Original article

Pineapple response to nitrogen application on tropical peat: I. Effect of N on plant growth, N uptake and recovery

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Pineapple response to nitrogen application on tropical peat: I. Effect of N on plant growth, N uptake and recovery.

Abstract — Introduction. Field experiments were conducted to investigate the effects of nitrogen (N) on plant growth, N uptake and recovery by pineapple cv. Gandul, a Spanish group variety grown on tropical peat at two locations (site 1 and site 2) at Johore, Malaysia. **Materials and methods**. Six levels of N as urea at the rates of 0, 200, 400, 600, 800 and 1 000 kg·ha^{-1} N were applied at both sites. **Results and discussion**. The application of N had significant effects on plant height at site 1 and on plant height, number of leaves, D-leaf area and D-leaf dry weight at site 2, 10 months after planting. Nitrogen applications until 800 kg·ha^{-1} increased D-leaf N concentrations at both sites. The total N uptake was not influenced significantly with the applied N, but tended to increase with higher dosage at both sites. The highest recovery of 15 and 16 % resulted with the application of 200 kg·ha^{-1} N at site 1 and site 2, respectively. Recovery of nitrogen declined with subsequent increase in N levels at both sites. **Conclusion**. Pineapples grown on peat soil met their demand for N from the mineralization of organic matter and the dependence on the applied N was minimized to a large extent at both sites. © Éditions scientifiques et médicales Elsevier SAS

Malaysia / *Ananas comosus* / growth / nitrogen fixation / peat / fertilizer application / nitrogen

Réponse de l'ananas à l'apport d'azote sur tourbe tropicale : I. Effet de N sur la croissance des plantes, l'absorption de N et sa restitution.

Résumé — Introduction. Des expérimentations en champ ont été conduites pour étudier les effets de l'azote (N) sur la croissance des plantes, l'absorption de N et sa restitution par le cv. d'ananas Gandul, une variété du groupe Spanish, cultivé sur la tourbe tropicale en deux endroits (site 1 et site 2) à Johore, en Malaisie. **Matériel et méthodes**. Six doses d'azote ont été appliquées sous forme d'urée aux taux de 0, 200, 400, 600, 800 et 1 000 kg·ha^{-1} N sur les deux sites. **Résultats et discussion**. Dix mois après plantation, au site 1, l'application d'azote a eu des effets significatifs sur la hauteur des plantes ; au site 2, elle en a eu sur la hauteur des plantes, le nombre de feuilles, la surface de la feuille D et son poids sec. Jusqu'à 800 kg·ha^{-1} N, les applications d'azote ont augmenté la concentration en azote dans la feuille D, quel que soit le site. L'absorption totale d'azote n'a pas été sensiblement influencée par la dose d'azote apportée mais, sur les deux sites, elle a eu tendance à augmenter avec les doses croissantes. La plus forte restitution, de 15 % (site 1) et 16 % (site 2), a été obtenue avec l'application de 200 kg·ha^{-1} N puis, pour les deux sites, elle a diminué avec les doses croissantes qui ont suivi. **Conclusion**. Les ananas cultivés sur tourbe ont satisfait leur demande en azote à partir de la minéralisation de la matière organique et leur dépendance à l'égard de l'azote appliqué a été fortement réduite, quel que soit le site d'expérimentation. © Éditions scientifiques et médicales Elsevier SAS

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1. introduction

Pineapple (*Ananas comosus* [L.] Merr.) is an important fruit crop in Malaysia where it is cultivated mainly on peat. In this country, a vast area has been under pineapple production, for both fresh market and canning industry, for more than a century. At present, Gandul, a Spanish group variety is the main cultivar grown for canning and well adapted to peat soil [1].

The pineapple nitrogen (N) requirement is high and it depletes the natural N reserves of the soil if it is not adequately and correctly supplied with fertilizers. However, this requirement varies to a large extent depending on soil, climate, variety, management practices and many other factors. Research regarding the effect of N on the growth of pineapple cv. Gandul, N uptake and the recovery of the applied N from peat soils is limited. Although peat contains high amount of total N, pineapples respond with additional N application [2]. Therefore, the present study was designed to investigate the influence of N on plant growth characteristics, N uptake and the recovery of the applied N by the cultivar Gandul grown on peat soil.

Table I.
Physical and chemical properties of peat soil at two locations (designated as site 1 and site 2) at Johore, Malaysia, where field experiments were conducted to study pineapple response to N application.

Soil characteristics	Site 1	Site 2
Bulk density (g·cm^{-3})	0.20	0.27
Ash content (%)	4	15
Porosity (%)	85	51
Maximum water holding capacity (%)	492	143
pH (1:01)	3.45	3.48
Organic carbon (%)	51.9	47.9
Total nitrogen (%)	1.99	1.45
Extractable phosphorus (mg·kg^{-1})	58.7	51.6
Exchangeable potassium (cmol(+)·kg^{-1})	4.7	3.04
Exchangeable calcium (cmol(+)·kg^{-1})	1.90	1.20
Exchangeable magnesium (cmol(+)·kg^{-1})	0.38	0.22
Extractable copper (mg·kg^{-1})	30	49
Cation exchange capacity (cmol(+)·kg^{-1})	107.5	114.7

2. materials and methods

Field experiments were conducted at two locations (designated as site 1 and site 2) at the Peninsula (Pineapple) Plantation Estate, Simpang Rengam, Johore, Malaysia. The main difference between the two sites is that site 1 has been under continuous pineapple cultivation for the last 24 years and site 2 for about 42 years.

The soil physical and chemical properties have been analysed in the two sites (*table I*). Five levels of additional N application were used: 0, 200, 400, 600, 800 and 1 000 kg·ha^{-1}. The control consisted of plots without N addition. Each plot received a blanket dose of 72 kg·ha^{-1} P_2O_5, 800 kg·ha^{-1} K^2O, 32 kg·ha^{-1} CaO, 24 kg·ha^{-1} MgO and 3.2 kg·ha^{-1} CuO. The sources of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg) and copper (Cu) were urea, China phosphate rock, muriate of potash, calcium sulphate, magnesium sulphate and copper sulphate. The experiments were carried out in a randomized complete block design with three replications. Fertilizers (N, P, K, Ca and Mg) were applied in four splits at 2, 4, 6 and 8 months after planting. The percentages of nutrients applied at four splits were N (22 + 22 + 28 + 28), P_2O_5 (33 + 33 + 17 + 17) and K2O (13 + 13 + 37 + 37). CaO and MgO were applied at four equal splits and the whole amount of copper was applied 2 months after planting as foliar spray.

Ground suckers of about 40 cm in length with 20 leaves were planted. A plantation of 62 117 plants·ha^{-1} was maintained with a double-row planting system (76.2 cm × 55.9 cm × 24.4 cm). Flower induction was achieved 10 months after planting by pouring 50 ml of the solution containing 200 mL·L^{-1} ethephon (2-chloroethylphosphonic acid) into the centre of the growing apex of each plant.

Data on plant height, number of leaves, length, area and dry weight of the longest leaf (D-leaf) and D-leaf N concentration were measured 10 months after planting.

Nitrogen uptake was calculated by multiplying the plant (leaf, stem and fruit) N

concentrations with the plant populations at harvest. The percent recovery of the applied N was calculated as the total N weight in dry matter in the fertilized plot, minus the total N weight in dry matter in the control plot, multiplied by 100 [3]. The analyses of variance were calculated using the statistical package of MSTAT (MSTAT-C, Michigan State University) and mean values were compared by Duncan's New Multiple Range test (DMRT) at 5 % level of significance when a significant F value existed.

3. results and discussion

3.1. plant growth characteristics

The height of plants at 10 months after planting was significantly influenced with N application at both sites. The greatest plant height was produced with the application of 800 and 1 000 kg·ha^{-1} N at sites 1 and 2, respectively, but it was similar to those produced with other N treated plants except for the control, which produced the shortest plants (*table II*). The number of leaves was not influenced by N application at site 1. However, it was significantly influenced with N application at site 2. The highest number of leaves was produced with 400 kg·ha^{-1} N. Leaves produced with all other N levels were similar except for the control, which produced the lowest number at this site. Similar effects of N were also observed in other studies with the cultivar Gandul on peat soil. Selamat and Ramlah [2] found a significant effect of N on plant height at nine months after planting. However, the height of plants was significantly different only in plants raised from the control plots. Similar to the present study result at site 1, Selamat and Ramlah [2] did not find any significant effect of N on leaf number of the cv. Gandul at 9 months after planting on peat soil. However, significant increase in leaf number of Smooth Cayenne pineapple had been reported on mineral soil [4].

Nitrogen did not have significant effects on D-leaf length, area and dry matter weight at site 1. However, D-leaves area and dry

Table II
Effect of different nitrogen doses on growth and N concentration in leaves of pineapple cv. Gandul grown in peat soil at two sites (Johore, Malaysia).

Nitrogen (kg·ha^{-1})	Plant height (cm)	Number of leaves	D-leaf length (cm)	D-leaf area (cm^2)	D-leaf dry weight (g)	N concentration in D-leaves (%)
Site 1						
0	104.9b	53.5	90.7	297.6	6.53	0.90b
200	107.2ab	55.4	92.6	300.7	6.70	0.94b
400	108.4ab	54.6	94.7	322.6	6.95	1.02ab
600	110.4ab	55.4	93.9	329.1	6.56	1.06ab
800	114.0a	55.7	92.7	326.6	6.70	1.13a
1 000	107.8ab	52.5	90.8	330.6	6.72	1.09ab
Site 2						
0	100.7b	51.8c	88.9	300.8b	5.90b	0.85c
200	106.8ab	56.3b	92.5	327.4ab	6.80ab	0.93bc
400	109.6a	60.6a	96.9	353.7ab	7.30a	1.04ab
600	110.3a	57.1b	95.2	319.3ab	6.48a	1.07ab
800	108.3ab	55.6b	97.2	355.1a	7.40a	1.05a
1 000	112.3a	56.0b	97.6	365.2ab	6.90a	1.09ab

Means within a column followed by the same letters are not significantly different at 5 % level by Duncan's New Multiple Range test.

weights were influenced with the application of N at site 2. The highest leaf area was produced with 800 kg·ha^{-1} N, followed by other N treatments and differed statistically only from the control plants. Although the leaf area and leaf dry weight increased with N application at site 2, the change was significant only with the control. The increase resulted largely with low to moderate N applications. Higher N doses tended to depress the D-leaf characteristics of pineapples grown on peat soil. Asoegwu [4] observed a significant increase in D-leaf area in comparison to the control with small dressing of N, but he did not find any change with high N doses.

The N concentrations in D-leaves at 10 months after planting (forcing time) were influenced by N treatments at both sites. The highest N concentration was recorded with the application of 800 kg·ha^{-1} N, followed by 1 000, 600 and 400 kg·ha^{-1} N, and it statistically differed from 0 and 200 kg·ha^{-1} N at sites 1 and 2 (*table II*). The effect of N on the leaf N content has been reported by numerous researchers in different pineapple varieties. Rao et al. [5] observed a gradual increase in leaf N concentration with increased levels of N. Velez-Ramos and Borges [6] did not find any significant increase of leaf N concentration with increased levels of N, but the content continued to increase with N dressing. The leaf highest N concentration of 2.17 % was shown to produce with the application of 784 kg·ha^{-1} N at 4-months growth stage. However, Mustaffa [7] found a significant increase in leaf N concentration with different rates of N and the highest concentration of 2.24 % was achieved with 700 kg·ha^{-1} N. Ramirez and Gonzalez-Tejera [8] found the leaf highest N concentration of 1.93 % with the application of 336 kg·ha^{-1} N.

Table III
Influence of the applied nitrogen on N uptake and recovery by pineapple cv. Gandul grown on peat soil at two sites (Johore, Malaysia).

Nitrogen (kg·ha^{-1})	Nitrogen uptake (kg·ha^{-1})		Nitrogen recovery (%)	
	Site 1	Site 2	Site 1	Site 2
0	197.0	183.5	0	0
200	216.9	210.3	14.0	16.1
400	226.4	226.8	8.7	13.0
600	240.1	255.7	7.6	10.3
800	276.0	236.0	10.1	7.4
1 000	275.7	266.0	8.2	9.2

3.2. N uptake and recovery

Nitrogen uptake by pineapples was not influenced with the applied N at either site. However, at site 1, the highest uptake of 276 kg·ha^{-1} N resulted from the application of 800 kg·ha^{-1} N and the least of 197 kg·ha^{-1} N was from the control (*table III*). At site 2, the highest amount of 266 kg·ha^{-1} N was taken up with the application of 1000 kg·ha^{-1} N and the lowest of 184 kg·ha^{-1} N with the control.

At site 1, the N recovery declined until 600 kg·ha^{-1} N with increased N and, thereafter, showed somewhat inconsistent results. At site 2, N recovery declined until the application of 800 kg·ha^{-1} N, but showed a slight increase with 1 000 kg·ha^{-1} N. At site 1, the highest recovery of 15 % resulted with the application of 200 kg·ha^{-1} N and the least of 8 % was from 600 kg·ha^{-1} N. At site 2, about 16 % N was recovered from the application of 200 kg·ha^{-1} N and declined to the least of 7 % with 800 kg·ha^{-1} N. Results indicated that the recovery of the applied N from peat soil is very low at both sites.

In tropical and subtropical environments, the efficiency of the applied N is an average of 50 %, but it varies from 20 to 80 % [9]. Results of N uptake by pearl millet in the savanna region of Nigeria indicated that as high as 88 kg·ha^{-1} N was taken up by the hybrid variety out of the application of 100 kg·ha^{-1} N [10]. Nonetheless, Chew et al. [11] reported that up to about 4 % of the applied N was available to Napier grass in peat soil. In the present studies, applications of N resulted in a very low recovery and decreased subsequently with the increased N application at both sites. The highest recoveries ranged from 15 to 16 %, which occurred with the application of 200 kg·ha^{-1} N at both sites.

4. conclusion

Generally, the N demand for a good crop is enormous and pineapple response with high N dressing is clearly shown on mineral soils. But pineapple grown on peat soil meets its demand for N to a large extent from the mineralization of organic matter and, thereby, the dependence on the applied N is minimised. A bulk of N was applied in the field, but the crop failed to uptake available N for enhancing the growth. This might be due to high the loss of N by different means or the availability of one or more nutrient in excess seriously counteracting the uptake of other elements and making unbalance either in the plant or in the soil.

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Respuesta de la piña al aporte de nitrógeno en turba tropical: I. Efecto del N en el crecimiento de las plantas, absorción de N y su restitución.

Resumen — Introducción. Se han realizado experimentos en el campo para estudiar el efecto de N en el crecimiento de las plantas, la absorción de N y su restitución por el cv. de piña 'Gandul', una variedad del grupo Spanish, cultivada sobre turba tropical en dos lugares (sitio 1 y sitio 2) de Johore (Malasia). **Material y métodos**. Se aplicaron seis dosis de nitrógeno en forma de urea con una tasa de 0, 200, 400, 600, 800 y 1 000 kg·ha^{-1} N en ambos sitios. **Resultados y discusión**. Diez meses después de la plantación, en el sitio 1, la aplicación de nitrógeno tuvo efectos significativos sobre la altura de las plantas; en el sitio 2, la tuvo sobre la altura de las plantas, el número de hojas, la superficie de la hoja D y su peso seco.

Hasta 800 kg·ha^{-1} N, las aplicaciones de nitrógeno aumentaron la concentración de nitrógeno en la hoja D en ambos sitios. La absorción total de N en ambos sitios, ha tenido tendencia a aumentar con las dosis crecientes. La mayor restitución, 15 % (sitio 1) y 16 % (sitio 2) se obtuvo con la aplicación de 200 kg·ha^{-1} N, para ir luego disminuyendo con las dosis crecientes que siguieron. **Conclusión.** Las piñas cultivadas en turba han visto satisfechas sus necesidades de N a partir de la mineralización de la materia orgánica y su dependencia de nitrógeno aplicado se ha visto fuertemente reducida sea cual fuere el sitio de experimentación. © Éditions scientifiques et médicales Elsevier SAS

Malasia / *Ananas comosus* / crecimiento / fijación del nitrógeno / turba / aplicación de abonos / nitrógeno