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Standardization of Leaf Sampling Technique in Jackfruit Nutrient Status Diagnosis

Yan Sun[1,2,3], Jianfeng Yang[1,2,3], Hua Wang[1,2,3], Chao Zu[1,2,3], Lehe Tan[1,2,3*], Gang Wu[1,2,3]

[1]Spice and Beverage Research Institute, Chinese Academy of Tropical Agricultural Sciences, Wanning, China
[2]Key Laboratory of Genetic Resources Utilization of Spice and Beverage Crops, Ministry of Agriculture, Wanning, China
[3]Hainan Provincial Key Laboratory of Genetic Improvement and Quality Regulation for Tropical Spice and Beverage Crops, Wanning, China
Email: *tlh3687@163.com

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Abstract

In China, little information is known about the nutrient requirements of jackfruits and the traditional nutrient management usually depends on the experience. Therefore, in this study, an attempt was made to standardize the leaf sampling technique and the suitable range of leaf nutrient concentrations for jackfruit (*Artocarpus heterophyllus* Lam.) nutrient status diagnosis. The sampling result was affected by canopy height, leaf age and time of sampling. Therefore, the three factors were studied. The results illustrated that the stability in level of nutrient concentrations was in 3 - 6 month-old leaves from the central part of the canopy. The most stable period was from April to May for leaf sampling. It was recommended that the stable intra-canopy and stable period of nutrient concentrations could be used as the standards of leaf sampling technique. Based on the leaf sampling technique, the standard of leaf nutrient concentrations was summarized, and could be used as the standard of nutrient suitability evaluation.

Keywords

Jackfruit, Nutrient Status Diagnosis, Leaf Sampling Technique, Standardization

1. Introduction

The jackfruit is widely cultivated and popular fruit in tropical regions. In China, its planting area is about 10,000 hectares, of which is more than 5000 hectares in Hainan. Its fruit is the largest tree-borne fruit, and its growth

*Corresponding author.

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consumes large amounts of nutrients from soil. However, little information is known about the nutrient requirements of jackfruits. For years, the leaf nutrient analysis is widely used for plant nutrient status diagnosis [1]-[6]. Comparison of the results of leaf analysis and the standard of leaf nutrient concentrations, the level of sufficiency or deficiency of plant nutrient status can be estimated, and as a result the optimum fertilization rate may be recommended [7] [8]. However, the value of leaf analysis depends on sampling technique, including canopy height, leaf age and time of sampling [9]-[13].

The sampling technique has been worked out in many fruiting plants, such as apple, pear, bael and lime [14]-[17]. However, there is still a dearth of the leaf sampling technique in jackfruit, and thus more data need to be provided. In this paper, through the field sampling and lab test, the canopy height, leaf age and time of sampling for jackfruit were determined. The purpose of this paper is to standardize the sampling technique of jackfruit, and recommend fertilizer.

2. Materials and Methods

2.1. Site

During 2011-2013, field experiments were performed at 8 high yielding orchards of jackfruit in Hainan, China. The sites are located in north latitude 18˚9' - 20˚11', east longitude 108˚21' - 111˚03' and altitude 1 - 1000 m. The tropical climate is characterized by average annual temperature of 23˚C - 25˚C and average annual rainfall of 1000 - 2000 mm. The soil of the experimental orchards is latosol (sandy clay loam).

2.2. Sampling

The leaves were sampled on a population of 10 representative trees in each plot. The samples were collected between 8 and 10 AM from all four directions to avoid variation at the end of every month for one year, and the sampling period was from 2011 to 2013. The collected samples should be brought to the laboratory on the same day, and then they were washed in tap water and distilled water, respectively.

2.3. Samples Analysis

The analyses were carried out on dry leaf samples after grinding. The diacid (H_2SO_4-H_2O_2) digests were used for determination of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), copper (Cu) and zinc (Zn). N was determined by the Kjeldahl digestion method. P was determined by Mo-Sb Anti spectrophotometric method. K was determined by flame photometer. Ca, Mg, Fe, Mn, Cu and Zn were determined by atomic absorption spectrophotometry. Sulfur (S) was determined by BaCl turbidimetry after acid (HNO_3-$HClO_4$-HCl) digestion method. Boron (B) was determined by azomethine-H spectrophotometric method [16] [18].

2.4. Statistical Analysis

The standard of leaf nutrient concentrations, which consist of deficient range, low range, optimum range, high range and excess range for each nutrient, has been derived using the mean and standard deviation of leaf nutrient concentrations. The optimum nutrient range was the values derived from "mean − 4/3 SD (standard deviation) to mean + 4/3 SD"; The low range was obtained by calculating "mean − 4/3 SD to mean − 8/3 SD" and the values below "mean − 8/3 SD" were considered as deficient range; The values from "mean + 4/3 SD to mean + 8/3 SD" were taken as high range and the values above "mean + 8/3 SD" were taken as excessive range [18].

All statistics were calculated using SPSS (version 19.0) statistical software.

3. Results

3.1. Canopy Height and Leaf Age of Sampling

As can be seen from the **Table 1**, besides Ca, Mn and B, the higher leaf nutrient concentrations are found from the lower canopy. The higher concentrations of N, P, K, Cu and Zn in the 3 - 6 month-old leaves are observed from the lower canopy; The higher concentration of Fe in the over 6 month-old leaves is found from the lower canopy. Compared with the over 6 month-old leaves, the N, P, K, Cu and Zn concentrations are higher in the 3 -

Table 1. Effect of canopy height and age on jackfruit leaf nutrient concentrations.

Nutrient	1	2	3	4	5	6	Mean
N (%)	2.31	2.65	2.29	2.64	2.32	2.73	2.49
P (%)	0.15	0.21	0.15	0.21	0.15	0.21	0.18
K (%)	0.97	1.88	0.99	1.85	0.95	2.04	1.45
Ca (%)	1.41	1.01	1.38	1.01	1.38	0.93	1.19
Mg (%)	0.29	0.29	0.29	0.29	0.31	0.29	0.29
S (%)	0.23	0.22	0.22	0.22	0.22	0.23	0.22
Fe ($mg \cdot kg^{-1}$)	90.26	91.97	94.43	95.92	106.52	93.58	95.45
Mn ($mg \cdot kg^{-1}$)	530.28	421.48	523.17	427.05	522.68	359.54	464.03
Cu ($mg \cdot kg^{-1}$)	6.77	13.37	7.21	12.78	7.03	14.82	10.33
Zn ($mg \cdot kg^{-1}$)	29.83	33.77	28.90	33.94	30.74	33.98	31.86
B ($mg \cdot kg^{-1}$)	39.59	34.22	41.73	35.00	40.30	35.14	37.66

1: over 6 month-old leaves from the upper canopy; 2: 3 - 6 month-old leaves from the upper canopy; 3: over 6 month-old leaves from the central canopy; 4: 3 - 6 month-old leaves from the central canopy; 5: over 6 month-old leaves from the lower canopy; 6: 3 - 6 month-old leaves from the lower canopy.

6 month-old leaves, but the Ca, Mn and B are lower. Mg and S levels are relatively constant in the plants. The results indicated that the stability of leaf nutrient concentrations in the jackfruit was in the 3 - 6 month-old leaves from the central canopy.

3.2. Time of Sampling

The seasonal changes in the populations of leaves on the most suitable sampling parts of jackfruit are showed in **Figure 1**. From the graph, we know that the leaf nutrient concentrations of K and Cu are both increase during spring and summer, and then show a large fluctuation but no clear trends; The concentration levels of Ca, Zn and B increase during springtime, and then slightly decrease; The concentration levels of P, Mg and S are relatively constant throughout the year; The concentration of N is the highest (3.18%) in December, and then drop; The maximum content of Fe (127.48 $mg \cdot kg^{-1}$) is in January, and then tend to decline until October; The maximum accumulation of Mn is in February, and then fall until May followed by a gradual rise until September. The results demonstrated that the stability of leaf nutrient concentrations in the jackfruit was from April to May.

3.3. The Standard of Leaf Nutrient Concentrations

The leaves were sampled in the 3 - 6 month-old leaves from the central canopy between April and May of 2011-2013. The mean and range of jackfruit leaf nutrient concentrations is shown in **Table 2**. As can be seen from the data of the range of leaf nutrient concentrations, the leaf nutrient status in different jackfruit orchard varied differently. Compared to the leaf macronutrient (N, P, K, Ca, Mg, S) concentrations range, the leaf micronutrient (Fe, Mn, Cu, Zn, B) concentrations are more wide range. The standard of leaf nutrient concentrations is shown in **Table 3**. The optimum range of N, P, K, Ca, Mg, S, Fe, Mn, Cu, Zn and B is obtained. Below the optimum range is considered as hidden hunger or severely deficient, and above the optimum range is considered as luxury absorption or excessive toxicity.

4. Discussion

In this study, we found that the stability of leaf nutrient concentrations in the jackfruit was in the 3 - 6 month-old leaves from the central canopy between April and May. Sampling parts, which the nutrient concentrations approximated to the average of the whole plant, could be used as the most suitable sampling parts [9] [13] [14] [16]. Therefore, in the study of bael leaf sampling technique, 6 - 7 month-old leaves were stability for the evaluation of N, P and K, whereas in this study, the 3 - 6 month-old leaves from the central canopy may be most suitable to develop foliar nutrient standards for jackfruit. Additionally, the young leaf nutrient concentrations are unstable because of their in the stage of continued growth, so the leaves were not sampled, and the nutrients over 6 month-old leaves may be transferred or accumulated, so the leaves were also not suitable for sampling. Some other researches indicated that there were significant differences in leaf nutrient concentrations among four di-

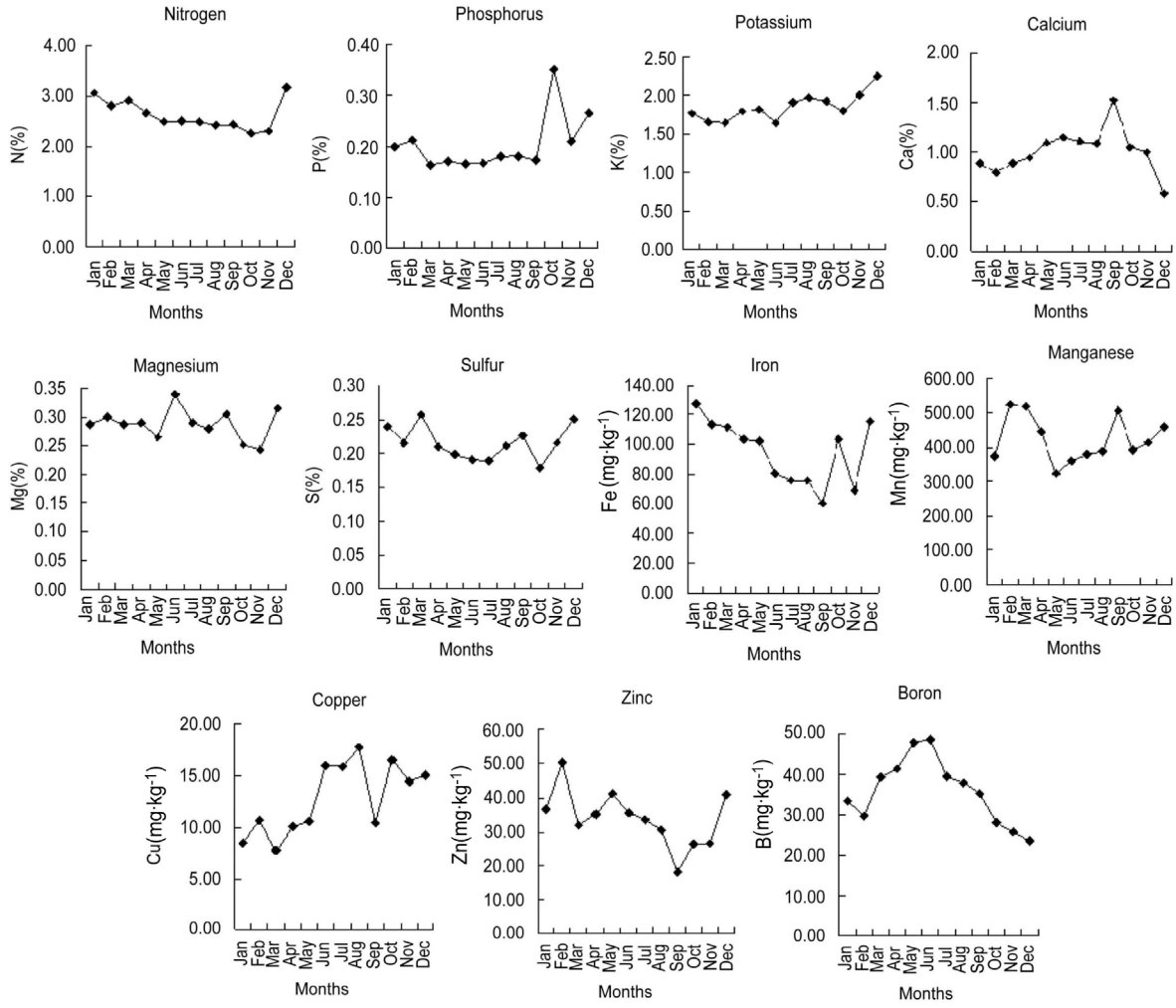

Figure 1. Changes in leaf nutrient concentrations of jackfruit during annual growth cycle of 2011-2013.

Table 2. The mean and range of leaf nutrient concentrations of jackfruit.

Nutrient	Macronutrient (%)						Micronutrient (mg·kg^{-1})				
	N	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn	B
Mean	2.59	0.17	1.81	1.03	0.28	0.20	102.72	384.83	10.35	38.30	44.65
Min	2.35	0.15	1.19	0.80	0.16	0.18	84.58	184.53	5.99	32.17	36.65
Max	2.73	0.18	2.08	1.38	0.42	0.22	117.83	505.78	15.29	44.77	59.24
SD	0.13	0.01	0.32	0.21	0.10	0.02	10.70	108.84	3.04	4.18	7.96

Data are based on 30 samples.

rections of the same canopy [13], accordingly, sampled from different direction may lead to wrong result. Therefore, further works are needed to resolve this untouched problem.

Time of sampling, which the nutrient concentrations approximated to the annual average, could be used as the most suitable sampling time [6] [10] [13] [14] [16]. Therefore, in the study of olive leaf sampling technique, the wintertime was stability for the evaluation of N, whereas in this study, the period from April to May may be most suitable to develop foliar nutrient standards for jackfruit. In addition, the jackfruit ripening period is from June to July, and the best time for fertilization is after harvest. For a better growth in the following year, the jackfruit nutritional status was evaluated between April and May. Subsequently, the best fertilizer programs can be planned.

Table 3. The standard of leaf nutrient concentrations of jackfruit for getting optimum yield.

Nutrient	Deficiency	Low	Optimum	High	Excess
N (%)	<2.24	2.24 - 2.41	2.42 - 2.76	2.77 - 2.94	>2.94
P (%)	<0.14	0.14 - 0.15	0.16 - 0.18	0.19 - 0.20	>0.20
K (%)	<0.96	0.96 - 1.37	1.38 - 2.24	2.25 - 2.66	>2.66
Ca (%)	<0.47	0.47 - 0.74	0.75 - 1.31	1.32 - 1.59	>1.59
Mg (%)	<0.01	0.01 - 0.14	0.15 - 0.41	0.42 - 0.55	>0.55
S (%)	<0.15	0.15 - 0.16	0.17 - 0.23	0.24 - 0.25	>0.25
Fe ($mg \cdot kg^{-1}$)	<74.19	74.19 - 88.44	88.45 - 116.99	117.00 - 131.25	>131.25
Mn ($mg \cdot kg^{-1}$)	<94.59	94.59 - 239.70	239.71 - 529.95	529.96 - 675.07	>675.07
Cu ($mg \cdot kg^{-1}$)	<2.24	2.24 - 6.29	6.30 - 14.40	14.41 - 18.46	>18.46
Zn ($mg \cdot kg^{-1}$)	<27.15	27.15 - 32.72	32.73 - 43.87	43.88 - 49.45	>49.45
B ($mg \cdot kg^{-1}$)	<23.42	23.42 - 34.03	34.04 - 55.26	55.27 - 65.88	>65.88

The standard of leaf nutrient concentrations consist of deficient range, low range, optimum range, high range and excess range for each nutrient, and it may be used as the standard of nutrient suitability evaluation. However, the availability of fertilizers is closely related to soil nutrient supplying power and plant nutrient absorption capacity, therefore, how to fertilize the jackfruit in the condition of below or above the optimum range is needed further research.

5. Conclusion

For the evaluation of jackfruit nutritional status, this study has determined the jackfruit sampling technique, including the canopy height, leaf age and time of sampling. The stable intra-canopy of leaf sampling was the 3 - 6 month-old leaves from the central canopy, and the stable period of leaf sampling was between April and May. Also, this study has determined the standard of suitable leaf nutrient concentrations. Our work continues for 3 years, and the obtained data provide a basis of reference standards for jackfruit leaf nutrient analysis. The results of the paper may be used for jackfruit nutrient status diagnosis and helping to plan fertilizer programs.

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