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Foliar nutrient status of guava under ultra high density cultivation practices

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Abstract
Field studies were conducted to assess the leaf nutrient status of guava (*Psidium guajava*) established under an ultra-high-density planting system at 4444, 5000, 6666 and 10000 plants ha^{-1}. The trial was performed at the Horticultural Research Station, Assam Agricultural University, Guwahati, using a factorial randomized block design with two factors: four planting densities and three nutrient regimes. Leaf concentrations of nitrogen (N), phosphorus (P) and potassium (K) were only marginally affected by planting density, although a gradual decline in nutrient content was observed with increasing plant population. Plants at the lowest density (4444 plants ha^{-1}) showed the highest leaf nutrient concentrations: N = 1.48% and 1.58%, P = 0.23% and 0.25%, and K = 0.59% and 0.61% in the first and second years, respectively. Nutrient regime had a significant effect on leaf N, P and K regardless of planting density; concentrations increased with higher nutrient application. The maximum leaf nutrient concentrations-N (1.52% and 1.61%), P (0.26% and 0.28%), and K (0.62% and 0.63%)-were observed in plants receiving the N_3 nutrient treatment (70:45:35 g NPK plant^{-1} in the first year and 130:75:65 g NPK plant^{-1} in the second year).

Keywords: Leaf nutrient, guava, plant density, nutrient regime

Introduction

Guava (*Psidium guajava* L.) popularly known as the 'Apple of the Tropics' is one of the most referred and legendary fruit owing to its nutritious, deliciousness and pleasing flavour. It is an ideal fruit for the nutritional security and used for both, fresh consumption and processing (Singh *et al.*, 2007) [9]. Guava is a naturally vigorous plant, quite hardy and has been extensively cultivated owing to its wider edapho-climatic adaptability and ease in cultivation. The agro-climatic conditions of northeastern region of India are quite suitable for cultivation of guava, it has the potential to make useful contribution to commercial horticulture and can be a potential choice for diversification of fruit crops to enhance the income level of fruit growers in this region (Borah *et al.*, 2023) [2]. In India, guava is cultivated largely through traditional planting system, under which plants grow tall, develop large canopy architecture and take several years to reach full commercial bearing (Shalini *et al.*, 2010) [8]. The importance of guava as a commercial fruit crop has been well recognized and consequently, its growing popularity amongst growers and consumers has paved the way for improvements in existing production technology to enhance yield and profitability. One such innovative technology is the high density planting system which has been well appreciated in guava as there is great scope for enhancing productivity and income per unit area. Unlike other fruit trees, the guava plant has a unique bearing habit, it is highly amenable to pruning and responds well to different plant densities.

The plant density and nutrition have significant relevance in plant growth and development and imbalances between these two adversely affect the production and quality of fruit. With the increase in the number of plants per unit area in dense planting, the nutrient management becomes the primary concern and optimal supply of nutrients is essential for proper growth and development. Guava is a fast-growing fruit crop, deficiency of one or other nutrients at their critical stage of growth and development adversely affect the fruit yield and quality. Guava crop is very responsive to the application of inorganic fertilizers; fertilization of guava not only enhanced the yield but also improved the quality (Shankar, 1966; Singh and Singh, 1970) [9, 12].

In high density arrangements, it has been observed that the nutrient consumption is higher than in conventional plantings. However, the systematic studies on high density planting and its nutrient management are very meager in guava crop. In this background, the present experiment was undertaken to assess the leaf nutrient status of guava under the influence of high density planting system under subtropical conditions of north east India.

Materials and Methods

The present research work was carried out at the Experimental Farm of Horticultural Research Station, Assam Agricultural University, Kahikuchi, Guwahati, India which is situated between 26°6'26.8272" North latitude and 91°36'41.796" East longitude with an altitude of 57.4 m above mean sea level. The annual rainfall ranges from 1500 to 2600 mm with an average of 1752 mm, a major portion of which is received during April to September. In the summer, temperature varies from 19 °C to 35 °C, while the winter temperature ranges from 11 °C to 25 °C and the mean relative humidity varies from 64 percent to 85 percent. The soil of the experimental field is classified as sandy loam with pH-5.05, EC-0.13 ds/m and OC-0.53%. The experiment was conducted during the year 2017-2020 and laid out in Factorial Randomised Block Design (RBD) with 3 replications and two factors comprising four planting densities i.e. D_1 (4444 plants ha^{-1}), D_2 (5000 plants ha^{-1}), D_3 (6666 plants ha^{-1}), D_4 (10000 plants ha^{-1}) and three nutrient regimes viz., N_1 (50:25:15 g NPK plant^{-1} for first year and 110:55:45 g NPK plant^{-1} for second year), N_2 (60:35:25 g NPK plant^{-1} for first year and 120:65:55 g NPK plant^{-1} for second year) and N_3 (70:45:35 g NPK plant^{-1} for first year and 130:75:65 g NPK plant^{-1} for second year).

The experimental material consisted of six months old grafted guava plantlets cv. Lalit of uniform growth and vigour and planted in the first week of August 2017. The nutrients were applied in the form of Urea, Single Super Phosphate (SSP) and Muriate of Potash (MOP) respectively in two splits, first in March-April with the onset of pre-monsoon and second at September-October, before the withdrawal of monsoon for proper growth and development. The doses were applied as per the treatment combinations, in ring method at 20-30 cm away from the stem, 10-20 cm deep and then properly covered with soil. All the experimental plants were maintained under uniform cultural practices for the entire course of the investigation. The third pair of recently matured leaves were sampled for determining nutrient status in the plant sample of guava. A sample of twenty-five numbers of leaves was collected from the four directions of each observational plant at bloom stage. The collected leaf samples were decontaminated from dust and other foreign materials before laboratory analysis.

In relation to the leaf nutrient content, the results were analysed and interpreted following the statistical procedure for factorial RBD, and the summarized data has been presented via tables using the interpretations obtained from the statistical procedure (Gomez and Gomez, 1984; Snedecor and Cochran, 1968) [4, 14].

Results and Discussion

This study examined the foliar nutrient concentration in guava in terms of nitrogen, phosphorus, and potassium percentages, after being planted at different densities and fertilised at different rates. The results in relation to these were discussed in detail below and the findings are presented in tables.

Nitrogen content

The data registered on the effect of plant density, nutrient regime and their interaction on leaf nitrogen content (%) was presented in Table 1. A review of the data in Table 1 revealed that there was non-significant difference among different planting densities in respect of nitrogen content of leaves during both the years. The highest nitrogen content was recorded in leaves taken from plants under the lowest density D_1 (1.41% and 1.55%) and the lowest was observed in the highest density D_4 (1.31% and 1.49%) respectively during the winter and rainy season of 2018-19. A similar trend was noticed in both the seasons of 2019-20 also, where nitrogen content was found maximum in D_1 (1.50% and 1.65%) against the minimum value of 1.41% and 1.57% in D_4. The lowest nitrogen content recorded in the leaves of plants under high density indicated that the plant utilised this element maximum during different stages of its growth and development. The higher competition among the plants for nutrients in closely spaced plants could have been the reason behind this result. Similar results were also obtained by Singh and Bal (2002) [11] who observed no significant effect on leaf nitrogen, phosphorous and potassium in guava.

However, the interpretation of data in relation to the effect of nutrient regime pointed out that there was a marked variation in nitrogen content of leaves and the increasing level of nutrient enhanced the leaf nitrogen content (%) during the two seasons for both years. In the first year, the highest nitrogen content was recorded in leaves of plants treated with N_3 (1.44% and 1.59%) in winter and rainy season respectively followed by N_2 (1.37% and 1.54%) and it was found minimum in N_1 (1.27% and 1.42%) regime. Similarly, during the second year, the highest nitrogen content in leaf was recorded at N_3 and lowest at N_1 regime and the general pattern of increasing efficiency of nutrient regime on leaf nitrogen content was $F_1 < F_2 < F_3$ respectively during winter and rainy seasons of both the year. The increasing trend of nitrogen content in leaves was also observed by Kumar *et al.* (2009) [6] with increasing levels of respective nutrients and inferred that application of higher dose of nitrogen resulted in more uptake by the plant from the soil which led to better growth. Kotur *et al.* (1997) [5] also reported that leaf nitrogen content increased continuously with an increased level of N from 0 to 800 g per tree per year. The results of the interaction of plant density and nutrient regime with leaf nitrogen content revealed non-significant differences among different treatment combinations during the winter and rainy seasons of both years.

Table 1: Effect of plant density, nutrient regime and their interaction on Leaf nitrogen (N) content (%)

Treatment	2018-19		2019-20	
	Winter Season	Rainy Season	Winter Season	Rainy Season
Plant Density (D)				
D_1	1.41	1.55	1.50	1.65
D_2	1.39	1.53	1.48	1.63
D_3	1.34	1.50	1.42	1.59
D_4	1.31	1.49	1.41	1.57
SEm ±	0.04	0.04	0.03	0.03
CD (5%)	NS	NS	NS	NS
Nutrient Regime (N)				
N_1	1.27	1.42	1.36	1.52
N_2	1.37	1.54	1.47	1.62
N_3	1.44	1.59	1.52	1.69
SEm ±	0.04	0.03	0.03	0.03
CD (5%)	0.10	0.10	0.08	0.09
Interaction (D X N)				
D_1N_1	1.25	1.39	1.34	1.50
D_1N_2	1.42	1.56	1.51	1.66
D_1N_3	1.56	1.69	1.64	1.80
D_2N_1	1.34	1.43	1.37	1.58
D_2N_2	1.39	1.60	1.55	1.63
D_2N_3	1.43	1.57	1.51	1.67
D_3N_1	1.23	1.45	1.36	1.48
D_3N_2	1.37	1.50	1.41	1.62
D_3N_3	1.41	1.56	1.48	1.66
D_4N_1	1.26	1.43	1.35	1.52
D_4N_2	1.31	1.50	1.42	1.57
D_4N_3	1.37	1.53	1.45	1.63
SEm ±	0.07	0.07	0.06	0.06
CD (5%)	NS	NS	NS	NS

Phosphorous content

The perusal of data presented in Table 2 indicated that leaf phosphorous content did not change considerably with planting density in either year of investigation. Although the phosphorous content was found to increase with a decrease in planting density, the difference among the density was inconclusive during both winter and rainy seasons. In both the years, the highest phosphorous content was recorded in planting density D_1 (0.21% and 0.25%) during winter and rainy seasons of 2018-19 and 0.22% and 0.27% was observed in the corresponding seasons for 2019-20. Brar *et al.* (2013) [3] observed a similar effect and reported that the mineral composition of leaf is not altered significantly with plant spacing. The NPK content of leaf was found higher in wider spacing might be due to less competition among the plants for nutrients and water that leads to more availability of nutrients to the plants (Tripathi *et al.*, 2020) [15].

However, the data presented in Table 2 reveal that there is marked variation across different nutrient regimes in respect of the phosphorous content of leaves during both years of experimentation. The highest leaf phosphorous content i.e. 0.25% and 0.27% in 2018-19 and 0.24% and 0.31% in 2019-20 respectively during winter and the rainy season was recorded in plants fertilised with N_3 level of nutrient. However, the minimum phosphorous content in the leaf was observed in N_1 (0.13%, 0.16% and 0.12%, 0.15%) during the two seasons of both years. The increasing trend in leaf elemental concentration with increasing levels of nutrient was also reported by Bisht *et al.* (2010) [1] in papaya and Kumawat *et al.* (2019) [7] in guava. As for the interaction effect, data analysis showed no significant differences among combinations of treatments over the two seasons of both years, but the treatment combination D_1N_3 (0.28% in winter, 2018-19 and 0.41% in rainy season, 2019-20) and D_2N_2 (0.31% in rainy season, 2018-19 and 0.28% in winter, 2019-20) registered the highest phosphorous content in leaf.

Table 2: Effect of plant density, nutrient regime and their interaction on Leaf phosphorous (P) content (%)

Treatment	2018-19		2019-20	
	Winter Season	Rainy Season	Winter Season	Rainy Season
Plant Density (D)				
D_1	0.21	0.25	0.22	0.27
D_2	0.19	0.24	0.21	0.25
D_3	0.18	0.21	0.17	0.23
D_4	0.18	0.20	0.17	0.22
SEm ±	0.03	0.03	0.03	0.04
CD (5%)	NS	NS	NS	NS
Nutrient Regime (N)				
N_1	0.13	0.16	0.12	0.15
N_2	0.19	0.25	0.22	0.26
N_3	0.25	0.27	0.24	0.31
SEm ±	0.03	0.02	0.02	0.03
CD (5%)	0.08	0.07	0.07	0.10
Interaction (D X N)				
D_1N_1	0.14	0.19	0.17	0.11
D_1N_2	0.22	0.26	0.23	0.28
D_1N_3	0.28	0.30	0.27	0.41
D_2N_1	0.14	0.13	0.10	0.15
D_2N_2	0.20	0.31	0.28	0.32
D_2N_3	0.24	0.28	0.24	0.29
D_3N_1	0.12	0.16	0.12	0.17
D_3N_2	0.18	0.21	0.17	0.23
D_3N_3	0.25	0.27	0.23	0.29
D_4N_1	0.12	0.14	0.11	0.16
D_4N_2	0.17	0.21	0.18	0.23
D_4N_3	0.24	0.24	0.21	0.26
SEm ±	0.05	0.05	0.05	0.07
CD (5%)	NS	NS	NS	NS

Potassium content

The observations on the effect of plant density and nutrient regime on potassium content of leaf for the individual season of first and second year are presented in Table 3. Similar to the leaf phosphorous content, the potassium content also did not vary significantly with planting density in either year of investigation and was found lesser in the leaves of winter season crop than rainy season. During the winter and rainy seasons of 2018-19, the highest potassium content in leaf was recorded in density D_1 (0.53% and 0.65%) and the lowest was observed in D_4 (0.46% and 0.53%) respectively. A similar trend was observed in 2019-20 also, where planting density D_1 (0.54% and 0.67%) and D_4 (0.45% and 0.54%) registered maximum and minimum values in terms of leaf potassium content. The higher leaf potassium content in the leaves of plants under wider spacing was also reported by Brar *et al.* (2013) [3]. Singh *et al.* (2017) [13] observed a similar trend and recorded the highest nitrogen, phosphorus, and potassium content in leaves taken from widely spaced plants and the minimum in leaves of plants at closer spacing. This could be explained by the fact that uptake and translocation of nutrients from the soil to the aerial parts of the plant is higher in wider spacing compared to narrower ones.

The experimental findings revealed that potassium content in the leaf was significantly influenced by nutrient regime during both seasons in all the years. The maximum potassium content i.e. 0.57% and 0.68% respectively in winter and rainy season of 2018-19 was recorded in N_3 regime followed by N_2 (0.52% and 0.61%) and N_1 (0.40% and 0.50%). In the year 2019-20, the potassium content increased from 0.39-0.57% during winter and 0.53-0.69% during the rainy season with increase in nutrient level from N_1 to N_3. Kumar *et al.* (2009) [6] observed higher status of leaf nutrients due to the application of higher levels of respective nutrients in guava and reported that the mineral composition of leaf in terms of potassium increased with increasing level of K. The interaction effect of both the factors under consideration revealed that potassium content in leaf did not vary significantly in either year of investigation.

Table 3: Effect of plant density, nutrient regime and their interaction on Leaf potassium (K) content (%)

Treatment	2018-19		2019-20	
	Winter Season	Rainy Season	Winter Season	Rainy Season
Plant Density (D)				
D_1	0.53	0.65	0.54	0.67
D_2	0.52	0.63	0.50	0.65
D_3	0.47	0.57	0.46	0.59
D_4	0.46	0.53	0.45	0.54
SEm ±	0.04	0.04	0.05	0.04
CD (5%)	NS	NS	NS	NS
Nutrient Regime (N)				
N_1	0.40	0.50	0.39	0.53
N_2	0.52	0.61	0.50	0.62
N_3	0.57	0.68	0.57	0.69
SEm ±	0.03	0.04	0.04	0.03
CD (5%)	0.10	0.10	0.11	0.10
Interaction (D X N)				
D_1N_1	0.38	0.50	0.38	0.55
D_1N_2	0.54	0.66	0.55	0.68
D_1N_3	0.68	0.80	0.68	0.79
D_2N_1	0.41	0.58	0.45	0.54
D_2N_2	0.59	0.63	0.50	0.68
D_2N_3	0.56	0.67	0.54	0.72
D_3N_1	0.42	0.46	0.36	0.53
D_3N_2	0.47	0.60	0.50	0.58
D_3N_3	0.53	0.64	0.54	0.65
D_4N_1	0.40	0.48	0.39	0.48
D_4N_2	0.47	0.53	0.45	0.52
D_4N_3	0.51	0.59	0.51	0.62
SEm ±	0.07	0.07	0.08	0.07
CD (5%)	NS	NS	NS	NS

Conclusion
The key findings of the experiment indicated that leaf concentrations of nitrogen (N), phosphorus (P) and potassium (K) were only marginally affected by planting density, although they declined progressively as density increased. By contrast, nutrient regime had a significant effect on foliar N, P and K irrespective of planting density, with concentrations rising consistently as nutrient levels increased. From the overall assessment, it is concluded that nutrient management has significant relevance in growth and development of guava and plants at the lowest density exhibited the highest leaf elemental concentrations, and foliar nutrient content increased markedly with higher nutrient applications. The maximum leaf nutrient concentrations were observed in plants under highest level of nutrient regime (70:45:35 g NPK plant^{-1} in the first year and 130:75:65 g NPK plant^{-1} in the second year).

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