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# Effect of Foliar Sprays of Nitrogen and Calcium on Fruit Quality Attributes, Yield and Leaf Nutrient Content of Apple

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## ABSTRACT

*The effect of foliar spray of nitrogen and calcium-containing fertilizers on several fruit quality attributes, yield and leaf nutrient content of Apple Cv. "Red Delicious" was investigated. Trees were planted at 5x6 meters in a private orchard at Shopian in Jammu and Kashmir, India. The experiment involved two foliage sprays, first spray was applied one month after petal fall and second was one and half months after petal fall. The treatments were comprised: control (sprayed with water), 0.5 % Urea, 0.5% Calcium nitrate and 0.5% Urea + 0.5% Calcium nitrate. Application of 0.5% N + 5% calcium significantly increased the fruit length (7.95 cm), fruit diameter (7.93 cm), fruit weight (214.42 g), fruit acidity (0.90%) and yield (127.96 Kg tree/tree). The maximum TSS (13.48 $^{o}$Brix) and total sugars (9.88 %) were obtained in fruits when treated with 0.5% Urea followed by 0.5% Urea + 0.5% Calcium nitrate. Calcium nitrate 0.5% significantly increased fruit firmness (8.64 Kg/ cm$^2$) and total phenol (162.02 mg GAE/100 g FW). Foliar spray of nitrogen in combination with calcium significantly increased the Ca content in apples and also increased N, K and Ca in the leaves as compared to the control. It could be concluded that application of two sprays of urea and calcium nitrate at an interval of 40 days during the early fruit development stages of apple.*

***Key words:*** *Red Delicious apple, Urea, Calcium nitrate, Quality, Yield*

## INTRODUCTION

Apples are the most popular delicious fruit in temperate climatic zone. In India it is mostly cultivated in Jammu and Kashmir, Himachal Pradesh, Uttarakand and some extent to North Eastern hills. The productivity of apple in Jammu and Kashmir is 10.7 tonnes/ha has highest than the other states in India[3]. In the last five years the effect of climatic changes has shown poor performance of some quality attributes of apple. Foliar nutrition is given as supplemental to overcome the adverse effect of limited nutrient supply through soil to the plants. The long dry spells occurs during May-June in Kashmir then sudden rainfall makes the fruit quality verse due to the deficiency of nutrients. Foliar nutrition is an alternative to rectify these problems and to maintain the quality, yield and nutrient status of leaves.

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Eating quality and colour are the key factors driving the choice of consumers for purchasing and consumption of fruits[18]. In spite of high calcium content present in orchard soil but due to soil and climatic factors, makes plants unable to take nutrient. Calcium nitrate and calcium chloride are commonly used fertilizers for foliar fertilization[8]. Adequate Ca content in apple tissue is necessary to obtain high quality fruit[12]. Calcium is an important element that plays a major role in fruit quality and storability. The low mobility of Ca in the plant poses serious problems to enhance the distribution of this element to the fruit via Ca application to the root system[4].Treatment of aerial plant parts with Ca sprays, is recommended and applied in many fruit production areas of the world, either as routine applications to prevent the occurrence of localised Ca deficiency in the fruit or to improve fruit quality[5].

Foliar spray of nitrogen can help to satisfy the tree nitrogen demand early in the season or to improve the reserve nitrogen status after harvest in the fall. Early foliar N spray is beneficial for fruit set and early fruit growth when leaf analysis shows less than 2.2 % leaf N the previous year[10]. Nitrogen is required for the initial growth of deciduous trees in the spring during cell division. Nitrogen is major element, required by all plants, adequate nitrogen is essential for tree growth, blossom formation, fruit set and size all of which combine to determine a crop yield[30].

The ability of plant leaves to absorb nutrients has resulted in foliar application of nutrients becoming an alternative method for supplying nutrients to plants[13]. Urea is one of the most common nitrogen (N) sources for foliar applications, as it is study the effect of foliar application of nitrogen and calcium on fruit quality, yield and leaf mineral content of apple trees. Urea is highly soluble, inexpensive, has a relatively low potential for injuring foliage, and is absorbed rapidly and efficiently by the leaves of most crop plants[31]. Urea is considered the most suitable form of N for foliar application because of its non polarity, rapid absorption, low phytotoxicity and high solubility[6,14]. The objective of this experiment was to study the effect of foliar application of nitrogen and calcium on fruit quality, yield and leaf mineral content of apple trees.

## MATERIAL AND METHODS

This experiment was carried out in 2017 on 20 years old apple trees Cv. Red Delicious on commercial orchard at Shopian in Jammu and Kashmir, India. The trees were planted 5 x 6 m apart grafted on apple seedling and receiving the common cultural practices. Foliar treatments were applied two times after petal fall at an interval of 40 days. The fertilizer products were used in this experiment are Urea (contain s 46% nitrogen) and Calcium nitrate (contains 15.5% nitrogen and 18% calcium). The trees were sprayed by adding Wetcit (2 ml/L) as a wetting agent with the following treatments.

$T_1$: Control (Sprayed with water)
$T_2$: N @ 0.5% as Urea
$T_3$: Calcium @ 0.5% as Calcium Nitrate
$T_4$: Combination of both $T_2$ and $T_1$

The Physicochemical analysis of experiment soil was indicated in (Table 1.) It was carried out before the start of experiment. The soil samples were air dried, crushed to pass a through 2-mm screen and analysed for pH at a 1:1 soil to water ratio, electrical conductivity in a 1:5 soil to water extract, organic matter content, available N, available K and available Ca.

**Table 1. Physical and chemical properties of experiment soil**

| Depth (cm) | Texture | pH | EC (dS/m) | O.M (%) | Kg/ha | | | Meq/100g soil | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | N | P | K | Ca | Mg |
| 0-30 | Sandy loam | 5.8 | 0.46 | 1.49 | 302.32 | 15.52 | 345.22 | 1.3 | 1.2 |

The effect of applied treatments was studied by evaluating their influence on the following parameters.

The entire fruit which reached to its maturity was harvested by hand picking from each tree, weighed by an ordinary balance and yield was recorded in (Kg/tree). Fruit length and diameter of ten fruits per tree were measured with the help of a digital vernier calliper and average fruit length was expressed in centimetres (cm). Fruits from individual replications were weighed individually on a sensitive balance and the average fruit weight was recorded in grams (g). Fruit firmness was measured by using a digital penetrometer Model: 53205. Total soluble solids analysis was performed with a refractometer and total sugars content of fruits were estimated using A.O.A.C.[1], methods. Total phenols were estimated by extracting the fruit samples in 80 % ethanol. The colour was developed with Folin Caocatu reagent and the absorbance of the developed colour was recorded with a UV-570455 spectrophotometer at 650 nm wavelength.

Sample of apple were dried in an oven at 70 $^{o}$C for 24 hrs. After that 0.3 gram of dried sample were weighing in digestion flasks and treated with 18 ml distilled water, 100 sulphuric acid and 6 gram of sulphuric acid. After 12 hrs the flasks were heated for 2hrs on eclectic at 200 $^{o}$C and temperature increased to 400 $^{o}$C and hydrogen peroxide (25-30%) was added to sample to complete the digestion. Add 10 ml of distilled water and samples were agitated until a clean solution was obtained. After cooling, the solution was filtered with Whatman No. 42 filter, transferred to a volumetric flask and diluted to final volume of 50 ml with distilled water. Calcium was estimated in atomic absorption spectrophotometer using the flame method with air and acetylene. Sadzawka *et al.*[26].

To estimate the nutritional status of the trees the leaves samples were collected at the end of July or the beginning of August. Samples of 10 mid-shoot leaves from current season's extension growth on shoots of representative vigour, in the periphery area around the each tree were collected. Plant material was dried at 65$^{o}$C for 72 hrs and ground in a mill to pass a 30 mesh screen and digested in the mixture of $HNO_3$ and $H_2SO_4$ (9:4). The contents of K were measured by Flame photometer. Total nitrogen content in leaves was determined by Kjeldahl's method as described by Jackson[19].

The experimental field was designed to Randomized Block Design (RBD) with three replicates and each replication consists of four treatments. 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 %.

## RESULTS AND DISCUSSION

### Fruit physical characteristics

Effect of different foliar fertilization of urea and calcium nitrate either alone or in combination on fruit length and diameter are shown in (Table 2.). It was concluded that all the treatments increased significantly fruit length and diameter as compared to control. The highest fruit length (7.95 cm) and fruit diameter (7.93 cm) was obtained by spraying 5% Urea + 0.5% Calcium nitrate followed by 0.5% Urea was recorded (7.82 cm and 7.65cm) as compared to control (7.29 cm and 6.95 cm). All the treatments increased significantly fruit weight as compared to control. The highest fruit weight (214.42 g) was recorded by spraying 0.5% Urea + 0.5% Calcium nitrate followed by 0.5% Calcium nitrate (192.12 g), 5% Urea (189.02 g) as compared to control (183.32 g). Etehadnejad and Aboutalebi[15] observed greatest fruit length and fruit diameter in foliar application of 5g$L^{-1}$ urea. The present results are conformity with the[20,21]. they reported that different level of $CaCl_2$ of level (2.5) g $L^{-1}$ and $CaCl_2$ of level (5) g $L^{-1}$ showed the significant effect on fruit weight. These are highly correlated with dry matter content.

### Fruit Chemical characteristics

Application of 0.5% Urea with 0.5% Calcium nitrate increased significantly fruit acidity

(0.90%) followed by 5% Calcium nitrate) as compared to control (0.64%). As regard to TSS and total sugars, the maximum TSS (13.48 $^{o}$Brix) and total sugars (9.88%) was significantly increased by application of 0.5% Urea followed by 0.5% Urea + 0.5% Calcium nitrate (13.08 $^{o}$Brix) and (9.47 %) and minimum was found by application of 5% Calcium nitrate (11.88 $^{o}$Brix), (8.91%). The present results are in conformity with the findings of[11,27]. who reported that application of calcium delayed the increase in free sugars of fruits, which were steadily increased in storage. As the fruit proceeds to ripening process, the degradation of polysaccharides to simple sugars occurs that might increase TSS content of the fruits

**Table 2. Effect of foliar spray of urea and calcium nitrate on physico-chemical properties of apple Cv. Red Delicious**

| Treatments | Fruit length (cm) | Fruit breadth ( cm) | Fruit weight (g) | Acidity (%) | TSS ($^{0}$Brix) | Total sugars (%) |
|---|---|---|---|---|---|---|
| Control | 7.29 | 6.95 | 183.32 | 0.64 | 12.85 | 8.95 |
| Urea (0.5%) | 7.82 | 7.65 | 189.02 | 0.71 | 13.48 | 9.88 |
| Calcium nitrate (0.5%) | 7.32 | 7.46 | 192.12 | 0.73 | 11.88 | 8.91 |
| Urea (0.5%) + Calcium nitrate (0.5%) | 7.95 | 7.93 | 214.42 | 0.90 | 13.08 | 9.47 |
| C.D $_{0.05\%}$ | 0.02 | 0.01 | 12.57 | 0.07 | 0.07 | 0.02 |

**Fruit nutrient composition**

Fruit calcium content of apple cv. Red Delicious was significantly influenced by foliar fertilization of urea and calcium nitrate. The data presented in (Table 3.) revealed that highest fruit calcium (6.33 mg/100g) was noticed in fruits applied 0.5% Urea + 0.5% Calcium nitrate followed by 0.5% calcium nitrate as compared to control (4.38 mg/100g). The similar results were conformity with Fallahi and Eichert[16]. in apple. Foliar application of calcium in the form of 0.5% calcium nitrate significantly increased the calcium content in Red delicious apple fruits. Our results are in agreement with those recorded by[22,29]. Higher calcium levels in fruit are sometimes associated with increased fruit firmness at harvest[7].

**Fruit firmness**

Results depicted in (Table 3.), the spray of 0.5% calcium nitrate enhanced remarkably fruit firmness followed by 0.5% Urea + 0.5% calcium nitrate as compared to control. The same trend was obtained by other studies such as[32], they found that treatment with calcium effectively increased fruit firmness. Calcium serves as an intermolecular binding agent that stabilizes pectin-protein complexes of the middle lamella. Calcium also plays an important role in the cell membrane by inducing rigidity at the membrane surface of apple fruit tissue[17]. The fruit firmness decreased during cold storage. In fact, storage at low temperature, due to the decomposition of the middle membrane, results in cell separation and fruit firmness reduction[9].

**Table 3. Effect of foliar application of urea and calcium nitrate on fruit quality and yield of apple Cv. Red Delicious**

| Treatments | Fruit calcium (mg/100g) | Fruit firmness (Kg/cm$^{2}$) | Total phenol (mg GAE/100 g FW) | Yield (Kg/ tree) |
|---|---|---|---|---|
| Control | 4.38 | 6.67 | 150.88 | 118.36 |
| Urea (0.5%) | 4.96 | 7.64 | 145.92 | 123.26 |
| Calcium nitrate (0.5%) | 5.40 | 8.64 | 162.02 | 120.46 |
| Urea (0.5%) + Calcium nitrate (0.5%) | 6.33 | 8.53 | 159.60 | 127.96 |
| C.D $_{0.05\%}$ | 0.53 | 0.01 | 0.76 | 0.76 |

The application of calcium nitrate caused a significant increase in the amount of total phenol. Treatment of 0.5% calcium nitrate showed the highest phenol content (162.02 mg GAE/100 g FW) and lowest was observed with the application 0.5 % Urea (145.92 mg GAE/100 g FW). Similar results were agreement with Moradinezhad *et al*.[24], in Jujube fruit.

The increment in yield was also achieved by the combined application of urea and calcium nitrate. The maximum fruit yield (127.96 Kg/tree) was obtained from the treatment receiving 0.5% urea + 0.5% calcium nitrate showed significant difference with control (118.36 Kg/tree). The present results are in conformity with the findings of Shahin *et al*.[28], in apple and Meena *et al*.[23], in Nagpur Mandarin. The increment in the yield could be explained as a result of increasing fruit physical characteristics such as fruit length, fruit breadth and fruit weight. The increase in yield of apple fruits by application of macronutrient treatments may be due to the direct or indirect involvement of nutrients which provide better mobilization of nutrients, amino acids and metabolites for the growth and development of fruits by spurt in metabolic activities and catalytic cellular pathways. These activities favour the plant system to improve their size, weight and volume and thereby synergistically increased the total yield of apple.

**Table 4. Effect of foliar application of urea and calcium nitrate on leaf macronutrient content of apple trees Cv. Red Delicious**

| Treatments | N (%) | K (%) | Ca (%) |
|---|---|---|---|
| Control | 2.5 | 1.76 | 1.37 |
| Urea (0.5%) | 2.7 | 1.65 | 1.53 |
| Calcium nitrate (0.5%) | 2.7 | 1.45 | 1.60 |
| Urea (0.5%) + Calcium nitrate (0.5%) | 2.9 | 1.24 | 1.22 |
| C.D $_{0.05\%}$ | 0.87 | 0.21 | 0.24 |

**Leaf mineral composition**

Data presented in (Table 4.) obviously shows that some leaf macro-nutrients content (N, K and Ca) were responded better and resulted in a significant increase in their leaf contents as compared to the control. Concerning the leaf nitrogen content, data indicated that treated trees with 0.5% urea + 0.5% Calcium nitrate induced significantly the greatest values of leaf N content followed by 0.5% Urea. On the other hand, the lowest leaf N was detected with leaves produced from trees treated with tap water (control) which exhibited statistically the least value of leaf nitrogen content. With respect to leaf calcium content, the leaf calcium content was significantly higher in trees applied with 0.5% calcium nitrate followed by 0.5% Urea + 0.5% calcium nitrate treatments as compared to the control which exhibited statistically the least values of calcium content in leaves. Regarding the leaf potassium content, data showed that, responded significantly effect to all treatments under study as compared to control and Calcium nitrate, which showed the least significant values and the poorest leaves in their K content. The obtained results regarding the response of leaf mineral content to the different investigated treatments were in general agreement with that previously reported by Amiri *et al*.[2], in apple. Nitrogen is a constituent of essential cellular components such as amino acids, proteins and nucleic acids. It promotes photosynthesis because the N increases the amount of chlorophyll is the only substance capable of integrating the growth and metabolic activity at the cellular level, the role of N as an osmotic agent, which allows to retain the water in the vacuoles, has been considered as important to its nutritional function. Ca is a macronutrient that plays important biochemical functions and supports many metabolic processes, in addition to activating several enzyme systems, thus

contributing to the proper development of plants[25].

## CONCLUSIONS

The present investigation concluded that foliar applications of calcium and urea cause prominent effect on physicochemical characterises of apple fruits. The results of this study clearly showed that urea and calcium nitrate increased the concentration of nitrogen, potassium and calcium in the leaves and increased the fruit yield and fruit quality of apple. The foliar application of calcium nitrate increased fruit firmness by providing additional strength to the cell wall. It could be concluded that application of two sprays of urea and calcium nitrate at an interval of 40 days during the early fruit development stage.

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