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Comparison of Nutrient Concentration in Leaves of Healthy and Leaf Margin Affected Banana Gardens of Hiriyur Taluk, Chitradurga District, Karnataka, India

Hanumanta D. Lamani [a++*], Ashok L. B. [b#], Shaziya, K. L. [c†] and Vinutha, B. B. [d†]

[a] Department of Soil Science and Agricultural Chemistry, College of Agriculture, UAHS, Shivamogga, India.
[b] Department of Soil Science and Agricultural Chemistry, College of Horticulture Hiriyur, KSNUAHS, Shivamogga, India.
[c] Department of Soil Science and Agricultural Chemistry, UAS, GKVK, Bangalore, Karnataka, India.
[d] Department of Agronomy, University of Agricultural Sciences, GKVK, Bengaluru 560065, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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[++] MSc. Student;
[#] Associate Professor;
[†] Ph.D. Scholar;
**Corresponding author: Email: hanumantlamani86@gmail.com;*

ABSTRACT

Banana leaves have been traditionally utilized in various parts of India for serving food, wrapping food items and for religious as well as cultural purposes. Despite their extensive use, there is limited scientific data available on the nutrient composition of banana leaves, particularly in the Hiriyur Taluk of Chitradurga District, Karnataka. This study aimed to analyse and compare the nutrient composition of banana leaves from healthy and margin-affected gardens in different locations. Samples of banana leaves were collected from Babbur Farm, Chillhalli, Venakalgudda, KC Roppa, Goguddu, Gudihalli, Biranhalli, Gounahalli, Vadadhalli, and Bagganadu Villages in Hiriyur Taluk. The leaves were analysed for nitrogen, phosphorus, potassium, calcium, magnesium, sulphur and micronutrients. The proximate analysis revealed that in margin-affected gardens, these nutrients were found to be in the ranges of 2.24-3.25%, 0.14-0.34%, 2.31-3.48%, 0.70-1.08% 0.35-0.58% and 0.24-0.41%, respectively, and in healthy gardens ranged from 2.86-3.26%, 0.31-0.53%, 2.86-3.49%, 0.87-1.08%, 0.45-0.56% and 0.30-0.36%, respectively. Micronutrients (Fe, Mn, Cu, Zn, B and Cl) content were also reported high in healthy banana gardens compared to leaf margin affected gardens. Statistical analysis indicated significant differences in the nutrient composition of banana leaves. The differences in nutrient composition observed among the banana gardens in Hiriyur Taluk could be attributed to various factors, including soil quality and different agricultural practices.

Keywords: Nutrient concentration; leaf margin; fruit crops; banana leaves.

1. INTRODUCTION

Banana (*Musa* spp.) is one of the most important fruit crops grown in India, contributing significantly to the agricultural economy and serving as a staple food for millions of people. Apart from the fruit, various parts of the banana plant, including the leaves, have been utilized for culinary, cultural and medicinal purposes for centuries. Banana leaves, in particular, are widely used in Indian cuisine for serving food, wrapping food items for steaming or grilling, and as eco-friendly disposable plates. In recent years, there has been a growing interest in the nutritional composition of banana leaves due to their potential health benefits and culinary applications. Banana leaves are rich in fibre, vitamins and minerals, making them not only an excellent packaging material but also a nutritious addition to the diet. However, the nutrient composition of banana leaves can vary depending on several factors, including the variety of banana, soil quality, environmental conditions and agricultural practices [1].

Hiriyur Taluk, located in the Chitradurga District of Karnataka, is renowned for its banana cultivation. The region boasts a favourable climate and fertile soil, making it conducive to banana farming. However, like any agricultural area, banana plantations in Hiriyur Taluk are susceptible to various biotic and abiotic stresses, including pests, diseases and environmental factors. One common issue affecting banana plants is leaf margin necrosis, a condition characterized by the browning and death of leaf margins.

Leaf margin necrosis can have detrimental effects on banana plant health and productivity. While the exact causes of this condition may vary, it is often associated with nutrient deficiencies, particularly in essential minerals such as potassium, calcium and magnesium. These nutrients play crucial roles in plant growth, development and stress tolerance [2]. Therefore, understanding the nutrient composition of banana leaves affected by leaf margin necrosis compared to healthy banana garden leaves is essential for effective management strategies and optimizing plant nutrition [3]. Despite the importance of banana leaves in traditional Indian cuisine and agriculture, there is limited scientific research available on the nutrient composition of banana leaves, particularly in the context of leaf margin necrosis. Most studies have focused on the nutritional value of the banana fruit, while the leaves have received relatively less attention. Furthermore, research specifically addressing the nutrient composition of banana leaves affected by leaf margin necrosis is scarce.

This study aims to address this gap by conducting a comparative analysis of the nutrient composition of banana leaves from healthy banana gardens and those affected by leaf margin necrosis in Hiriyur Taluk, Chitradurga

District, Karnataka. By systematically analysing the proximate composition of banana leaves from both healthy and affected plants, this study seeks to provide valuable insights into the nutritional status of banana plants in the region and the potential impact of leaf margin necrosis on plant health and productivity.

2. MATERIALS AND METHODS

Collection of leaf samples: The present investigation was carried out by identifying the banana leaf margin-affected gardens of Hiriyur Taluk, Chitradurga district through the survey. Total 20 leaf samples (2 samples per village) were collected from 10 villages (Babbur farm, Chillhalli, Venakalgudda, KC Roppa, Goguddu, Gudihalli, Biranhalli, Gounahalli, Vadadhalli and Bagganadu) and leaf samples were analyzed in laboratoty. The petiole of the 3rd fully opened leaf from the apex and leaf lamina of 20 cm^2 area in the central part of the leaf on both sides of the midrib at bud differentiation or 16th leaf stage were collected from the plants in the fields from where soil samples were drawn. Fifteen leaves were collected for each sample. Abnormal, diseased and insect-attacked leaves were avoided in the collection.

Analysis of leaf samples: The procedure which was followed by Munshi et al. [4] was adopted for the preparation of leaf samples for analysis. The nitrogen (N) content of leaf tissue (cold digested with concentrated sulfuric acid and then digested with hydrogen peroxide) was estimated by the micro-Kjeldahl distillation method [5]. The phosphorus (P) content of leaf tissue was determined by Vanado-molybdo phosphoric yellow colour method by using a spectrophotometer (Jasco V-530 UV/ visible spectrophotometer) at 470 nm wavelength [6]. The concentration of potassium (K) in diacid extract was determined by using flame photometer (Systronics flame photometer 128) [7]. The calcium (Ca) in the leaf samples was estimated by versenate titration using murexide as an indicator in the presence of 16% sodium hydroxide [6]. Combined estimation of calcium and magnesium (Ca+Mg) was carried out in the diacid extract by Versenate titration using ammonium hydroxide and ammonium chloride buffer and Eriochrome black-indicator [6]. Sulphur (S) in the diacid extract was determined by a turbidimetric method using a spectrophotometer (Jasco V-530 UV/visible spectrophotometer) at a wavelength of 420 nm [8].

3. RESULTS AND DISCUSSION

3.1 Nitrogen (N), Phosphorous (P) and Potassium (K) content of banana leaves collected from leaf margin affected and healthy banana gardens

The N content in leaf tissues of banana leaf margin-affected gardens varied from 2.24 to 3.25 per cent (mean value 2.77 per cent) with minimum leaf N in Vadadhalli village and maximum in the Bagganadu village (Table 1). It was noticed that the N (3.67) content of the leaf was medium (2.92-3.71 %) in banana leaf margin-affected gardens. Whereas in healthy banana gardens, it varied from 2.24 to 3.26 per cent with mean value 3.06 per cent with the minimum leaf N in Gounahalli village and maximum in Vadadahalli village (Table 2). The P content in leaf tissues of banana leaf margin-affected gardens varied from 0.14 to 0.34 per cent with a mean value of 0.26 per cent. It was noticed that the P content of the leaf was low to medium (0.17- 0.22%) in banana leaf margin-affected gardens. In banana leaf margin-affected gardens, the minimum leaf phosphorous was reported in Vadadhalli village and the maximum leaf phosphorous was reported in the Goguddu village (Table 1). Whereas in healthy banana gardens, it varied from 0.31 to 0.53 with a range of 0.44 per cent, the minimum leaf phosphorus reported in Babbur farm village and maximum leaf phosphorus reported in the Gudihalli village Table 2.

The K content in leaf tissues of banana leaf margin-affected gardens of Hiriyur taluk varied from 2.31 to 3.48 per cent with a mean value of 2.77 per cent. It was noticed that K content in leaf tissue was medium (2.67-3.47%). In banana leaf margin-affected gardens, minimum leaf potassium was reported in Bagganadu village and maximum leaf potassium was reported in Biranhalli village (Table1). Whereas in healthy banana gardens, it varied from 2.86 to 3.49 with a range of 3.06 the minimum leaf K reported in Goguddu village and maximum leaf K reported in the Biranhalli village (Table 2).

There was a significant difference observed between banana leaf margin affected and healthy banana gardens for leaf nitrogen. According to the ratings for leaf nitrogen concentration for banana [9], leaf tissue concentration of nitrogen was medium in both banana leaf margin affected and healthy banana gardens. From the investigation, it was

reported that there was a decrease in leaf tissue concentration of nitrogen in banana leaf margin-affected gardens compared to healthy banana gardens. The leaf nitrogen concentration was higher in the healthy banana gardens followed by banana leaf margin-affected gardens. Wiebel et al. [10] reported that the mean leaf nitrogen concentration of banana was 2.23 and 2.69 per cent under a standard and progressive system of cultivation. A similar level of nitrogen has also been confirmed by Turner and Barkus [11], Bhargava and Reddy [12] and Hussain et al. [13].

Significant differences were observed between banana leaf margin affected and healthy banana gardens for leaf phosphorus. As per the ratings of leaf phosphorus concentration in

Table 1. Leaf tissue concentration of macronutrient in banana leaf margin affected gardens

Villages	Location	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)
Babbur farm	1	2.82	0.32	2.66	0.84	0.43	0.32
	2	2.53	0.28	2.68	0.92	0.46	0.35
Chillahalli	3	2.60	0.30	3.25	0.87	0.35	0.31
	4	2.49	0.31	2.67	0.70	0.39	0.33
Venakalgudda	5	2.75	0.24	2.51	0.88	0.41	0.30
	6	2.84	0.21	2.42	0.87	0.42	0.36
KC Roppa	7	2.91	0.30	2.49	0.81	0.46	0.29
	8	2.86	0.32	2.80	0.74	0.44	0.24
Goguddu	9	2.76	0.31	3.15	0.88	0.42	0.35
	10	3.03	0.34	2.70	0.93	0.40	0.32
Gudihalli	11	2.65	0.29	2.36	0.82	0.46	0.38
	12	2.79	0.28	3.20	0.91	0.49	0.36
Biranhalli	13	3.01	0.29	2.46	0.79	0.42	0.38
	14	2.71	0.30	3.48	0.80	0.37	0.41
Gounahalli	15	2.68	0.21	3.38	1.08	0.48	0.34
	16	3.20	0.19	2.82	0.86	0.41	0.33
Vadadhalli	17	2.24	0.14	2.62	0.79	0.44	0.32
	18	2.95	0.26	3.24	0.76	0.43	0.29
Bagganadu	19	3.25	0.25	2.31	0.82	0.46	0.33
	20	2.51	0.18	2.39	0.86	0.58	0.32
Range	Min	2.24	0.14	2.31	0.7	0.35	0.24
	Max	3.25	0.34	3.48	1.08	0.58	0.41
	Mean	2.77	0.26	2.77	0.84	0.43	0.33
	S D	0.24	0.05	0.37	0.08	0.04	0.03

Table 2. Leaf tissue concentration of macronutrient in the healthy banana gardens

Villages	Location	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)
Babbur farm	1	3.25	0.31	3.15	0.88	0.49	0.35
Chillahalli	2	3.01	0.48	2.88	0.92	0.53	0.35
Venakalgudda	3	3.20	0.47	3.25	0.97	0.45	0.31
KC Roppa	4	3.03	0.49	2.96	0.90	0.49	0.33
Goguddu	5	3.14	0.47	2.86	0.88	0.51	0.30
Gudihalli	6	2.98	0.53	3.08	0.87	0.48	0.36
Biranhalli	7	2.91	0.38	3.49	1.01	0.56	0.32
Gounahalli	8	2.86	0.43	2.90	0.94	0.49	0.34
Vadadhalli	9	3.26	0.48	3.15	1.08	0.48	0.35
Bagganadu	10	3.03	0.44	2.95	0.93	0.51	0.32
Range	Min	2.86	0.31	2.86	0.87	0.45	0.3
	Max	3.26	0.53	3.49	1.08	0.56	0.36
	Mean	3.06	0.44	3.06	0.93	0.49	0.33
	S D	0.13	0.06	0.19	0.06	0.03	0.02

banana [9], it was noticed that the phosphorus concentration in banana leaf margin affected gardens the concentration of phosphorus showed low to medium while it was medium to high in healthy banana gardens of Hiriyur taluk. Sairam [14] observed the range of 0.20 to 0.95 per cent of leaf phosphorus in banana gardens of the Kadapa and Kurnool districts. A similar level of phosphorus has also been confirmed by Hussain et al. [13].

Similarly significant difference was observed between banana leaf margin affected and healthy banana gardens for leaf potassium, concentration of leaf potassium as per the ratings suggested by Tandon [9]. Leaf tissue concentration of potassium was medium in both banana leaf margin affected and healthy banana gardens of Hiriyur taluk. The concentration of potassium decreased significantly in banana leaf margin-affected gardens compared to healthy banana gardens. Similar work was comparable to the ranges of leaf potassium as observed by confirmed by Hussain et al. [13].

3.2 Calcium (Ca), Magnesium (Mg) and Sulphur (s) Content of Banana Leaves Collected from Leaf Margin Affected and Healthy Banana Gardens

The results indicated that the concentration of Ca in leaf tissues of banana leaf margin-affected gardens of Hiriyur taluk varied from 0.7 to 1.08 per cent with a mean value of 0.84 per cent. From the results, it was noticed that the leaf tissue concentration of Ca was medium in banana leaf margin-affected gardens. The minimum leaf calcium reported in Chillahalli village and maximum leaf calcium reported in the Gounahalli village (Table 1). Whereas in healthy banana gardens it varied from 0.87 to 1.08 with a range of 0.93 the minimum leaf calcium reported in Gudihalli village and maximum leaf calcium reported in the Vadadahalli village (Table 2).

The results indicated that the concentration of Mg in leaf tissues of banana leaf margin-affected gardens of Hiriyur taluk varied from 0.35 to 0.58 per cent with a mean value of 0.43 per cent. From the results, it was noticed that the leaf tissue concentration of magnesium was medium in banana leaf margin-affected gardens. The minimum leaf magnesium was reported in Chillahalli village and the maximum leaf magnesium was reported in the Bagganadu village (Table 1). Whereas in healthy banana gardens, it varied from 0.45 to 0.56 with a range of 0.49 the minimum leaf magnesium reported in Venakalgudda village and maximum leaf magnesium reported int he Biranhalli village (Table 2).

Results indicated that the concentration of S in leaf tissues of banana leafmargin-affected gardens of Hiriyur taluk varied from 0.24 to 0.41 per cent with a mean value of 0.33 per cent. From the results, it was noticed that the leaf tissue concentration of sulphur concentration was medium to high, the minimum leaf sulphur was reported in KC Roppa village and the maximum leaf sulphur was reported in the Biranhalli village (Table 1). Whereas in healthy banana gardens, it varied from 0.30 to 0.36 with a range of 0.33 the minimum leaf sulphur reported in Goguddu village and maximum leaf sulphur reported in the KC Roppa village (Table 2).

From the results, it was noticed that the leaf tissue concentration of calcium and magnesium was medium (0.52-1.20 and 0.31 to 0.40 %) in banana leaf margin affected and healthy banana gardens of all the villages of Hiriyur taluk. From the findings, it was reported that the concentration of calcium and magnesium decreased significantly in banana leaf margin-affected gardens compared to healthy banana gardens.

As per the ratings of leaf calcium concentration in banana leaf established by Tandon [9], these samples were considered to be sufficient to high in calcium. Sairam [14] reported 0.81 per cent as the mean leaf calcium concentration in banana orchards of the Kadapa and Kurnool district. Similar findings were also made by Adinarayana et al*.* [15] in banana gardens of Krishna district.

Similarly, leaf tissue concentration of Mg was medium in banana leaf margin affected and healthy banana gardens of all the villages of Hiriyur taluk, as per the rating given by Tandon [9]. The sulphur content was medium to high in both banana leaf margin affected and healthy banana gardens.

It was reported that the concentration of calcium and magnesium was decreased significantly in banana leaf margin-affected gardens compared to healthy banana gardens of Hiriyur taluk.

Sulphur reported no significant difference between the banana leaf margin affected and healthy banana gardens of Hiriyur taluk.

According to the leaf sulphur ratings [9], these leaf samples are rated as low to the high category in banana leaf margin affected gardens, whereas in healthy banana gardens, it was medium to high.

3.3 The Independent T-test for Major Nutrient Concentrations in the Banana Leaf of Banana Leaf Margin Affected and Healthy Banana Gardens

The information on independent t-test for major nutrient concentrations of banana leaf margin affected and healthy banana gardens is presented in Table 3. macronutrient concentration in banana leaf margin affected and healthy banana gardens of Hiriyur taluk, it was observed that nitrogen, phosphorous, potassium, calcium and magnesium concentration decrease significantly in banana leaf margin affected gardens compared to healthy banana gardens.

3.4 Iron (Fe), Manganese (Mn), Copper (Cu), Boron (B) and Chloride (Cl) Content of Banana Leaves Collected from Leaf Margin Affected and Healthy Banana Gardens

The leaf Fe concentration of banana leaf affected gardens varied from 72.90 to 105.50 ppm with a mean value of 85.28 ppm. In the banana leaf margin affected gardens, the minimum leaf tissue concentration of iron reported in Babbur farm village and maximum iron concentration recorded in Biranhalli village of Hiriyur. From the findings, it was found that in banana leaf margin affected gardens iron concentration was medium to high (95-158 ppm) (Table 4). Where as in healthy banana gardens it was varied from 92.75 to 163.18 with a range of 130.18 the minimum leaf iron reported in Chillahalli village and maximum leaf iron reported in the Venakalgudda village (Table 5).

The leaf Mn concentration of banana leaf margin affected gardens varied from 120.50 to 164.00 ppm with a mean value 143.38 ppm. In the banana leaf margin affected gardens, the minimum leaf tissue concentration of Mn reported in Goguddu village and maximum Mn concentration reported in Babbur farm village of Hiriyur. From the findings, it was found that in banana leaf margin affected gardens Mn concentration was medium (626-2221ppm) (Table 4). Where as in healthy banana gardens it was varied from 152.00 to 262.50 with a range of 225.88 the minimum leaf Mn reported in Goguddu village and maximum leaf Mn reported in the Chillahalli village.

The leaf Cu concentration of banana leaf margin affected gardens varied from 8.5 to 17.6 ppm with a mean value of 13.57 ppm, in the banana leaf margin affected gardens, the minimum leaf tissue concentration of Cu reported in Biranhalli village and maximum Cu concentration reported in KC Roppa village of Hiriyur. From the findings in banana leaf margin affected gardens of Hiriyur taluk, it was found that the concentration of Cu low to medium (7-13 ppm) (Table 4). Where as in healthy banana gardens it was varied from 11.80 to 17.30 with a range of 15.14 the minimum leaf Cu reported in K C Roppa village and maximum leaf Cu reported int he Gounahalli village (Table 5).

The leaf Zn concentration of banana leaf margin affected gardens varied from 8.30 to 16.60 ppm with a mean value of 13.40 ppm. In banana leaf margin affected gardens, the minimum leaf tissue concentration of zinc reported in Chillahalli village and maximum zinc concentration reported in Bagganadu village of Hiriyur. From the findings in banana leaf margin affected gardens of Hiriyur taluk, it was found that the concentration of Zn low to medium () banana margin affected gardens (Table 4). Where as in healthy banana gardens it was varied from 18.45 to 30.50 with a range of 25.00 the minimum leaf Zn reported in Gudihalli and Biranhalli village and maximum leaf Zn reported in the Bagganadu village (Table 5).

Table 3. The independent t-test for leaf macronutrients in banana leaf margin affected and healthy gardens

Parameters	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)
AG Mean value	2.77	0.26	2.77	0.84	0.43	0.33
HG Mean value	3.06	0.44	3.06	0.93	0.49	0.33
T statistic	4.08**	7.80**	2.76*	3.29**	4.33**	0.14

**Significant at 5% level, ** Significant at 1% level, HG: Healthy garden, AG: Affected garden*

Table 4. Leaf tissue concentration of micronutrient in banana leaf margin affected gardens

Villages	Location	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)	B (ppm)	Cl^- (ppm)
Babbur farm	1	90.40	164.00	12.70	14.50	13.80	911.34
	2	72.90	155.50	13.50	12.25	13.30	784.48
Chillahalli	3	87.47	140.00	15.75	8.30	12.10	867.56
	4	84.23	150.30	15.50	16.50	15.80	991.23
Venakalgudda	5	98.22	120.50	17.50	13.80	12.50	714.45
	6	74.25	161.00	17.20	12.82	13.20	866.36
KC Roppa	7	86.34	162.00	17.60	14.25	14.40	942.95
	8	88.23	156.00	10.25	16.60	16.90	866.45
Goguddu	9	95.55	120.50	8.70	14.75	15.60	914.65
	10	89.40	133.50	17.10	15.10	12.60	874.21
Gudihalli	11	82.25	142.50	17.50	11.50	16.10	933.63
	12	79.65	122.00	9.20	16.50	14.30	912.65
Biranhalli	13	105.50	133.30	8.70	11.50	13.20	864.67
	14	80.20	122.80	8.50	11.00	15.20	884.95
Gounahalli	15	86.23	156.00	13.30	12.28	13.40	784.64
	16	73.10	142.50	12.25	13.05	15.60	855.69
Vadadhalli	17	78.60	156.80	14.30	14.45	12.50	630.74
	18	88.23	135.60	14.60	13.05	13.50	761.36
Bagganadu	19	86.30	141.40	13.10	13.32	11.90	944.64
	20	78.62	151.50	14.30	12.48	12.30	832.65
Range	Min	72.90	120.50	8.50	8.30	11.90	630.74
	Max	105.50	164.00	17.60	16.60	16.90	991.23
	Mean	85.28	143.38	13.57	13.40	13.91	856.96
	S D	8.36	14.59	3.15	2.05	1.49	86.30

Table 5. Leaf tissue concentration of micronutrient in the healthy banana gardens

Villages	Location	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)	B (ppm)	Cl (ppm)
Babbur farm	1	140.32	260.00	14.70	27.81	17.40	550.23
Chillahalli	2	92.75	262.00	15.70	28.50	16.20	482.69
Venakalgudda	3	163.30	230.50	12.90	24.50	16.40	339.36
K C Roppa	4	104.40	262.50	11.80	27.80	16.20	474.36
Goguddu	5	105.50	152.00	16.60	27.30	18.40	443.65
Gudihalli	6	143.40	160.50	17.10	18.45	15.50	433.25
Biranhalli	7	130.30	220.50	16.65	18.45	16.10	650.12
Gounahalli	8	128.15	260.00	17.30	20.70	18.70	355.36
Vadadhalli	9	133.20	190.30	14.85	26.00	15.80	411.96
Bagganadu	10	160.55	260.50	13.80	30.50	15.20	433.45
Range	Min	92.75	152.00	11.80	18.45	15.20	339.36
	Max	163.30	262.50	17.30	30.50	18.70	650.12
	Mean	130.18	225.88	15.14	25.00	16.59	457.44
	S D	23.53	43.74	1.87	4.33	1.18	90.94

Table 6. The independent t-test for leaf micronutrients in banana leaf margin affected and healthy gardens

Parameters	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)	B (ppm)	Cl (ppm)
AG Mean value	85.28	143.38	13.57	13.40	13.91	856.96
HG Mean value	130.18	225.88	15.14	25.00	16.59	457.44
T statistic	1.69	1.83	2.01	1.43	1.80	11.53**

**Significant at 5% level, ** Significant at 1% level, HG: Healthy garden, AG: Affected garden*

The leaf B concentration of banana leaf margin affected gardens varied from 11.90 to 16.90 ppm with a mean value of 13.91 ppm in the banana leaf margin affected gardens, the minimum leaf tissue concentration of B reported in Bagganadu village and maximum boron concentration reported in Gounahalli village of Hiriyur. From the findings of Hiriyurtaluk gardens, it was found that the concentration of B medium (12-18 ppm) in the case of banana leaf margin affected gardens (Table 4). Where as in healthy banana gardens it was varied from 15.20 to 18.70 with a range of 16.59 the minimum leaf boron reported in Bagganadu village and maximum leaf boron reported in the Gounahalli village (Table 5).

The results indicated that the concentration Cl in leaf tissues of banana leaf margin affected gardens of Hiriyur taluk varied from 630.74 to 991.23 ppm with a mean value of 856.96 ppm. In the banana leaf margin affected gardens, the minimum leaf tissue concentration of Cl reported in Vadadhalli village and maximum Cl concentration reported in Chillahalli village of Hiriyur taluk, it was noticed that the leaf tissue concentration of chloride concentration was high in the banana leaf margin affected gardens (Table 4). Where as in healthy banana gardens it was varied from 339.36 to 650.12 with a range of 457.44 the minimum leaf Cl reported in Venakalgudda village and maximum leaf Cl reported in the Biranhalli village (Table 5).

It was reported that leaf tissue concentration of Cu decreases significantly in banana leaf margin affected gardens compared to healthy banana gardens. From the findings in banana leaf margin affected gardens of Hiriyur taluk, it was found that the concentration of Cu low to medium. Similarly, in the case of healthy banana gardens Cu was medium. According to Chapman [16], the lower critical limit for copper for banana below which deficiency occurs in 8.00 ppm. From this, a conclusion drawn that none of the leaf samples was deficient in copper. Similar findings also reported by Sairam [14] and also observed that the leaf copper concentration of banana ranged from 8.00 to 16.38 ppm with a mean value12.25 ppm and also confirmed the non-existence of copper deficiency in this region. Leaf copper was high in healthy banana gardens followed by banana leaf margin affected gardens.

From the results, it was recorded that the concentration of Zn in leaf decreases significantly in leaf margin affected gardens in comparison to healthy banana gardens. From the findings in banana leaf margin affected and healthy banana gardens of Hiriyur taluk, it was found that the concentration of Zn in the leaf of banana leaf margin affected gardens was low to medium, whereas, in the case of healthy banana gardens it was medium. As per the critical limit 15.00 ppm of leaf zinc concentration in banana [16], The leaf zinc concentration was high in healthy banana gardens followed by banana leaf margin affected gardens. The similar ranges of leaf zinc content obtained were also reported by Wiebel et al. [10].

In healthy banana gardens concentration boron varied from 15.2 to 18.7 ppm with a mean value of 16.59 ppm. It was reported that leaf tissue concentration of B decreases significantly in affected gardens compared to healthy banana gardens, it was found that the concentration of boron was medium in the case of leaf margin affected and healthy banana gardens. The threshold level for deficiency of boron in banana leaf was 14.00 ppm [17].

It was reported that leaf tissue concentration of chloride increases significantly in banana leaf margin affected gardens compared to healthy banana gardens. From the findings in Hiriyur taluk gardens, it was found that the concentration of chloride was high in the case of banana leaf margin affected gardens and low to medium in healthy banana gardens. From the results, it was noticed that the leaf tissue concentration of chloride content was higher in the banana leaf margin affected gardens compared to healthy banana gardens, these findings are supported by Ali et al. [18].

3.5 The Independent T-test for Leaf Micronutrients of Banana Leaf Margin Affected and Healthy Banana Gardens is Presented in Table 5

The analysis of micronutrient concentrations in banana leaf margins from affected and healthy gardens in Hiriyur taluk is summarized in Table 6. Results indicate a significant increase in chloride concentration in affected gardens compared to healthy ones. However, no marked differences were observed for iron (Fe), manganese (Mn), copper (Cu), zinc (Zn) and boron (B) levels between the two garden types.

4. CONCLUSION

The research on the nutrient analysis in leaves of healthy banana gardens of Hiriyur Taluk, Chitradurga district, reports the nitrogen (N),

potassium (K), calcium (Ca), magnesium (Mg), manganese (Mn) and boron (B) range was medium to high, phosphorus (P), zinc (Zn) and copper (Cu) concentration was low to medium, sulphur (S) and iron (Fe) was medium to high, where as in case of banana leaf margin affected gardens nitrogen (N), potassium (K), calcium (Ca), magnesium (Mg), manganese (Mn) and boron (B) range was low to medium, phosphorus (P), zinc (Zn) and copper (Cu) concentration was medium, sulphur (S) and iron (Fe) was medium to high, overall nutrient content of banana leaves reported to be high in case of healthy gardens compared to leaf margin affected gardens.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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