INTERNATIONAL JOURNAL OF ADVANCED BIOLOGICAL RESEARCH

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EFFECT OF CALCIUM & BORON APPLICATION ON QUALITY AND YIELD OF APPLE UNDER TEMPERATE CONDITIONS OF KASHMIR

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ABSTRACT

A field experiment was conducted at Krishi Vigyan Kendra- Bandipora, SKUAST-Kashmir to study "Effect of Calcium & Boron applications on quality & yield of Apple (*var.* Red Delicious) under temperate conditions of Kashmir". It included four treatments of Calcium nitrate ($CaNO_3$) @ 0g/tree (control), 250g/tree, 500g/tree and 750g/tree for calcium supply and four treatments of Granubor Natur @ 0g/tree (control), 50 gm/tree, 75 gm/tree and 100gm/tree for boron fertilization. Highly significant results were obtained by application of calcium in the form of $CaNO_3$ @ 500 g/tree & boron in the form Granubor Natur @ 100g/tree; with reference to some physical fruit attributes like fruit length, diameter, weight and chemical parameters like TSS, acidity along with total sugars over the traditional system of orcharding (where farmers do not use calcium & boron in their orchards). Further; yield enhancement was recorded to the extent of 31.59%. Farmer was highly satisfied as the problems of fruit drop, small fruit size, poor colour & lower yields were redressed as a result of this on farm trial (OFT). As far as economics is concerned, Net Return of Rs. 4,05,392 / ha was obtained by the above doses of nutrient formulations compared to Rs. 2,79,685/ha obtained under control treatment (farmers practice). Further the benefit cost ratio of 4.36 was recorded under the described treatment.

KEY WORDS: Apple, Granubor, Calcium nitrate, Quality, Yield.

INTRODUCTION

Fruit cultivation in India is one of the major export businesses which contribute significantly to economy of the country. India stands second in fruit production with annual production of 306 million tones and accounts for around 10% of the world's total fruit production. For production of healthy, high quality and palatable fruit, the cultivation of apple calls for incredible attention. Being premier table temperate fruit; apple has been cultivated in South- East Asia and Europe from times immemorial and spread by man in almost every nook and corner of the world (Mitra *et al*., 1991). The records of its introduction in India by British in the Kullu valley of H.P dates back to 1865, while the 'Delicious' cultivars of apple were introduced to Shimla hills in 1917. Kashmir, however, located in monsoon shadow of greater Himalayas, has been more favoured for apple cultivation since times immemorial (Salaria, 2008).Apple fruit is well characterized for their taste, flavor and dietary values. It is one of the genera of pome fruit trees of the temperate zones belonging to the Rosaceae family and is one of the most important garden crops and due to its high adaptability and it is one of the most extensively fruit trees cultivated in temperate zones . Healthy and superior quality of fruit as one of the most crucial organs of the trees is in direct relation with health of humans. Apple storability and quality in large extent is determined by the genotype of the cultivars. Some other factors may influence expression of this peculiarity. The role of balanced nutrition on fruit storability is well known. Adequate nutrition ensures a balance in fruit mineral composition.

Presently 99.0% of India's apple production area falls under North western hills covering J&K, Himachal Pradesh and Uttrakhand to small extent north eastern hills (Ghosh, 2005). J&K being major apple producing state of the country; dominates the scene of commercial cultivation and marketing. The area under apple crop in J&K is 1.64 lac ha with annual production of 18.82 lac MT (Anonymous, 2018). Apple grown in Kashmir holds national and international pride for its delicacy and superb aroma. The state has been declared as Agro-export zone for apple where 25 lakh people directly or indirectly are eating out their livelihood from fruit Industry. The export of the fruit holds a promising status and is very important for boosting economy of the state and promotion in that direction. Boron is an essential trace element required for optimal growth and development of higher plants. Apple trees (*Malus x domestica* Borkh.) have been known to have high requirements for boron (Shorrocks, 1997). It is important in pollen germination and pollen tube growth resulting in successful fruit setting (Stanley and Lichtenberg, 1963). Therefore, B fertilization may increase yield, particularly when plants are grown on sandy soil with a low content of available B as shown by Yogaramarn and Greenham (1982) and Nyornova and

Brown (1997). Although the mechanism of B translocation within plants has not been well understood, the effect of B fertilization of apple trees on fruit quality as altered by several biological and environmental factors such as cultivar, orchard location, rainfall, air temperature has been well known for many years (Wilcox and Woodbridge, 1942; . Both low and excessive concentration of B in apple trees cause poor fruit quality. Apples with a low B concentration have a short storage life because of the high susceptibility to a breakdown (Perring and Samuelson, 1988). On the other hand, high B concentration in apples enhances the incidence of internal disorders, particularly water core and internal breakdown (Marlow and Loescher, 1984).

Calcium is an important nutrient element, which can affect apple quality after harvest. Calcium deficiency expresses itself in the form of cork spot, which develop primarily during the early part of the growing season, bitter pit, which develops during storage of the crop, and senescent breakdown, which forms during and after storage. Calcium provides cell wall rigidity by cross-linking of pectic chains of the middle lamella .Disintegration of cell walls and the collapse of affected tissues are typical symptoms of calcium deficiency. The proportion of calcium pectate in cell walls is very important for the ripening of fruit. The increase of fruit calcium content leads to the increase fruit firmness of fruit and delays fruit ripening or prevents calcium-related disorders. Increases in calcium concentration both in fruit flesh and skin have been found in Jonathan apples and always, the increase in concentration in the peel was far greater than in the pulp. Several authors have reported changes in fruit quality traits, particularly flesh firmness, acids and color, associated with increases of calcium concentration in the pulp of fruits. Calcium accumulation in apples is influenced by different management practices and ecological conditions. Experimental results indicated different effects of applying calcium fertilizers. In most part of the world, pre-harvest calcium treatment is generally effective in increasing fruit calcium and reducing spoilage. The favorable effect of calcium obtained by Siddiqui and Bangerth on Golden Delicious apples, suggested that the observed effects of $CaCl_2$ on fruit firmness are likely to be associated with the calcium content of the covalently-bound pectin fractions. When they are applied as inorganic salts to the growing medium, above pH 6, Fe, and above pH 7 Mn, B, Cu and Zn have become insoluble forms, so their absorption by the plants decreased. It has been suggested that micro elements as inorganic or organic complexes should be applied to the leaves instead of adding them to the growing medium in order to resolve micro element requirements of the plants.

MATERIALS AND METHODS

A field experiment was conducted at Krishi Vigyan Kendra- Bandipora, SKUAST- Kashmir on Apple (*var.* Red Delicious) in the farmers field under temperate conditions with four treatments of Calcium nitrate @ 0g/tree (Control), 250 g/tree, 500 g/tree and 750 g/tree and four treatments of Granubor Natur @ 0 g/tree (Control), 50 gm/tree, 75g/tree and 100 g/tree for supply of calcium and boron respectively. Fruit samples were taken immediately to the laboratory after harvest and stored in a refrigerator at 4°C until analyses. Ten fruits from each replicate were randomly taken for determining the physical and chemical characteristics. The fruit samples were weighed in a pan balance and the mean weight of single fruit was expressed in grams per fruit. The length of all the ten fruits in a sample were recorded individually with the help of Verniers Calliper and the results were expressed average length in centimeters. Also, fruit diameter of ten fruits was recorded with the help of Verniers Calliper and expressed in centimeters on average basis. Fruit length was divided with the corresponding fruit diameter to obtain length diameter ratio. The yield was estimated by multiplying total number of fruits per tree with the average fruit weight of ten randomly selected fruits. The yield was expressed in kilograms per tree. The total soluble solids content was determined with the help of Erma make Japan hand Refractometer (0-32 ^{o}Brix range) in by putting a drop of juice on the prism and taking reading at room temperature. A temperature correction was applied where the readings were made at temperatures other than 20^{o}C (Ranganna, 1986).The total titrable acidity was calculated in terms of malic acid on the basis of 1 ml N/ 10 NaOH being equivalent to 0.0067 g anhydrous malic acid. The results were expressed as per cent of fresh weight of fruit pulp. Total sugars were estimated by titrating a sample solution against mixture containing 5 ml each of Fehling's solution A and B using methylene blue as indicator. The titration was continued till brick red colour appeared.

TABLE 1: Effect of calcium nitrate and Granubor Natur on production and economics of apple fruit

Technology Assessed / Refined	Production MT/ha	Net Return (Profit) in Rs. / ha	B:C Ratio	Remarks
Farmers Practice: Farmers do not use Calcium & Boron application in their orchards.	30.74 MT/ha (118.25 gs/tree)	279685	3.30	Soil testing, leaf tissue testing to be popularized for ascertaining the deficiency of macro/ micro nutrients & correcting the deficiencies on the farmers field.
Technology Assessed: Calcium in the form Calcium Nitrate ($CaNO_3$) @ 500 g/tree and Boron in the form of Granubor Natur @ 100 g/tree applied in the farmers field resulted in increase of 31.58% yield	40.46 MT/ha (155.60Kg/tree)	405392	4.36	

TABLE 2: Effect of calcium nitrate and Granubor Natur on fruit yield (kg/tree) and quality of apple (cv. Red Delicious)

Treatment (g/Tree)	Fruit weight (gms)	Fruit length (cm)	Fruit diameter (cm)	Yield: Kg/Tree	T.S.S%	Acidity %	Total Sugar%
T0:No Ca No_3 + No Granubor Natur	118.92	3.93	4.20	118.25	10.10	0.215	7.21
T1:No Ca No_3+ 50 g Granubor Natur	121.24	4.40	4.50	124.75	10.50	0.225	7.23
T2: No Ca No_3 + 75 g Granubor Natur	128.36	4.46	4.57	124.85	10.80	0.193	7.41
T3:No Ca No_3+ 100 g Granubor Natur	136.72	3.99	4.44	123.90	11.10	0.198	7.36
T4**: 250 Ca No_3**+ No Granubor Natur	126.55	4.01	4.58	132.40	11.00	0.201	7.28
T5: 250 Ca No_3+ 50 Granubor Natur	145.46	4.25	4.66	133.95	10.70	0.191	7.31
T6: 250 Ca No_3+ 75 Granubor Natur	142.72	4.52	5.14	136.90	10.40	0.187	7.26
T7: 250 Ca No_3+ 100 Granubor Natur	139.54	4.09	4.70	139.72	10.60	0.194	7.30
T8: 500 g Ca No_3+ No Granubor Natur	150.72	4.35	4.76	144.92	11.10	0.213	7.57
T9: 500 g Ca No_3+ 50 g Granubor Natur	151.33	4.58	4.80	147.50	10.80	0.198	7.65
T10:500 g Ca No_3 + 75 g Granubor Natur	152.38	4.46	4.82	149.75	10.30	0.201	7.77
T11:500 g Ca No_3+ 100 g Granubor Natur	**154.85**	**4.64**	**4.76**	**155.60**	**11.30**	**0.190**	**8.05**
T12: 750 g Ca No_3+ No Granubor Natur	148.95	4.63	4.54	150.45	11.10	0.200	7.32
T13: 750 g Ca No_3+ 50 g Boron	136.72	4.54	4.61	146.92	10.30	0.197	7.33
T14: 750 g Ca No_3+ 75 g Granubor Natur	138.25	4.21	4.48	142.11	10.40	0.214	7.28
T15: 750 ca+ 100g Granubor Natur	129.45	4.28	4.51	142.25	10.16	0.198	7.25

RESULTS AND DISCUSSION

Calcium in the form Calcium Nitrate ($CaNO_3$) @ 500 g/tree and Boron in the form of Granubor Natur @ 100 g/tree applied in the farmer's field resulted in maximum fruit length (4.64 cm) during both the years. Increasing Calcium Nitrate concentration from 500 to 750 g resulted in significant decline in fruit length. However, fruit length was significantly higher compared to the treatment where no calcium and boron was applied. Application of calcium nitrate and Granubor Natur in the present studies revealed pronounced effect on fruit size. The pre-harvest treatment with both the chemicals at lowest concentration produced significantly larger fruits in size in comparison to fruits treated with higher concentration. Mir *et al*. (1996) and Kilany and Kilany (1991) also observed significant change in fruit size i.e., length and diameter due to calcium chloride and boric acid treatment on apple. Similar results have been reported by Mehta and Jindal (1986) in plum and Wani (1997) in peach. Calcium is required for cell elongation and cell division (Burstrom, 1968), There is now evidence that auxin induced H+ secretion of meristematic cells is related to the presence of Ca2+ (Marme, 1983). However, the reduced fruit size in case of higher concentration of calcium chloride might be due to the reason that at higher levels of calcium, cell wall becomes too rigid there by, inhibiting cell elongation (Uhstrom, 1969). Boron is also known to result in an increase in calcium concentration which might have augmented the rigidity of cell wall.

Due to significant interaction effect of calcium nitrate and Granubor Natur it was noticed that calcium nitrate @ 500 g/tree and Granubor Natur @ 100 g/tree recorded the highest fruit diameter (4.76 cm) while as control treatment registered the lowest fruit diameter (4.20cm However, these treatments were at par with each other. Calcium Nitrate ($CaNO_3$) @ 500 g/tree and Granubor Natur @ 100 g/tree recorded length: diameter ratio of 0.97 whereas, control fruits recorded length diameter ratio of (0.93) .The highest fruit weight of 154.85g was recorded when trees received combined application of 500 g calcium nitrate with 100 g Granubor Natur respectively.. The lowest fruit weight of 118.92 g was observed under control .Calcium nitrate and Granubor Natur treatment resulted in heavier fruits as compared to control. With further increase in the concentration of calcium nitrate (750 g) ; there was a decline in fruit weight .

Striking effect of calcium and boron in enhancement of fruit weight and volume has been widely established (Mehta and Jindal 1986; Mir *et al.* 1996; Kumar *et al*., 2003 and Gautam *et al*. 1981).Out of various chemical treatment combinations, calcium nitrate at 500g plus Granubor Natur at 100g resulted in the highest fruit yield of 155.60 kg/tree. The lowest fruit yield 118.25 kg/ tree was observed when trees received no calcium and boron. (control treatment).

Present studies reveal a significant difference with the treatments of calcium nitrate and Granubor Natur in terms of their effect on fruit yield and physico- chemical composition of apple fruit over the traditional system of orcharding .With $CaNO_3$ @ 500 g/tree & boron in the form of Granubor Natur @ 100 gms/tree yield enhanced to the extent of 31.59% which decreased with further increase in calcium nitrate concentration. Striking effect of calcium nitrate and boron in enhancement of yield in apple has been well documented by various workers. (Bagdsarashvili and Tsutsunashuli 1980, Dube *et al*., 1973; Koul and Muthoo, 1999 and Bhat *et al*. (1997). Azad (1999) obtained higher yield in apple with combined application of calcium nitrate plus Granubor Natur in comparison to untreated fruits and it is established that a positive correlation exists between boron and tree vigour (Lidster *et-al* 1975). Improved yields have also been reported with foliar boron sprays in apple cv. Cox's Orange Pippin (Shorrocks *et al*., 1980). Highest T.S.S content was attained with combined application of calcium nitrate at 500g and Granubor Natur at 100g to the tune of 11.30%. The minimum T.S.S recorded was 10.10% under control. However, TSS decreased with further increase in concentration of calcium nitrate. Higher TSS induced by chemical treatments viz. calcium nitrate and Granubor Natur might be due to lesser utilization of sugars in metabolic processes as a result of reduced respiration (Gupta *et al*., 1980). The reduced rate of respiration could also cause accumulation of organic acids which have oxidized at slower rate. An examination of data shows that lowest acidity was recorded when combined application of calcium nitrate and Granubor Natur was applied at 500g and 100g. Maximum acidity of 0.215% was obtained under control during the study. Acidity decreased with further increase in calcium nitrate and Granubor Natur. The results were in accordance with those of Bhat and Farooqui (2004) ;who reported that acidity of apple cv. Red Delicious decreased with combined application of calcium chloride and boric acid. The results of the present study indicate that interaction effect of calcium nitrate and Granubor Natur revealed that both chemical treatments resulted in significantly higher sugars .This treatment interaction was superior in comparison to other treatments and the values for total sugar content observed were 8.05% .The lowest total sugar of 7.21 was noticed under control. Increase in higher content with the application of calcium nitrate and Granubor Natur was also reported by Sachdeva (1985) and Pant and Tewari (1987) in apple. Increase in higher content with the application of calcium nitrate and Granubor Natur was also reported by Sachdeva (1985) and Pant and Tewari (1987) in apple. Increase in sugar content may be attributed to translocation of sugars which is enhanced with boron (Davenport and Peryea, 1990). The increase in sugar was directly related to the decrease in acidity as well. Increase in sugar content may be attributed to translocation of sugars which is enhanced with boron (Davenport and Peryea, 1990). The increase in sugar was directly related to the decrease in acidity as well.

CONCLUSION

From the studies; it may be concluded that fruit chemo-metric properties of apple like fruit size, TSS and total sugars can be improved significantly by soil fertilization of calcium nitrate and Granubor .Accordingly, Calcium in the form of $CaNO_3$ @ 500 g/tree & Boron in the form Granubor Natur @ 100 g/tree proved most beneficial in enhancement of fruit physic-chemical quality. Moreover, problems of fruit drop, under size fruits, poor colour & lower yields can be redressed as seen during the conduct of this on farm trial (OFT).

ACKNOWLEDGEMENT

The authors are highly thankful to the orchardist (Mr. Altaf Ahmad Parray, Putshahi, Bandipora) and SKUAST-K authorities to enable us to conduct the trial.

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