Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2582-2845.8185

ISSN: 2582 – 2845

Ind. J. Pure App. Biosci. (2020) *8*(3), 574-584

Indian Journal of Pure & Applied Biosciences

Peer-Reviewed, Refereed, Open Access Journal

Research Article

Effects of Calcium and Potassium Application on Growht, Yield and Quality of Apple (*Malus x domestica* Borkh.) cv. Red Delicious

Miraj Qeyami* Anurag Bajpay and Ah Waris Jailani

Department of Horticulture, School of Agriculture Science and Technology

RIMT University, Mandi, Gobindgrah-147301, Punjab, India

*Corresponding Author E-mail: qeyami.786@gmail.com

Received: 11.05.2020 | Revised: 16.06.2020 | Accepted: 25.06.2020

ABSTRACT

The present study was conducted at a full bearing orchard of apple at Wathoo, Shopian near KVK Balpora, Jammu and Kashmir, India. The present study aimed to investigate the effect of calcium and potassium application on growth, yield and quality of apple cv. Red Delicious during the year 2019. The results reviled that maximum annual shoot growth, total soluble solids, TSS:acid ratio, total and reducing sugars and minimum acidity were observed in T_7 *(Calcium nitrate @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre). However, the maximum chlorophyll content, fruit physical parameters viz., fruit diameter, fruit length, weight, yield, volume and specific gravity were found in treatment* T_6 *(Calcium nitrate @ 500 gram/tree + Calcium chloride @ 2 gram/litre). However, the maximum fruit firmness and ascorbic acid was observed in treatment* T_3 *(Calcium chloride @ 500 gram/tree) and the minimum physiological loss in weight has been recorded under treatment* T_8 *(Calcium chloride @ 500 gram/tree + Calcium chloride @ 2 gram/litre) as compared to other treatments and control. The overall results indicated that calcium nitrate significantly influenced vegetative growth, chlorophyll content of leaf and fruit physical and Chemical parameters, However the highest ascorbic acid and lowest physiological loss in weight recorded by calcium chloride treatments.*

Keywords: *Red Delicious apple, Potassium sulphate, Calcium chloride, Calcium nitrate, Leaf chlorophyll, Physiological loss in weight*

INTRODUCTION

Apple (Malus × domestica Borkh.) is cultivated in worldwide. It belongs to family Rosaceae sub family Pomoideae and originated in the temperate region of the Western Asia between black and Caspian Sea. Apple is rich source of carbohydrates, proteins, minerals and Vitamin-C (Banday, 2015). The leading apple producing country in the world is China with an annual production of 41.0 million tons followed by United States of America with 4.7 million tons, Turkey with 3.0 million tons and India ranks 5th with 2.4 million tone annual production (Anonymous, 2019).

Cite this article: Qeyami, M., Bajpay, A., & Jailani, A.W. (2020). Effects of Calcium and Potassium Application on Growht, Yield and Quality of Apple (*Malus x domestica* Borkh.) cv. Red Delicious, *Ind. J. Pure App. Biosci. 8*(3), 574-584. doi: http://dx.doi.org/10.18782/2582-2845.8185

Apple is one of the dominant fruit crop among the temperate fruit crops in Kashmir due to higher returns and suitable climate for its cultivation. It is mainly grown in Jammu and Kashmir, Himachal Pradesh, Uttrakhand where the chilling requirements met for its successful fruitfulness, which accounts for over 90 percent of the total production of the country. Jammu and Kashmir is predominantly a horticultural state and economy of the state, especially rural areas which account for 75 per cent of the state's population, sustains on temperate fruit cultivation. The production of apple in Jammu and Kashmir is 18,82,319 MT over an area of 1,64,742 ha with productivity of 11.42 MT/ha (Anonymous, 2019). Calcium is known as an essential element for plant growth and development. It is considered as one of the most important minerals determining the quality of fruit since it is required for cell elongation and cell division and plays an important role in plant growth, development, maintaining and modulating various cell functions. It is very necessary to maintain membrane stability and is an integral part of the cell wall where it provides rigidity (Ajender, 2018). Calcium plays a vital role in decreasing the incidence of physiological disorders and internal breakdown (Conway et al., 2002). Calcium level in the tree tissues is in the same range of concentration as potassium and nitrogen (Ajender, 2018). Apple leaves frequently shows a need for higher calcium levels. Where, low calcium level in fruit causes several disorders the major ones are bitter pit, cork spot and senescent breakdown during storage (Khalifa et al., 2009). Potassium is an essential nutrient element which is required in large quantities in apple trees. It is essential for the manufacture and translocation of sugar and starches it plays an important role in uptake and translocation of water by the tree. The deficiency of potassium results in poor root development, colour, quality of the fruit, tips and margins of the leaves burn up and necrosis occurs. Some apple varieties are capable of absorbing more potassium from soils then others. The major apple variety grown in India, i.e Red delicious group has higher capability than varieties like Jonathan, York or Rome. Potassium is easily soluble in water and, therefore, soil application is very effective. Foliar spray of potassium sulphate has also been found effective in improving the quality of fruits. Good potassium nutrition also assists in the quick conversion of inorganic nitrogen in to proteins, thus effect of nitrogen fertilizer gets improved (Kumar et al., 2006) beside all Potassium activates different enzymes involved in plant growth, fruit size and colour. (Ajender et al., 2019).

MATERIALS AND METHODS

The experiment was conducted in a full bearing orchard of apple at Wathoo, Shopian near KVK Balpora, Jammu and Kashmir. The laboratory studies were conducted in Horticulture lab of the School of Agricultural Sciences and Technology, RIMT University, Mandi Gobindgarh, Punjab, India. The research was conducted on 25 years old apple orchard of cv. Red delicious. Thirty bearing trees with uniform size and vigour and planted at an orchard spacing of 7 x 7 m were randomly selected for study. All plants were given uniform cultural practices during the investigation. The present study comprised of 10 treatments, which consisted of inorganic fertilizers sources Potassium sulphate (K_2SO_4), Calcium chloride ($CaCl_2$) and Calcium Nitrate $Ca(NO_3)2$ and their combinations as follow

T1 Control
T2 Calcium nitrate @ 500 gram/tree
T3 Calcium Chloride @ 500 gram/tree
T4 Calcium Chloride @ 2 gram/litre
T5 Potassium sulphate @ 2.5 gram/litre
T6 Calcium nitrate @ 500 gram/tree + Calcium Chloride @ 2 gram/litre
T7 Calcium nitrate @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre
T8 Calcium Chloride @ 500 gram/tree + Calcium Chloride @ 2 gram/litre
T9 Calcium Chloride @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre
T10 Calcium Chloride @ 2 gram/litre + Potassium sulphate @ 2.5 gram/litre

The data obtained were subjected to analysis of variance. The data to be recorded will be analyzing using MS-excel and OPSTAT as per the design of experiment. Means were compared using RBD test with level of significance at 5 %. During the current study, standard methodology was adapted for estimation of different parameters which are described as under:

Vegetative growth and leaf chlorophyll content

vegetative growth was measured by selected two randomly scaffold branches in opposite direction in each replication were used for the observation and the average annual extension growth (cm) of the current season were recorded in the year following leaf drop and the average was calculated in cm. leaf chlorophyll content was measured by five normal leaves per plant were collected from current season's shoots randomly selected from all sides of the tree. The ccm-200 model of chlorophyll content meter (chlorophyll SPAD meter) device was used to determine the chlorophyll content of leaves which five SPAD measurements were taken per leaf and averaged and the readings recorded by SPAD meter.

Physical parameters:

The fruit size in terms of length and breadth of ten randomly selected fruits per replication was recorded with a digital Vernier calliper (Mitutoyo, Japan). The volume of fruits was measured by water displacement method ten selected fruits taken for measuring size and weight were immersed in a measuring cylinder filled with water up to a certain graduation. Weight of each fruit was recorded with the help of electronic balance and measured in grams, fruit yield was recorded as total fruits harvested in kg/plant. The specific gravity was calculated by dividing the fruit weight with fruit volume. Fruit firmness was determined by removing 1 cm thin peel at three places and the 11 mm plunger of effegi model penetrometer FT-3-27 was inserted in the fruit to record fruit firmness in Kg/cm^2. Similarly, colour intensity was measured by comparing the coloured surface of fruit with the colour chart and expressed in percent.

Chemical parameters

The TSS content was directly read on Zeis's hand refractometer by putting a drop of fruit juice on prism and reading as Brix^o at 20ºC (A.O.A.C., 1980). Acidity of collected and pro-cessed fruit was determined by diluting a known volume of fruit juice and titrating against 0.1 N sodium hydroxide solutions, using phenolphthalein as an indicator, and expressed as percent of malic acid. The ratio was obtained by dividing the corresponding value of total soluble solids to the titrable acidity. Ascorbic acid, total sugar and reducing sugar was estimated by titration method using 2, 6-dichloro indophenol as suggested by Ranganna (1986).

RESULTS AND DISCUSSION

Annual shoot growth: As result indicated in table 1 the maximum shoot growth (41.25 cm) was recorded with the treatment T_7 (Calcium nitrate @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre) which was statistically at par with T_2 and T_6 while the minimum annual shoot growth (27.64 cm) was recorded under T_{10} (Calcium Chloride @ 2 gram/litre + Potassium sulphate @ 2.5 gram/litre). This increase in cell size and number might be due to the optimum availability of nitrogen to the plant part which in turn led to the increase shoot growth (Simnani, 2012). Nitrogen is the main constituent of protein, amino acid, enzymes, vitamin and plant hormones which alters the rate of metabolic process in plant. The effect of potassium sulphate in annual shoot growth can be attributed to the fact that potassium being an activator of enzyme involved in synthesis of certain peptide bonds during protein synthesis and plays an important role in photosynthesis and translocation of carbohydrates (Banday, 2015). This is in line with finding of (Fediala et al. (2015) who reported an improve in shoot extension to "Anna" apple trees through application of calcium and potassium fertilizers.

Leaf chlorophyll (SPAD): Based on result indicated in table 1, Maximum leaf chlorophyll content (55.24 SPAD) was observed in T_6 (Calcium nitrate @ 500 gram/tree + Calcium chloride @ 2 gram/litre) which was found statistically at par with T_2 and T_4. Whereas, the lowest leaf chlorophyll content (47.81 SPAD) was observed in control. The increase in leaf chlorophyll may be due to the higher leaf N content. In the present study the nitrate forms of nitrogen in calcium nitrate due to quick nitrogen release the N content of leaves and enhance the Mg^{+2} absorption from the soil. Being constituent of chlorophyll, enhanced N and Mg contents attribute to increased chlorophyll content in the leaves (Jeet, 2006). This finding are in conformity to (Jeet, 2016) who reported an increase in chlorophyll content of apple leaves through application of calcium nitrate.

Table 1: Effects of calcium and potassium application on vegetative growth and leaf chlorophyll content of apple cv. Red Delicious

Treatments combination		Annual shoot growth (cm)	Leaf chlorophyll (SPAD)
T_1	Control	27.64	47.81
T_2	Calcium nitrate @ 500 gram/tree	37.90	54.13
T_3	Calcium Chloride @ 500 gram/tree	30.75	52.24
T_4	Calcium Chloride @ 2 gram/litre	31.00	52.16
T_5	Potassium sulphate @ 2.5 gram/litre	31.00	49.95
T_6	Calcium nitrate @ 500 gram/tree + Calcium Chloride @ 2 gram/litre	39.00	55.24
T_7	Calcium nitrate @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre	41.25	52.74
T_8	Calcium Chloride @ 500 gram/tree + Calcium Chloride @ 2 gram/litre	32.13	51.09
T_9	Calcium Chloride @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre	34.13	51.72
T_{10}	Calcium Chloride @ 2 gram/litre + Potassium sulphate @ 2.5 gram/litre	33.20	50.81
C.D 0.05%		**4.93**	**2.91**

Physical parameters:

Fruit length: It is evident form data in table 2 that the maximum fruit length (72.10 mm) was recorded in T_6 (Calcium nitrate @ 500 gram/tree + Calcium Chloride @ 2 gram/litre), which was found statistically at par with the treatments T_2, T_3, T_4, T_5, T_7, T_9 and T_{10}. However, the lowest fruit length (67.82 mm) was observed in the control.

Fruit diameter: The result indicates in table 2 that he maximum fruit diameter (70.81 mm) was recorded in T_6 (Calcium nitrate @ 500 gram/tree + Calcium chloride @ 2 gram/litre). Which was found statistically at par with the treatments T_2, T_3, T_4, T_5, T_7, T_8, T_9 and T_{10}. However, the lowest fruit diameter (65.71 mm) was observed in the control.

Fruit Volume: based on results reviled in table 2 the maximum fruit volume (192.33 cm^3) was recorded in T_6 (Calcium nitrate @ 500 gram/tree + Calcium chloride @ 2 gram/litre) which was found statistically at par with the T_3, T_4, T_5, T_9 and T_{10}. However, the lowest fruit volume (160.97 cm^3) was observed in control.

Fruit Weight: It is evident from the data that fruit weight was significantly affected by soil application of calcium nitrate either alone or in combination with different soil and foliar application of calcium chloride treatments. The maximum fruit weight (190.8 g) was recorded in T_6 (Calcium nitrate @ 500 gram/tree + Calcium chloride @ 2 gram/litre). Which was found statistically at par with the treatments T_4, T_5 and T_9. However, the lowest weight (171.3 g) was observed in the control.

Fruit Yield: The perusal of data showed in table 2 that the maximum fruit yield (190 kg/ tree) was recorded in T_6 (Calcium nitrate @ 500 gram/tree + Calcium chloride @ 2 gram/litre), which was found statistically at par with the treatments T_9 . However, the minimum yield (162 kg/ tree) was recorded in control.

Fruit specific gravity: The maximum specific gravity (1.13) was recorded in T_6 (Calcium nitrate @ 500 gram/tree + Calcium chloride @ 2 gram/litre), which was found statistically at par with T_{10}. However, the minimum specific gravity (0.72) was recorded in control.

The improvement of fruit length, diameter, weight, volume, specific gravity and yield by the application of treatment calcium nitrate may be attributed to quick supply of nutrients for longer period to the growth and development of fruits. The higher chlorophyll content in (table 1) in the present studies may also associated with higher size, weight, volume, specific gravity and yield of fruits under calcium nitrate + calcium chloride. As data pretend foliar application of calcium chloride with soil application of calcium nitrate recorded the highest physical characteristics of fruits which in the present study the role of calcium chloride might be due to the influence in enlarging cell size and enhancing the strength of carbohydrate sink. And as it seems that application of potassium sulphate either alone or in combination with other treatments increase the fruit physical parameters as a compare to the control, which this positive effect of potassium application on fruit physical parameters might be due to the state of (Mostafa et al., 2000) who claimed that potassium speeds up flow of assimilates high rates of CO_2 assimilation, this transport is as important as the photosynthesis process itself. They added that potassium not only promotes the translocation of newly synthesized photosynthates, but also has a beneficial effect on the mobilization of stored materials high concentrations of potassium are necessary for optimum efficiency of energy transfer. Potassium activates enzymes, which involved in the energy transfer, the build-up of ATP (energy-rich bonds) needed for CO_2 assimilation and the synthesis of sugar, starch, and protein, (Mostafa et al., 2000). These results are in conformity with findings of (Sarrwy et al., 2012) in date palm cv. "Amhat" in litchi cv. "Rose Scented" reported the highest fruit size (i.e. length and diameter), fruit weight through application of calcium nitrate.

Fruit firmness: As result indicated in table 2 that the maximum fruit firmness (5.52 kg/cm^2) was recorded in T_4 (Calcium chloride @ 2 gram/litre). Which was statistically at par with treatments T_2, T_3, T_6, T_7, T_8 and T_{10}. While, the minimum firmness (4.61 kg/cm^2) was recorded in control. The present findings revealed that the calcium chloride either alone or in combination with other treatments provide quite effective in enhancing fruit firmness The beneficial effects of calcium applications on fruit firmness could be attributed to the physiological role of calcium, which plays a binding role in the complex polysaccharides and proteins forming the cell wall (Ajender, 2018). The fruit firmness has direct relation with calcium pectate as calcium interact with pectic polymers of cell wall and act as cementing agent which gives strength to the cell wall (Ganai, 2006). These results are in conformity with (Casero et al., 2004) who reported that foliar applications of calcium increased the firmness of apple fruits.

Fruit colour: The result of presented study in table 2 indicated that there was no significant effect of different sources of calcium and potassium fertilizers on fruit colour during the year of study. However, the maximum fruit colour (3%) recorded in both T_9 (Calcium chloride @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre), and T_{10} (Calcium chloride @ 2 gram/litre + Potassium sulphate @ 2.5 gram/litre). While, the minimum fruit colour (2%) was recorded in control. The role of potassium in increasing the fruit colour may be due to the function of potassium that as it plays an important role in metabolic and physiological process of plant, by affecting the enzymatic activities, which were probably enhanced on account of variation in K_2O content, were resulting in increased CO_2 as-simulation and subsequent increase in carbohydrate and anthocyanin synthesis (Banday, 2015). While the effect of calcium on colour development is apparently in opposite to its general role in preservation of cellular organization is not well understood. Colour development may be an attendant physiological manifestation of this relationship. An indirect involvement of calcium in colour development has been shown by Ganai (2006) with McIntosh apple. These results are in conformity with findings of (Solhjoo et al., 2017) who observed an improvement of apple fruit colour by application of different concentration of calcium chloride and potassium sulphate.

Table 2: Effects of calcium and potassium application on physical characteristics of apple cv. Red Delicious

Treatments combination		Fruit length (mm)	Fruit diameter (mm)	Fruit volume (cm^3)	Fruit Weight (g)	Yield (kg/tree)	Specific gravity (g/cm^3)	Fruit Firmness kg/cm^2	Fruit colour (%)
T_1	Control	67.82	66.98	160.97	171.3	162.00	0.72	4.61	2
T_2	Calcium nitrate @ 500 gram/tree	69.96	69.81	178.53	175.5	178.00	0.88	5.20	2.3
T_3	Calcium Chloride @ 500 gram/tree	70.86	70.18	184.12	180.7	178.00	0.90	5.00	2.6
T_4	Calcium Chloride @ 2 gram/litre	71.29	70.23	186.49	186.5	179.00	0.93	5.52	2.6
T_5	Potassium sulphate @ 2.5 gram/litre	70.70	70.67	184.57	184.4	180.33	0.92	4.94	2.9
T_6	Calcium nitrate @ 500 gram/tree + Calcium Chloride @ 2 gram/litre	72.10	70.81	192.33	190.8	190.00	1.13	5.20	2.7
T_7	Calcium nitrate @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre	70.10	69.91	179.50	179.9	170.33	0.88	5.03	2.7
T_8	Calcium Chloride @ 500 gram/tree + Calcium Chloride @ 2 gram/litre	69.29	68.91	172.87	177.3	180.66	0.86	5.50	2.6
T_9	Calcium Chloride @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre	71.89	70.12	189.35	181.8	184.50	0.97	5.00	3
T_{10}	Calcium Chloride @ 2 gram/litre + Potassium sulphate @ 2.5 gram/litre	71.86	70.34	189.79	184.4	185.50	1.01	5.20	3
C.D $_{0.05\%}$		**2.12**	**2.09**	**8.25**	**5.6**	**7.64**	**0.15**	**0.50**	**N/S**

CHEMICAL PARAMETERS:

TSS: The perusal of data presented in table 3 revealed that all the treatments exhibited positive effect on apple quality and particularly there was an increase in total soluble solids content of apple with the application of calcium nitrate and potassium sulphate either alone or with their combinations. The maximum total soluble solids (13.75 ^{o}Brix) was observed in T_7 (Calcium nitrate @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre) which was found statistically at par with T_1,T_2,T_3,T_5,T_6,T_9 and T_{10}. However, the minimum total soluble solid (11.10 ^{o}Brix) was recorded in T_8 (Calcium chloride @ 500 gram/tree + Calcium chloride @ 2 gram/litre). The possible reason of increase in TSS and TSS acid ratio is adequate scope of nutrients to the plant, which hydrolyzed starch into sugar and helpful to increase the TSS and TSS acid ratio of fruit (Prasad et al., 2015). A higher increase in TSS and TSS acid ratio content with foliar application of potassium is related with role of potassium in translocation of sugar from leaves to fruits (Prasad et al., 2015). Which results better quality fruits in term of total soluble solid. These findings are in conformity with Kauchy et al. (2018) who reported the maximum TSS in apple fruit through application of calcium nitrate. Kaith et al. (2010) in "Starking Delicious" apple reported the same result through application of potassium shulphate.

Fruit Acidiy: The present data in table 3 indicated that the titratable acidity of apple fruit was significantly affected with the application of calcium nitrate and potassium sulphate either alone or with their combination. The lowest titratable acidity (0.20 %) content was recorded in T_7 (Calcium nitrate @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre). While the maximum titratable acidity (0.30 %) was recorded in T_8 (Calcium chloride @ 500 gram/tree + Calcium chloride @ 2 gram/litre).

TSS/acid ratio: As data indicate in table 3 that the highest TSS acid ratio (68.57) was recorded in T_7 (Calcium nitrate @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre). Which was found statistically at par with T_1 (control) and T_5. While the lowest TSS acid ratio (36.7) was recorded under T_8 (Calcium chloride @ 500 gram/tree + Calcium chloride @ 2 gram/litre). The decrease in the acidity might be due to reduction in the activities of enzyme by foliar application of these nutrients. Calcium nitrate being the source of nitrogen might have modified the vegetative growth, which in turn increase sugar metabolism and consequently decrease the acidity due to conversion of acid into sugar which resulted decrease in the acidity of fruits. The reduction in the acidity under potassium treatment might be due to conversion of organic acids into sugar and direct effect of potassium on enzymatic activity of cells and thus resulted in decreasing acid levels in the fruit (Banday, 2015). Further higher levels of calcium showed an increase in acidity of fruits, reason being increased level of calcium in fruits which can retard ripening and senescence process resulting in slower hydrolysis of polysaccharides into monosaccharide and ultimately no further increase in sugar content of fruit thus increased Titratable acidity (Prasad et al., 2015). Titratable acidity is directly related to the concentration of organic acids present in the fruit. These results are in agreement with the findings of Parsad et al. (2015) who reported the lowest acidity in pear through application of calcium nitrate under control.

Fruit Ascorbic acid: Maximum ascorbic acid (2.25 mg/100g) content was recorded in T_4 (Calcium chloride @ 2 gram/litre). Which was found statistically at par with T_3, T_6, T_8, T_9 and T_{10}. However, the minimum ascorbic acid (1.43 mg/100g) was recorded in control. The increase in ascorbic acid content might be speculated due to increased activity of enzymes responsible for the synthesis of the ascorbic acid precursor and also the reduction in the rate of respiration by these chemicals. Bhat et al. (2009) reported the maximum ascorbic acid content with foliar application of calcium chloride and minimum under control in cherry cv. "Makhmali", and urged that the increases in ascorbic acid content might be attributed to higher synthesis of some metabolites and intermediate substances which promoted the synthesis of precursor of ascorbic acid and resulted the improvement in ascorbic acid content. These results are in line with the findings of (Karim et al., 2012) in "Anna" apple and Prasad et al. (2015) in Pear cv. "Pathernakh" who reported the maximum ascorbic acid through a pre-harvest application of calcium chloride.

Total Sugar: The maximum total sugars (8.96 mg/100g) was recorded in treatment T_7 (Calcium nitrate @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre). Which was statically at par with T_9. while the minimum total sugar (7.81 mg/100g) was recorded under T_8 (Calcium chloride @ 500 gram/tree + Calcium chloride @ 2 gram/litre) respectively.

Reducing sugar: The maximum reducing sugars (6.55 mg/100g) was recorded in treatment T_7 (Calcium nitrate @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre). Which was statically at par with T_5, T_9 and T_{10}. While the minimum reducing sugar (5.64 mg/100g) was recorded in T_8 (Calcium chloride @ 500 gram/tree + Calcium chloride @ 2 gram/litre) which followed by T_3 and T_4 respectively. The effect of these nutrients on increase in total sugar contents could be attributed to the balance in nutrition status of the tree which advanced fruit maturity and ripening. The possible reason for increase in total sugar content may be due to hydrolysis of starch yielding mono and disaccharide, which owned a simplest form of sugar, and it could be one of the important reasons for the increase in total sugar content of fruits. Further higher levels of calcium do not showed improvement in total sugar, reason being increased level of calcium in fruits which can retard ripening and senescence process resulting in slower hydrolysis of polysaccharides into monosaccharide and ultimately no further increase in sugar content of fruit (Prasad et al., 2015). This results are also in conformity with the finding Prasad et al. (2015).

Table 3: Effects of calcium and potassium application on chemical characteristics of apple cv. Red Delicious

Treatments combination		Fruit TSS (^{o}Brix)	Acidity (%)	TSS/ acid ratio	Ascorbic acid (mg/100g)	Total sugar mg/100g	Reducing sugar mg/100g
T_1	Control	13.40	0.21	64.00	1.43	8.41	6.19
T_2	Calcium nitrate @ 500 gram/tree	13.00	0.22	59.56	1.57	8.06	6.19
T_3	Calcium Chloride @ 500 gram/tree	12.60	0.27	44.76	2.20	7.87	5.90
T_4	Calcium Chloride @ 2 gram/litre	12.23	0.23	54.17	2.25	8.81	5.93
T_5	Potassium sulphate @ 2.5 gram/litre	13.60	0.21	63.85	1.60	8.17	6.45
T_6	Calcium nitrate @ 500 gram/tree + Calcium Chloride @ 2 gram/litre	12.60	0.23	54.30	1.80	8.06	6.16
T_7	Calcium nitrate @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre	13.75	0.20	68.57	1.60	8.96	6.55
T_8	Calcium Chloride @ 500 gram/tree + Calcium Chloride @ 2 gram/litre	11.03	0.30	36.77	2.00	7.81	5.64
T_9	Calcium Chloride @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre	13.00	0.22	60.49	2.20	8.72	6.39
T_{10}	Calcium Chloride @ 2 gram/litre + Potassium sulphate @ 2.5 gram/litre	13.00	0.23	56.26	1.91	8.16	6.21
C.D $_{0.05\%}$		**1.18**	**0.01**	**7.12**	**0.55**	**0.26**	**0.34**

Physiological loss in weight: The data is presented in table 4 showed the effect of different concentration of calcium and potassium fertilizers on the physiological loss in weight of the apple fruit. Calcium chloride was found instrumental in depressing physiological loss in weight. The minimum loss in weight (2.3 %) was recorded in T_8 (Calcium chloride @ 500 gram/tree + Calcium chloride @ 2 gram/litre). While maximum weight in loss (5.3 %) was recorded under control after 30 days of storage.). This decrease in weight loss by application of calcium chloride might be due to its role in the maintenance of the fruit firmness, decrease in respiration rate and delayed senescence (Yadav & Shukla, 2009). These observations are supported by the finding of Rabiei et al. (2011) who stated that calcium treatments influenced peroxidase and catalase enzyme in the apple fruits which delayed breakdown of cells and hence maintained the higher firmness and reduced weight loss percentage during storage. Farag and Nagy (2012) also reported that the improvement of reduction in physiological weight loss during storage with application of calcium formulation might be attributed to their influence on maintaining the integrity of the plasma membrane These findings are in conformity with Tabatabaie, (1998) in "Red Delicious" which reported the minimum physiological loss in weight through calcium chloride application.

Table 4: Effects of calcium and potassium on physiological losses of apple cv. Red Delicious

Treatment Combinations		Physiological loss in Weight (%)			Mean A
		10 days	20 days	30 days	
T_1	Control	5.2	4.9	5.9	5.3
T_2	Calcium nitrate @ 500 gram/tree	3.0	3	2.9	3
T_3	Calcium Chloride @ 500 gram/tree	2.0	3	3.1	2.7
T_4	Calcium Chloride @ 2 gram/litre	2.8	2.3	2.9	2.7
T_5	Potassium sulphate @ 2.5 gram/litre	3.9	4	4.1	4.0
T_6	Calcium nitrate @ 500 gram/tree + Calcium Chloride @ 2 gram/litre	2.5	2.9	2.3	2.6
T_7	Calcium nitrate @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre	3.5	4.1	4.0	3.9
T_8	Calcium Chloride @ 500 gram/tree + Calcium Chloride @ 2 gram/litre	2.2	3.0	1.6	2.3
T_9	Calcium Chloride @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre	3.7	3.5	3	3.4
T_{10}	Calcium Chloride @ 2 gram/litre + Potassium sulphate @ 2.5 gram/litre	3.7	2.9	3.6	3.4
Mean B		3.3	3.3	3.3	
$LSD_{0.05\%}$		Treatments	0.95		
		Days	N/A		
		Treatment X Days	1.65		

CONCLUSION

The overall result can be concluded that fruit of Apple cv. Red Delicious treated with calcium nitrate (Calcium nitrate @ 500 gram/tree + Potassium sulphate @ 2.5 gram/litre, Calcium nitrate @ 500 gram/tree + Calcium chloride @ 2 gram/litre and Calcium nitrate @ 500 gram/tree + Calcium chloride @ 2 gram/litre) indicated maximum vegetative growth and chlorophyll content of leaf, fruit physical parameters, TSS, TSS acid ratio, total sugar, reducing sugars and lowest acidity. However, the highest ascorbic acid and lowest physiological loss in weight recorded by calcium (Calcium chloride @ 500 gram/tree + Calcium chloride @ 2 gram/litre) treatments.

Acknowledgements

The author would like to thank and acknowledge with gratitude from his respected family for providing my education opportunity and also extend his gratitude for the faculty of Agricultural Science and Technology of RIMT University (Punjab) for providing the necessary and laboratory facilities to carry out the research work.

REFERENCES

Ajender (2018). Effect of calcium, boron and zinc on growth, fruit quality and production of apple, Thesis, Dr.Yashwant Singh Parmar University of Horticulture and Forestry Solan (NAUNI) HP, Inida.

Ajender, Thakur, B. S., & Chawla, W. (2019). Effect of calcium chloride on growth, fruit quality and production of apple, *Journal of Pharmacognosy and Phytochemistry*. *SP1*, 588-593.

Anonymous (2019). Area and production statement for the year 2019. Department of Horticulture, Jammu and Kashmir Government.

Anonymous (2019). *Area and production statement of apple in the world for the year 2019.* Foreign Agricultural Service/USDA.

Banday, S. A. (2015). Effect of soil and foliar application of nitrogen and potassium on the yield, quality and nutrient status of apple cv. Red Delicious. Thesis, Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar, India.

Bhat, M. Y., Hafiza, A., Banday, F. A., Dar, M. A., Wani, A. I., Hassan, G. I., & Khajwall, M. H. (2009). Effect of harvest dates, pre harvest calcium sprays and storage period on physico-chemical characteristics of pear cv. Bartlett. *Appl. Biol. Sci. Res 11*(1), 31-35.

Casero, T., Benavides, A., Puy, J., & Recosens, I. (2004). Relationships between leaf and fruit nutrients and fruit quality attribute in "golden smoothie" apples using multivariate regression techniques. *J Plant Nutr 27*(2), 313- 324.

Conway, W. S., Sam, C. E., & Hickey, K. D. (2002). Pre-harvest calcium treatment of apple fruit and its effect on quality. *Acta Horticulture 594*, 413-419.

Farag, K. M., & Nagy, N. M. N. (2012). Effect of Pre- and Post-Harvest Calcium and Magnesium Compounds and Their Combination Treatments on "Anna" Apple Fruit Quality and Shelf Life. *Journal of Horticultural Science & Ornamental Plants (IJHSOP) 4*(2), 155-168.

Fediala, W., Mosa, A. E. J., Abd, N. A., Megeed, E. L., & Paszt, L. S. (2015). Effect of the Foliar Application of Potassium, Calcium, Boron and Humic Acid on Vegetative Growth, Fruit Set, Leaf Mineral, Yield and Fruit Quality of "Anna" Apple Tree. *Am. J. Exp. Agric 8*(4), 224-234.

Ganai, N. A. (2006). *Effect of pre-harvest calcium and boron application on the quality and yield of apple (Malus x domestica Borkh) cv. Red Delicious under temperate condition of Kashmir.* Ph.D. Thesis sher-e Kashmir University of Agricultural Science and Technology of Kashmir, Jammu and Kashmir, India.

Jeet, A. (2016). *Effect of nitrogen sources on growth, yield and nutritional status of apple (Malus* x *domestica* Borkh.) *cv. Oregon spur.* M.Sc. Thesis Dr. Yashwant Singh Parmar university of Horticulture and Forestry, Solan (Nauni) HP, India.

Kaith, N. S., Mehta, D. K., & Sharma, U. (2010). Effect of different level of potassium on growth, yield and fruit quality of apple (*Malus x domestica* Borkh). *Journal of Hill Agriculture 1*(2), 160-163.

Karim, F. M., Neven, F. M. N. (2012). Effect of pre and post-harvest calcium and magnesium compounds and their combination treatments on Anna apple fruit quality and shelf life. *Journal of Horticultural Science & Ornamental Plants (IJHSOP) 4*(2), 155-168.

Khalifa, R. K. M., Hafez, O. M., & Abd-El – Khair, H. (2009). Influence of foliar spraying with boron and calcium on productivity, fruit quality, nutritional status and controlling of blossom end rot disease of Anna Apple tree. *World J. Agric. Res 5*(2), 237-249.

Kuchay, M. A., Mallikarjuna, K., & Ali, M. T. (2018). Effect of Foliar Sprays of Nitrogen and Calcium on Fruit Quality Attributes, Yield and Leaf Nutrient Content of Apple, *Int. J. Pure App. Biosci 6*(6), 970-977.

Kumar, J., & Chandel, J. S. (2006). Effect of different levels of N, P and K on growth and yield of pear cv. Red Bartlett. *Progressive Horticulture 36*, 202-206.

Mostafa, M. F., El-Boray, M. S., Iraqi, M. A., & EL-Bary, A. A. (2000). Effect of potassium and boron application on yield, fruit quality and leaf mineral content of Anna apple trees. *J. Agric. Sci. Mansoura Univ. 24*(9), 4965 – 4977.

Prasad, B., Dimri, D. C., & Bora, L. (2015). Effect of pre-harvest foliar spray of calcium and potassium on fruit quality of Pear cv. "Pathernakh". *Academicjournals 10*(11), 392-396.

Rabiei, V., Shirzadeh, E., Sharafi, Y., & Mortazavi, N. (2011). Effects of postharvest applications of calcium nitrate and acetate on quality and shelf-life improvement of "Jonagold" apple fruit. *J. Med. Plants Res 5*(19), 4912-4917.

Ranganna, S. (1986). *Manual of analysis of fruits and vegetable products*. Tata McGraw Hill Publishing Co. Ltd., New Delhi, pp. 524

Sarrwy, S. M. A., Gadalla, E, G., & Mostafa, E. A. M. (2012). Effect of calcium nitrate and boric acid spray on fruit set, yield and fruit quality of cv. "Amhat" date palm. *World J. Agric. Res 8*(5), 506-515.

Simnani, S. A. (2012). Management of apple orchards by plant bio-regulators and nutrient sprays for improvement in growth, yield and quality of apple *(Malus X domestica* Borkh*) cv. Red Delicious.* Ph.D. Thesis S.K. University of Agricultural Sciences and Technology of Kashmir, Srinagar, India.

Solhjoo, S., Gharaghani, A., & Fallahi, E. (2017). Calcium and Potassium Foliar Sprays on fruit skin color, quality attributes and mineral nutrient concentration of apple cv. Red delicious. *Int. J. Fruit Sci 17*(4).

Tabatabaie, S. J., & Malakouti, M. J. (1988). The effect of calcium on fruit firmness and quality in Red Delicious Apple. *J Soil Water Conserv 12*(1), 43-49, 70-72.

Wojcik, P. (2005). Effect of foliar potassium on apple tree yielding, and fruit quality under conditions of low soil potassium availability. *Proceedings of the International Scientific Conference: Environmentally friendly fruit growing*, pp 44-50 Polli Estonia.

Yadav, S., & Shukla H. S. (2009). Effect of various concentration of plant growth regulators and mineral nutrients on quality parameters and shelf-life of aonla (*Emblica officinalis* G.) fruit. *India. J Agric Biochem 22*(1), 51-56.