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Evaluating leaf nutrient dynamics in apple cv. Jeromine

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Abstract
The investigation titled “Evaluating leaf nutrient dynamics in apple cv. Jeromine” was carried out over the years 2018-19 and 2019-20 at the Fruit Research Farm, Department of Fruit Science, Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India. The study examined three-year-old Jeromine apple trees grafted onto M9 rootstock, ensuring uniform vigour and size among the selected trees. These trees were planted at four different densities: 5333 (2.5 m × 0.75 m), 4000 (2.5 m × 1.00 m), 3200 (2.5 m × 1.25 m) and 2666 (2.5 m × 1.50 m) trees per hectare. Utilizing a randomized block design with six replications, the research assessed how planting density influenced leaf nutrient content. The findings revealed that leaf nutrient levels were significantly affected by the different planting densities, with the 2666 trees/ha (2.5 m × 1.5 m) density yielding the highest nutrient content. This study highlights the critical role of planting density in nutrient uptake for apple trees, suggesting that lower planting densities enhance nutrient absorption. These insights can guide horticultural practices to optimize nutrient management in apple orchards within similar agro-climatic regions.

Keywords: Apple, leaf nutrient, vigour, zinc, planting density

Introduction

In our country, most apple orchards are traditionally planted on seedling rootstocks with wider spacing. Standard varieties are typically planted at 7.5 x 7.5 meters, resulting in a planting density of 178 trees per hectare, while spur-type varieties are planted at 5.0 x 5.0 meters, with a density of 400 trees per hectare. These orchards have an average productivity of approximately 6 to 8 MT/ha, which is significantly lower compared to advanced countries where productivity ranges from 40 to 50 MT/ha. This low productivity, coupled with the challenges of managing large canopies in low-density plantations, leads to poor light penetration and distribution, resulting in inferior fruit quality. High-density apple plantings have been prevalent in Europe since the 1960s, and now most apple orchards in Europe, New Zealand, Australia, and America use intensive production systems with semi-dwarfing and dwarfing rootstocks. The current scenario of land fragmentation, rapid urbanization, and industrialization is reducing the availability of land for apple cultivation. Constraints such as limited suitable land, high land and management costs, labour issues, and the need for early returns on investment, along with increasing demand for horticultural produce, have driven the adoption of high-density planting systems. In India, the concept of high-density planting is relatively new but shows great promise, particularly in valley areas and less sloping lands. This modern approach has the potential to significantly improve both the productivity and quality of apple fruits.

Experimental Details

Three-year-old trees of the 'Jeromine' apple cultivar, grafted onto M9 rootstock and exhibiting uniform vigour and size, were selected for this study. The experimental design was a randomized block layout with four training treatments, each replicated six times, and included two trees per replication. Throughout the study, the trees were maintained under drip irrigation and fertigation systems, supported by a permanent trellis structure, and subjected to consistent cultural practices to ensure optimal health. Annual pruning was performed each January to remove dead, diseased, and undesirable branches.

In the planting densities experiment, trees were planted at four different spacings: 2.5 m × 0.75 m, 2.5 m × 1.0 m, 2.5 m × 1.25 m and 2.5 m × 1.5 m, resulting in densities of 5333, 4000, 3200, and 2666 trees per hectare, respectively. Using the Tall Spindle training system, the trees were maintained under consistent cultural practices throughout the study. The experiment employed a randomized block design, incorporating four density treatments, each replicated six times.

Leaf nutrient analysis

Collection and preparation of leaf samples

In July, leaf samples were gathered from the experimental trees, specifically from the middle section of the current season's growth around the tree periphery. Following the protocol suggested by Chapman (1964) [3], the samples were first rinsed under tap water, then in 0.1 N HCl, followed by distilled water, and finally in double-distilled water. The leaves were then spread out on filter paper sheets to dry at the surface. Afterward, they were placed in paper bags and dried in a hot air oven at 65 ± 5 °C for 48 hours. Once dried, the samples were crushed, ground, and stored in butter paper bags for the subsequent estimation of various nutrient elements.

Digestion of leaf samples

For the estimation of nitrogen (N), one gram of leaf sample was digested in concentrated sulfuric acid using a digestion mixture consisting of potassium sulfate (400 parts), copper sulfate (20 parts), mercuric oxide (3 parts), and selenium powder (1 part), as recommended by Jackson (1967) [4]. For the determination of phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), zinc (Zn), iron (Fe), copper (Cu), and manganese (Mn), the leaf samples were digested in a di-acid mixture containing nitric acid (HNO_3) and perchloric acid ($HClO_4$) in a 4:1 ratio, as per Jackson (1967) [4].

Determination of nutrient elements

Total nitrogen content was determined using the micro-Kjeldahl method (AOAC, 1980) [1] and expressed as a percentage of dry weight. Total phosphorus was measured using the vanadomolybdate phosphoric yellow color method (Koenig and Johnson, 1942) [5]. Total potassium was quantified using a flame photometer. Both phosphorus and potassium results were expressed as a percentage of dry weight.

Estimation of Ca, Mg, Fe, Mn, Cu, and Zn

Calcium, magnesium, iron, manganese, copper, and zinc were measured using an Atomic Absorption Spectrophotometer (Analyst 400, Perkin Elmer, USA) following the method described by Bradfield and Spencer (1965) [2]. These nutrients were reported in parts per million (ppm) on a dry weight basis.

Leaf nitrogen

Data on the effect of planting densities on leaf nitrogen contents are presented in Table 1. The data indicates that planting densities showed significant effect on leaf nitrogen contents, which decreased with the increase in planting density. The maximum leaf nitrogen content (2.73 and 2.78%) was recorded in 2666 trees/ha (2.5 m × 1.50 m), which was statistically at par with 3200 trees/ha (2.5 m × 1.25 m) of planting density. The minimum nitrogen content (2.50%) was recorded in 5333 trees/ha (2.5 m x 0.75 m) of planting density during the year 2018-19 and 2019-20, respectively and minimum nitrogen content (2.50 and 2.45%) was recorded in 5333 (trees/ha 2.5 m × 0.75 m) of planting density, during the year 2018-19 and 2019-20, respectively

Leaf phosphorus

It is evident from the data depicted in Table 1. that planting densities significantly affect the phosphorus content under different planting densities in both the years. The maximum phosphorus content (0.27%) was recorded in 2666 trees/ha (2.5 m × 1.50 m) during the year 2018-19. This treatment was superior to all other planting densities. However, phosphorus content was minimum (0.21%) in 5333 trees/ha (2.5 m × 0.75 m). Similar trend was observed in 2019-20, the maximum phosphorus content (0.27%) was recorded in 2666 trees/ha (2.5 m × 1.50 m) of planting density, which was statistically at par with 3200 trees/ha (2.5 m × 1.25 m) of planting density and the minimum phosphorus content (0.21%) in 5333 trees/ha (2.5 m × 0.75 m) of planting density.

Leaf potassium

The data on effect of planting densities on potassium and calcium content is presented in Table 1. All the planting densities had a significant effect on potassium and calcium during both the years. Leaf potassium content was positive affected by planting densities of apple. The maximum leaf potassium content (1.71%) was recorded in 2666 trees/ha (2.5 m × 1.50 m), which was superior to all other planting densities and the minimum potassium content (1.47%) was recorded in 5333 trees/ha (2.5 m x 0.75 m) during the year 2018. Similarly, during the year 2019, the maximum leaf potassium content (1.77%) was recorded in 2666 trees/ha (2.5 m × 1.50 m) of planting density, which was statistically at par with 3200 trees/ha (2.5 × 1.25 m) and minimum potassium content (1.53%) was recorded in 5333 trees/ha (2.5 m x 0.75 m) of planting density.

Leaf calcium

Data on leaf calcium contents in trees planted under different spacing is presented in Table 1, which varied significantly during both the years of study. The maximum leaf calcium content (1.62 and 1.67% during 2018-19 and 2019-20, respectively) was recorded in 2666 trees/ha (2.5 m × 1.50 m) of planting density, which was statistically at par with 3200 trees/ha (2.5 m × 1.25 m) of planting density and 4000 trees/ha (2.5 m × 1.00 m) of planting density. The minimum leaf calcium content (1.49% and 1.57% during 2018-19 and 2019-20, respectively) was recorded in 5333 trees/ha (2.5 m × 0.75 m) of planting density.

Leaf magnesium

Data on the effect of planting densities on leaf magnesium contents are presented in Table 1. The perusal of data shows that planting densities exhibited significant effect on leaf magnesium contents during both the years, which decreased with the increase in planting density. Different planting densities exhibited positive influence on leaf magnesium content. The maximum leaf magnesium content (0.54 and 0.58% during 2018-19 and 2019-20, respectively) was recorded in 2666 trees/ha (2.5 m × 1.50 m), which was superior to all other planting densities. The minimum leaf magnesium content (0.43 and 0.47% during 2018-19 and 2019-20, respectively) was recorded in 5333 trees/ha (2.5 m × 0.75 m) of planting density.

Leaf zinc

Planting densities exhibited a significant effect on leaf zinc content during both the years. The data presented in Table 2, shows that the maximum leaf zinc content (39.11 and 40.33 ppm during 2018-19 and 2019-20, respectively) was recorded in 2666 trees/ha (2.5 m × 1.50 m) of planting density, which was statistically at par with 3200 trees/ha (2.5 m × 1.25 m) of planting density and minimum leaf zinc content (35.60 ppm and 37.53 ppm during 2018-19 and 2019-20, respectively) was recorded in 5333 trees/ha (2.5 m × 0.75 m) of planting density.

Leaf iron

Data related to leaf iron contents given in Table 2, indicates that planting densities exerted significant effect during both the years. The maximum leaf Fe contents (254 and 263 ppm during 2018-19 and 2019-20, respectively) was observed in planting density of 2666 trees/ha, which was closely followed in planting density of 3200 trees/ha and was found statistically at par with each other during both the year and 4000 trees/ha in 2018. The minimum leaf iron content (238 and 245 ppm during 2018-19 and 2019-20, respectively) was recorded in 5333 trees/ha (2.5 m × 0.75 m) of planting density.

Leaf manganese

The data presented in Table 2, reveals that leaf manganese content was significantly influenced by planting densities during both the years of study. During the year 2018, the maximum leaf manganese content (73 ppm) was recorded in 2666 trees/ha (2.5 m × 1.50 m) of planting density, which was statistically at par with 3200 trees/ha (2.5 m × 1.25 m) of planting density. The minimum leaf manganese content (63 ppm) was recorded in 5333 trees/ha (2.5 m × 0.75 m). Similarly, during the year 2019, the maximum leaf manganese content (76 ppm) was recorded in 2666 trees/ha (2.5 m × 1.50 m) of planting density, which was statistically at par with 3200 trees/ha (2.5 m × 1.25 m) of planting density and 4000 trees/ha (2.5 m × 1.00 m) of planting density. The minimum leaf manganese content (66 ppm) was recorded in 5333 trees/ha (2.5 m × 0.75 m) of planting density.

Leaf copper

The data on effect of planting densities on copper content is presented in Table 2. All the planting densities had a significant effect on copper content during both the years. The maximum leaf copper content (8.22 and 8.31 ppm during 2018-19 and 2019-20, respectively) was recorded in 2666 trees/ha (2.5 m × 1.50 m) of planting density, which was statistically at par with 3200 trees/ha (2.5 m × 1.25 m) of planting density. The minimum leaf copper content (7.26 and 7.37 ppm during 2018-19 and 2019-20, respectively) was recorded in 5333 trees/ha (2.5 m × 0.75 m) of planting density.

Discussion

Leaf nutrient contents were significantly influenced by planting densities. The highest levels of leaf nitrogen, phosphorus, potassium, and other micronutrients were observed at a planting density of 2666 trees per hectare (2.5 m × 1.50 m), followed by 3200 trees per hectare (2.5 m × 1.25 m). This is attributed to wider spacing, which reduces competition among trees for nutrients and water, promoting better growth and development under high-density planting conditions. Conversely, leaves from plants grown under shelter exhibited lower total nitrogen content compared to those from trees grown in the open. This difference can be explained by the photosynthetic system's need to maintain high enzymatic activity. Pramanick *et al*. (2012) [7] also found that lower planting densities resulted in significantly higher nutrient levels in high-density apple plantings. In contrast, closer densities led to reduced macro and micronutrient levels due to increased competition for resources. These results align with Kumar *et al*. (2013) [6], who studied apricots and found that wider spacing yielded the highest leaf nitrogen, phosphorus, and potassium content compared to closer spacing.

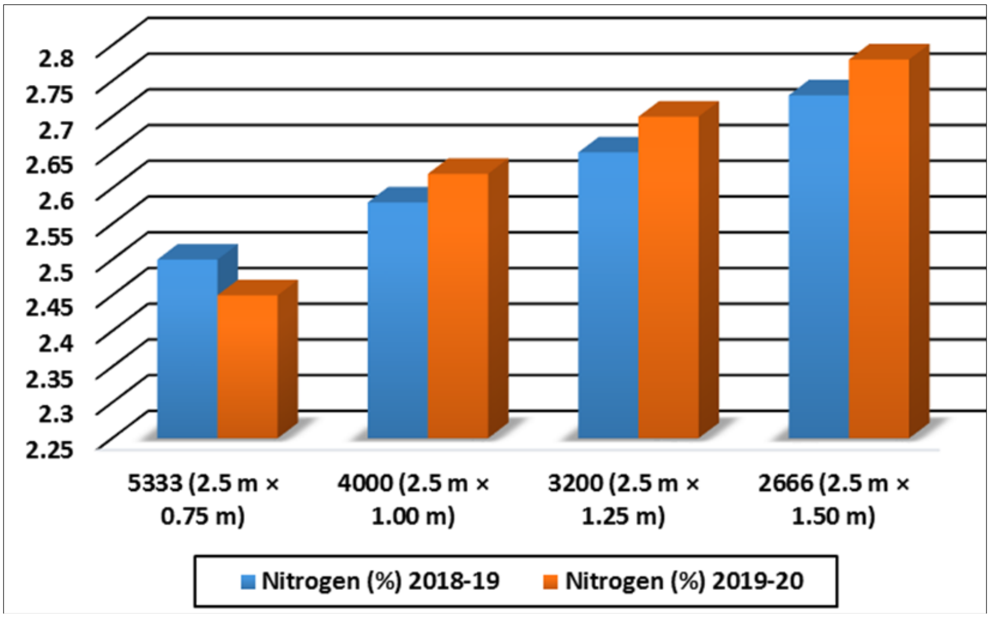

Fig 1: Nitrogen per cent in different planting densities of apple

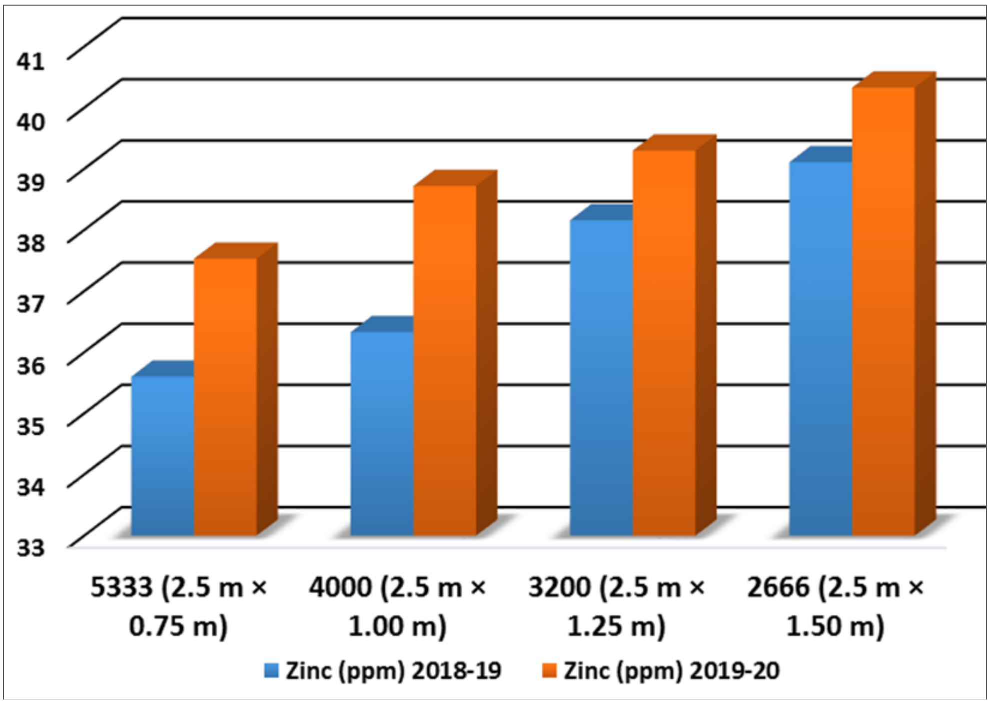

Fig 2: Zinc (ppm) in different planting densities of apple

Table 1: Evaluating leaf nutrient dynamics in apple cv. Jerome in the mid-hill Himalayas

	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Calcium (%)		Magnesium (%)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
5333 (2.5 m × 0.75 m)	2.50	2.45	0.21	0.24	1.47	1.53	1.49	1.57	0.43	0.47
4000 (2.5 m × 1.00 m)	2.58	2.62	0.23	0.26	1.55	1.60	1.57	1.62	0.46	0.52
3200 (2.5 m × 1.25 m)	2.65	2.70	0.24	0.27	1.63	1.75	1.59	1.63	0.49	0.54
2666 (2.5 m × 1.50 m)	2.73	2.78	0.27	0.29	1.71	1.77	1.62	1.67	0.54	0.58
$CD_{0.05}$	0.15	0.09	0.02	0.02	0.06	0.04	0.07	0.07	0.02	0.03

Table 2: Evaluating leaf nutrient dynamics in apple cv. Jerome in the mid-hill Himalayas

	Zinc (ppm)		Iron (ppm)		Manganese (ppm)		Copper (ppm)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
5333 (2.5 m × 0.75 m)	35.60	37.53	238	245	63	66	7.26	7.37
4000 (2.5 m × 1.00 m)	36.33	38.72	245	251	68	73	7.63	7.82
3200 (2.5 m × 1.25 m)	38.16	39.30	253	259	71	74	7.87	8.07
2666 (2.5 m × 1.50 m)	39.11	40.33	254	263	73	76	8.22	8.31
$CD_{0.05}$	1.32	1.51	9.61	8.30	4.9	4.1	0.43	0.37

Conclusion

From the present investigation, it is concluded that the apple trees of 2666 trees/ha (2.5 × 1.5 m) higher leaf nutrient content observed under mid-hills conditions of Himachal Pradesh.

Acknowledgements

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