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Effect of Calcium Nitrate and Calcium Carbonate on Plant Growth, Fruit Quality and Yield of Papaya Cv. Red Lady

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Abstract: A field experiment was performed to study the effects of foliar applications of $CaCO_3$ and $Ca(NO_3)_2$ on growth, quality, yield, and shelf life of papaya (Carica papaya) Cv. Red lady. Calcium (Ca) is one of the major plant nutrients which affects significantly the formation of the cell walls and cell membranes and also enables the production of biomass with proper plant growth and function. In the current experiment, papaya seedlings were well established in the orchard, well-irrigated with standardized nutrient solutions with all required inter-culture activities. Four different pre-harvest foliar application sprays were provided with two varying sources of Ca ($CaCO_3$ and $Ca(NO_3)_2$) at three concentrations of each with $CaCO_3$ (2%, 1%, 0.5%) $Ca(NO_3)_2$ (2%, 3%, 4%) at different stages of growth like flowering stage, fruit set stage, pre-harvest stage. The study revealed that foliar spray of above mentioned concentrations showed a profound improvement in vegetative growth of plants in terms of their height and diameter as compared to the plants in control treatment and also affected the fruit quality of papaya fruit.

Keywords: Foliar, Growth, Papaya, Quality, Yield.

1. INTRODUCTION

Papaya (Carica papaya L.) is a major fruit crop with many medicinal and nutritive properties (Kumar et al., 2021). It was introduced in India in 16th century from Malacca by Portuguese (Auxcilia et al., 2020). The total global production of papaya is estimated to be 6 million tonnes per year. With an annual output of 3 million tonnes, India is the world's largest papaya producer, accounting for nearly half of total papaya production.. In India, there are numerous varieties of papaya. In terms of popularity and cultivation, the red lady is India's most popular hybrid papaya variety., which has supplanted conventional varieties such as Coorg Honey Dew, Pusa Selections, and Coimbatore selections because of its gynodioecious nature, higher-production and red colored flesh characters (Kumar and Kaiding, 2016). As the global importance of fruit cultivation and consumption has increased, the market demand of papaya is also increasing day by day, but improper handling, post-harvest diseases and short storage life of papaya limit its marketability.

Plant nutritional status is one of the unavoidable elements influencing development, productivity, and quality of fruit trees in orchard. It is now well accepted that plants that are robust and vigorous are better equipped to tolerate biotic and abiotic stresses (Hosein-Beigiet et al., 2019). Studies have shown that certain applications of calcium can reduce the incidence of harmful microorganisms in fruits. It is also believed that the presence of calcium can contribute to the development of phenolic compounds. The increasing number of phenolic compounds in papaya is expected to make them a great food for humans. (Souza et. al, 2023). To manipulate plant productivity, a better understanding of the interactions between plants and the nutrition is required. Therefore, current research emphasized on the beneficial effects of calcium nitrate and calcium carbonate on yield and quality of papaya fruits. Also, plant growth, and economics of cv. red lady of papaya were evaluated.

2. MATERIALS AND METHODS

2.1 Experimental site and Plant materials

The experiment was conducted at the Horticulture farm of Lovely Professional University, Phagwara, Punjab (31.25º N, 75.70º E, 249 m elevation) during year 2021-22. Two month old transplanted plants were used for the experiment. The experiment was conducted in a randomized block design (RBD) with seven different treatments and three replications. All the cultural operations like weeding, irrigation, chemical sprays were uniformly conducted as per the plant requirements.

2.2 Treatments

Calcium nitrate (T_1 @2%, T_2 @1% and T_3 @0.5%) and Calcium carbonate (T_4 @2%, T_5 @3% and T_6 @4%) (T_7 control) was used as the source of calcium and foliar application was done to the plant, fruit and leaves (approximately 4 L per plant with Knapsack Sprayer) till the formulation started to drip from the plant canopy. Foliar sprays were applied four times during the crop growth cycle at 60, 90,120 and 150 days after planting.

2.3 Observations

The data were recorded on different growth characters like plant growth, stem girth and number of leaves (90,120 and 150 DAP). In yield attributes and quality parameter, the data was recorded at ripening stage. In all treatment, fruits in uniformity with respect to size and shape were harvested at the stage where the fruits were green with a yellowish tinge. Fruits were washed thoroughly with water and allowed to dry naturally before their further analysis.
In order to determine the physical properties of papaya fruits, random selection of three fruits from every treatment from each plant was done and fruit weight, fruit length and width were all measured to determine the yielding parameters of papaya.

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Statistical analysis

The analysis of the data obtained was done using SPSS v.21 software (SPSS Inc.) to arrive at homogenous subsets.

3. RESULT AND DISCUSSION

3.1 Growth parameters

Plant height

Application of calcium nitrate @ 2% resulted in maximum plant height, observed at 90, 120 and 150 days after planting (Table 2). Other treatments comprising calcium nitrate also significantly increased the height of papaya plants which may be due to the presence of nitrogen in Calcium nitrate which enhanced the growth attributes as nitrogen is said to be a key component in the plant structures made up of amino acids, serving as the building blocks of protein and needed in growth and development of plants (Leghari et al., 2016). Findings of (Madani et, al. 2015) has shown the Calcium treatments in tomato had significantly affected the height of plant.

Stem girth

Stem girth is regarded crucial indicators of papaya crop vitality. For a better yield, strong vegetative development is required. Foliar application of calcium nitrate @ 2% recorded maximum impact on stem girth at 90, 120 and 150 DAP followed by application of calcium nitrate @ 1% (Table 2). It might be due to the fact that all amino acids present in plant structures have nitrogen as their crucial component, and amino acids are responsible for the formation of plant proteins that are directly involved in the growth and developmental processes of cells, cell membrane and plant tissues (Hosseini et al., 2021). Where calcium is essential for proper cell division, cell elongation, and formation of the cell wall promoting tissue development and growth. It is crucial for the metabolism of starch, serves as a cofactor for numerous enzymes, and influences the photosynthetic process, DNA metabolism, and protein production, (Naser 2021).

Number of leaves and plant spread (N-S and E-W)

Different sources of calcium failed to make any significant effect on number of leaves as well as plant spread (Table 2). However, all the foliar treatments comprising of calcium were significantly superior to control. Superior performance of calcium included treatments against control might be because of the nitrogen present calcium nitrate which resulted into lush growth of papaya plants thus helping the plants to grow and develop their leaves, stems, and other vegetative components (Bloom, 2015).

3.2 Yielding parameters

Fruit weight

An increase in the foliar application of calcium solution resulted in elevated fruit weight with maximum fruit weight of 1439.4 g recorded under Calcium carbonate @ 3% (Table 1). This might be due to mobilization of minerals and photo-assimilates from other regions of the plant to growing fruits, as well as engagement in cell growth and division, which resulted in

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increased fruit weight in treated plants. Fruit set, cell division, and cell growth are all aided by auxin. Both of these developmental processes use calcium as a secondary messenger and impact calcium distribution patterns. Foliar calcium feeding resulted in enhanced fruit weight by maintaining a lower level of auxins in various areas of the fruit, which aided in fruit growth (Hocking et al., 2016; Zaman et al., 2019; Nagwaet al. 2017).

Fruit length and width (cm)

The data revealed that the increase in size (length and width) of fruit with maximum yield obtained when papaya plants were sprayed with calcium carbonate at 3% indicated in Table 1. It might be because of high calcium content in calcium carbonate. Calcium's role in cell growth, cell division, and greater amount of intercellular gaps in the mesocarpic cells may explain the larger size of fruits (Zaman et al., 2019; Badran, 2015).

3.3 Quality parameters

Total soluble solids (TSS)

Maximum TSS of 14.12 recorded under Calcium nitrate @ 2% (Table 1). Application of calcium nitrate and calcium carbonate both showed significant effect on TSS it might be due to greater chlorophyll levels in the leaves. Greater chlorophyll and nutrient levels in the leaves may have resulted in increased metabolite synthesis and translocation to the fruits, resulting in higher total soluble solids content in the fruits (Kumar et al., 2021; Shah and Sajid, 2017; Bisen et al,. 2014).

Titrable acidity

The finding of results shows that the minimum recorded acidity was found in treatment calcium nitrate @ 2% as shown in (Table 1). The conversion of acids into sugars and their use as a respiratory substrate throughout advance development and fruit growth appears to be the cause of the reduction in titrable acidity. Calcium composites lowered Titrable acidity by increasing sturdy mobs in cell walls. The creation of fractious connections between the carboxyl groups of polyuronide chains located in the middle lamella of the cell wall might explain this action (Young-Sik et al,. 2022; Zeraatgar et al,. 2018). The similar findings has been observed in tomato by (Mazumder et, al 2021).

Ascorbic acid

The data revealed that increase in foliar application of calcium sources resulted in high ascorbic acid content. Calcium compounds bind to membranes and strengthen their stability. This might be because calcium nitrate delayed the oxidation process, resulting in a slower rate of transformation of L-ascorbic acid to de-hydro ascorbic acid. The activities of oxidizing enzymes may be inhibited in fruits treated with 2% Calcium nitrate (Table 1), resulting in a greater ascorbic acid concentration preventing free radicals and responsive oxygen class from joining to membranes & contributing to health of biological membranes. Furthermore, calcium complexes increase the activity of Ascorbate peroxidase, which causes interruption in the fast oxidation of ascorbic acid which increases Vit.C content (Zeraatgar et al. 2018; Akladious and Mohamed ,2018).

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Total sugars

Different sources of calcium shows an average result on Total sugars (Table 1). However all the treatments shows a higher content of sugar compare to the control treatment. Which might be related to the quick conversion of starch to sugar, which is aided by calcium (Sinha et al. 2019)

3.4 Economics

Investigated data showed Treatment T_1 with calcium nitrate @2% yielded the highest benefit cost ratio of (3.37) Table 1, followed by treatments T_2 and T_3 with benefit cost ratios of 2.53 and 2.30, respectively. Treatment T_7 control had the lowest benefit-to-cost ratio of 1.10. This might be due to the higher yield obtained under this treatment.

4. CONCLUSION

In the case of nutrient deficiency, foliar treatment can play a significant role and be effectively used as a micronutrient. These elements will be quickly absorbed by the plants, and their levels in the leaves will increase significantly. In this research, results revealed that foliar spray of Ca source led to increase the vegetative growth and quality of papaya fruits. Moreover, Calcium nitrate at 2 % showed a promising result on quality parameters including TSS, Ascorbic content, total sugars. Hence, it can be concluded that application of calcium nitrate at 2 % in foliar form is beneficial for papaya crop.

Table 1. Effect of Calcium nitrate and Calcium carbonate on Yield and Quality parameters.

Treatments	Fruit weight (g)	Fruit length (cm)	Fruit width (cm)	TSS (%)	Titrable acidity (%)	B:C ratio	Ascorbic acid (mg/100 ml)	Total sugars	Reducing sugars	Non-reducing sugars
T_1	1241^d	19.96^c	18.83^c	14.13^a	0.018^g	3.37	24.13^a	6.97^a	4.77^a	2.18^a
T_2	1126^e	19.93^c	17.89^d	13.94^b	0.021^f	2.53	23.39^d	6.81^b	4.67^b	2.13^b
T_3	1056^f	19.27^d	16.89^e	13.37^c	0.026^e	2.3	22.88^c	6.47^c	4.61^c	1.86^{cd}
T_4	1266^c	21.97^b	18.97^c	12.29^e	0.033^b	1.58	20.33^f	6.19^f	4.31^f	1.87^{cd}
T_5	1439^a	23.60^a	20.79^a	12.83^d	0.028^d	1.69	21.69^d	6.39^d	4.54^d	1.83^d
T_6	1333^b	23.65^a	19.62^b	12.66^d	0.031^c	1.79	20.86^e	6.30^e	4.40^e	1.89^c
T_7	975^g	18.60^e	16.30^f	11.75^f	0.036^a	1.1	19.12^g	6.00^g	4.11^g	1.88^c

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Table 2. Effect of Calcium nitrate and Calcium carbonate on Growth parameters.

Treatments	**plant height(cm)**			**Stem girth (cm)**			**Number of Leaves**			**Plant Spread (N-S and E-W)**					
	90 DAP	120 DAP	150 DAP	90 DAP	120 DAP	150 DAP	90 DAP	120 DAP	150 DAP	90 DAP		120 DAP		150 DAP	
										(N-S and E-W)		(N-S and E-		(N-S and E-	
T1	94.97^{a}	117.57^{a}	135.23^{a}	22.19^{a}	32.31^{a}	38.97^{a}	25.96^{a}	35.02^{a}	45.67^{a}	117.83^{a}	113.13^{a}	144.43^{a}	139.03^{a}	191.66^{a}	186^{a}
T2	92.97^{b}	113.84^{b}	130.86^{b}	20.82^{b}	30.52^{ab}	38.33^{a}	23.97^{b}	32.61^{b}	43.11^{b}	116.06^{b}	111.83^{b}	142.03^{b}	135.3^{b}	188.4^{ab}	182.33^{b}
T3	91.69^{c}	110.06^{c}	126.58^{c}	20.55^{b}	28.61^{bc}	36.46^{b}	21.54^{c}	31.28^{c}	41.43^{c}	114.93^{b}	110.2^{c}	140.53^{b}	133.13^{c}	185.43^{bc}	179^{c}
T4	72.73^{f}	100.57^{f}	114.41^{f}	18.21^{d}	26.61^{cd}	34.93^{c}	19.62^{e}	28.06^{f}	38.27^{e}	107.36^{e}	103.43^{e}	135.53^{d}	128.23^{e}	166.83^{e}	160.86^{f}
T5	77.70^{e}	102.32^{e}	118.16^{e}	18.40^{d}	28.36^{bc}	35.12^{c}	20.68^{d}	29.00^{e}	39.99^{d}	109.86^{d}	104.16^{e}	135.6^{d}	129.86^{d}	176.43^{d}	169.83^{e}
T6	80.70^{d}	107.33^{d}	125.15^{d}	19.28^{c}	29.98^{b}	36.17^{b}	20.84^{d}	30.06^{d}	41.81^{c}	111.96^{c}	108.1^{d}	138.23^{c}	130.23^{d}	182.5^{c}	173.26^{d}
T7	70.54^{g}	95.97^{g}	101.98^{g}	17.63^{d}	24.87^{d}	30.22^{d}	17.44^{f}	2538^{g}	34.63^{f}	95.46^{f}	90.76^{f}	129.93^{e}	122.96^{f}	158.33^{f}	150^{g}

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