and the movement of sugars in the plant (Patile *et al*., 2008). Thus both are important for fruit quality (Kazuhiro *et al*., 2004). The increased dry weight with increasing $CaCl_2$ and boron combine application indicated that calcium effect depends on the presence of boron (Wojvik *et al*., 1999; Tariq and Mote, 2007).

Total Soluble Solids: The total soluble solids (TSS) content of fruit varied significantly among litchi cultivars with maximum TSS content (22.54%) in cultivars Gola followed by cultivars China and Surahi with 20.63 and 19.58% respectively, while the lowest TSS contents (16.42%) was observed in cultivar Bedana (Table 1). The total soluble solids were not significantly affected by 1-2% calcium chloride applied alone or in combination with 0.5-1.5% Borax, but increased significantly with 3% Calcium chloride and Borax combinations. The treatments and cultivar interaction was, however, nonsignificant. The treatments and cultivar interaction was, however, nonsignificant. Total soluble solids content of fruits is a major quality parameter which is correlated with texture and composition (Ali *et al*., 2004). The TSS content of fruit was significantly different among litchi cultivars but Calcium chloride and Borax treatments or their interaction with cultivars was not significant (Table 1). Litchi cultivars vary considerably in morphological and biochemical characteristics (Khurshid *et al*., 2004), thus considerable variation were observed in total soluble solids contents of litchi fruit (Waseem *et al*., 2002, Islam *et al*., 2003). The TSS content of fruit is influenced by application of Ca, K, Zn, Cu and B (Brahamchari *et al*., 1997; Hasan and Jana, 2000). Thus, increase in TSS content with application of CaCl2 + Borax strengthened this opinion, though relatively high Ca concentration (3%) was required for increase in total soluble solids in litchi fruit.

Total Sugars: The highest total sugars was obtained in cultivar Gola (21.45%) followed by 19.33 and 18.26% in cultivars China and Surahi, respectively, while the lowest total sugars content (15.35%) was recorded in cultivar Bedana. The total sugars in control fruit (17.5%) were not significantly affected by $CaCl_2$ application but increased significantly with $CaCl_2$ + Borax application with the maximum total sugars (19.49%) recorded with $CaCl_2$ 3% + Borax 1.0% application. The influence of cultivar x treatments interaction on total sugars was not significant (Table 2). The sucrose, fructose and glucose are major sugars that contribute to total sugar content of litchi fruit (Jiang *et al*., 2006). The litchi cultivars vary greatly in total sugars (Khurshid *et al*., 2004; Wang *et al*., 2006). Among, the studied cultivars, Gola is a good total sugars accumulator while Bedana appeared as poor total sugars accumulator. The foliar application of several nutrients such as Ca $(NO_3)_2$ (0.5 and 1%), $CaCl_2$ (0.5 and 1%), K_2SO_4 (0.5 and 1%), $ZnSO_4$ (0.5, 1.0, 1.5 and 2.0%), $CuSO_4$ (0.5, 1.0, 1.5 and 2.0%) have shown significant effect on fruit quality of litchi by increasing total and reducing sugar (Hasan and Jana, 2000). Similarly the Borax application has shown to increase total sugars (Stine *et al*., 2011). Yet no significant difference was observed with different treatments, probably due to relatively lower concentration of Borax (0.5-1.5%) used in this study.

Reducing Sugars: The reducing sugars content of the fruit was highest in cultivar Gola (18.06%) followed by cultivars China (14.32%) and Surahi (13.78%), respectively, while cultivar Bedana had lowest reducing sugars (5.71%). The reducing sugars were 12.27% in control and were not significantly affected by the application of $CaCl_2$ alone. However, the reducing sugars were significantly higher with $CaCl_2$ + Borax application and the maximum (13.17%) with $CaCl_2$ 3% + Borax 1.0% application (Table 2). Reducing sugars represent more than 70% of total sugars in litchi fruit (Jiang *et al*., 2006). The reducing sugars were significantly different among various litchi cultivars fruits with maximum in cultivar Gola followed by cultivars China and Surahi, respectively, while cultivar Bedana had the lowest reducing sugars (Table 2). Variations in reducing sugars content of litchi cultivars are so marked (Waseem *et al*., 2002; Wang *et al*., 2006), that litchi cultivars are grouped on the basis of sugar composition such as monosaccharide prevalent types, disaccharide prevalent types, and intermediate types (Wang *et al*., 2006). Thus, it seems like cultivar Gola is monosaccharide prevalent type while Bedana is a disaccharide prevalent type. The differences in reducing sugars were nonsignificant for different treatments or the interaction of cultivars and treatment.

Non-reducing Sugars: The non-reducing sugars contents of fruit were significantly different among different litchi cultivars (Table 2). The maximum non-reducing sugars (9.80%) was recorded in cultivar Bedana followed by

5.44 and 4.72% in cultivars China and Surahi accordingly, while cultivar Gola had lowest non reducing sugars (3.58%). The non reducing sugars in control (5.23%) were at par with $CaCl_2$ treatments but application of $CaCl_2$ + Borax increased the non reducing sugars significantly and maximum (6.21%) with $CaCl_2$ (2%) + Borax (0.5%). The difference in non reducing sugars was in accordance with reports that litchi cultivar had significant variations in their biochemical composition (Waseem *et al*., 2002, Wang *et al*., 2006). The litchi cultivars are grouped as monosaccharides and polysaccharides types on the basis of their sugar composition (Wang *et al*., 2006). Thus, it seems like cultivars Gola is monosaccharide prevalent type while Bedana is polysaccharide prevalent type. The non reducing sugars were not significantly affected by $CaCl_2$ or Borax treatments or cultivars x treatment interaction.

Specific Gravity: The specific gravity of fruit was highest (1.1051) in cultivars Gola followed by 1.0899 in cultivar Surahi (Table 2). The cultivars China and Bedana fruit had significantly lower specific gravity of 1.0555 and 1.0397, respectively. However, the specific gravity was the least in Bedana. The specific gravity of litchi fruit was not significantly affected by different treatments or cultivars interactions with $CaCl_2$ and Borax treatments (Table 2). The specific gravity is generally correlated with composition of tissue such as starch content of tubers, dry matter, juice content and total sugars (Zaltzman *et al*., 1987). Thus, specific gravity of fruit can be used as maturity and quality index in many fruits and vegetables such as apricots, strawberries, tomato, pea, etc (Zaltzman *et al*., 1987; McGlone, 2007). Despite the earlier reports of significant differences in specific gravity of litchi fruit (Jurgen, 1990), it was not significantly affected by $CaCl_2$ and Borax or the cultivars x treatments interaction (Table 2).

Planned means comparison: The planned paired means comparison of control vs. rest of the treatment means showed non significant increase in fruit weight, pulp weight, pulp dry weight, total soluble solids contents and specific gravity of litchi fruit but showed increase in total sugars (17.50%), reducing sugars (12.27%) and non reducing sugars (5.23) in control to 18.69, 13.09 and 6.01%, respectively (Table 3). The calcium chloride treatments means revealed superior fruit weight (20.10 g), pulp weight (15.27 g) and pulp dry weight (13.93%) as compared to 19.87 g, 14.88 g and 13.76%, respectively in control fruits (Table 3). The $CaCl_2$ + Borax treatments means with fruit weight (20.54 g), TSS (15.08%), total sugars (19.10%), reducing sugars (13.09), non-reducing sugars (6.01%) and specific gravity (1.07) were superior than both control and $CaCl_2$ treatment means (Table 3).

Table 1. Effect of Calcium chloride and Borax application on the fruit weight (g), pulp weight (g), Pulp Dry Weight (%) and TSS (%) of litchi cultivars

Cultivars	Fruit Weight (g)	Pulp Weight (g)	Pulp Dry Weight (%)	TSS (%)
China	21.92 b	16.27 c	14.69	20.63 b
Gola	23.54 a	17.16 a	14.72	22.54 a
Surahi	20.89 c	16.37 b	14.63	19.58 c
Bedana	15.20 d	11.17 d	14.73	16.42 d
LSD	0.0236	0.0195	NS	0.848
Treatments				
Control	19.87 b	14.88 b	13.76 c	19.81 b
$CaCl_2$ 1%	20.07 ab	14.93 b	13.96 c	19.65 b
$CaCl_2$ 2%	20.10 ab	14.92 b	13.94 c	19.62 b
$CaCl_2$ 3%	20.14 ab	14.98 b	13.90 c	19.65 b
$CaCl_2$ 1% + Borax 0.5%	20.45 ab	15.10 ab	14.77 b	19.67 b
$CaCl_2$ 1% + Borax 1.0%	20.43 ab	15.13 ab	14.77 b	20.67 ab
$CaCl_2$ 1% + Borax 1.5%	20.20 ab	15.14 ab	14.75 b	20.80 ab
$CaCl_2$ 2% + Borax 0.5%	20.48 ab	15.33 ab	15.03 a	20.76 ab
$CaCl_2$ 2% + Borax 1.0%	20.50 ab	15.36 ab	14.98 a	20.72 ab
$CaCl_2$ 2% + Borax 1.5%	20.52 ab	15.39 ab	15.01 a	20.74 ab
$CaCl_2$ 3% + Borax 0.5%	20.74 a	15.64 a	15.50 a	21.17 a
$CaCl_2$ 3% + Borax 1.0%	20.78 a	15.69 a	15.49 a	21.01 a
$CaCl_2$ 3% + Borax 1.5%	20.79 a	15.69 a	15.40 a	21.03 a
LSD at α 0.05	0.697	0.359	0.647	1.286
Interactions				
Cultivars x Treatments	ns	ns	ns	ns

Means followed by different letters in a column are significant at $P < 0.05$

The application of Calcium chloride and Borax increases the size and weight of litchi fruit (Brahamchari *et al*., 1997). The increase in size was also accompanied by increased pulp weight (Kazuhiro *et al*., 2004). The increased pulp dry weight indicated that increased fruit weight involved greater movement of sugars to the fruit (Patile *et al*., 2008) and that influence was more with combination of Calcium chloride and boron (Tariq and Mote, 2007). This assumption was further strengthened by higher TSS, Total sugars, reducing sugars, non reducing sugars and specific gravity recorded with application of Calcium chloride + Borax (McGlone, 2007).

Table 2. Influence of Calcium chloride and Borax application on the total sugars, reducing and non reducing sugars and specific gravity of litchi fruit

Cultivars	Total Sugars (%)	Reducing Sugars (%)	Non reducing Sugars (%)	Specific Gravity
China	19.33	14.11 b	5.23 b	1.0555 c
Gola	21.45	17.96 a	3.49 d	1.1051 a
Surahi	18.26	13.66 b	4.60 c	1.0899 b
Bedana	15.35	5.63 d	9.72 a	1.0397 d
LSD	0.976	0.994	0.412	0.0006
Treatments				
Control	17.5 b	12.27 b	5.23	1.0722
$CaCl_2$ 1%	17.45 b	12.29 b	5.16	1.0695
$CaCl_2$ 2%	17.45 b	12.28 b	5.17	1.0696
$CaCl_2$ 3%	17.46 b	12.27 b	5.19	1.0685
$CaCl_2$ 1% + Borax 0.5%	18.82 a	12.98 a	5.84 a	1.0735
$CaCl_2$ 1% + Borax 1.0%	19.49 a	13.30 a	6.19 a	1.0733
$CaCl_2$ 1% + Borax 1.5%	19.09 a	13.10 a	5.99 a	1.0738
$CaCl_2$ 2% + Borax 0.5%	19.47 a	13.26 a	6.21 a	1.0750
$CaCl_2$ 2% + Borax 1.0%	18.86 a	12.98 a	5.88 a	1.0735
$CaCl_2$ 2% + Borax 1.5%	19.12 a	13.07 a	6.05 a	1.0728
$CaCl_2$ 3% + Borax 0.5%	18.71a	12.88 a	5.83 a	1.0750
$CaCl_2$ 3% + Borax 1.0%	19.31 a	13.17 a	6.14 a	1.0733
$CaCl_2$ 3% + Borax 1.5%	19.05 a	13.05 a	6.00 a	1.0735
LSD at α 0.05	0.932	0.4330	0.590	Ns
Interactions				
Cultivars x Treatments	ns	ns		Ns

Means followed by different letters in a column are significant at $P < 0.05$

Table 3. Planned paired means comparison of $CaCl_2$ and Borax in relation to fruit quality attributes

Treatment Pairs	Fruit Weight (g)	Pulp Weight (g)	Pulp Dry Weight (%)	TSS (%)	Total Sugars (%)	Reducing Sugars (%)	Non reducing Sugars (%)	Specific Gravity
Control	19.87	14.88	13.76	19.81	17.50	12.27	5.23	1.07219
Rest	20.43	15.27	14.77	19.79	18.69	12.89	5.80	1.07259
CaCl2	20.10	14.94	13.93	19.64	17.46	12.28	5.18	1.0692
CaCl2 + Borax	20.54	15.38	15.08	19.84	19.10	13.09	6.01	1.0737
Control vs. Rest	ns	ns	ns	ns	*	*	*	ns
Control vs. $CaCl_2$	*	*	*	ns	Ns	ns	Ns	*
Control vs. $CaCl_2$ + Borax	*	ns	ns	*	*	*	*	*
$CaCl_2$ vs. $CaCl_2$ + Borax	*	*	*	*	*	*	*	*

* Difference among treatments is significant at $P < 0.05$

Conclusion: Cultivar Gola was superior in fruit weight, pulp weight, TSS, total sugars, reducing sugars and specific gravity, while cultivar Bedana had highest non-reducing sugars (9.80%). Litchi fruit quality varies significantly as influenced by $CaCl_2$ and Borax treatments. Foliar application of $CaCl_2$ and Borax increased fruit weight, pulp weight and pulp dry weight but combination of $CaCl_2$ with Borax was more effective than calcium chloride alone application.

REFERENCES

AOAC. (1995). Official Methods of Analysis, 16th (ed). Association of Official Analytical Chemist, Washington, DC.

Brahamchari, V.S., G. S. Yadav, K. Naresh and N. Kumar (1997). Effect of foliar feeding of calcium, zinc and boron on yield and quality attributes of litchi (*Litchi chinensis* Sonn). Orissa J. Hort. 25: 49-52.

Crane, J.H. and B. Schaffer (2004). Increased exposure to temperatures below 55 or 60° F are correlated with increased yield of ‘Mauritius’ lychee (*Litchi chinensis* Sonn.) in Homestead Florida. Proc. Fla. State Hort. Soc. 117: 206-208.

Ganeshamurthy, A.N., G.C. Satisha and P. Prakash (2011). Potassium nutrition on yield and quality of fruit crops with special emphasis on banana and grapes. Karnataka J. Agric. Sci., 24: 29-38.

Hasan, M.D.A. and A. Jana (2000). Foliar feeding of potassium, calcium, zinc and copper in improving the chemical composition of fruits in litchi cv. Bombai. Env. Ecol. 18: 497-499.

Haq, I. and A. Rab (2012). Characterization of physico-chemical attributes of Litchi fruit and its relation with fruit skin cracking. The J. Anim. Plant Sci. 22: 142-147.

Huang, X.M., H.C. Wang, J. Li, J. Yin, W. Yuan, L. Lu and H.B. Huang (2005). An overview of calcium’s role in lychee fruit cracking. Acta Hort. 665: 231-240.

Islam, M.S., M. Ibrahim, M.A. Uddin and S.K. Biswas (2003). Studies on the fruit characteristics, bio-chemical composition and storage behaviour of litchi varieties. Pakistan J. Biol. Sci. 6: 70-72.

Imtiaz, M,, A. Rashid, P. Khan, M.Y. Memon and M. Aslam (2010). The role of micronutrients in crop production and human health. Pakistan J. Bot. 42: 2565-2578.

Jiang, Y.M., Y. Wang, L. Song, H. Liu, A. Lichter, O. Kerdchoechuen, D.C. Joyce and J. Shi (2006). Postharvest characteristics and handling of litchi fruit - An overview. Aust. J. Exp. Agric. 46: 1541-1556.

Jurgen, G. (1990). Quality in cherries with foliar fertilizers. English Abstract, Erwerbsobstbau, 32: 147-149

Kadir, S.A. (2005). Influence of pre harvest calcium application on storage quality of ‘Jonathan’ apple in Kansas. Trans. Kansas Acad. Sci. 118: 129-36.

Kazuhiro, I., M. Masashi and F. Hiroyuki (2004). The effect of spraying of calcium to the fruit quality, the quality keeping period and the tree vigor of ‘kousui’ in the green house. Bulletin Saga Prefectural Fruit Tree Exp. Sta., 15: 8-14.

Khurshid, S., I. Ahmad and A.A. Anjum (2004). Genetic diversity in different morphological characteristics of litchi (*Litchi chinensis* Sonn.). Int. J. Agri. Biol., 6: 1062-1065.

Li, J.G., H.B. Huang, F.F. Gao, X.M. Huang and H.C. Wang (2001). An overview of litchi fruit cracking. Acta Hort. 558: 205-208.

Marisa, M.W. (2006) Ascorbic acid and mineral composition of longan (*Dimocarpus longan*), lychee (*Litchi chinensis*) and rambutan (*Nephelium lappaceum*) cultivars grown in Hawaii. J. Food Comp. Anal., 19: 655-663.

McGlone, V.A., J.C. Christopher and B.J. Robert (2007). Comparing density and VNIR methods for predicting quality parameters of yellow fleshed kiwifruit (*Actinidia chinensis*). Postharvest Biol. Technol. 46: 1-9.

Menzel, C.M. and D.R. Simpson (1987). Lychee nutrition: A review. Scientia Hortic. 31: 195-224.

Patile B.C., R.M. Hosmani, P.S. Ajjappalavara, B.H. Naik, R.P. Smith and K.V. Ukkund (2008). Effect of foliar application of micronutrients on growth and yield components of tomato (*Lycopersicon esculentum* Mill.). Karnataka J. Agric. Sci. 21: 428-430.

Rajwana, I.A., A.U. Malik, A.S. Khan and R. Anwar (2010). Lychee industry in Pakistan: Potential and Prospects. Acta Hortic. 863: 67-72.

Ruby, R., V.S. Brahmachari and R. Rani (2001). Effect of foliar application of calcium, zinc and boron on cracking and physicochemical composition of litchi. Orissa J. Hort. 29: 50-54.

Shah, S.S.H. (2003). Fruit orchard survey in district Haripur. Project for Horticulture Promotion (East), Abbottabad, KP, Pakistan. pp. 14-15.

Sivakumara, D., L. Terryb and L. Korsten (2010). An overview on litchi fruit quality and alternative postharvest treatments to replace sulfur dioxide fumigation. Food Rev. Int. 26: 162-188.

Steel, R.G.D. and J.H. Torrie (1997). Principles and Procedures of Statistics. 3rd ed. McGraw Hill Book Co. Inc., New York, USA.

Stino, R.G., S.M. Abdel-Wahab, S.A. Habashy and R.A. Kelani (2011). Productivity and fruit quality of three mango cultivars in relation to foliar spray of calcium, zinc, boron and potassium. J. Hort Sci. and Ornamental plants. 3: 91-98.

Tariq, M. and C.J.B. Mote (2007). Calcium-boron interaction in radish plants grown in sand culture. Pakistan J. Agri. Sci. 44: 122-129.

Wang, H.C., H.B. Huang, X.M. Huang and Z.Q. Hu (2006). Sugar and acid compositions in the arils of *Litchi chinensis* Sonn.: cultivar differences and evidence for the absence of succinic acid. J. Hort. Sci. Biotech. 81: 57-62.

Waseem, K., A. Ghafoor and S.U. Rahman (2002). Effect of fruit orientation on the quality of Litchi (*Litchi chinenesis* Sonn) under the Agro-Climatic Conditions of Dera Ismail Khan–Pakistan. Int. J. Agric. Biol. 4: 503–505.

Wojvik, P., G. Cieslinski and A. Mika (1999). Apple yield and fruit quality as influenced by boron applications. J. Plant Nut. 22: 1365-1377.

Zaltzman, A., B.P. Verma and Z. Schmilovitch (1987). Potential of quality sorting of fruits and vegetables using fluidized bed medium. Trans. ASAE. 30: 823-831.