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Research Article
Determining an Appropriate Leaf Position to Establish Norms of Diagnosis and Recommendation Integrated System for Ratoon Pineapple

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Abstract

Background and Objective: Diagnosis and recommendation integrated systems (DRIS) are used to determine the nutrition status of several crops global. The study was conducted to determine a suitable leaf position to establish diagnosis and recommendation integrated system norms for N, P, K, Ca, Mg, Na, Cu, Fe, Zn and Mn nutrients in ratoon pineapple. **Materials and Methods:** On-farm research was designed in this study. Uninfected pineapple leaf samples were collected from 60 pineapple farms in Hau Giang. The t-test was used to compare mean values while F-test was used to compare variances between the high-yielding and low-yielding groups. **Results:** The results illustrated that the pineapple yield in the high-yielding group ($\geq$15.0 t ha^{-1}, 26 farms) reached 18.4 t ha^{-1}, higher than those in the low-yielding one (<15.0 t ha^{-1}, 34 farms), producing 12.4 t ha^{-1}. Concentrations of N, P, K, Ca, Mg, Cu and Zn in the high-yielding group outweighed those in the low-yielding group, while concentrations of Na, Fe and Mn in the low-yielding group were higher than those in the high-yielding one. A total of 18-24 out of 90 nutrient ratio pairs were selected to establish the DRIS norms at leaves +1, +3, +7, +14, +15, +18, +20, +22 and +24. The DRIS norms were set based on the leaf position with the number of ratios, which had statistically different means and variances $\geq$18 between the high-yielding and low-yielding groups. **Conclusion:** Nine norms were built at leaves +1, +3, +7, +14, +15, +18, +20, +22 and +24 from the high-yielding group to diagnose nutrients in ratoon pineapple.

Key words: Acid sulfate soil, diagnosis and recommendation integrated system, DRIS, nutrition, nutrient ratio pairs, ratoon, pineapple

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Pineapple (*Ananas comosus* L.) is a cultivar with a high economic value whose global cultivation area has become wider over time[1,2]. In 2017, the global productivity of pineapple reached 25.9 million t per year[3]. However, the shortage of some nutrients has affected its potential production[4] because macronutrients including N, P and K remarkably influence the growth, the fruit quality and especially the yield of pineapple[5,6]. Micronutrients are also vital in the vegetative stage of pineapple as they when sufficiently provided, offer various benefits, e.g. Ca affect fruit hardness, while a lack of Mg leads to shorter stems[7,8]. On the contrary, excessive amounts of nutrients can become toxic to plants[9]. In addition, interactions among nutrients can have contributory or competitive effects. Fertilizing both Mg and Zn together noticeably impacts plant height and concentrations of chlorophyll in leaves[8], while higher Na content results in low concentrations of K, Ca, P and Mg[10]. Therefore, maintaining nutrients at the balance threshold is required for the yield to reach its highest value[11]. Simultaneously, concentrations of nutrients differ among different leaf ages[6], so using a mono-variant cannot help verify pineapple nutrition status well, resulting in poor nutrition management or dreadful environmental quality given by the overuse of chemical fertilizers[2]. Along with obstacles in evaluating the nutrition status of pineapple, some approaches based on the relationships among nutrients have been applied.

The diagnosis and recommendation integrated system (DRIS) is a method used to assess the excess and deficiency of nutrients for plants via concentrations of nutrients in leaves[12] by comparing such concentrations in the tissues of nutrient ratio pairs[13]. The DRIS can be used to determine nutrient imbalance, deficiency, or excess as well as rank nutrients in order from the most important to the least important[14]. To this day, many DRIS norms have been established for different fruit plants, such as maize, almond, cacao and banana[15-18]. For pineapple, its DRIS norms have been built based on concentrations of N, P and K[19], N, P, K, Ca and Mg in Brazil[20], and N, P, K, Ca, Mg and S in Benin[21,22]. Because different regions have different cultivation techniques, crops, cultivars and soil capacity to provide nutrients, DRIS norms need to be built specifically for each region to enhance their reliability[23]. Moreover, pineapple has many different leaf positions at a certain stage of growth, which can be a model for establishing DRIS norms[2]. Thus, this study was conducted to determine the appropriate leaf position for establishing DRIS norms for the nutrients N, P, K, Ca, Mg, Na, Cu, Fe, Zn and Mn for ratoon pineapple cultivated in acid-sulfate soil.

MATERIALS AND METHODS

Study area: The experiment observed the ratoon pineapple cultivated in 2020 in Long My District, Vi Thanh City, Hau Giang Province.

Chemical and regents: All chemical compounds were used from Merck. These compounds were described by Sparks *et al.*[24].

Experimental design: On-farm research was designed on 60 farms. A total of 60 soil samples were collected from 60 farms of ratoon pineapple planted in acid sulfate soil in Hau Giang Province, Vietnam. These samples were left to dry naturally and then smashed and filtered via a 0.5×2.0 mm sieve to analyze the soil properties. The soil analysis methods were compiled by Sparks *et al.*[24].

Soil analysis: The soil samples were measured for pH_{H_2O} and electrical conductivity (EC) via extraction with distilled water at 1:2.5 and analysis with a pH meter and an EC meter, respectively. Soil pH_{KCl} was extracted via 0.1 M KCl, with soil and KCl at a ratio of 1:2.5 and measured with a pH meter. The concentration of organic matter was oxidized using a mixture of saturated H_2SO_4 and $K_2Cr_2O_7$ before being titrated by 0.5 N $FeSO_4$. The total acid was measured via soil extraction with 1.0 M KCl, with soil and KCl at a ratio of 1:12.5 and titrated via 0.01 N NaOH with a colour indicator (1% phenolphthalein). The soil samples for total N determination were broken down by a mixture of saturated H_2SO_4-$CuSO_4$-Se at a ratio of 100:10:1, determined by the Kjeldahl distilling method and titrated by 0.01 N H_2SO_4. The NH_4^+ concentration was extracted from the soil using 2.0 M KCl, detected (in colour) by a mixture of sodium nitroprusside, sodium salicylate, sodium citrate, sodium tartrate, sodium hydroxide and sodium hypochlorite and detected in a spectrometer at a wavelength of 650 nm. The available N in the form of NO_3^- was extracted from the soil using 2.0 M KCl, measured (in colour) using 0.5 M HCl, vanadium (III) chloride, sulfanilamide and N-(1-naphthyl) ethylenediamine dihydrochloride and measured in a spectrometer at a wavelength of 540 nm. The soil samples for total P were disintegrated using saturated H_2SO_4 and $HClO_4$, exposed in (coloured) phosphomolybdate with ascorbic acid as a reductant and measured in a spectrometer at a wavelength of 880 nm. Concentrations of Fe-P, Al-P and Ca-P were determined via soil extraction with corresponding chemicals of 0.1 M NaOH, 0.5 M NH_4F and 0.25 M H_2SO_4 and measured in a spectrophotometer at a wavelength of 880 nm. Available P

content was determined via the Bray II method, by which the samples were extracted using a mixture of 0.1 N HCl and 0.03 N NH_4F with soil and water at 1:7 and measured in a spectrophotometer at a wavelength of 880 nm. The Al^{3+} content was extracted using 1.0 N KCl and titrated by 0.01 N H_2SO_4. Concentrations of Fe^{2+} and soluble iron were extracted via 1.0 N KCl, with soil and KCl at a ratio of 10:25 and treated with ammonium acetate-acetic acid, 10% hydroxylamine chloride and 0.25% octophenanthroline, to be colourized and determined using the colorimetric method at a wavelength of 520 nm. The Fe_2O_3 was extracted via oxalate-oxalic acid and the total Fe was digested. These two forms were measured via Atomic Absorption Spectroscopy (AAS) at a wavelength of 248.3 nm. The soil samples were determined for cation exchange capacity (CEC) via extraction with 0.1 M $BaCl_2$ and titrated with 0.01 M EDTA. The exchanging cations (K^+, Na^+, Ca^{2+} and Mg^{2+}), were extracted using 0.1 M $BaCl_2$ and determined via AAS at wavelengths of 766, 589, 422.7 and 285.5 nm. The total Mn was measured via AAS at a wavelength of 279.5 nm.

Plant analysis: Sixty pineapple leaf samples were collected at the pre-flowering stage. Thirty leaves were collected from each pineapple tree, from the first E leaf to the A leaf. In further detail, the E leaf corresponds to the +1 leaf and the collection was carried out until the +30 leaf. The leaves were removed from mud, cut at two ends and dried up at 70°C for 72 hrs before being milled. The leaf analysis method was conducted according to the instructions of Temminghoff and Houba[25]. The milled samples were turned into inorganic forms via an oxidizing mixture (18 mL of distilled water, 100 mL of 96% H_2SO_4 and 6.0 g of salicylic acid). During digestion, H_2O_2 was added to completely oxidize the pineapple leaves. The inorganic solution was adjusted to a volume of 50 mL to determine concentrations of N, P, K, Ca, Mg, Na, Cu, Fe, Zn and Mn. In particular, N content was determined using the Kjeldahl distilling method and titrated using 0.01 N H_2SO_4. The P concentration was determined using a colorimetric method with L-ascorbic acid and measured by a spectrophotometer at a wavelength of 880 nm. Concentrations of K, Ca, Mg, Na, Cu, Fe, Zn and Mn were measured using AAS at wavelengths of 766, 422.7, 285.2, 589, 325, 248.3, 214.1 and 279.5 nm, respectively.

The DRIS norms were established following the method of Beaufils[26], with the high-yielding and low-yielding groups divided according to Letzsch and Sumner[27]. The selection of nutrient ratio pairs or their reverse versions was conducted based on the description of Letzsch[28] and Walworth and Sumner[29], with variance ratios between nutrients in the high-yielding (r) and low-yielding (b) groups:

$$[S^2(A/B)b/S^2(A/B)r]>[S^2(B/A)b/S^2(A/B)r]$$

$$\text{Correlation of norms} = A/B$$

$$[S^2(A/B)b/S^2(A/B)r]<[S^2(B/A)b/S^2(A/B)r]$$

$$\text{Correlation of norms} = B/A$$

where, $S^2(A/B)_r$ was the variance between nutrient ratio pairs A and B in the high-yielding group (r) and $S^2(A/B)_b$ was that in the low-yielding one (b). A table of DRIS norms was established according to the method of Beaufils[26] with the means and standard deviation of the nutrient ratio pairs in the high-yielding group.

Statistical analysis: The t-test was used to compare the means and the F-test was applied to compare differences among variances of 90 nutrient ratio pairs. Principal Component Analysis (PCA) of the soil characteristics and draught of the graphical biplot was conducted using the XLSTAT 2017 software within Microsoft Excel 2017.

RESULTS

Analysis of soil components affecting pineapple cultivation: The values of pH and concentrations of Ca^{2+}, Mg^{2+}, total Fe, NO_3^-, Al^{3+} and K^+ were high and distributed close to the x-axis (the primary components), so they played important roles in the primary component, while the concentrations of total acid, Fe_2O_3 and Fe^{2+}, which were distributed on the opposite side at an angle of 180°, were considered to be low and inversely correlated to the mentioned component. Total N concentration was allocated on the positive side and close to the y-axis (the secondary components), showing a high amount in the soil. Concentrations of available P, insoluble P forms, NH_4^+ and total Mn were on the negative side of the y-axis, i.e., they were low in content in the soil. Thereby, the soil for pineapple cultivation in the Vinh Vien commune had high amounts of total N and NO_3^- (Fig. 1a).

Concentrations of Fe_2O_3, total P, total Mn, organic matter, Fe-P and EC were assigned toward both the x-axis and y-axis with fairly high values. Meanwhile, concentrations of total acid, Fe^{2+} and CEC were near the y-axis with high contents in soil, while other parameters-including total N, NH_4^+, NO_3^-, available P, insoluble P and pH-were distributed on the negative side of the y-axis with lower values and affected the secondary components (Fig. 1b).

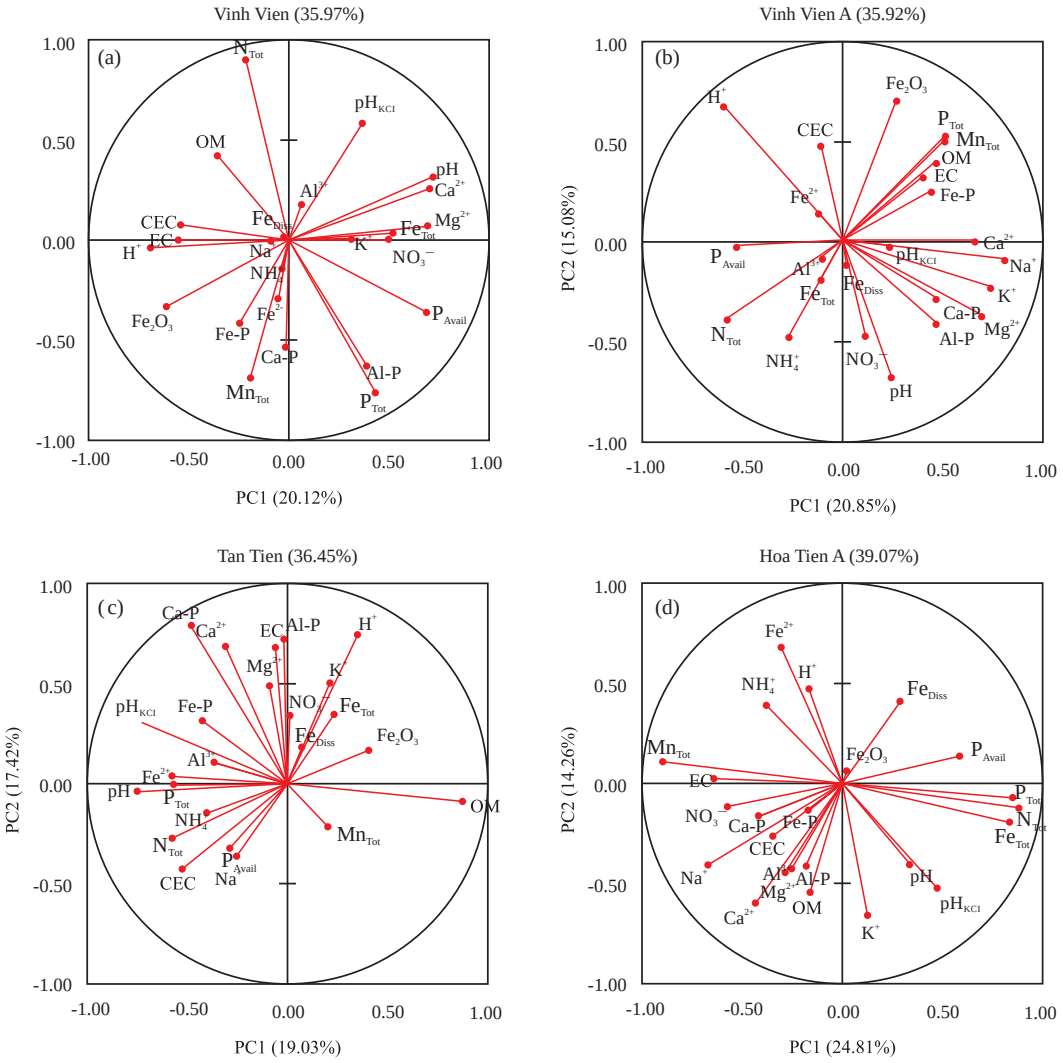

Fig. 1(a-d): Principal component analysis of acid sulfate soil properties for planting pineapple in sites (a) Vinh Vien, (b) Vinh Vien A, (c) Tan Tien and (d) Hoa Tien A

Note: H^+: Total acid, Fe_{Diss}: Dissolved iron, N_{Tot}: Total nitrogen, P_{Tot}: Total potassium, Fe_{Tot}: Total iron, Mn_{Tot}: Total manganese, P_{Avail}: Available potassium and OM: Organic matter

Soil properties, including insoluble P, Ca^{2+}, Mg^{2+}, Fe^{2+}, Al^{3+} and pH_{KCl} were mainly allocated toward the positive side of the y-axis and valued highly. In further detail, concentrations of total N, NH_4^+, total P, available P, Na^+ and values of pH and CEC were low and distributed on nearly the negative side of the y-axis, so they severely affected the secondary components. A high pH_{KCl} value and low organic matter content (180°) on opposite sides to each other was an important factor to improve the chemical properties of soil and limit acid sulfate soil effects on cultivars. The values of pH_{H_2O} appeared on the negative side and close to the x-axis, while the values of Fe_2O_3, dissolved Fe and total Fe was high. The NO_3^- concentration was high and distributed on the positive side of both the x-axis and y-axis (Fig. 1c).

Concentrations of available P, Fe_2O_3 and dissolved Fe were distributed toward the positive side of both the x-axis and y-axis. To be more specific, available P content was close to the x-axis and impacted significantly on the primary components. The values of pH_{H_2O} and pH_{KCl} went toward the negative side of the y-axis and were valued lowly. On the other hand, concentrations of total acid, total Mn and Fe^{2+} were distributed on the opposite side and showed high values. This might be due to the reverse correlation between pH and total acid and Fe^{2+}, which were shown by a distribution 180° apart. Concentrations of total P and total N had high values and were close to the x-axis, showing that they had key effects on the primary components. Concentrations of insoluble P, Al^{3+}, organic matter, cations, NO_3^- and CEC were on the negative side of both the x-axis and y-axis, with low values (Fig. 1d).

The PCA results in the soil intensively used for pineapple cultivation in the communes of Vinh Vien, Vinh Vien A, Tan Tien and Hoa Tien accounted for 35.97, 35.92, 36.45 and 39.07%, respectively, according to variances (Fig. 1a-d). Generally, the soil properties in these communes were all influenced directly by low pH. Pineapple nutrient uptake, growth and development were inhibited by a significant reduction in the availability of soil nutrients.

Determining suitable leaf positions for DRIS norms establishment: Table 1 indicate that pineapple yield in the high-yielding group ($\geq$15.0 t ha^{-1}) was 18.4 t ha^{-1} on average, higher at 1% significance than that in the low-yielding one (<15.0 t ha^{-1}), which was 12.4 t ha^{-1}. In further detail, the number of farms in the high-yielding group and in the low-yielding group was 26 (43.3%) and 34 (56.7%), respectively. The mean concentrations of N, P, K, Ca, Mg, Cu and Zn in the high-yielding group were higher at 5-10% significance than those in the low-yielding one. However, the means of Na, Fe and Mn concentrations in the low-yielding group were higher than those in the high-yielding one.

A total of 9 out of 30 leaf positions were selected as more than 18 nutrient ratio pairs met both requirements: (i) Variance ratio was higher between that ratio and its reverse and (ii) Means and variances were statistically different. These selected nutrient ratio pairs were from leaf positions at +1, +3, +7, +14, +15, +18, +20, +22 and +24, corresponding to 18, 20, 20, 20, 23, 21, 18, 18 and 19 ratio pairs (Tables 2-10). Selected nutrient ratio pairs were compared to these values of DRIS norms for pineapple in the world (Table 11).

Establishing DRIS norms for ratoon pineapple: The nutrient ratio pairs in the DRIS norms at leaf +1 consisted of N/K, Mn/N, P/K, P/Ca, Mn/100 P, 100 Na/K, Cu/K, Fe/100 K, Zn/K, Mn/K, Mn/100 Ca, Na/Mg, Fe/1,000 Mg, Mn/100 Mg, 100 Na/Cu, Fe/10 Cu, Mn/Cu and Mn/Zn, with the average content ratio, coefficient of variation (CV), variance in the high-yielding group and variance ratio between the low-yielding and high-yielding groups being 0.095-42.0, 22.6-57.7, 0.0011-410.0 and 1.94-17.8%, respectively (Table 2).

There were 20 nutrient ratio pairs in the DRIS norms at leaf +3: N/K, 10 Na/N, Cu/N, Mn/N, Ca/K, Mg/K, Cu/K, Fe/100 K, Zn/K, Mn/K, Na/Ca, Mn/100 Ca, Na/Mg, Cu/Mg, Fe/1,000 Mg, Mn/100 Mg, 1,000 Na/Zn, Fe/10 Cu, Fe/Zn and Mn/Zn, with, in the high-yielding group, the average nutrient concentration ratio at 0.048-115.6, the CV at 28.7-76.4%, the variance at 0.00021-2,098.8 and the variance ratio between the low-yielding and high-yielding groups at 1.88-50.6 (Table 3).

The nutrient ratio pairs 10 Na/N, Fe/100 N, Mn/N, P/Na, 100 Na/K, Fe/100 K, Mn/K, Na/Ca, Cu/10 Ca, Mn/100 Ca, Na/Mg, Fe/1,000 Mg, Mn/100 Mg, 100 Na/Cu, 1,000 Na/Zn, Fe/10 Cu, Mn/Cu, Fe/Zn, Fe/Mn and Mn/Zn were selected for the DRIS norms at leaf +7. In-depth, the values recorded in the high-yielding group consisted of the average nutrient concentration ratio (0.10-62.5), the CV (27.3-86.0%), the variance (0.0022-827.2) and the variance ratio between the low-yielding and high-yielding groups (1.64-4.67) (Table 4).

The results of establishing the DRIS norms at leaf +14 with nutrient ratio pairs were N/10 Na, Fe/100 N, Mn/N, P/Na, Fe/1,000 P, Mg/K, 100 Na/K, Cu/K, Fe/100 K, Na/Ca, Fe/1,000 Ca, Mn/100 Ca, Na/Mg, Fe/1,000 Mg, Mn/100 Mg, 1,000 Na/Zn, Fe/10 Cu, Mn/Cu, Fe/Zn and Mn/Zn. In detail, the results recorded in the high-yielding group were 0.063-66.1 for the average nutrient concentration ratio, 23.0-67.7% for the CV, 0.00050-1,415.2 for the variance and 2.00-20.6 for the variance ratio between the low-yielding and high-yielding groups (Table 5).

Up to 23 nutrient ratio pairs were chosen for the DRIS norms at leaf +15. They included N/K, 10 Na/N, Fe/100 N, N/Zn, Mn/N, Mn/100 P, Ca/K, Mg/K, 100 Na/K, Fe/100 K, Na/Ca, Fe/1,000 Ca, Mn/100 Ca, Na/Mg, Fe/1,000 Mg, 100 Mg/Zn, Mn/100 Mg, 100 Na/Cu, 1,000 Na/Zn, Fe/10 Cu, Mn/Cu, Fe/Zn and Mn/Zn. To be more specific, the high-yielding group had an average nutrient concentration ratio, CV, variance and variance ratio between the low-yielding and high-yielding groups of 0.048-58.9, 24.4-60.4%, 0.00014-725.7 and 1.64-16.5, respectively (Table 6).

The nutrient ratio pairs for the DRIS norms at leaf +18 included 10 Na/N, Fe/100 N, Mn/N, Na/P, Fe/1,000 P, Mn/100 P, 100 Na/K, Fe/100 K, Na/Ca, Fe/1,000 Ca, Mn/100 Ca, Na/Mg, Fe/1,000 Mg, Mn/100 Mg, 100 Na/Cu, 10,000 Na/Fe, 1,000 Na/Zn, Fe/10 Cu, Mn/Cu, Fe/Zn and Mn/Zn. The nutrient ratios in the high-yielding group had an average nutrient concentration ratio of 0.089-64.3, a CV of 27.1-91.0%, a variance of 0.0013-1,737.1 and a variance ratio between the low-yielding and high-yielding groups at 1.77-7.46 (Table 7).

Table 8 shows the nutrient ratio pairs chosen for the DRIS norms at leaf +20, including 10 Na/N, Fe/100 N, Mn/N, Na/P, 100 Na/K, Fe/100 K, Mn/K, Na/Ca, Fe/1,000 Ca, Mn/100 Ca, Na/Mg, Fe/1,000 Mg, Mn/100 Mg, 100 Na/Cu, 1,000 Na/Zn, Mn/Cu, Fe/Zn and Mn/Zn, with values of 0.092-58.0, 18.8-77.7, 0.0024-439.4 and 1.64-20.1% in the high-yielding group for the average nutrient concentration ratio, the CV, the variance and the variance ratio between the low-yielding and high-yielding groups, respectively.

Table 1: Mean concentrations, coefficient of variation, variance and variance ratios of N, P, K, Ca, Mg, Na, Cu, Fe, Zn and Mn at leaf +1, +3, +7, +14, +15, +18, +20, +22 and +24

		+1				+3				+7			
Items	Yielding group	Mean	CV (%)	Variance	S^2_i/S^2_h	Mean	CV (%)	Variance	S^2_i/S^2_h	Mean	CV (%)	Variance	S^2_i/S^2_h
Yield (Mg ha^{-1})	High	18.4***	17.9	10.8	0.15^{ns}								
	Low	12.4	10.3	1.63									
N (%)	High	1.50***	15.4	0.053	0.69^{ns}	1.63***	11.6	0.036	0.53^{ns}	1.56***	20.3	0.10	0.41^{ns}
	Low	1.04	18.5	0.037		1.19	11.5	0.019		1.28	15.8	0.041	
P (%)	High	0.20	40.7	0.0065	0.27^{ns}	0.21***	31.8	0.0046	0.27^{ns}	0.20***	30.9	0.0039	0.29^{ns}
	Low	0.16	25.6	0.0017		0.16	21.7	0.0012		0.16	20.8	0.0011	
K (%)	High	2.07***	18.0	0.14	0.92^{ns}	2.25***	15.4	0.12	1.22^{ns}	1.86**	26.6	0.24	1.42^{ns}
	Low	1.27	28.2	0.13		1.40	27.3	0.15		1.54	38.1	0.35	
Ca (%)	High	0.13***	27.4	0.0013	0.31^{ns}	0.11***	24.4	0.00066	0.45^{ns}	0.10***	23.2	0.00059	0.29^{ns}
	Low	0.091	21.7	0.00039		0.084	20.5	0.00030		0.080	16.4	0.00017	
Mg (%)	High	0.13***	22.9	0.00092	0.74^{ns}	0.14***	17.7	0.00058	0.68^{ns}	0.11***	21.8	0.00063	0.59^{ns}
	Low	0.10	25.6	0.00068		0.10	19.5	0.00039		0.092	21.1	0.00037	
Na (%)	High	0.023	36.6	0.000071	1.49^{ns}	0.020	45.5	0.000082	2.65***	0.015	44.9	0.000048	2.10**
	Low	0.028	36.5	0.00011		0.026**	56.3	0.00022		0.022***	45.7	0.00010	
Cu (ppm)	High	17.3**	26.0	20.2	0.64^{ns}	15.1	33.1	25.1	2.68***	16.9	19.9	11.3	3.25***
	Low	14.8	24.4	13.0		15.9	51.5	67.3		15.8	38.3	36.9	
Fe (ppm)	High	284.0	28.3	6440.1	1.46^{ns}	269.8	30.4	6732.6	0.96^{ns}	262.6	27.2	5116.9	1.17^{ns}
	Low	411.8***	23.6	9434.2		387.6***	20.8	6491.3		396.8***	19.5	5991.0	
Zn (ppm)	High	37.5	30.6	132.0	0.98^{ns}	30.5	32.2	96.4	1.97**	27.4	41.4	128.7	0.91^{ns}
	Low	32.8	34.7	129.5		27.3	50.4	189.4		23.2	46.5	116.8	
Mn (ppm)	High	62.0	43.5	726.7	2.28^{ns}	83.6	61.0	2597.3	1.40^{ns}	91.4	31.7	838.2	1.45^{ns}
	Low	101.9***	40.0	1658.9		102.9	58.5	3629.1		111.8***	31.2	1217.3	
		+14				+15				+18			
Items	Yielding group	Mean	CV (%)	Variance	S^2_i/S^2_h	Mean	CV (%)	Variance	S^2_i/S^2_h	Mean	CV (%)	Variance	S^2_i/S^2_h
Yield (Mg ha^{-1})	High	18.4***	17.9	10.8	0.15^{ns}								
	Low	12.4	10.3	1.63									
N (%)	High	1.66***	20.1	0.11	0.42^{ns}	1.64***	16.8	0.076	0.76^{ns}	1.75***	17.8	0.098	0.60^{ns}
	Low	1.41	15.5	0.047		1.38	17.4	0.057		1.49	16.3	0.059	
P (%)	High	0.18***	26.3	0.0023	0.85^{ns}	0.18***	34.9	0.0043	0.40^{ns}	0.19***	33.6	0.0043	0.33^{ns}
	Low	0.14	30.1	0.0019		0.14	29.0	0.0017		0.15	25.5	0.0014	
K (%)	High	1.81**	39.1	0.51	1.05^{ns}	2.00***	30.6	0.37	0.58^{ns}	1.75**	38.2	0.45	0.65^{ns}
	Low	1.42	51.2	0.53		1.31	35.6	0.22		1.34	40.1	0.29	
Ca (%)	High	0.092***	27.4	0.00063	0.46^{ns}	0.093**	29.0	0.00073	1.05^{ns}	0.093***	19.3	0.00032	1.15^{ns}
	Low	0.069	24.9	0.00029		0.077	36.0	0.00076		0.074	25.7	0.00036	
Mg (%)	High	0.10**	21.8	0.00050	0.45^{ns}	0.10**	22.1	0.00050	0.89^{ns}	0.11***	23.4	0.00068	0.59^{ns}
	Low	0.092	16.5	0.00023		0.087	24.4	0.00044		0.092	21.9	0.00040	
Na (%)	High	0.016	38.3	0.000035	4.86***	0.017	36.5	0.000036	1.27^{ns}	0.015	27.8	0.000019	5.18***
	Low	0.024***	53.8	0.00017		0.021***	31.9	0.000046		0.027***	36.9	0.000096	
Cu (ppm)	High	15.0	11.3	2.90	5.40***	18.2***	39.1	50.6	0.39^{ns}	18.8**	29.1	30.0	0.74^{ns}
	Low	13.7	28.8	15.6		13.6	32.6	19.9		15.9	29.5	22.1	
Fe (ppm)	High	246.6	22.0	2949.8	4.02***	312.3	20.5	4092.3	2.63***	291.2	21.4	3890.6	2.71***
	Low	389.3***	28.0	11865.3		397.0***	26.1	10748.3		382.5***	26.8	10539.9	
Zn (ppm)	High	24.0	40.3	93.8	0.77^{ns}	25.6	32.1	67.9	1.34^{ns}	24.3	44.3	116.5	0.84^{ns}
	Low	19.8	42.7	72.2		19.3	49.3	91.3		19.7	50.2	97.8	
Mn (ppm)	High	99.9	40.5	1641.2	2.49***	91.4	36.1	1092.7	2.10**	102.5	47.5	2370.4	1.81*
	Low	141.7***	45.1	4090.5		124.6***	38.4	2290.0		143.2***	45.7	4283.9	
		+20				+22				+24			
Items	Yielding group	Mean	CV (%)	Variance	S^2_i/S^2_h	Mean	CV (%)	Variance	S^2_i/S^2_h	Mean	CV (%)	Variance	S^2_i/S^2_h
Yield (Mg ha^{-1})	High	18.4***	17.9	10.8	0.15^{ns}								
	Low	12.4	10.3	1.63									
N (%)	High	1.84***	20.5	0.14	0.61^{ns}	1.89***	20.1	0.14	0.53^{ns}	1.85***	18.1	0.11	0.43^{ns}
	Low	1.49	19.8	0.087		1.51	18.2	0.076		1.50	15.5	0.055	
P (%)	High	0.18	39.8	0.0051	0.44^{ns}	0.18	38.1	0.0049	0.46^{ns}	0.18**	30.6	0.0030	0.34^{ns}
	Low	0.15	31.0	0.0022		0.15	30.5	0.0022		0.15	28.0	0.0018	

Table 1: Continue

		+20				+22				+24			
Items	Yielding group	Mean	CV (%)	Variance	S^2_l/S^2_h	Mean	CV (%)	Variance	S^2_l/S^2_h	Mean	CV (%)	Variance	S^2_l/S^2_h
K (%)	High	1.84**	41.1	0.57	0.87^{ns}	1.77***	26.9	0.23	0.88^{ns}	1.59**	36.0	0.33	0.39^{ns}
	Low	1.42	49.5	0.50		1.36	32.7	0.20		1.18	51.7	0.38	
Ca (%)	High	0.094***	21.0	0.00038	0.94^{ns}	0.10***	22.4	0.00050	0.66^{ns}	0.10***	20.5	0.00046	0.02^{ns}
	Low	0.076	25.0	0.00036		0.078	23.4	0.00033		0.083	26.6	0.00049	
Mg (%)	High	0.11***	19.5	0.00049	0.97^{ns}	0.11***	18.3	0.00046	0.90^{ns}	0.13***	20.4	0.00075	0.71^{ns}
	Low	0.094	23.3	0.00048		0.099	20.4	0.00041		0.094	21.6	0.00041	
Na (%)	High	0.016	48.5	0.000063	7.10***	0.017	30.3	0.000028	4.63***	0.016	42.5	0.000049	1.18^{ns}
	Low	0.027**	79.3	0.00045		0.025***	44.7	0.00013		0.027***	41.9	0.00013	
Cu (ppm)	High	16.1	29.9	23.2	0.82^{ns}	17.8***	28.0	25.1	0.43^{ns}	16.4	25.2	17.1	0.62^{ns}
	Low	13.7	31.7	19.0		14.5	22.6	10.8		16.2	25.9	17.8	
Fe (ppm)	High	317.2	23.4	5497.2	1.23^{ns}	289.8	26.6	5955.7	1.36^{ns}	290.5	30.9	8046.1	0.68^{ns}
	Low	379.1***	21.7	6763.0		398.5***	22.6	8107.5		404.8***	26.0	11042.4	
Zn (ppm)	High	24.6**	33.1	66.4	0.99^{ns}	24.8**	37.5	86.8	1.07^{ns}	26.4**	33.1	77.0	0.69^{ns}
	Low	19.8	40.7	65.7		19.8	48.4	92.7		21.4	40.1	73.6	
Mn (ppm)	High	94.4	18.6	308.1	1.01^{ns}	102.3	32.9	1134.4	2.83***	107.6	39.1	1774.6	0.90^{ns}
	Low	111.8***	15.8	311.1		130.6**	43.3	3206.4		129.3	39.8	2644.8	

High-yielding group ≥15.0 Mg ha^{-1}, low-yielding group <15.0 Mg ha^{-1}, mean yield and foliar nutrient contents of low and high-yielding groups are significantly different at 1% (***) and 5% (**) level of probability by t-test, variances of low and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) level of probability by F-test and ns: No significant difference

Table 2: Mean, coefficient of variation (CV) and variance (S^2) of nutrient ratios of the low- and high-yielding groups, the variance ratio (S^2_l/S^2_h) and the selected ratios for pineapple leaf +1 DRIS norms

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/S^2_h	Selected ratio
N/P	8.83	41.1	13.2	7.01	40.8	8.18	0.62	
P/N	0.13	41.8	0.0031	0.17	39.8	0.0044	1.41^{ns}	X
N/K	0.75***	22.6	0.029	0.95	59.2	0.32	11.10***	X
K/N	1.41	24.7	0.12	1.28	36.2	0.21	1.77	
N/Ca	12.30	28.3	12.1	11.96	28.5	11.6	0.96^{ns}	
Ca/N	0.087	27.2	0.00056	0.09	28.5	0.00066	1.18	X
N/Mg	11.90	27.1	10.4	11.96	45.2	26.2	2.52	
Mg/N	0.089	24.0	0.00046	0.10	35.8	0.0014	2.95**	X
N/10 Na	7.23***	33.8	5.95	4.41	60.4	7.12	1.20	
10 Na/N	0.16***	42.3	0.0044	0.29	45.1	0.017	3.77^{ns}	X
N/Cu	0.094**	35.8	0.0011	0.08	34.6	0.00068	0.61	
Cu/N	11.80**	29.4	12.0	14.71	32.3	22.5	1.88^{ns}	X
100 N/Fe	0.58***	36.0	0.043	0.27	32.7	0.0077	0.18	
Fe/100 N	1.95***	35.6	0.48	4.14	33.6	1.93	4.00^{ns}	X
N/Zn	0.047	58.4	0.00074	0.04	44.2	0.00025	0.34	
Zn/N	25.50***	31.3	63.7	33.16	43.4	207.4	3.26^{ns}	X
N/Mn	0.029***	40.7	0.00014	0.01	54.8	0.000047	0.35	
Mn/N	42.00***	48.2	410.0	103.92	52.7	3002.9	7.32***	X
P/K	0.10***	35.5	0.0011	0.14	50.9	0.0054	4.72***	X
K/P	11.90***	37.9	20.4	8.44	47.8	16.3	0.80	
P/Ca	1.52**	30.4	0.21	1.88	34.2	0.41	1.94**	X
Ca/P	0.71**	26.5	0.036	0.60	36.2	0.047	1.33	
P/Mg	1.55	41.1	0.41	1.73	40.2	0.49	1.20^{ns}	X
Mg/P	0.78	46.6	0.13	0.68	44.2	0.089	0.68	
P/Na	9.80**	51.3	25.3	6.79	55.1	14.0	0.55^{ns}	X
Na/P	0.15	85.1	0.016	0.19	49.4	0.0087	0.54	
10 P/Cu	0.13	61.7	0.0060	0.12	30.8	0.0013	0.21	
Cu/10 P	10.30	46.5	22.9	9.49	32.3	9.41	0.41^{ns}	X
1000 P/Fe	0.77***	51.1	0.15	0.41	34.6	0.020	0.13	
Fe/1000 P	1.77***	65.9	1.36	2.68	31.4	0.71	0.52^{ns}	X
100 P/Zn	0.58	53.6	0.10	0.55	39.6	0.048	0.49	
Zn/100 P	2.17	45.4	0.97	2.16	45.6	0.97	1.00^{ns}	X

Table 2: Continue

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l / S^2_h	Selected ratio
100 P/Mn	0.33***	25.3	0.0070	0.18	33.8	0.0036	0.51	
Mn/100 P	3.20***	26.2	0.71	6.27	33.7	4.48	6.35***	X
K/Ca	16.80	25.8	18.8	14.52	35.3	26.3	1.40***	
Ca/K	0.063**	26.2	0.00028	0.08	48.7	0.0015	5.54	X
K/Mg	16.40**	28.0	21.1	12.61	23.3	8.62	0.41^{ns}	
Mg/K	0.066***	26.8	0.00031	0.08	24.1	0.00041	1.32	X
K/100 Na	1.03***	46.0	0.22	0.51	46.8	0.057	0.26	
100 Na/K	1.20***	53.4	0.41	2.59	88.5	5.25	12.9***	X
K/Cu	0.13***	31.4	0.0016	0.09	45.4	0.0018	1.14	
Cu/K	8.53***	28.9	6.08	13.49	60.3	66.1	10.9***	X
100 K/Fe	0.79***	32.3	0.065	0.33	37.1	0.015	0.22	
Fe/100 K	1.44***	41.7	0.36	3.74	67.4	6.34	17.7***	X
K/Zn	0.063***	48.0	0.00090	0.04	43.4	0.00034	0.37	
Zn/K	18.60***	33.8	39.5	28.30	50.2	202.0	5.11***	X
K/Mn	0.039***	38.2	0.00022	0.02	65.5	0.00010	0.46	
Mn/K	29.80***	37.6	125.1	89.69	52.6	2227.4	17.8***	X
Ca/Mg	1.01	26.7	0.073	0.96	36.6	0.12	1.71*	X
Mg/Ca	1.07	30.7	0.11	1.17	33.0	0.15	1.36	
Ca/Na	6.40***	43.3	7.66	3.78	51.8	3.82	0.50	
Na/Ca	0.20***	68.9	0.020	0.33	44.2	0.021	1.08^{ns}	X
10 Ca/Cu	0.082	45.5	0.0014	0.07	39.4	0.00069	0.50	
Cu/10 Ca	14.40	35.4	25.8	17.07	33.5	32.7	1.27^{ns}	X
1000 Ca/Fe	0.50***	40.7	0.042	0.23	31.0	0.0052	0.12	
Fe/1000 Ca	2.47***	58.2	2.06	4.74	33.0	2.44	1.18^{ns}	X
100 Ca/Zn	0.40**	65.1	0.068	0.30	29.3	0.0076	0.11	
Zn/100 Ca	3.09**	36.5	1.27	3.62	27.3	0.98	0.77^{ns}	X
100 Ca/Mn	0.23***	32.5	0.0057	0.11	50.2	0.0029	0.50	
Mn/100 Ca	4.79***	36.4	3.05	11.81	48.8	33.3	10.9***	X
Mg/Na	6.37***	38.2	5.93	4.03	40.4	2.65	0.45	
Na/Mg	0.18***	44.9	0.0068	0.30	57.9	0.030	4.33***	X
Mg/Cu	0.0082	37.6	0.000010	0.01	45.6	0.000012	1.23	
Cu/Mg	138.30	38.0	2758.5	160.58	47.4	5785.3	2.10**	X
1000 Mg/Fe	0.51***	41.2	0.044	0.26	30.7	0.0062	0.14	
Fe/1000 Mg	2.30***	41.0	0.89	4.35	42.8	3.46	3.91***	X
100 Mg/Zn	0.39	48.9	0.037	0.34	37.5	0.016	0.44	
Zn/100 Mg	2.90	29.7	0.74	3.41	41.0	1.95	2.64***	X
100 Mg/Mn	0.25***	51.4	0.017	0.12	63.8	0.0062	0.36	
Mn/100 Mg	4.87***	44.9	4.78	10.93	49.1	28.8	6.02***	X
100 Na/Cu	0.15**	53.0	0.0061	0.21	55.2	0.014	2.21**	X
Cu/100 Na	8.55	46.1	15.6	6.22	59.2	13.6	0.87	
10000 Na/Fe	0.85	36.7	0.10	0.70	35.0	0.061	0.63	
Fe/10000 Na	1.33	34.3	0.21	1.65	43.1	0.51	2.44***	X
1000 Na/Zn	0.70	57.8	0.16	0.95	46.0	0.19	1.18^{ns}	X
Zn/1000 Na	1.80	42.8	0.59	1.35	58.7	0.63	1.05	
1000 Na/Mn	0.47	68.6	0.10	0.35	69.6	0.058	0.56	
Mn/1000 Na	3.09	60.1	3.46	4.25	58.1	6.09	1.76*	X
10 Cu/Fe	0.65***	36.8	0.058	0.37	28.5	0.011	0.19	
Fe/10 Cu	1.75***	38.9	0.47	2.94	32.3	0.90	1.94**	X
Cu/Zn	0.55	61.7	0.11	0.51	43.7	0.051	0.44	
Zn/Cu	2.43	52.8	1.64	2.49	58.4	2.11	1.29^{ns}	X
Cu/Mn	0.33***	47.8	0.025	0.17	50.5	0.0073	0.29	
Mn/Cu	3.81***	49.6	3.57	7.19	42.1	9.18	2.57***	X
Fe/Zn	8.95***	59.4	28.3	13.82	35.5	24.1	0.85^{ns}	X
Zn/Fe	0.15***	49.9	0.0055	0.08	42.3	0.0012	0.23	
Fe/Mn	5.65	59.6	11.3	4.85	51.7	6.29	0.56	
Mn/Fe	0.24	51.2	0.015	0.26	48.2	0.016	1.07^{ns}	X
Zn/Mn	0.72***	54.3	0.15	0.38	54.4	0.043	0.28	
Mn/Zn	1.86***	57.7	1.15	3.50	56.2	3.86	3.35***	X

Mean nutrient ratios of low and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) levels of probability by t-test, variances of nutrient ratios of low and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) level of probability by F-test and ns: No significant difference

Table 3: Mean, coefficient of variation (CV) and variance (S^2) of nutrient ratios of the low- and high-yielding groups, the variance ratio (S^2_l/S^2_h) and the selected ratios for pineapple leaf +3 DRIS norms

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/S^2_h	Selected ratio
N/P	8.57	37.7	10.50	7.80	25.7	4.01	0.38	
P/N	0.13	34.3	0.0020	0.14	25.7	0.0012	0.60^{ns}	X
N/K	0.74**	18.3	0.018	1.04	79.6	0.68	37.00***	X
K/N	1.39**	17.4	0.058	1.20	31.7	0.14	2.47	
N/Ca	16.20	22.4	13.1	14.80	23.4	11.9	0.91^{ns}	X
Ca/N	0.065	27.1	0.00031	0.071	22.8	0.00026	0.83	
N/Mg	12.40	25.2	9.81	14.80	27.8	11.6	1.19	
Mg/N	0.085	22.6	0.00037	0.087	24.3	0.00045	1.22^{ns}	X
N/10 Na	9.36***	33.0	9.52	5.86	61.7	13.1	1.37	
10 Na/N	0.12***	42.6	0.0027	0.22	56.2	0.016	5.83***	X
N/Cu	0.13**	52.5	0.0043	0.089	49.7	0.0020	0.46	
Cu/N	9.40***	35.5	11.2	13.60	53.2	52.3	4.68***	X
100 N/Fe	0.67***	36.5	0.060	0.32	24.8	0.0063	0.11	
Fe/100 N	1.68***	32.7	0.30	3.29	23.6	0.60	1.99^{ns}	X
N/Zn	0.060	41.8	0.00063	0.054	44.0	0.00056	0.89	
Zn/N	19.00	34.2	42.1	23.20	53.1	151.4	3.60***	X
N/Mn	0.052	122.0	0.0039	0.031	127.4	0.0015	0.39	
Mn/N	52.30***	63.8	1113.4	88.40	61.5	2956.5	2.66*	X
P/K	0.10	31.8	0.00092	0.14	98.6	0.020	21.70***	X
K/P	11.70**	37.2	18.8	9.24	36.3	11.3	0.60	
P/Ca	2.04	31.4	0.41	1.99	30.7	0.37	0.90	
Ca/P	0.53	26.8	0.020	0.55	27.9	0.023	1.15^{ns}	X
P/Mg	1.62	40.0	0.42	1.66	35.2	0.34	0.81^{ns}	X
Mg/P	0.71	38.1	0.074	0.67	34.2	0.053	0.72	
P/Na	12.60***	50.1	39.8	7.66	61.0	21.8	0.55	
Na/P	0.11***	69.6	0.0057	0.16	45.9	0.0056	1.00^{ns}	X
10 P/Cu	0.17**	70.9	0.014	0.12	40.2	0.0022	0.16	
Cu/10 P	8.05	49.7	16.0	10.30	52.7	29.6	1.85**	X
1000 P/Fe	0.89***	50.2	0.20	0.43	31.5	0.019	0.093	
Fe/1000 P	1.50***	65.1	0.95	2.54	30.8	0.61	0.64^{ns}	X
100 P/Zn	0.76	43.8	0.11	0.72	48.0	0.12	1.09	
Zn/100 P	1.56	39.2	0.37	1.77	50.7	0.80	2.15**	X
100 P/Mn	0.77	138.6	1.15	0.41	124.4	0.26	0.22	
Mn/100 P	4.86	88.0	18.3	6.85	66.6	20.8	1.14^{ns}	X
K/Ca	22.30***	25.2	31.8	17.40	36.5	40.1	1.26	
Ca/K	0.048**	30.0	0.00021	0.071	76.7	0.0030	14.4***	X
K/Mg	17.30**	32.2	31.1	14.10	32.2	20.5	0.66	
Mg/K	0.063**	28.7	0.00033	0.084	58.2	0.0024	7.26***	X
K/100 Na	1.28***	33.9	0.19	0.67	46.2	0.095	0.50	
100 Na/K	0.88	37.8	0.11	2.87	214.1	37.7	341.8***	X
K/Cu	0.17***	39.9	0.0044	0.11	61.5	0.0044	0.99	
Cu/K	6.75***	31.7	4.59	14.50	105.3	232.1	50.6***	X
100 K/Fe	0.91***	33.5	0.093	0.38	38.0	0.021	0.22	
Fe/100 K	1.22***	33.6	0.17	3.25	64.9	4.45	26.4***	X
K/Zn	0.083	45.2	0.0014	0.065	58.8	0.0014	1.02	
Zn/K	14.10**	38.8	30.0	23.80	93.8	496.9	16.6***	X
K/Mn	0.068	120.0	0.01	0.037	130.7	0.0024	0.36	
Mn/K	37.70***	65.4	608.4	85.90	78.2	4507.6	7.41***	X
Ca/Mg	0.80	28.9	0.053	0.86	31.8	0.076	1.42^{ns}	X
Mg/Ca	1.35	25.9	0.12	1.27	31.3	0.16	1.30	
Ca/Na	6.12***	40.8	6.25	3.95	45.4	3.20	0.51	
Na/Ca	0.20***	54.0	0.012	0.32	58.3	0.035	3.00***	X
10 Ca/Cu	0.086	72.9	0.0039	0.064	58.5	0.0014	0.35	
Cu/10 Ca	15.60	42.4	43.5	19.90	53.8	114.5	2.63***	X
1000 Ca/Fe	0.45***	56.2	0.065	0.23	32.1	0.0053	0.082	
Fe/1000 Ca	2.79***	44.1	1.51	4.81	28.6	1.89	1.25^{ns}	X
100 Ca/Zn	0.37	32.4	0.014	0.36	36.3	0.017	1.20	

Table 3: Continue

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/S^2_h	Selected ratio
Zn/100 Ca	2.91	22.7	0.44	3.24	49.0	2.51	5.77***	X
100 Ca/Mn	0.42	144.2	0.36	0.24	130.9	0.10	0.27	
Mn/100 Ca	9.13**	69.8	40.6	13.50	64.7	76.5	1.88**	X
Mg/Na	8.12***	41.4	11.3	4.83	47.8	5.35	0.47	
Na/Mg	0.16**	76.4	0.015	0.27	72.4	0.038	2.53***	X
Mg/Cu	0.01**	53.1	0.000031	0.0076	50.3	0.000015	0.47	
Cu/Mg	115.60***	39.6	2093.8	162.80	53.1	7469.3	3.57***	X
1000 Mg/Fe	0.56***	38.0	0.045	0.27	28.2	0.0060	0.13	
Fe/1000 Mg	2.06***	37.4	0.59	4.00	35.9	2.06	3.47***	X
100 Mg/Zn	0.50	40.5	0.040	0.46	49.2	0.051	1.26	
Zn/100 Mg	2.31	36.7	0.72	2.78	51.9	2.08	2.89***	X
100 Mg/Mn	0.44	131.4	0.34	0.25	120.8	0.092	0.27	
Mn/100 Mg	6.36***	64.2	16.7	10.40	60.8	39.7	2.38**	X
100 Na/Cu	0.15	50.3	0.0054	0.19	60.3	0.013	2.35**	X
Cu/100 Na	8.84	56.2	24.7	7.50	65.4	24.1	0.97	
10000 Na/Fe	0.82	64.5	0.28	0.69	64.1	0.20	0.71	
Fe/10000 Na	1.56	42.1	0.43	1.82	48.6	0.79	1.83*	X
1000 Na/Zn	0.74**	62.1	0.21	1.12	61.8	0.48	2.29**	X
Zn/1000 Na	1.80**	50.2	0.82	1.25	62.6	0.61	0.75	
1000 Na/Mn	0.59	121.0	0.52	0.66	122.9	0.66	1.27^{ns}	X
Mn/1000 Na	4.94	76.6	14.3	5.17	77.1	15.9	1.11	
10 Cu/Fe	0.59***	37.7	0.050	0.42	51.3	0.047	0.95	
Fe/10 Cu	1.95***	40.6	0.63	2.83	40.2	1.30	2.07**	X
Cu/Zn	0.59	57.8	0.12	0.76	73.5	0.31	2.68***	X
Zn/Cu	2.58	82.4	4.52	2.20	84.3	3.43	0.76	
Cu/Mn	0.35	96.1	0.11	0.32	104.4	0.11	0.96	
Mn/Cu	5.42	68.5	13.8	6.83	67.3	21.1	1.53^{ns}	X
Fe/Zn	10.00***	46.3	21.6	17.50	47.0	67.7	3.14***	X
Zn/Fe	0.13***	61.4	0.0064	0.074	56.0	0.0017	0.27	
Fe/Mn	6.86	113.0	60.1	9.38	120.6	127.7	2.12**	X
Mn/Fe	0.29	55.6	0.027	0.27	59.2	0.025	0.95	
Zn/Mn	1.24	148.2	3.41	1.01	147.7	2.23	0.65	
Mn/Zn	3.23***	65.4	4.48	5.43	72.7	15.6	3.48***	X

Mean nutrient ratios of low and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) levels of probability by t-test, variances of nutrient ratios of low and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) level of probability by F-test and ns: No significant difference

Table 4: Mean, coefficient of variation (CV) and variance (S^2) of nutrient ratios of the low and high-yielding groups, the variance ratio (S^2_l/S^2_h) and the selected ratios for pineapple leaf +7 DRIS norms

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/S^2_h	Selected ratio
N/P	8.21	25.5	4.40	8.29	26.9	4.97	1.13^{ns}	X
P/N	0.13	28.5	0.0014	0.13	25.6	0.0011	0.79	
N/K	0.90	34.5	0.10	0.96	40.6	0.15	1.58	
K/N	1.23	33.1	0.17	1.27	51.2	0.42	2.54***	X
N/Ca	15.40	25.4	15.4	16.30	16.1	6.92	0.45^{ns}	X
Ca/N	0.069	29.1	0.00041	0.063	17.0	0.00011	0.28	
N/Mg	14.30	36.4	27.3	16.30	30.2	19.9	0.73	
Mg/N	0.076	27.0	0.00043	0.073	29.0	0.00045	1.06^{ns}	X
N/10 Na	12.00**	51.4	38.1	8.09	90.5	53.5	1.40	
10 Na/N	0.10***	61.8	0.0042	0.18	50.1	0.0078	1.86**	X
N/Cu	0.10	27.7	0.00071	0.093	40.8	0.0014	2.01	
Cu/N	11.20	29.5	11.0	12.70	42.2	28.6	2.59***	X
100 N/Fe	0.68***	54.8	0.14	0.34	32.0	0.012	0.086	
Fe/100 N	1.78***	40.1	0.51	3.20	31.0	0.98	1.93***	X
N/Zn	0.075	86.8	0.0043	0.067	46.4	0.0010	0.22	
Zn/N	18.10	40.1	52.84	17.90	42.6	58.6	1.11^{ns}	X
N/Mn	0.019***	43.6	0.000072	0.013	41.5	0.000029	0.40	

Table 4: Continue

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/ S^2_h	Selected ratio
Mn/N	62.50***	46.0	827.2	91.30	42.1	1477.8	1.79*	X
P/K	0.11	37.7	0.0018	0.12	42.2	0.0025	1.37	
K/P	9.78	31.2	9.31	9.87	40.0	15.6	1.68*	X
P/Ca	1.97	33.5	0.44	2.08	25.7	0.29	0.66	
Ca/P	0.55	27.4	0.023	0.51	27.1	0.019	0.84^{ns}	X
P/Mg	1.88	50.7	0.91	1.85	31.6	0.34	0.38	
Mg/P	0.62	34.9	0.047	0.59	27.7	0.026	0.55^{ns}	X
P/Na	15.70**	55.2	75.4	10.50	105.1	123.8	1.64*	X
Na/P	0.089***	79.4	0.0050	0.14	48.2	0.0048	0.96	
10 P/Cu	0.12	36.2	0.0020	0.11	37.8	0.0018	0.90^{ns}	X
Cu/10 P	9.30	43.5	16.3	9.95	35.6	12.5	0.77	
1000 P/Fe	0.88***	56.8	0.25	0.42	22.6	0.0089	0.036	
Fe/1000 P	1.48***	54.9	0.65	2.52	23.2	0.34	0.52^{ns}	X
100 P/Zn	0.95	78.4	0.56	0.88	52.5	0.21	0.38	
Zn/100 P	1.47	45.4	0.45	1.55	59.2	0.85	1.90**	X
100 P/Mn	0.26***	54.1	0.020	0.16	38.4	0.0038	0.19	
Mn/100 P	5.30**	62.1	10.8	7.27	41.1	8.92	0.82^{ns}	X
K/Ca	18.20	31.2	32.3	20.30	48.5	96.9	3.00***	X
Ca/K	0.060	28.5	0.00029	0.059	39.6	0.00055	1.93	
K/Mg	16.60	31.6	27.5	17.60	45.0	62.9	2.28	
Mg/K	0.065	26.0	0.00029	0.067	40.6	0.00074	2.60***	X
K/100 Na	1.46***	57.5	0.71	0.88	70.0	0.38	0.53	
100 Na/K	0.93***	62.4	0.33	1.53	50.9	0.60	1.81*	X
K/Cu	0.11	38.5	0.0020	0.11	48.5	0.0028	1.44	
Cu/K	9.77	32.6	10.1	11.70	56.3	43.8	4.31***	X
100 K/Fe	0.77***	41.3	0.10	0.40	39.0	0.024	0.24	
Fe/100 K	1.51***	41.4	0.39	2.89	38.2	1.22	3.11***	X
K/Zn	0.085	65.3	0.0031	0.056	66.9	0.0033	1.07	
Zn/K	15.60	46.5	53.3	17.70	60.0	112.8	2.11**	X
K/Mn	0.022***	34.1	0.000057	0.015	40.7	0.000035	0.63	
Mn/K	52.40***	45.9	578.7	79.4	39.5	983.5	1.70*	X
Ca/Mg	0.95	29.1	0.077	0.91	28.0	0.065	0.85^{ns}	X
Mg/Ca	1.14	28.2	0.10	1.17	23.9	0.078	0.76	
Ca/Na	8.22**	55.9	21.1	5.10	108.6	30.6	1.45	
Na/Ca	0.16***	64.6	0.011	0.28	49.1	0.019	1.79*	X
10 Ca/Cu	0.064	24.9	0.00025	0.058	46.1	0.00072	2.84	
Cu/10 Ca	16.70**	27.3	20.8	20.50	42.5	76.4	3.67***	X
1000 Ca/Fe	0.45***	44.1	0.039	0.21	27.8	0.0034	0.087	
Fe/1000 Ca	2.67***	43.9	1.37	5.13	28.5	2.14	1.56^{ns}	X
100 Ca/Zn	0.47	62.5	0.087	0.42	47.4	0.039	0.45	
Zn/100 Ca	2.64	38.2	1.02	2.93	44.9	1.73	1.69*	X
100 Ca/Mn	0.13***	50.2	0.0044	0.080	41.5	0.0011	0.25	
Mn/100 Ca	9.44***	50.7	22.8	14.70	41.6	37.4	1.64*	X
Mg/Na	9.06**	59.6	29.1	5.84	115.0	45.1	1.55	
Na/Mg	0.14***	54.0	0.0060	0.25	52.6	0.017	2.86***	X
Mg/Cu	0.0071	31.7	0.0000051	0.066	42.4	0.0000077	1.53	
Cu/Mg	154.60	31.8	2423.4	185.70	58.0	11589.2	4.78***	X
1000 Mg/Fe	0.48***	45.2	0.048	0.24	28.3	0.0046	0.10	
Fe/1000 Mg	2.38***	36.4	0.75	4.57	34.6	2.50	3.34***	X
100 Mg/Zn	0.54	75.8	0.16	0.48	46.8	0.050	0.30	
Zn/100 Mg	2.47	43.9	1.18	2.64	50.3	1.76	1.49^{ns}	X
100 Mg/Mn	0.14***	40.6	0.0032	0.090	36.6	0.0011	0.34	
Mn/100 Mg	8.37***	43.4	13.1	12.80	40.8	27.5	2.08**	X
100 Na/Cu	0.10***	49.3	0.0022	0.16	62.5	0.010	4.63***	X
Cu/100 Na	13.20	62.9	68.9	10.20	92.3	89.2	1.29	
10000 Na/Fe	0.67	60.6	0.16	0.57	44.2	0.064	0.39	
Fe/10000 Na	2.07	63.6	1.73	2.48	91.1	5.11	2.95***	X

Table 4: Continue

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/ S^2_h	Selected ratio
1000 Na/Zn	0.72**	86.0	0.38	1.16	74.3	0.74	1.94**	X
Zn/1000 Na	2.00**	43.8	0.77	1.36	86.4	1.38	1.80	
1000 Na/Mn	0.19	56.3	0.011	0.21	50.0	0.011	0.97	
Mn/1000 Na	6.98	49.3	11.8	6.83	95.0	42.0	3.56***	X
10 Cu/Fe	0.71***	41.0	0.084	0.41	38.3	0.025	0.29	
Fe/10 Cu	1.60***	32.4	0.27	2.80	38.9	1.18	4.39***	X
Cu/Zn	0.79	67.7	0.28	0.90	76.3	0.47	1.65	
Zn/Cu	1.69	47.9	0.65	1.73	63.1	1.20	1.83*	X
Cu/Mn	0.20**	37.1	0.0057	0.16	49.5	0.0060	1.05	
Mn/Cu	5.55***	35.5	3.89	8.00	47.1	14.2	3.66***	X
Fe/Zn	11.40***	51.9	35.3	21.80	58.8	164.9	4.67***	X
Zn/Fe	0.11***	56.0	0.0040	0.064	61.2	0.0015	0.38	
Fe/Mn	3.04***	34.0	1.07	3.88	35.2	1.86	1.75*	X
Mn/Fe	0.36**	31.5	0.013	0.29	38.9	0.013	0.99	
Zn/Mn	0.35	70.1	0.060	0.24	71.6	0.031	0.51	
Mn/Zn	4.15**	55.4	5.29	6.14	57.6	12.5	2.37**	X

Mean nutrient ratios of low and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) levels of probability by t-test, variances of nutrient ratios of low and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) level of probability by F-test and ns: No significant difference

Table 5: Mean, coefficient of variation (CV) and variance (S^2) of nutrient ratios of the low- and high-yielding groups, the variance ratio (S^2_l/S^2_h) and the selected ratios for pineapple leaf +14 DRIS norms

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/ S^2_h	Selected ratio
N/P	9.54	24.4	5.43	10.20	30.3	9.69	1.78*	X
P/N	0.11	26.6	0.00088	0.10	29.5	0.0010	1.11	
N/K	1.01	31.6	0.10	1.26	52.2	0.43	4.25***	X
K/N	1.13	47.7	0.29	1.06	57.2	0.36	1.26	
N/Ca	19.00	27.1	26.4	21.40	22.7	23.6	0.89^{ns}	X
Ca/N	0.056	29.8	0.00028	0.049	22.9	0.00013	0.44	
N/Mg	17.20	37.2	40.9	21.40	24.0	14.4	0.35	
Mg/N	0.066	33.5	0.00048	0.067	24.8	0.00028	0.57^{ns}	X
N/10 Na	11.90**	34.5	16.9	8.01	90.5	52.6	3.11***	X
10 Na/N	0.10***	54.9	0.0030	0.17	51.9	0.0084	2.82	
N/Cu	0.11	23.7	0.00070	0.11	32.2	0.0013	1.79*	X
Cu/N	9.44	24.5	5.34	9.89	27.7	7.51	1.41	
100 N/Fe	0.71***	34.4	0.060	0.38	28.9	0.012	0.21	
Fe/100 N	1.55***	33.9	0.27	2.82	30.3	0.73	2.64***	X
N/Zn	0.078	37.5	0.00085	0.083	42.5	0.0013	1.48^{ns}	X
Zn/N	14.60	36.3	28.1	14.10	42.8	36.9	1.31	
N/Mn	0.020***	54.4	0.00012	0.012	51.9	0.000042	0.34	
Mn/N	66.10***	56.9	1415.2	106.80	55.2	3474.8	2.46***	X
P/K	0.10	29.1	0.0010	0.13	59.0	0.0059	6.10***	X
K/P	10.10	27.4	7.66	10.40	55.1	33.3	4.35	
P/Ca	2.08	34.0	0.50	2.22	32.2	0.51	1.02^{ns}	X
Ca/P	0.52	31.0	0.02	0.49	31.8	0.024	0.92	
P/Mg	1.87	36.4	0.46	1.64	34.0	0.31	0.67^{ns}	X
Mg/P	0.62	43.9	0.074	0.67	32.2	0.047	0.63	
P/Na	13.20**	35.6	22.2	8.97	117.4	110.8	4.99***	X
Na/P	0.099***	78.2	0.0060	0.18	61.6	0.012	2.14	
10 P/Cu	0.12	29.8	0.0013	0.11	43.0	0.0025	1.84*	X
Cu/10 P	8.98	36.2	10.6	10.00	37.5	14.2	1.34	
1000 P/Fe	0.77***	31.6	0.059	0.39	34.5	0.018	0.32	
Fe/1000 P	1.45***	40.0	0.33	2.81	34.2	0.92	2.75***	X
100 P/Zn	0.86	45.2	0.15	0.92	59.8	0.30	2.02	
Zn/100 P	1.37	38.7	0.28	1.51	57.7	0.76	2.69***	X
100 P/Mn	0.22***	49.9	0.012	0.12	52.1	0.0044	0.36	

Table 5: Continue

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/ S^2_h	Selected ratio
Mn/100 P	6.46***	76.0	24.1	10.50	55.1	33.6	1.39^{ns}	X
K/Ca	21.20	55.5	139.6	23.10	67.1	240.6	1.72	
Ca/K	0.056	33.6	0.00035	0.061	53.5	0.0011	3.13***	X
K/Mg	18.30	41.7	58.4	16.00	58.1	87.2	1.49	
Mg/K	0.063**	35.3	0.00050	0.079	45.3	0.0013	2.64***	X
K/100 Na	1.30***	43.9	0.32	0.71	63.1	0.20	0.63	
100 Na/K	0.98***	61.7	0.36	2.08	77.6	2.62	7.12***	X
K/Cu	0.12	39.2	0.0023	0.11	64.2	0.0056	2.45	
Cu/K	9.20**	30.1	7.68	12.40	59.0	53.8	7.00***	X
100 K/Fe	0.74***	27.8	0.042	0.39	57.6	0.051	1.21	
Fe/100 K	1.46***	30.3	0.19	3.46	58.2	4.05	20.6***	X
K/Zn	0.089	55.5	0.0024	0.095	82.5	0.0062	2.56***	X
Zn/K	15.20	57.5	76.3	18.50	65.3	146.1	1.91	
K/Mn	0.021***	47.5	0.00010	0.010	38.6	0.000017	0.17	
Mn/K	62.60***	61.1	1462.9	107.30	35.7	1465.8	1.00^{ns}	X
Ca/Mg	0.93**	34.9	0.10	0.76	27.4	0.043	0.41	
Mg/Ca	1.21	37.1	0.20	1.41	28.2	0.15	0.79^{ns}	X
Ca/Na	6.64***	39.4	6.84	4.01	98.4	15.63	2.28	
Na/Ca	0.18***	61.0	0.013	0.37	50.7	0.036	2.78***	X
10 Ca/Cu	0.063	36.1	0.00051	0.052	31.8	0.00028	0.54	
Cu/10 Ca	17.70	31.7	31.6	20.50	25.1	26.70	0.84^{ns}	X
1000 Ca/Fe	0.39***	40.3	0.025	0.18	33.2	0.0038	0.15	
Fe/1000 Ca	2.94***	42.8	1.58	5.92	30.0	3.16	2.00**	X
100 Ca/Zn	0.43	42.9	0.034	0.40	49.9	0.041	1.22	
Zn/100 Ca	2.72	39.6	1.16	3.04	47.8	2.10	1.80*	X
100 Ca/Mn	0.10***	48.3	0.0028	0.061	57.2	0.0012	0.44	
Mn/100 Ca	12.1***	60.7	54.2	22.80	60.8	192.7	3.56***	X
Mg/Na	7.48**	42.6	10.1	5.18	82.6	18.3	1.80	
Na/Mg	0.15***	43.3	0.0047	0.27	62.3	0.030	6.37***	X
Mg/Cu	0.0069	24.4	0.0000029	0.0071	28.2	0.0000040	1.41	
Cu/Mg	152.70	24.5	1395.2	151.70	29.3	1976.3	1.42^{ns}	X
1000 Mg/Fe	0.44***	37.4	0.027	0.25	27.7	0.0048	0.17	
Fe/1000 Mg	2.51***	31.4	0.62	4.33	30.9	1.79	2.89***	X
100 Mg/Zn	0.48	36.6	0.031	0.55	45.5	0.063	2.01**	X
Zn/100 Mg	2.40	43.8	1.10	2.22	47.1	1.09	0.99	
100 Mg/Mn	0.11***	29.0	0.0011	0.078	45.8	0.0013	1.19	
Mn/100 Mg	9.70***	37.6	13.3	15.80	48.1	57.7	4.33***	X
100 Na/Cu	0.10***	38.7	0.0016	0.18	45.2	0.0072	4.41	
Cu/100 Na	10.80	35.2	14.5	8.25	116.0	91.7	6.30***	X
10000 Na/Fe	0.65	41.4	0.073	0.67	60.8	0.16	2.28	
Fe/10000 Na	1.73	32.9	0.32	2.26	108.4	6.05	18.4***	X
1000 Na/Zn	0.77***	66.9	0.26	1.46	64.5	0.88	3.32***	X
Zn/1000 Na	1.73***	47.4	0.67	1.08	80.3	0.75	1.12	
1000 Na/Mn	0.17	44.0	0.0058	0.20	60.5	0.014	2.53	
Mn/1000 Na	6.89	44.7	9.49	7.42	74.3	30.4	3.21***	X
10 Cu/Fe	0.64***	24.7	0.024	0.37	35.7	0.017	0.70	
Fe/10 Cu	1.65***	23.0	0.14	2.98	31.0	0.85	5.93***	X
Cu/Zn	0.72	38.7	0.078	0.84	58.2	0.23	3.07***	X
Zn/Cu	1.62	42.8	0.47	1.59	58.3	0.86	1.80	
Cu/Mn	0.17***	39.2	0.0047	0.11	48.9	0.0033	0.70	
Mn/Cu	6.68***	41.3	7.63	11.10	55.0	37.4	4.90***	X
Fe/Zn	12.00***	44.3	28.3	24.20	68.3	274.0	9.67***	X
Zn/Fe	0.10***	54.8	0.0033	0.055	52.8	0.00085	0.25	
Fe/Mn	2.83	41.8	1.40	3.38	54.6	3.41	2.44***	X
Mn/Fe	0.42	43.3	0.033	0.38	50.4	0.038	1.16	
Zn/Mn	0.29**	60.3	0.030	0.19	77.5	0.022	0.74	
Mn/Zn	5.05***	67.7	11.6	9.68	79.0	58.5	5.00***	X

Mean nutrient ratios of low- and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) levels of probability by t-test, variances of nutrient ratios of low and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) level of probability by F-test and ns: No significant difference

Table 6: Mean, coefficient of variation (CV) and variance (S^2) of nutrient ratios of the low and high-yielding groups, the variance ratio (S^2_l/S^2_h) and the selected ratios for pineapple leaf +15 DRIS norms

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/S^2_h	Selected ratio
N/P	9.51	28.1	7.17	10.30	31.7	10.8	1.51^{ns}	X
P/N	0.11	29.3	0.0011	0.11	34.4	0.0013	1.22	
N/K	0.88***	28.8	0.064	1.18	38.3	0.20	3.16****	X
K/N	1.22**	27.9	0.11	1.00	47.0	0.22	1.90	
N/Ca	18.80	29.2	30.1	19.60	30.9	36.8	1.22^{ns}	X
Ca/N	0.057	28.1	0.00026	0.056	30.5	0.00029	1.11	
N/Mg	17.20	31.8	30.0	19.60	27.2	20.8	0.69	
Mg/N	0.064	31.6	0.00041	0.064	28.5	0.00033	0.82^{ns}	X
N/10 Na	10.9***	33.5	13.5	7.25	43.8	10.1	0.74	
10 Na/N	0.10***	36.8	0.0014	0.16	36.3	0.0033	2.36**	X
N/Cu	0.11	54.0	0.0035	0.12	47.5	0.0030	0.86^{ns}	X
Cu/N	11.60	48.0	31.1	10.30	40.9	18.0	0.58	
100 N/Fe	0.55***	34.6	0.037	0.36	24.7	0.0081	0.22	
Fe/100 N	1.94***	25.2	0.24	2.93	27.8	0.66	2.76***	X
N/Zn	0.069**	30.6	0.00045	0.093	60.9	0.0032	7.10***	X
Zn/N	15.70	29.1	21.0	14.10	47.4	44.9	2.14	
N/Mn	0.021***	53.9	0.00014	0.013	44.7	0.000034	0.25	
Mn/N	58.9***	45.7	725.7	95.70	50.0	2294.2	3.16***	X
P/K	0.098	36.8	0.0013	0.12	47.6	0.0034	2.60***	X
K/P	11.40	35.2	16.1	10.00	44.1	19.4	1.20	
P/Ca	2.10	39.2	0.67	2.04	39.8	0.65	0.97	
Ca/P	0.53	33.1	0.031	0.57	41.7	0.055	1.77*	X
P/Mg	1.95	39.4	0.59	1.75	33.9	0.35	0.59	
Mg/P	0.61	47.9	0.087	0.66	43.3	0.081	0.93^{ns}	X
P/Na	12.50***	44.4	31.1	7.36	41.7	9.44	0.30	
Na/P	0.098***	51.9	0.0026	0.16	39.2	0.0038	1.48^{ns}	X
10 P/Cu	0.12	58.0	0.0053	0.12	50.6	0.0037	0.69^{ns}	X
Cu/10 P	11.30	63.0	51.1	10.50	48.2	25.7	0.50	
1000 P/Fe	0.64***	49.2	0.10	0.37	30.7	0.013	0.13	
Fe/1000 P	1.89***	45.6	0.74	2.94	31.2	0.84	1.13^{ns}	X
100 P/Zn	0.78	39.6	0.095	1.05	88.7	0.86	9.04***	X
Zn/100 P	1.49	40.3	0.36	1.51	59.4	0.80	2.21	
100 P/Mn	0.24***	57.4	0.019	0.13	46.4	0.0037	0.19	
Mn/100 P	5.69***	60.4	11.8	9.39	48.1	20.4	1.73*	X
K/Ca	21.80	25.9	32.1	19.40	50.0	94.6	2.94	
Ca/K	0.048***	24.4	0.00014	0.066	51.4	0.0012	8.36***	X
K/Mg	20.60**	40.0	68.4	16.30	49.2	64.4	0.94	
Mg/K	0.055***	36.1	0.00040	0.073	40.4	0.00088	2.21**	X
K/100 Na	1.32***	40.3	0.28	0.68	48.0	0.10	0.37	
100 Na/K	0.90***	54.0	0.23	1.80	47.9	0.74	3.10***	X
K/Cu	0.13	65.4	0.0076	0.10	42.4	0.0019	0.25	
Cu/K	10.00	52.3	27.9	11.20	40.5	20.6	0.74^{ns}	X
100 K/Fe	0.67***	41.1	0.075	0.35	39.4	0.018	0.25	
Fe/100 K	1.69***	35.1	0.35	3.38	46.4	2.45	6.94***	X
K/Zn	0.088	49.9	0.0019	0.090	68.9	0.0039	1.99**	X
Zn/K	14.50	51.5	56.3	16.50	59.0	94.9	1.68	
K/Mn	0.026***	62.2	0.00026	0.011	30.5	0.000012	0.044	
Mn/K	50.90***	48.7	617.0	97.00	27.7	721.6	1.17^{ns}	X
Ca/Mg	0.95	36.9	0.12	0.93	39.9	0.13	1.11	
Mg/Ca	1.15	29.7	0.11	1.26	42.6	0.28	2.43***	X
Ca/Na	6.27***	37.7	5.59	4.20	68.0	8.13	1.45	
Na/Ca	0.19***	57.9	0.012	0.32	49.0	0.024	1.88**	X
10 Ca/Cu	0.060	54.1	0.0011	0.064	56.9	0.0013	1.25^{ns}	X
Cu/10 Ca	21.00	48.1	101.6	20.20	48.2	94.9	0.93	
1000 Ca/Fe	0.31***	32.8	0.010	0.20	33.1	0.0043	0.41	

Table 6: Continue

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/ S^2_h	Selected ratio
Fe/1000 Ca	3.59***	35.8	1.65	5.63	34.8	3.83	2.32**	X
100 Ca/Zn	0.40	50.1	0.041	0.54	81.5	0.19	4.63***	X
Zn/100 Ca	3.00	43.6	1.72	2.81	54.3	2.32	1.35	
100 Ca/Mn	0.12***	58.9	0.0050	0.073	57.5	0.0018	0.35	
Mn/100 Ca	10.60***	45.2	23.2	18.90	61.0	134.2	5.78***	X
Mg/Na	7.00***	43.1	9.10	4.65	54.0	6.31	0.69	
Na/Mg	0.17***	49.2	0.0074	0.27	43.9	0.013	1.82*	X
Mg/Cu	0.0063	37.0	0.0000054	0.0069	32.5	0.0000059	0.91^{ns}	X
Cu/Mg	180.90	36.5	4370.1	163.50	35.5	3376.8	0.77	
1000 Mg/Fe	0.34***	30.8	0.011	0.23	32.5	0.0055	0.50	
Fe/1000 Mg	3.22***	31.7	1.04	4.83	33.5	2.62	2.50***	X
100 Mg/Zn	0.43**	34.1	0.021	0.61	76.2	0.21	10.0***	X
Zn/100 Mg	2.65	40.0	1.12	2.44	61.5	2.26	2.01	
100 Mg/Mn	0.12***	28.0	0.0011	0.080	45.2	0.0013	1.13	
Mn/100 Mg	9.04***	33.2	8.99	15.30	48.4	54.7	6.09***	X
100 Na/Cu	0.10***	57.7	0.0039	0.18	50.8	0.0081	2.07**	X
Cu/100 Na	12.60***	62.0	61.7	7.34	55.5	16.5	0.27	
10000 Na/Fe	0.55	43.0	0.056	0.56	35.8	0.040	0.71	
Fe/10000 Na	2.08	35.6	0.55	2.07	45.5	0.89	1.61*	X
1000 Na/Zn	0.71***	51.8	0.13	1.42	65.5	0.86	6.26***	X
Zn/1000 Na	1.76***	51.8	0.83	0.99	55.4	0.29	0.36	
1000 Na/Mn	0.21	61.5	0.017	0.19	49.5	0.0092	0.53	
Mn/1000 Na	6.32	50.4	10.2	6.42	49.2	9.97	0.98^{ns}	X
10 Cu/Fe	0.59***	38.5	0.052	0.35	30.6	0.011	0.22	
Fe/10 Cu	1.97***	47.2	0.87	3.15	37.9	1.43	1.64*	X
Cu/Zn	0.78	51.0	0.16	0.99	78.4	0.59	3.68***	X
Zn/Cu	1.70	58.6	1.00	1.70	75.9	1.66	1.66	
Cu/Mn	0.21***	46.8	0.0099	0.12	35.4	0.0018	0.18	
Mn/Cu	5.43***	32.7	3.14	9.58	37.6	12.9	4.13***	X
Fe/Zn	13.3***	37.4	25.0	27.90	72.9	414.4	16.5***	X
Zn/Fe	0.087***	44.5	0.0015	0.05	58.5	0.0010	0.63	
Fe/Mn	3.88	46.8	3.29	3.60	40.1	2.07	0.63	
Mn/Fe	0.30	34.9	0.011	0.33	40.5	0.017	1.58^{ns}	X
Zn/Mn	0.32***	53.0	0.030	0.19	76.6	0.021	0.71	
Mn/Zn	3.95***	47.9	3.57	8.78	70.1	37.8	10.6***	X

Mean of nutrient ratios of low- and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) levels of probability by t-test, variances of nutrient ratios of low and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) level of probability by F-test and ns: No significant difference

Table 7: Mean, coefficient of variation (CV) and variance (S^2) of nutrient ratios of the low- and high-yielding groups, the variance ratio (S^2_l/S^2_h) and the selected ratios for pineapple leaf +18 DRIS norms

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/ S^2_h	Selected ratio
N/P	9.69	29.0	7.92	10.40	25.5	7.13	0.90^{ns}	X
P/N	0.11	26.8	0.00089	0.10	25.9	0.00069	0.78	
N/K	1.12	37.8	0.18	1.29	43.7	0.31	1.75*	X
K/N	1.04	49.2	0.26	0.95	50.3	0.23	0.87	
N/Ca	19.60	27.5	29.1	21.10	27.2	32.9	1.13^{ns}	X
Ca/N	0.054	22.5	0.00015	0.050	24.9	0.00016	1.07	
N/Mg	16.80	35.1	35.0	21.10	27.9	22.6	0.65^{ns}	X
Mg/N	0.066	34.4	0.00052	0.063	28.0	0.00031	0.60	
N/10 Na	12.20***	32.9	16.2	6.04	26.9	2.63	0.16	
10 Na/N	0.092***	40.2	0.0013	0.18	28.9	0.0026	1.93**	X
N/Cu	0.10	38.2	0.0015	0.10	38.1	0.0015	1.00^{ns}	X
Cu/N	11.20	38.7	18.8	11.10	37.4	17.2	0.92	
100 N/Fe	0.64***	34.3	0.048	0.42	35.8	0.022	0.47	
Fe/100 N	1.73***	33.7	0.34	2.65	33.1	0.77	2.25**	X
N/Zn	0.092	75.7	0.0048	0.097	64.2	0.0039	0.80	

Table 7: Continue

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/ S^2_h	Selected ratio
Zn/N	14.00	39.1	30.0	13.20	44.6	34.7	1.15^{ns}	X
N/Mn	0.023***	61.2	0.00020	0.013	52.2	0.000048	0.24	
Mn/N	64.30***	64.8	1737.1	102.70	55.6	3261.0	1.88**	X
P/K	0.12	48.6	0.0036	0.12	45.5	0.0034	0.93	
K/P	9.84	42.9	17.8	9.75	50.8	24.5	1.38^{ns}	X
P/Ca	2.20	41.4	0.82	2.12	35.9	0.57	0.70^{ns}	X
Ca/P	0.52	37.6	0.039	0.52	30.3	0.024	0.64	
P/Mg	1.93	47.8	0.85	1.72	34.9	0.36	0.42	
Mg/P	0.67	55.4	0.13	0.66	42.4	0.079	0.58^{ns}	X
P/Na	14.10***	50.3	50.4	6.09	34.1	4.33	0.09	
Na/P	0.093***	60.8	0.0032	0.18	41.2	0.0059	1.83*	X
10 P/Cu	0.11	53.2	0.0040	0.10	41.6	0.0018	0.46	
Cu/10 P	11.30	57.0	41.9	11.50	45.7	27.7	0.66^{ns}	X
1000 P/Fe	0.72***	45.9	0.11	0.43	42.8	0.034	0.31	
Fe/1000 P	1.74***	53.4	0.86	2.84	50.3	2.03	2.36**	X
100 P/Zn	1.03	80.5	0.69	0.99	69.2	0.47	0.68	
Zn/100 P	1.36	46.5	0.40	1.38	49.0	0.45	1.14^{ns}	X
100 P/Mn	0.26***	69.6	0.034	0.13	56.7	0.0059	0.17	
Mn/100 P	6.61****	79.8	27.8	10.90	64.2	49.2	1.77*	X
K/Ca	19.20	35.6	46.8	19.70	53.0	109.8	2.34	
Ca/K	0.058	31.6	0.00033	0.064	49.9	0.0010	3.09***	X
K/Mg	16.10	36.6	34.6	15.10	41.5	39.6	1.14	
Mg/K	0.069	30.1	0.00043	0.077	38.8	0.00089	2.06**	X
K/100 Na	1.26***	58.7	0.54	0.56	46.1	0.066	0.12	
100 Na/K	1.01**	50.3	0.26	2.30	60.8	1.94	7.46***	X
K/Cu	0.10	44.2	0.0019	0.093	60.7	0.0032	1.63	
Cu/K	11.70	38.7	20.7	13.30	44.9	35.9	1.73*	X
100 K/Fe	0.61***	39.5	0.059	0.36	42.8	0.024	0.41	
Fe/100 K	1.83***	36.2	0.43	3.15	38.3	1.45	3.32***	X
K/Zn	0.091	63.7	0.0033	0.093	75.0	0.0049	1.46^{ns}	X
Zn/K	15.80	62.6	98.5	17.4	68.9	143.4	1.46	
K/Mn	0.021***	48.8	0.00010	0.010	38.6	0.000016	0.16	
Mn/K	63.50***	61.6	1534.8	109.10	35.3	1485.4	0.97^{ns}	X
Ca/Mg	0.87	31.8	0.077	0.85	35.9	0.095	1.22	
Mg/Ca	1.25	31.3	0.15	1.33	39.1	0.27	1.78*	X
Ca/Na	6.47***	35.6	5.32	3.07	39.3	1.45	0.27	
Na/Ca	0.17***	38.7	0.0046	0.37	41.7	0.024	5.40***	X
10 Ca/Cu	0.053	33.6	0.00032	0.049	30.4	0.00023	0.71	
Cu/10 Ca	20.96	33.4	49.1	22.20	31.6	49.1	1.00^{ns}	X
1000 Ca/Fe	0.33***	28.3	0.0088	0.20	38.1	0.0063	0.72	
Fe/1000 Ca	3.27***	31.3	1.04	5.51	38.4	4.48	4.28***	X
100 Ca/Zn	0.48	66.7	0.10	0.5	74.1	0.14	1.34	X
Zn/100 Ca	2.79	56.0	2.44	2.87	56.4	2.64	1.08	
100 Ca/Mn	0.11***	62.0	0.0053	0.064	51.6	0.0011	0.21	
Mn/100 Ca	11.60***	54.9	40.7	21.0	58.6	152.5	3.74***	X
Mg/Na	7.82***	41.5	10.5	3.82	39.5	2.28	0.22	
Na/Mg	0.14***	41.6	0.0037	0.30	40.3	0.014	3.93***	X
Mg/Cu	0.0063	27.6	0.0000030	0.0062	35.0	0.0000047	1.58^{ns}	X
Cu/Mg	174.50	35.1	3750.4	179.80	34.1	3770.6	1.01	
1000 Mg/Fe	0.39***	26.0	0.010	0.25	28.6	0.0053	0.50	
Fe/1000 Mg	2.71***	27.1	0.54	4.32	33.7	2.12	3.90***	X
100 Mg/Zn	0.55	46.0	0.064	0.60	53.1	0.10	1.58^{ns}	X
Zn/100 Mg	2.26	50.9	1.33	2.30	61.5	2.00	1.50	
100 Mg/Mn	0.13***	41.8	0.0029	0.075	39.0	0.00086	0.29	
Mn/100 Mg	9.19***	46.8	18.5	15.70	43.5	46.6	2.52***	X
100 Na/Cu	0.089***	40.5	0.0013	0.18	45.7	0.0069	5.30***	X
Cu/100 Na	13.00***	41.0	28.6	6.64	43.9	8.48	0.30	
10000 Na/Fe	0.55***	30.7	0.028	0.77	56.4	0.19	6.71***	X
Fe/10000 Na	2.03	43.6	0.78	1.63	44.2	0.52	0.67	

Table 7: Continue

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/ S^2_h	Selected ratio
1000 Na/Zn	0.83***	91.0	0.57	1.86	86.8	2.61	4.55***	X
Zn/1000 Na	1.68***	49.6	0.69	0.84	61.9	0.27	0.39	
1000 Na/Mn	0.18	59.2	0.012	0.23	65.1	0.023	1.88***	X
Mn/1000 Na	6.98	56.8	15.7	6.11	56.5	11.9	0.76	
10 Cu/Fe	0.66***	31.4	0.043	0.43	35.5	0.024	0.56	
Fe/10 Cu	1.64***	30.1	0.24	2.57	36.5	0.88	3.60***	X
Cu/Zn	1.06	84.0	0.79	1.12	70.6	0.63	0.80	
Zn/Cu	1.52	67.0	1.04	1.47	71.6	1.11	1.07^{ns}	X
Cu/Mn	0.22***	52.9	0.013	0.12	43.2	0.0031	0.22	
Mn/Cu	5.64***	50.1	7.97	9.41	52.6	24.5	3.08***	X
Fe/Zn	15.10***	57.2	75.1	24.80	53.7	177.9	2.37**	X
Zn/Fe	0.090***	58.2	0.0027	0.056	61.4	0.0012	0.43	
Fe/Mn	3.40	43.5	2.19	3.11	44.1	1.87	0.86	
Mn/Fe	0.34	38.7	0.017	0.38	41.4	0.024	1.39^{ns}	X
Zn/Mn	0.30**	73.3	0.051	0.18	80.4	0.022	0.43	
Mn/Zn	5.13***	60.0	9.49	9.94	72.6	52.1	5.49***	X

Mean nutrient ratios of low and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) levels of probability by t-test, variances of nutrient ratios of low and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) level of probability by F-test and ns: No significant difference

Table 8: Mean, coefficient of variation (CV) and variance (S^2) of nutrient ratios of the low and high-yielding groups, the variance ratio (S^2_l/S^2_h) and the selected ratios for pineapple leaf +20 DRIS norms

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/ S^2_h	Selected ratio
N/P	11.10	27.5	9.30	10.40	32.0	11.1	1.20	
P/N	0.098	31.7	0.0010	0.11	33.0	0.0012	1.28^{ns}	X
N/K	1.12	35.5	0.16	1.28	48.1	0.38	2.38**	X
K/N	1.03	45.4	0.22	1.00	58.3	0.34	1.56	
N/Ca	20.30	24.5	24.9	20.80	33.9	49.9	2.00**	X
Ca/N	0.052	27.6	0.00021	0.053	29.5	0.00024	1.15	
N/Mg	17.30	41.3	51.3	20.80	32.9	30.7	0.60	
Mg/N	0.066	34.1	0.00051	0.066	33.8	0.00050	0.98^{ns}	X
N/10 Na	48.00	376.6	32704.0	7.58	67.0	25.7	0.00079	
10 Na/N	0.092***	53.1	0.0024	0.18	67.6	0.015	6.33***	X
N/Cu	0.12	35.0	0.0019	0.12	45.2	0.0030	1.56^{ns}	X
Cu/N	9.26	43.5	16.2	9.74	40.3	15.4	0.95	
100 N/Fe	0.62***	43.9	0.076	0.42	34.7	0.020	0.27	
Fe/100 N	1.81***	36.6	0.44	2.66	32.7	0.75	1.71*	X
N/Zn	0.084	44.4	0.0014	0.086	40.8	0.0012	0.89	
Zn/N	13.70	33.7	21.5	13.40	37.0	24.7	1.15^{ns}	X
N/Mn	0.020***	29.8	0.000037	0.014	27.4	0.000014	0.39	
Mn/N	54.10***	32.8	314.3	78.40	29.5	533.3	1.70*	X
P/K	0.10	47.8	0.0027	0.14	58.2	0.0062	2.34**	X
K/P	11.00	39.8	19.3	10.30	61.9	41.1	2.13	
P/Ca	1.99	42.3	0.71	2.12	37.7	0.64	0.90^{ns}	X
Ca/P	0.57	35.7	0.042	0.52	30.2	0.025	0.59	
P/Mg	1.69	50.2	0.72	1.79	49.1	0.77	1.07^{ns}	X
Mg/P	0.73	45.4	0.11	0.68	44.5	0.092	0.83	
P/Na	50.20	382.1	36933.1	8.18	93.2	58.2	0.0016	
Na/P	0.11***	77.7	0.0073	0.19	78.0	0.021	2.95***	X
10 P/Cu	0.12	49.5	0.0037	0.12	37.6	0.0021	0.56	
Cu/10 P	10.20	50.3	26.7	9.63	41.2	15.7	0.59^{ns}	X
1000 P/Fe	0.62**	54.0	0.11	0.43	38.2	0.026	0.24	
Fe/1000 P	2.05**	51.1	1.11	2.70	38.7	1.09	0.99^{ns}	X
100 P/Zn	0.77	38.4	0.088	0.88	44.7	0.15	1.76*	X
Zn/100 P	1.47	36.6	0.29	1.37	44.7	0.37	1.29	
100 P/Mn	0.20***	46.6	0.0087	0.14	40.0	0.0033	0.38	
Mn/100 P	6.05***	44.2	7.16	7.94	34.5	7.49	1.05^{ns}	X

Table 8: Continue

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/ S^2_h	Selected ratio
K/Ca	19.60	31.6	38.3	21.60	80.8	305.6	7.96**	X
Ca/K	0.056	28.8	0.00026	0.069	58.4	0.0016	6.25	
K/Mg	16.60	43.5	52.6	16.00	54.4	76.1	1.45	
Mg/K	0.070	37.1	0.00067	0.081	51.9	0.0018	2.63***	X
K/100 Na	8.42	433.8	1335.1	0.72	85.1	0.37	0.00028	
100 Na/K	1.08**	71.4	0.61	2.46	141.9	12.1	20.10***	X
K/Cu	0.12	58.5	0.0055	0.12	66.8	0.0062	1.13	
Cu/K	10.00	43.5	18.9	12.40	69.3	74.3	3.92***	X
100 K/Fe	0.60***	40.7	0.060	0.38	45.8	0.031	0.51	
Fe/100 K	1.95***	43.9	0.74	3.26	60.1	3.82	5.20***	X
K/Zn	0.084	57.3	0.0023	0.089	77.2	0.0047	2.04	
Zn/K	15.00	42.2	40.4	17.40	58.8	104.5	2.59***	X
K/Mn	0.020***	43.2	0.000075	0.013	54.2	0.000050	0.68	
Mn/K	58.00***	36.1	439.4	95.60	47.3	2041.0	4.64***	X
Ca/Mg	0.85	27.8	0.056	0.85	35.5	0.091	1.64*	X
Mg/Ca	1.26	28.6	0.13	1.31	32.2	0.17	1.35	
Ca/Na	26.10	381.7	9969.1	3.89	75.7	8.67	0.00087	
Na/Ca	0.19***	61.3	0.013	0.37	72.3	0.070	5.21***	X
10 Ca/Cu	0.063	35.6	0.00050	0.060	39.4	0.00055	1.10^{ns}	X
Cu/10 Ca	17.90	38.7	48.3	18.80	33.4	39.5	0.82	
1000 Ca/Fe	0.31***	33.8	0.011	0.21	39.8	0.0072	0.65	
Fe/1000 Ca	3.54***	33.3	1.39	5.35	35.6	3.61	2.60***	X
100 Ca/Zn	0.42	42.3	0.032	0.44	45.1	0.040	1.24	
Zn/100 Ca	2.74	38.0	1.08	2.76	46.0	1.60	1.48^{ns}	X
100 Ca/Mn	0.10***	26.5	0.00074	0.070	31.3	0.00048	0.65	
Mn/100 Ca	10.60***	33.2	12.4	15.60	31.6	24.5	1.97**	X
Mg/Na	27.60	359.0	9838.6	4.63	58.6	7.38	0.00075	
Na/Mg	0.15***	66.8	0.010	0.29	69.1	0.039	3.63***	X
Mg/Cu	0.0075	28.9	0.0000047	0.0075	36.8	0.0000075	1.60	
Cu/Mg	143.00	26.2	1406.8	155.50	45.5	4998.3	3.55***	X
1000 Mg/Fe	0.37***	26.1	0.0096	0.26	32.5	0.0070	0.73	
Fe/1000 Mg	2.86***	29.5	0.72	4.20	26.5	1.23	1.73*	X
100 Mg/Zn	0.51	38.7	0.038	0.55	43.1	0.057	1.47	
Zn/100 Mg	2.21	33.8	0.56	2.27	56.5	1.65	2.96***	X
100 Mg/Mn	0.12***	17.8	0.00047	0.085	23.5	0.00040	0.85	
Mn/100 Mg	8.45***	18.8	2.54	12.40	29.1	13.1	5.18***	X
100 Na/Cu	0.11**	66.7	0.0056	0.23	121.5	0.079	14.1***	X
Cu/100 Na	33.40	335.4	12577.1	7.22	72.4	27.3	0.0022	
10000 Na/Fe	0.57	76.5	0.19	0.80	126.7	1.03	5.41***	X
Fe/10000 Na	9.61	396.1	1450.3	1.95	65.1	1.60	0.0011	
1000 Na/Zn	0.78***	71.2	0.31	1.46	62.9	0.83	2.67***	X
Zn/1000 Na	6.57	373.6	604.1	0.95	62.4	0.35	0.00059	
1000 Na/Mn	0.18	52.3	0.0089	0.23	63.7	0.022	2.50***	X
Mn/1000 Na	25.10	375.4	8899.3	5.48	54.0	8.74	0.0010	
10 Cu/Fe	0.53***	39.8	0.045	0.37	36.5	0.018	0.41	
Fe/10 Cu	2.14***	40.4	0.75	2.94	27.7	0.66	0.88^{ns}	X
Cu/Zn	0.73	50.2	0.14	0.85	60.4	0.26	1.93	
Zn/Cu	1.65	41.3	0.47	1.65	60.4	0.99	2.14**	X
Cu/Mn	0.17***	21.2	0.0013	0.13	39.8	0.0026	1.97	
Mn/Cu	6.21***	29.5	3.36	8.88	34.4	9.32	2.77***	X
Fe/Zn	14.80***	53.9	64.0	22.50	45.5	105.0	1.64*	X
Zn/Fe	0.084***	44.1	0.0014	0.056	52.9	0.00088	0.64	
Fe/Mn	3.42	25.1	0.74	3.48	25.8	0.80	1.08^{ns}	X
Mn/Fe	0.31	30.2	0.0090	0.31	31.1	0.0093	1.03	
Zn/Mn	0.27***	38.7	0.010	0.18	46.3	0.0072	0.66	
Mn/Zn	4.31***	41.5	3.21	6.54	38.9	6.47	2.02**	X

Mean nutrient ratios of low and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) levels of probability by t-test, variances of nutrient ratios of low and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) level of probability by F-test and ns: No significant difference

At leaf +22, the nutrient ratio pairs selected for the DRIS norms were 10 Na/N, Mn/N, Na/P, Mn/100 P, 100 Na/K, Fe/100 K, Na/Ca, Fe/1,000 Ca, Mn/100 Ca, Na/Mg, Fe/1,000 Mg, Mn/100 Mg, 100 Na/Cu, 1,000 Na/Zn, Fe/10 Cu, Mn/Cu, Fe/Zn and Mn/Zn. The values recorded in the high-yielding group were the average nutrient concentration ratio (0.10-59.1), the CV (30.6-64.5%), the variance (0.0013-887.2) and the variance ratio between the low-yielding and high-yielding groups (1.82-16.4) (Table 9).

The N/Mg, 10 Na/N, P/Mg, Na/P, 100 Na/K, Cu/K, Fe/100 K, Na/Ca, Fe/1,000 Ca, Mn/100 Ca, Na/Mg, Cu/Mg, Fe/1,000 Mg, Mn/100 Mg, 1,000 Na/Zn, 1,000 Na/Mn, Cu/Zn, Fe/Zn and Mn/Z were chosen for the DRIS norms at leaf +24. The average nutrient concentration ratio, CV, variance and variance ratio between the low-yielding and high-yielding groups were recorded in the high-yielding group as 0.10-126.6, 29.2%-71.7, 0.0034-1,577.8 and 1.63-3.60%, respectively (Table 10).

Table 9: Mean, coefficient of variation (CV) and variance (S^2) of nutrient ratios of the low- and high-yielding groups, the variance ratio (S^2_l/S^2_h) and the selected ratios for pineapple leaf +22 DRIS norms

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/S^2_h	Selected ratio
N/P	11.30	30.7	12.2	10.40	27.9	8.52	0.70^{ns}	X
P/N	0.10	38.2	0.0014	0.10	28.5	0.00087	0.62	
N/K	1.13	29.1	0.11	1.26	45.5	0.33	3.06***	X
K/N	0.97	31.8	0.094	0.96	45.0	0.19	1.99	
N/Ca	19.40	23.1	20.1	20.30	28.2	32.9	1.63	
Ca/N	0.054	21.6	0.00014	0.053	28.6	0.00023	1.68*	X
N/Mg	16.80	30.9	27.0	20.30	29.9	22.8	0.84	
Mg/N	0.064	27.8	0.00032	0.068	29.5	0.00040	1.25^{ns}	X
N/10 Na	11.80***	31.6	13.9	7.83	73.1	32.7	2.35	
10 Na/N	0.10***	47.6	0.0021	0.17	46.3	0.0063	2.94***	X
N/Cu	0.11	29.6	0.0011	0.11	44.5	0.0025	2.29**	X
Cu/N	9.83	34.1	11.2	9.95	29.6	8.69	0.77	
100 N/Fe	0.73***	51.8	0.14	0.40	33.9	0.018	0.13	
Fe/100 N	1.64***	41.7	0.47	2.73	27.8	0.57	1.22^{ns}	X
N/Zn	0.087	46.1	0.0016	0.10	68.6	0.0048	3.03***	X
Zn/N	13.50	36.9	24.8	13.20	47.3	39.2	1.58	
N/Mn	0.022***	62.6	0.00019	0.013	43.6	0.000041	0.18	
Mn/N	59.10***	50.3	887.2	92.20	53.4	2423.9	2.73***	X
P/K	0.11	41.4	0.0019	0.13	46.9	0.0036	1.82	
K/P	10.60	34.7	13.5	9.98	54.9	30.0	2.21**	X
P/Ca	1.88	41.0	0.59	2.05	32.9	0.45	0.77	
Ca/P	0.60	30.9	0.034	0.54	33.3	0.032	0.93^{ns}	X
P/Mg	1.65	45.3	0.56	1.67	42.3	0.50	0.88	
Mg/P	0.74	44.7	0.11	0.72	48.2	0.12	1.11^{ns}	X
P/Na	11.80**	51.6	37.4	8.11	80.6	42.6	1.14	
Na/P	0.11***	64.5	0.0054	0.18	55.5	0.0099	1.82*	X
10 P/Cu	0.11	47.0	0.0026	0.12	52.8	0.0037	1.40^{ns}	X
Cu/10 P	11.30	49.8	31.7	10.30	39.1	16.3	0.52	
1000 P/Fe	0.73***	69.5	0.26	0.41	42.4	0.030	0.12	
Fe/1000 P	1.89***	56.6	1.14	2.83	39.5	1.25	1.10^{ns}	X
100 P/Zn	0.81	48.8	0.16	1.02	65.2	0.44	2.81***	X
Zn/100 P	1.46	35.6	0.27	1.35	51.4	0.48	1.78	
100 P/Mn	0.21**	53.6	0.012	0.14	53.0	0.0058	0.47	
Mn/100 P	6.73**	64.0	18.6	9.90	64.6	40.9	2.20**	X
K/Ca	18.00	25.5	21.2	18.50	41.3	58.4	2.75***	X
Ca/K	0.059	27.6	0.00027	0.063	41.9	0.00071	2.66	
K/Mg	15.60	33.0	26.6	14.30	40.3	33.6	1.26	
Mg/K	0.070	30.2	0.00045	0.080	36.2	0.00084	1.86**	X
K/100 Na	1.13***	44.5	0.25	0.67	57.4	0.15	0.58	
100 Na/K	1.09***	53.0	0.33	2.02	57.5	1.35	4.05***	X
K/Cu	0.11	38.6	0.0016	0.10	42.6	0.0018	1.10	
Cu/K	10.70	36.5	15.5	11.70	38.9	20.8	1.34^{ns}	X
100 K/Fe	0.67***	45.6	0.093	0.36	41.7	0.022	0.25	
Fe/100 K	1.78***	44.9	0.64	3.27	42.5	1.93	3.00***	X
K/Zn	0.084	57.4	0.0023	0.11	107.7	0.014	6.00***	X
Zn/K	15.30	47.6	53.1	17.40	65.1	129.6	2.44	

Table 9: Continue

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/S^2_h	Selected ratio
K/Mn	0.019***	41.0	0.000060	0.01	28.4	0.000010	0.16	
Mn/K	62.50***	52.7	1085.2	97.20	29.9	845.1	0.78^{ns}	X
Ca/Mg	0.89	33.6	0.090	0.83	33.2	0.075	0.83	
Mg/Ca	1.23	31.1	0.15	1.36	36.0	0.24	1.62*	X
Ca/Na	6.30**	35.4	4.96	4.22	90.5	14.6	2.95	
Na/Ca	0.19***	49.1	0.0083	0.34	46.9	0.025	3.07***	X
10 Ca/Cu	0.059	29.2	0.00030	0.056	34.6	0.00038	1.29^{ns}	X
Cu/10 Ca	18.50	31.4	34.0	19.30	28.3	30.0	0.88	
1000 Ca/Fe	0.37***	34.3	0.016	0.21	34.1	0.0049	0.30	
Fe/1000 Ca	3.04***	38.2	1.34	5.39	30.9	2.77	2.06**	X
100 Ca/Zn	0.48	53.1	0.063	0.55	80.9	0.20	3.13***	X
Zn/100 Ca	2.67	49.4	1.75	2.72	56.3	2.35	1.35	
100 Ca/Mn	0.11***	54.6	0.0039	0.069	44.2	0.00095	0.25	
Mn/100 Ca	11.10***	52.3	33.8	18.10	57.0	106.9	3.16***	X
Mg/Na	7.33***	38.0	7.77	4.95	61.1	9.13	1.18	
Na/Mg	0.15***	36.0	0.0031	0.26	51.2	0.018	5.89***	X
Mg/Cu	0.0069	26.3	0.0000033	0.0072	34.6	0.0000063	1.92**	X
Cu/Mg	157.20	31.6	2466.8	152.40	32.6	2472.7	1.00	
1000 Mg/Fe	0.44***	41.4	0.033	0.26	30.6	0.0064	0.19	
Fe/1000 Mg	2.56***	30.6	0.61	4.23	34.3	2.10	3.42***	X
100 Mg/Zn	0.54	40.0	0.046	0.70	75.5	0.28	6.00***	X
Zn/100 Mg	2.21	44.2	0.96	2.14	58.7	1.58	1.65	
100 Mg/Mn	0.13***	47.1	0.0036	0.086	35.2	0.00091	0.25	
Mn/100 Mg	8.89***	31.9	8.07	13.50	44.9	37.0	4.60***	X
100 Na/Cu	0.10***	35.4	0.0013	0.19	52.0	0.0094	7.23***	X
Cu/100 Na	10.90**	33.8	13.7	7.88	95.1	56.0	4.07	
10000 Na/Fe	0.64	47.3	0.092	0.66	50.3	0.11	1.19	
Fe/10000 Na	1.77	30.0	0.28	2.06	83.0	2.94	10.4***	X
1000 Na/Zn	0.83***	58.3	0.24	1.76	75.2	1.76	7.47***	X
Zn/1000 Na	1.60**	52.7	0.71	1.08	90.8	0.96	1.35	
1000 Na/Mn	0.19	49.8	0.0090	0.22	58.4	0.017	1.86**	X
Mn/1000 Na	6.33	43.3	7.52	6.35	57.7	13.4	1.79	
10 Cu/Fe	0.65***	34.3	0.050	0.38	31.4	0.015	0.29	
Fe/10 Cu	1.69***	31.9	0.29	3.00	56.0	2.83	9.74***	X
Cu/Zn	0.84	51.8	0.19	1.07	82.6	0.78	4.10***	X
Zn/Cu	1.51	49.1	0.55	1.61	84.2	1.83	3.34	
Cu/Mn	0.20***	44.7	0.0077	0.13	43.8	0.0031	0.40	
Mn/Cu	6.09***	43.2	6.92	9.51	50.0	22.6	3.27***	X
Fe/Zn	13.80***	50.5	48.7	28.20	86.6	599.1	12.3***	X
Zn/Fe	0.10***	79.5	0.0064	0.053	55.5	0.00085	0.13	
Fe/Mn	3.04	31.7	0.93	3.52	42.2	2.21	2.37***	X
Mn/Fe	0.37	38.5	0.020	0.34	48.8	0.028	1.41	
Zn/Mn	0.28**	55.8	0.0247	0.19	66.9	0.016	0.68	
Mn/Zn	4.90***	58.8	8.29	10.70	108.8	136.6	16.4***	X

Mean nutrient ratios of low- and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) levels of probability by t-test, variances of nutrient ratios of low and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) level of probability by F-test and Ns: No significant difference

Table 10: Mean, coefficient of variation (CV) and variance (S^2) of nutrient ratios of the low- and high-yielding groups, the variance ratio (S^2_l/S^2_h) and the selected ratios for pineapple leaf +24 DRIS norms

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/S^2_h	Selected ratio
N/P	11.00	24.8	7.50	10.30	22.2	5.34	0.71	
P/N	0.10	24.3	0.00055	0.10	23.7	0.00058	1.06^{ns}	X
N/K	1.31	41.3	0.29	1.53	45.6	0.49	1.68	
K/N	0.88	36.6	0.10	0.83	59.3	0.24	2.33**	X
N/Ca	18.10	20.1	13.2	19.3	29.8	33.2	2.51***	X
Ca/N	0.057	20.2	0.00013	0.056	27.7	0.00024	1.80	
N/Mg	14.30**	29.2	17.5	19.3	31.5	28.5	1.63*	X
Mg/N	0.075**	25.9	0.00038	0.064	29.8	0.00037	0.98	

Table 10: Continue

	High-yielding group (n = 26)			Low-yielding group (n = 34)				
Ratio of nutrients	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/ S^2_h	Selected ratio
N/10 Na	13.60***	52.7	51.4	6.55	46.2	9.13	0.18	
10 Na/N	0.10***	61.2	0.0034	0.18	48.5	0.0079	2.34**	X
N/Cu	0.12**	31.3	0.0014	0.10	36.2	0.0013	0.91^{ns}	X
Cu/N	9.32	39.3	13.3	11.10	31.2	12.0	0.90	
100 N/Fe	0.77***	82.7	0.41	0.39	25.9	0.010	0.02	
Fe/100 N	1.66***	47.9	0.63	2.74	26.5	0.52	0.83^{ns}	X
N/Zn	0.075	29.1	0.00048	0.078	34.1	0.00072	1.51	
Zn/N	14.40	30.3	19.1	14.30	38.4	30.4	1.59^{ns}	X
N/Mn	0.021***	49.6	0.00011	0.013	46.1	0.000040	0.38	
Mn/N	63.40**	58.5	1377.7	90.00	46.2	1729.9	1.26^{ns}	X
P/K	0.12**	39.8	0.0024	0.15	47.0	0.0052	2.23	
K/P	9.48	37.8	12.8	8.72	68.3	35.4	2.76***	X
P/Ca	1.75	34.0	0.35	1.93	33.9	0.43	1.21^{ns}	X
Ca/P	0.63	31.0	0.039	0.57	31.7	0.033	0.86	
P/Mg	1.37**	34.0	0.21	1.72	37.8	0.42	1.97**	X
Mg/P	0.83	36.4	0.090	0.68	41.6	0.079	0.88	
P/Na	13.30***	64.2	73.8	6.58	49.2	10.4	0.14	
Na/P	0.11***	71.7	0.0060	0.19	55.8	0.011	1.90**	X
10 P/Cu	0.12	43.0	0.0026	0.10	49.2	0.0026	1.00^{ns}	X
Cu/10 P	10.60	58.4	38.7	11.70	41.1	23.3	0.60	
1000 P/Fe	0.78**	104.2	0.65	0.39	31.6	0.015	0.02	
Fe/1000 P	1.90***	66.7	1.61	2.83	33.7	0.91	0.56^{ns}	X
100 P/Zn	0.72	36.3	0.067	0.77	33.3	0.066	0.98^{ns}	X
Zn/100 P	1.58	35.2	0.31	1.44	35.1	0.26	0.83	
100 P/Mn	0.20**	52.9	0.011	0.14	52.7	0.0056	0.50	
Mn/100 P	7.40	81.3	36.2	9.59	56.3	29.2	0.81^{ns}	X
K/Ca	15.40	31.8	24.1	15.80	65.5	107.7	4.47***	X
Ca/K	0.07	38.9	0.00081	0.085	54.6	0.0021	2.72	
K/Mg	12.20	40.9	25.0	13.20	61.8	67.0	2.68***	X
Mg/K	0.094	36.2	0.0012	0.092	38.5	0.0012	1.09	
K/100 Na	1.17***	57.0	0.44	0.48	48.1	0.054	0.12	
100 Na/K	1.21***	64.2	0.60	2.56	46.7	1.43	2.38**	X
K/Cu	0.10**	48.4	0.0025	0.075	44.6	0.0011	0.44	
Cu/K	11.6***	42.9	25.11	15.90	45.0	51.7	2.06**	X
100 K/Fe	0.66***	80.8	0.28	0.32	69.3	0.049	0.17	
Fe/100 K	2.08***	50.4	1.10	4.10	46.4	3.62	3.29***	X
K/Zn	0.066	50.3	0.0011	0.065	72.4	0.0022	2.04**	X
Zn/K	18.60	43.3	65.3	21.60	52.4	129.0	1.98	
K/Mn	0.016***	36.5	0.000035	0.0096	44.2	0.000018	0.51	
Mn/K	74.0***	52.7	1522.2	116.00	28.1	1065.7	0.70^{ns}	X
Ca/Mg	0.80	24.8	0.039	0.92	34.6	0.10	2.57***	X
Mg/Ca	1.33	26.0	0.12	1.21	33.1	0.16	1.33	
Ca/Na	7.63***	49.0	13.9	3.69	63.7	5.54	0.40	
Na/Ca	0.17***	62.3	0.011	0.35	52.9	0.034	3.04***	X
10 Ca/Cu	0.0679***	33.1	0.00051	0.053	32.0	0.00029	0.58	
Cu/10 Ca	16.4**	34.5	32.2	20.70	34.1	49.8	1.55^{ns}	X
1000 Ca/Fe	0.41***	55.0	0.051	0.22	33.4	0.0052	0.10	
Fe/1000 Ca	2.91***	46.1	1.80	5.28	42.2	4.96	2.75***	X
100 Ca/Zn	0.43	32.5	0.019	0.44	39.7	0.030	1.56	
Zn/100 Ca	2.63	39.6	1.09	2.81	55.6	2.44	2.25**	X
100 Ca/Mn	0.11***	43.5	0.0024	0.076	58.3	0.0020	0.83	
Mn/100 Ca	10.90***	53.2	34.0	17.00	49.1	70.0	2.06**	X
Mg/Na	10.20***	71.8	54.1	4.02	43.7	3.09	0.057	
Na/Mg	0.13***	53.9	0.0050	0.30	45.3	0.018	3.60***	X
Mg/Cu	0.0087***	32.1	0.0000078	0.0061	29.2	0.0000032	0.40	
Cu/Mg	126.60***	31.4	1577.8	179.80	33.1	3538.1	2.24**	X
1000 Mg/Fe	0.56***	78.9	0.19	0.25	32.8	0.0065	0.034	
Fe/1000 Mg	2.28***	42.0	0.92	4.54	34.7	2.47	2.70***	X
100 Mg/Zn	0.56	37.3	0.043	0.50	41.1	0.043	0.99	

Table 10: Continue

Ratio of nutrients	High-yielding group (n = 26)			Low-yielding group (n = 34)				
	Mean	CV (%)	Variance (S^2_h)	Mean	CV (%)	Variance (S^2_l)	S^2_l/ S^2_h	Selected ratio
Zn/100 Mg	2.04	38.1	0.61	2.40	46.1	1.23	2.02**	X
100 Mg/Mn	0.15***	52.8	0.0060	0.08	44.9	0.0014	0.23	
Mn/100 Mg	8.36***	45.3	14.3	14.2	43.3	38.0	2.65***	X
100 Na/Cu	0.11***	77.9	0.0076	0.18	47.5	0.0071	0.94^{ns}	X
Cu/100 Na	11.90***	52.7	39.8	7.23	59.0	18.1	0.46	
10000 Na/Fe	0.60	42.8	0.066	0.72	60.3	0.19	2.88***	X
Fe/10000 Na	1.95	43.2	0.71	1.80	55.1	0.99	1.39	
1000 Na/Zn	0.70***	59.6	0.18	1.44	55.0	0.63	3.55***	X
Zn/1000 Na	1.96***	61.5	1.46	0.93	56.5	0.28	0.19	
1000 Na/Mn	0.17**	64.3	0.012	0.24	59.7	0.020	1.66*	X
Mn/1000 Na	7.42**	45.8	11.5	5.60	54.9	9.47	0.82	
10 Cu/Fe	0.67**	73.8	0.25	0.43	39.3	0.028	0.12	
Fe/10 Cu	1.94**	59.7	1.35	2.74	48.0	1.74	1.29^{ns}	X
Cu/Zn	0.69**	42.7	0.086	0.89	45.5	0.17	1.90**	X
Zn/Cu	1.74	45.3	0.62	1.49	63.2	0.89	1.43	
Cu/Mn	0.17	38.7	0.0044	0.14	44.2	0.0039	0.90^{ns}	X
Mn/Cu	6.96	56.1	15.2	8.22	36.3	8.91	0.59	
Fe/Zn	12.10***	42.6	26.6	20.80	34.2	51.1	1.92**	X
Zn/Fe	0.12**	120.3	0.019	0.054	39.4	0.00046	0.023	
Fe/Mn	3.00	40.8	1.49	3.70	50.5	3.49	2.34**	X
Mn/Fe	0.42	65.7	0.074	0.34	50.7	0.030	0.41	
Zn/Mn	0.29**	49.9	0.020	0.20	59.8	0.014	0.70	
Mn/Zn	4.57***	56.6	6.68	7.31	64.7	22.37	3.35***	X

Mean nutrient ratios of low and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) levels of probability by t-test, variances of nutrient ratios of low and high-yielding groups are significantly different at 1% (***), 5% (**) and 10% (*) level of probability by F-test and ns: No significant difference

Table 11: DRIS established for pineapple cultivated in acid sulfate soil in a high-yielding group in Hau Giang

Ratio of nutrients	Norms based on leaf +1		Norms based on leaf +3		Norms based on leaf +7		Norms based on leaf +14		Norms based on leaf +15		Agbangba *et al.*[22]		Agbangba *et al.*[21]		Teixeira *et al.*[20]	
	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)
N/K	0.75	22.6	0.74	18.3	-	-	-	-	0.88	28.8	-	-	0.6	44.5	0.59	0.17
N/Mg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N/10 Na	-	-	-	-	-	-	11.9	34.5	-	-	-	-	-	-	-	-
10 Na/N	-	-	0.12	42.6	-	-	-	-	-	-	-	-	-	-	-	-
Cu/N	-	-	9.40	35.5	-	-	-	-	-	-	-	-	-	-	-	-
Fe/100 N	-	-	-	-	1.78	10.1	1.55	33.9	1.94	25.2	-	-	-	-	-	-
N/Zn	-	-	-	-	-	-	-	-	0.069	30.6	-	-	595.4	44.3	-	-
Mn/N	42.0	48.2	52.3	63.8	62.5	46.0	66.1	56.9	58.9	45.7	-	-	-	-	-	-
P/Ca	1.52	30.4	-	-	-	-	-	-	-	-	-	-	-	-	0.24	0.07
P/Mg	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P/Na	-	-	-	-	15.7	55.2	13.2	35.6	-	-	-	-	-	-	-	-
Na/P	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fe/1000 P	-	-	-	-	-	-	1.45	40.0	-	-	-	-	-	-	-	-
Mn/100 P	3.21	26.2	-	-	-	-	-	-	5.69	60.4	-	-	-	-	-	-
P/K	0.095	35.5	-	-	-	-	-	-	-	-	-	-	0.3	54.4	0.04	18
Ca/K	-	-	0.048	30.0	-	-	-	-	0.048	24.4	-	-	0.9	38.6	-	-
Mg/K	-	-	0.063	28.7	-	-	0.063	35.3	0.055	36.1	-	-	0.4	42.9	-	-
100 Na/K	1.20	53.4	-	-	0.93	62.4	0.98	61.7	0.90	54.0	-	-	-	-	-	-
Cu/K	8.53	28.9	6.75	31.7	-	-	9.20	30.1	-	-	-	-	-	-	-	-
Fe/100 K	1.44	41.7	1.22	33.6	1.51	41.4	1.46	30.3	1.69	35.1	-	-	-	-	-	-
Zn/K	18.6	33.8	14.1	38.8	-	-	-	-	-	-	0.0007	56.1	-	-	-	-
Mn/K	29.8	37.6	37.7	65.4	52.4	45.9	-	-	-	-	-	-	-	-	-	-
Na/Ca	-	-	0.20	54.0	0.16	64.6	-	-	0.19	57.9	-	-	-	-	-	-
Cu/10 Ca	-	-			16.7	27.3	-	-	-	-	-	-	-	-	-	-
Fe/1000 Ca	-	-			-	-	-	-	3.59	35.8	-	-	-	-	-	-
Mn/100 Ca	4.79	36.4	9.13	96.8	9.44	50.7	-	-	10.6	45.2	-	-	-	-	-	-
Na/Mg	0.18	44.9	0.16	76.4	0.14	54.0	-	-	0.17	49.2	-	-	-	-	-	-
Cu/Mg	-	-	115.6	39.6	-	-	-	-	-	-	-	-	-	-	-	-
Fe/1000 Mg	2.30	41.0	2.06	37.4	2.38	36.4	-	-	3.22	31.7	-	-	-	-	-	-

Table 11: Continue

Ratio of nutrients	Norms based on leaf +1		Norms based on leaf +3		Norms based on leaf +7		Norms based on leaf +14		Norms based on leaf +15		Agbangba *et al.*[22]		Agbangba *et al.*[21]		Teixeira *et al.*[20]	
	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)
100 Mg/Zn	-	-	-	-	-	-	-	-	0.43	34.1	-	-	-	-	-	-
Mn/100 Mg	4.87	44.9	6.36	64.2	8.37	43.4	-	-	9.04	33.2	-	-	-	-	-	-
100 Na/Cu	0.15	53.0	-	-	0.10	49.3	-	-	0.10	57.7	-	-	-	-	-	-
Cu/100 Na	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10000 Na/Fe	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1000 Na/Zn	-	-	0.74	62.1	0.72	86.0	0.77	66.9	0.71	51.8	-	-	-	-	-	-
1000 Na/Mn	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fe/10 Cu	1.75	38.9	1.95	40.6	1.60	32.4	1.65	23.0	1.97	47.2	-	-	-	-	-	-
Cu/Zn	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mn/Cu	3.81	49.6	-	-	5.55	35.5	6.68	41.3	5.43	32.7	-	-	-	-	-	-
Fe/Zn	-	-	10.0	46.3	11.4	51.9	12.0	44.3	13.3	37.4	-	-	-	-	-	-
Fe/Mn	-	-	-	-	3.04	34.0	-	-	-	-	-	-	-	-	-	-
Mn/Zn	1.86	57.7	3.23	65.4	4.15	55.4	5.05	67.7	3.95	47.9	-	-	-	-	-	-

Ratio of nutrients	Norms based on leaf +18		Norms based on leaf +20		Norms based on leaf +22		Norms based on leaf +24		Agbangba *et al.*[22]		Agbangba *et al.*[21]		Teixeira *et al.*[20]	
	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)	Mean	CV (%)
N/K	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N/Mg	-	-	-	-	-	-	14.3	29.2	-	-	-	-	4.49	1.85
N/10 Na	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10 Na/N	0.092	40.2	0.092	53.1	0.10	47.6	0.10	61.2	-	-	-	-	-	-
Cu/N	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fe/100 N	1.73	33.7	1.81	36.6	-	-	-	-	-	-	-	-	-	-
N/Zn	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mn/N	64.3	64.8	54.1	32.8	59.1	50.3	-	-	-	-	-	-	-	-
P/Ca	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P/Mg	-	-	-	-	-	-	1.37	34.0	-	-	-	-	0.34	0.07
P/Na	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Na/P	0.093	60.8	0.11	77.7	0.11	64.5	0.11	71.7	-	-	-	-	-	-
Fe/1000 P	1.74	53.4	-	-	-	-	-	-	-	-	-	-	-	-
Mn/100 P	6.61	79.8	-	-	6.73	64.0	-	-	-	-	-	-	-	-
P/K	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ca/K	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mg/K	-	-	-	-	-	-	-	-	-	-	-	-	-	-
100 Na/K	1.01	50.3	1.08	71.4	1.09	53.0	1.21	64.2	-	-	-	-	-	-
Cu/K	-	-	-	-	-	-	11.6	42.9	-	-	-	-	-	-
Fe/100 K	1.38	36.2	1.95	43.9	1.78	44.9	2.08	50.4	-	-	-	-	-	-
Zn/K	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mn/K	-	-	58.0	36.1	-	-	-	-	-	-	-	-	-	-
Na/Ca	0.17	38.7	0.19	61.3	0.19	49.1	0.17	62.3	-	-	-	-	-	-
Cu/10 Ca	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fe/1000 Ca	3.27	31.3	3.54	33.3	3.04	38.2	2.91	46.1	-	-	-	-	-	-
Mn/100 Ca	11.6	54.9	10.6	33.2	11.1	52.3	10.9	53.2	-	-	-	-	-	-
Na/Mg	0.14	41.6	0.15	66.8	0.15	36.0	0.13	53.9	-	-	-	-	-	-
Cu/Mg	-	-	-	-	-	-	126.6	31.4	-	-	-	-	-	-
Fe/1000 Mg	2.71	27.1	2.86	29.5	2.56	30.6	2.28	42.0	-	-	-	-	-	-
100 Mg/Zn	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mn/100 Mg	9.19	46.8	8.45	18.8	8.89	31.9	8.36	45.3	-	-	-	-	-	-
100 Na/Cu	0.089	40.5	0.11	66.7	0.10	35.4	-	-	-	-	-	-	-	-
Cu/ 100Na	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10000 Na/Fe	0.55	30.7	-	-	-	-	-	-	-	-	-	-	-	-
1000 Na/Zn	0.83	91.0	0.78	71.2	0.83	58.3	0.70	59.6	-	-	-	-	-	-
1000 Na/Mn	-	-	-	-	-	-	0.17	64.3	-	-	-	-	-	-
Fe/10 Cu	1.64	30.1	-	-	1.69	31.9	-	-	-	-	-	-	-	-
Cu/Zn	-	-	-	-	-	-	0.69	42.7	-	-	-	-	-	-
Mn/Cu	5.64	50.1	6.2	29.5	6.09	43.2	-	-	-	-	-	-	-	-
Fe/Zn	15.1	57.2	14.8	53.9	13.8	50.5	12.1	42.6	-	-	-	-	-	-
Fe/Mn	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mn/Zn	5.13	60.0	4.31	41.5	4.90	58.8	4.57	56.6	-	-	-	-	-	-

DISCUSSION

The results of soil analysis showed that Al^{3+} and Fe^{2+} concentrations were high (Fig. 1a-d). Pineapple is capable of enduring well under acid sulfate soil conditions, but at low pH, high concentrations of Al^{3+} and Fe^{2+} affect its nutrient uptake[30]. Meanwhile, the DRIS was built based on interactions among nutrients, thereby overcoming obstacles for plants[15,16,31]. Thus, DRIS norms were established for pineapple according to nutrition status and cultivating practices in Hau Giang Province.

One of the drawbacks of the DRIS is that it is heavily affected by environmental factors, so to widely apply the DRIS, the natural characteristics of each region must be considered, especially soil properties. At that time, applying the DRIS to regions with similar features was promising. The analysis results in the experimented region illustrated the influences of soil on pineapple cultivation. Soil suitable for planting pineapple has a pH of roughly 4.5-6.5, with plenty of organic matter and K^{+}[32], while the soil at the experimented region was evaluated to be at the highly acidic threshold, with moderate K^{+} concentration, which needed to be improved. In the case of increasing pH and concentrations of K, Ca and Mg and decreasing Fe, pineapple growth in acid sulfate soil is promoted[33]. According to Bian *et al.*[34], low pH results in high toxicity, while the essential nutrients are not sufficient for plants. One of the most important components limiting the effects of low pH is enhancing organic matter to increase CEC[35]. In addition, supplying mineral elements (e.g., P) boosts root respiration, plant development, chlorophyll content and dry matter and supplying Ca aids in adjusting soil acidity and reducing Al^{3+} toxicity[36].

To analyze nutrient concentrations in pineapple, a group of D leaves is recommended for use. However, pineapple has different leaf groups that have not been studied for establishing DRIS norms. In this research, nine leaf positions were selected (Tables 2-10) to form the norms and to fully exploit the potentials of the remaining leaf positions in the studies of Agbangba *et al.*[21,22], Angeles *et al.*[19] and Teixeira *et al.*[20], where only the D leaf was used to establish DRIS norms.

The data was divided into the high-yielding and low-yielding groups, following Letzsch and Sumner[27], whose method has been used to build DRIS norms for pineapple by most studies[19-22]. The high-yielding group had a yield above 88 t ha^{-1} according to Agbangba *et al.*[21], above 65 t ha^{-1} according to Teixeira *et al.*[20] and above 15 t ha^{-1} in this study. The differences in yield can be explained by different agronomic characteristics between the "Smooth Cayenne" and "Queen" pineapples, soil properties, cultivating techniques and farm designing methods. Nevertheless, the number of samples belonging to the high-yielding group accounted for 43.3% (data not shown), which was 10% larger to ensure a significant difference between the two yield groups, as proposed by Letzsch and Sumner[27].

At the advent of the DRIS, all the nutrient ratios were selected to build norms for rubber trees[26]. However, Letzsch[28] and Walworth and Sumner[29] have claimed that using the F value to choose nutrient ratios for the norms is highly reliable. Agbangba *et al.*[21,22] also chose ratios with variances higher than 1 and a symmetric coefficient in standard distribution lower than 1 to establish the norms. Therefore, using the values of ratios with higher variance as well as significant differences in means and variances aimed to establish highly reliable DRIS norms. The study found 42 nutrient ratio pairs from 10 nutrients: N, P, K, Ca, Mg, Na, Cu, Fe, Zn and Mn. The number of nutrient ratio pairs chosen from the DRIS norms of the nine leaf positions was higher than those in the studies of Agbangba *et al.*[21,22] and Teixeira *et al.*[20] (Table 11). From three macronutrients, Angeles *et al.*[19] built three nutrient ratios: N/P, P/N and P/K. Teixeira *et al.*[20] selected ten nutrient ratios: P/N, N/K, P/K, N/Ca, N/Mg, P/Ca, P/Mg, Ca/K, Mg/K and Mg/Ca for the norms. Agbangba *et al.*[21,22] established the DRIS norms for two pineapple varieties: "Smooth Cayenne" pineapple from 12 nutrient ratio pairs (P/N, K/N, Mg/N, S/N, Zn/N, Zn/P, K/Ca, K/Mg, Zn/K, Mg/Ca, Zn/Ca and Zn/Mg) and "Perola" pineapple from 10 nutrient ratio pairs (N/K, N/Ca, N/Zn, P/K, P/Zn, Ca/K, Mg/K, Mg/Ca, Ca/Zn and Mg/Zn). For further evaluation, there were similarities among the nutrient ratio pairs of Zn/K in the study of Agbangba *et al.*[21], N/K, N/Zn, P/K, Ca/K and Mg/K in that of Agbangba *et al.*[22] and N/K, P/Ca, P/K, N/Mg and P/Mg in that of Teixeira *et al.*[20]. However, the CVs in the corresponding ratios were lower than those in the study of Agbangba *et al.*[21,22]. Most of the similarities in the nutrient ratios in this study, compared to those in previous studies, were from leaves +1 to +15, while the other leaf positions were qualified to build DRIS norms. Thereby, except at leaf D (+3), the other leaf positions were suitable to establish DRIS norms, such as at leaves +1, +7, +14, +15, +18, +20, +22 and +24. Simultaneously, because these studies were different in terms of natural conditions and cultivars, the norms were affected[22]. Some similar nutrient ratios were potent enough to establish representative norms based on a database of regions with similar characteristics. Moreover, based on the established DRIS norms, their sensitivity in omission trials should be evaluated.

CONCLUSION

Pineapple yield in the high-yielding group was higher than that in the low-yielding one, with the corresponding results at 18.4 and 12.4 t ha^{-1}. On the other hand, at leaves +1 to +30, the concentrations of the nutrients N, P, K, Ca, Mg, Cu and Zn in the high-yielding group were higher than those in the low-yielding one, while the concentrations of Na, Fe and Mn in the low-yielding group outweighed those in the high-yielding one. Nine DRIS norms at leaves +1, +3, +7 +14, +15, +18, +20, +22 and +24, with the number of nutrient ratios ranging from 18 to 24, were established. In addition, the norms had high reliability given their high variance ratios.

SIGNIFICANCE STATEMENT

This study discovers the leaf positions for establishing DRIS norms that can be beneficial for the diagnosis of plant nutrients. The novelty of this research is that leaf position other than D-leaf as +1, +3, +7 +14, +15, +18, +20, +22 and +24 used for diagnosis of plant nutrients.

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