International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume: 10, Issue: 05 "September-October 2024"

PINEAPPLE GROWTH PERFORMANCE, FRUIT QUALITY AND YIELD INFLUENCED BY FOLIAR FERTILIZATION ON CLAY SOIL AND PEAT SOIL

[1*]Mohd Nizam Zubir, [2]Badril Hisham Abu Bakar, [2]Siti Noor Aliah Baharom, [2]Rohazrin Abdul Rani, [2]Adli Fikri Ahmad Sayuti and [1]Mohd Zuhaidy Abdul Rahman

[1]Horticulture Research Centre, Malaysia Agriculture Research and Development Institute (MARDI), 82000 Pontian, Johor, Malaysia.

[2]Engineering Research Centre, Malaysia Agriculture Research and Development Institute (MARDI), 42400 Serdang, Selangor.

*Corresponding author

DOI: https://doi.org/10.51193/IJAER.2024.10506

Received: 06 Sep. 2024 / Accepted: 17 Sep. 2024 / Published: 21 Oct. 2024

ABSTRACT

Small scale pineapple farmer conducting fertilization programme for pineapple with application of granular fertilizer. Meanwhile, large scale pineapple plantation conducts fertilization programme through foliar feeding to accommodate usage of plastic mulching for weed suppression and high-density planting requirement. Thus, this study was conducted to evaluate different treatments of foliar fertilizer by comparing pineapple growth performance, fruit quality and expected yield on two different soil types namely clay and peat soil. This study was conducted using MD2 pineapple planted on completely randomized block design with application of five foliar fertilizer treatments with four replications. Granular fertilizer treatment was chosen as control. Usage of foliar fertilizer was suitable for pineapple plants on both soil type. Pineapple plant grew better on peat soil based on plant growth parameters. Foliar fertilizers were only affecting on plant height and D-leaf length only during early vegetative stage. Pineapple on clay soil produce heavier inflorescence with smaller crown but pineapple on peat soil produced sweeter fruit. Fertilizer treatments affect fruit quality parameters on inflorescence and crown fresh weight, total soluble solids and total titratable acid. T2 YARA kristalon green at 3.77g/plant proves to be an effective foliar fertilizer for pineapples, improving fruit quality with higher total soluble solids and better yield.

ISSN: 2455-6939

Volume: 10, Issue: 05 "September-October 2024"

Keywords: Foliar fertilizer, MD2 pineapple, peat soil, clay soil

1. INTRODUCTION

Fertilization program for pineapple (*Ananas comosus*) could be conducted through basal application or through foliar fertilization. Small scale farmers usually conducted fertilization through basal application with granular fertilizer. Meanwhile, large scale farmer accomplished fertilization mainly through foliar fertilizer due to fertilizer application convenience and to fulfil high density planting requirement for pineapple especially for MD2 variety and the use of plastic covers that necessitate application of fertilizers entirely through foliar spray. Any basal application will be conducted before plastic covers were installed. Commonly, foliar spray contains micronutrients to correct nutrient deficiency in plant while macronutrients such as nitrogen and potassium are supplied to the plant through basal application which is absorbed through plant roots. For pineapple, both macro and micronutrients are combined and sprayed together to the plant within short interval to reduce nutrients leaching and increased nutrients absorption.

In many bromeliad species specifically pineapple, the dead cells on outer layer of pineapple leaves, can absorbed water and nutrients and the stalk can carry both into the inner leaf tissues (Coppens d'Eeckenbrugge and Leal, 2018). This trait enables nutrients in the fertilizer to be absorbed by pineapple plants either by leaves or roots. Pineapple leaves crescent-shaped allows it to collect water in the rosette. Application of foliar spray takes advantage of this special leaves arrangements to collect small particles of foliar spray to trickle down the leaves and to be collected around the rosette or to be slowly drip down to roots area for nutrients absorption.

Both clay soil and peat soil are often considered marginal soil and require thorough land preparation to be suitable for plant cultivation. Pineapple cultivation on clay soil requires land preparation such as ploughing and harrowing in order to break soil structure to be well aerated. These steps require long dry period around two weeks which was difficult for tropical region. Meanwhile, peat soil did not require such measures except well drainage system in order to manage excess water during rainy season. Typically, heavy machinery can be used on clay soil, but it poses challenges on peat soil, making it difficult for tractors to operate effectively. This is particularly important for applying foliar fertilizers.

Clay soil onsite was categorized as Parit Botak Series that developed on acid sulfate marine clay soil with grayish brown colour and heavy clay content. This soil type has low pH with moderate medium to coarse angular blocky, sticky and shallow imperfect drained soil. Soil containing more than 66% clay are less suited for pineapple due to its properties which are easily compacted, poor drainage and prone to becoming waterlogged (Vásquez-Jiménez & Bartholomew, 2018). Clay soil also could shrink during dry period which causes pineapple roots to break and vulnerable to

ISSN: 2455-6939

Volume: 10, Issue: 05 "September-October 2024"

pathogens. Meanwhile, peat soil onsite was categorized as moderately deep peat soil. Nutrients in peat soil is prone to washout (Balasundram et al., 2018) especially in tropical region such as Malaysia that experience high humidity and heavy rainfall.

In order to determine the suitability of foliar spray for MD2 pineapple on clay and peat soil, six treatments of fertilizer spray were tested. Data on plant growth parameters, fruit quality and yield will be taken to determine which fertilizer are suitable for MD2 pineapple on both soil types.

2. MATERIALS AND METHODS

2.1 Field Preparation

A field study was conducted at Malaysian Agricultural Research and Development Institute (MARDI) Pontian, Johor, Malaysia from September 2021 to November 2022 (1°30'17" N latitude, 103°27'6" E longitude, clay soil) and May 2022 to August 2023 2022 (1°30'11" N latitude, 103°27'23" E longitude, peat soil). Mean monthly precipitation ranging from 160 mm to 320 mm all year round. This study was conducted using a randomized complete block design (RCBD) with six treatments (Table 1). All fertilizers except T1 were applied through foliar spray based on month after planting, MAP as stated in Table 1. Fertilizer application for T1 was conducted through basal application and served as control for this study.

Table 1: Schedule for each fertilizer treatments.

Treatment	Description	Application frequency	Solubility
T1	Borduex mixture spray, 100 mL per plant 32 g/L of hydrated lime 2.1 g/L of copper sulfate 2.1 g/L zinc sulfate 2.1 g/L of iron sulfate	1.5 MAP and 4.5 MAP	Moderately soluble
	NPK granular fertilizer (15:15:15)	3 and 6 MAP	Not applicable
	NPK granular fertilizer (12:12:17:2)	9 MAP	Not applicable
T2	YARA Kristalon Green 18:18:18 3.77g/plant	1, 2, 3, 4, 5, 6, 7, 8 & 9 MAP	Highly soluble

ISSN: 2455-6939

Volume: 10, Issue: 05 "September-October 2024"

T3	YARA Kristalon Green 18:18:18 1.89g/plant	1, 2, 3, 4, 5, 6, 7, 8 & 9 MAP	Highly soluble
T4	YARA Kristalon Green 18:18:18 2.83g/plant	1, 2, 3, 4, 5, 6, 7, 8 & 9 MAP	Highly soluble
T5	Borduex mixture spray, 100 mL per plant 32 g/L of hydrated lime 2.1 g/L of copper sulfate 2.1 g/L zinc sulfate 2.1 g/L of iron sulfate	1.5 MAP and 4.5 MAP	Moderately soluble
	NPK single fertilizer, Department of Agriculture Kedah (Jabatan Pertanian Negeri Kedah, 20--) NPK 15:15:15 NPK 12:12:17	3, 3.5, 4, 6, 7 & 7.5 MAP 8.5 & 9 MAP	Sparingly soluble
T6	PIP fertilizer Programme PIP COLEACP (2011)	1, 2, 3, 4, 5, 6, 7, 8 & 9 MAP	Highly soluble
Degree of solubility (descending order): highly soluble, moderately soluble, sparingly soluble & insoluble			

The experimental area was divided into four blocks, each containing 6 individual plots. Each subplot measuring 9.5m × 6.0m was planted with 294 (14 ×21) plants per plot arranged in a double row planting (6 × 5) with planting distance of 30 cm × 60 cm × 90 cm. Each individual plot was separated with a spacing of 4 m to prevent foliar drift during fertilizer application. Pineapple suckers with average length of 30 cm were obtained from Kulim Pineapple Farm, Ulu Tiram Johor, Malaysia. Prior to planting, planting materials were treated with fungicide containing mancozeb (80% w/w Ken-Manco, Kenso Corporation, Selangor, Malaysia) at a rate of 1 g/L solution. The plot was not irrigated and water level was maintained approximately 1.0 m throughout the study. Weed control was managed through hand weeding and application of selective herbicide with

ISSN: 2455-6939

Volume: 10, Issue: 05 "September-October 2024"

active ingredient of ametryn (45% w/w Amepax 500, Imaspro Resources, Selangor, Malaysia). Flowering induction was conducted on 10 MAP with application of 50 mL solution of 300 mg/L ethephon (2-chloroethyl) phosphonic acid and 24 g/L of urea applied to the pineapple rosette starting in the late evening.

2.2 Plant Growth Rate

For vegetative data collection, 32 plants from each treatment; 8 plants per replication of treatment were chosen randomly. Data collection included plant height, D-leaf length (data not shown) and width, and number of functional leaves at 3, 6 and 9 MAP. The D-leaf is the longest leaf that can serve as an index of plant growth and plant nutrient status (Vásquez-Jiménez & Bartholomew, 2018). Plant height was measured vertically from the tip of D-leaf to the ground using a meter ruler. D-leaf length was measured from the tip to the base while D-leaf width was measured horizontally approximately 5 cm from the base using either a 1 m or 30 cm ruler. The number of functional leaves was manually counted excluding leaves shorter than 10 cm.

2.3 Pineapple Fruit Quality and Yield

Twelve plants from each treatment; three plants per replication of treatment were chosen with the same maturity index of 2. Fruit, inflorescence and crown weight and length were recorded. The fresh weight was determined with electronic balance (FX-3000i, A&D, Tokyo, Japan) while the length was recorded using caliper. Total soluble solid (TSS) and Total Titratable Acid (TTA) were recorded using pocket Brix- Acidity Meter F5 ATAGO. The estimated yield of each treatment was derived by multiplying the fresh fruit weight (infructescence with crown) by 37,000, assuming 85% yield from planting density of 43,500 plants per hectare. The plant fresh weight includes the weight of all functional leaves, stem and peduncle but excludes the fruit and root parts below ground level.

2.4 Cost Estimation

The cost for each fertilizer applied in this study was calculated. The cost of labor, planting materials, weed control, foliar fertilizer and flowering induction were not included. The cost was calculated in Ringgit Malaysia based on the price of fertilizer during the study was conducted.

2.5 Data Analysis

Data were analysed using two-way analysis of variance (ANOVA). The differences between means were separated using Duncan's multiple range test (DMRT) at 5% significance level. Statistical analysis was performed using SAS software version 9.4.

ISSN: 2455-6939

Volume: 10, Issue: 05 "September-October 2024"

3. RESULT AND DISCUSSION

3.1 Pineapple plant growth parameter

Table 2: Plant growth rate parameters throughout vegetative stage of MD2 pineapple influenced by soil type and different fertilizers type.

Treatments	Plant height (cm)			D-leaf length (cm)			D-leaf width (cm)			Number of functional leaves		
Soil Type, S \ MAP	**6**	**8**	**10**	**6**	**8**	**10**	**6**	**8**	**10**	**6**	**8**	**10**
Clay	63.8	78.5	93.2	57.0	68.9	80.1	5.3	5.9	5.8	24.4	33.1	38.9
Peat	78.3	91.1	101.5	69.6	79.0	89.5	5.6	5.4	5.2	30.9	37.8	46.1
P	***	***	***	***	***	***	***	***	***	***	***	***
Fertilizer, F \ MAP	**6**	**8**	**10**	**6**	**8**	**10**	**6**	**8**	**10**	**6**	**8**	**10**
1	72.1^{ab}	85.7	96.9	64.6^{a}	74.7	87.0	5.5	5.8	5.5	26.7	36.3	42.5
2	71.5^{ab}	85.5	101.5	63.0^{a}	73.4	88.1	5.5	5.5	5.5	28.5	35.8	43.8
3	67.1^{c}	83.8	95.3	58.9^{b}	73.2	83.6	5.4	5.5	5.1	27.2	35.4	41.2
4	71.8^{ab}	85.8	99.6	63.8^{a}	74.8	85.5	5.6	5.7	5.5	27.7	36.5	45.6
5	73.5^{a}	85.6	99.8	65.3^{a}	74.9	85.8	5.5	5.6	5.6	28.1	35.8	45.6
6	70.2^{b}	86.3	97.3	63.8^{a}	75.9	86.7	5.3	5.8	5.3	27.6	34.8	41.7
P	***	ns	ns	***	ns	ns	ns	ns	ns	ns	ns	ns
S*F	ns	***	***	ns	***	*	ns	ns	**	ns	ns	ns
F value	1.95	5.21	3.88	1.65	4.19	2.22	1.70	2.08	4.02	1.50	0.11	0.85

(*p<0.05, **p<0.01, ***p<0.001, ns; not significant)

Means with different letters within the column indicate significant differences according to DMRT

Soil type definitely affected on all parameters for pineapple plant growth rate (Table 2). Peat soil is much better media compared to clay soil for pineapple plant growth. The pineapple plant grown in peat soil was taller and had more leaves, but the leaves were narrower. In line with the findings of Nur Syahidah et al. (2021), which reported that pineapples cultivated on mineral soil exhibited wider leaves compared to those grown on peat soil, our experiment similarly observed a significant increase in leaf width for plants grown in clay soil compared to peat soil.

During early vegetative stage on 6 MAP, fertilizer treatments showed significant effect on plant height and D-leaf length but the trend discontinued. D-leaf width and number of leaves were both not affected by different fertilizer treatments. Towards the end of the vegetative stage, there were no significant differences in plant growth parameters among the different fertilizer treatments.

Table 3: MD2 pineapple fruit quality influenced by different soil type and different fertilizers type.

Treatment	Inflorescence fresh weight (kg)	Crown fresh weight (kg)	Inflorescence to crown Ratio	Inflorescence length (cm)	Crown length (cm)	TSS (°Bx)	TTA (%)	Ratio (TSS/TTA)
Soil Type, S								
Clay	1.74	0.36	4.88	17.8	27.6	13.7	0.55	23.5
Peat	1.30	0.45	2.99	15.7	32.3	14.4	0.51	28.1
p	***	***	***	***	***	**	***	***
Fertilizer, F								
1	1.54	0.43[a]	3.5[b]	17.2	32.3[a]	13.8[bc]	0.54[ab]	24.3[b]
2	1.53	0.44[a]	3.9[ab]	16.9	30.8[ab]	14.2[abc]	0.56[a]	25.6[b]
3	1.48	0.44[a]	3.5[b]	16.3	30.7[ab]	14.8[a]	0.49[b]	30.5[a]
4	1.53	0.39[ab]	4.1[ab]	16.6	28.9[b]	14.2[ab]	0.52[ab]	25.8[b]
5	1.42	0.38[b]	3.8[ab]	16.5	29.1[b]	13.5[c]	0.57[a]	24.3[b]
6	1.59	0.36[b]	4.4[a]	17.2	28.6[b]	13.7[bc]	0.53[ab]	24.8[b]
p	ns	***	*	ns	**	**	*	***
S*F	**	ns	*	**	***	**	*	*
F value	3.501	2.231	2.837	3.144	5.316	3.501	3.018	3.114

(*p<0.05, **p<0.01, ***p<0.001, ns; not significant)

Means with different letters within the column indicate significant differences according to DMRT.

3.2 Pineapple fruit quality parameters

Based on fruit quality parameters, soil type significantly affected all the parameters (Table 3). Pineapple on clay soil produced heavier inflorescence with smaller crown hence increasing inflorescence to crown ratio. Nevertheless, pineapple on peat soil produced sweeter fruit with slightly lower acid.

Higher inflorescence to crown ratio on pineapple on clay soil compared to peat soil is a good indicator for conversion of plant energy reserve to fruit part; the inflorescence instead of vegetative part; the crown. The trend also followed by T6 fertilizer treatment. Lower ratio is also an indicator of pineapple fruit with larger crown which is common for pineapple grown on peat soil that are undesirable for market due to consumer preference that had to pay extra for excessive crown weight.

Meanwhile, fruit quality parameters such as crown fresh weight, inflorescence to crown ratio, crown length, TSS and TTA were significantly differed influenced by fertilizer treatments. Although no significant result shown on inflorescence fresh weight, T6 showed the heaviest inflorescence followed by T1, T2 and T4. Heavier crown weight was recorded on T1 to T4. Even T6 fertilizer treatment had heavier inflorescence, lower TSS value slightly gave disadvantages to this treatment. All foliar fertilizer sources from YARA on T2, T3 and T4 regardless of its concentration recorded °Bx higher than 14. This is could due to application of multiple microelements within the fertilizer which affects TSS. In general, all foliar fertilizers in this study produced fruit with °Bx above 12 which is a prerequisite for export market.

TTA were significantly affected by soil type and fertilizer treatments with the lowest recorded on T3. MD2 is recognized as a pineapple variety with high sugar content and low acid content, typically ranging from 0.4% to 0.45% (Malezieux & Bartholomeew, 2003). However, the recorded data did not support this characterization. This discrepancy could be attributed to variations in soil type affecting the TTA of the fruit.

3.3 Expected fruit yield

Table 4: MD2 expected yield influenced by different soil type and different fertilizers type.

Treatments	Fruit fresh weight (kg)	Plant fresh weight (kg)	Plant to fruit ratio	Expected yield (t/ha)
Soil Type, S				
Clay	1.86	2.87	1.49	65.8
Peat	1.75	4.46	2.54	62.6
p	***	***	***	***
Fertilizer, F				
1	1.80	3.61	1.98^{bc}	64.6
2	1.88	3.84	2.04^{bc}	66.5
3	1.80	3.60	2.00^{bc}	63.8
4	1.79	3.48	1.96^{c}	63.2
5	1.77	3.66	2.06^{b}	64.4
6	1.78	3.85	2.27^{a}	61.9
p	ns	Ns	*	ns
S*F	**	Ns	*	ns
F value	3.659	0.715	2.413	1.755

ISSN: 2455-6939

Volume: 10, Issue: 05 "September-October 2024"

Based on table 4, pineapple cultivated on clay soil produced heavier fruit with lower plant fresh weight compared to peat soil thus affecting plant to fruit ratio significantly. Loosely structured peat soil facilitates rapid pineapple growth, leading to larger and heavier plants. However, this does not necessarily result in heavier fruit, as the data indicate that heavier fruit was actually produced on clay soil. It is expected to achieve higher yield on clay soil compared to peat soil due to the difference on fruit weight produced from clay soil.

Fresh fruit weight and plant fresh weight were not affected by different fertilizer treatments and this trend is also reflected in the expected yield. Plant to fruit ratio is a useful indicator of how efficiently a plant converts its reserve energy into fruit, with a lower ratio indicating better efficiency. T6 fertilizer recorded the highest ratio indicating that it is less effective in conversion of plant energy reserve into fruit. The highest expected yield was recorded with T2, although the result was not statistically significant.

3.4 Cost of fertilizer

Table 5: Cost analysis for different fertilizer treatments for MD2 pineapple grown on clay and peat soil.

Treatment	Fertilizer treatment	Total Fertilizer Cost (RM)
T1	NPK granular fertilizer (control)	RM12,873 (0%)
T2	YARA kristalon green 3.77g/plant	RM14,627 (+14%)
T3	YARA kristalon green 1.89g/plant	RM7,313 (-45%)
T4	YARA kristalon green 2.83g/plant	RM10,951 (-15%)
T5	NPK single fertilizer	RM5,470 (-58%)
T6	PIP fertilizer Programme	RM7,772 (-40%)

Note: Cost of fertilizer was calculated based on market price during the study was conducted. Calculation was made throughout one cycle of pineapple with estimation of 43,500 pineapple plants per hectare.

Based on table 5, the cost for each foliar fertilizer were calculated and tabulated. T1, NPK granular fertilizer will serve as the control and the baseline for this comparison. Fertilizer costs account for approximately 20% of the total production cost (data not shown) where the percentage could be different based on different geographical location and fertilizer market condition. Based on table 4, T2 was the only fertilizer treatment that exceeded the cost, increasing by an additional 14%,

ISSN: 2455-6939

Volume: 10, Issue: 05 "September-October 2024"

while T5, the NPK single fertilizer, had the lowest cost offering a 58% savings. T2, T3, T4 and T6 fertilizers exhibited the highest degree of solubility followed by Borduex mixture on T1 and T5 with T5 having the lowest solubility. For fertilizers with lower solubility, using a powered sprayer is recommended, as it can handle coarser filter and ensure that sparingly soluble materials are effectively applied to the plants.

4. CONCLUSION

The application of foliar fertilizer is suitable for pineapple plants and is comparable to the application of granular fertilizer in terms of effectiveness. Clay soil and peat soil could be cultivated with pineapple plants with good yield. T2, YARA Kristalon Green at 3.77g/plant, appears to be a suitable foliar fertilizer for pineapples, as it promotes high fruit quality with elevated TSS, good yield and a high inflorescence-to-crown ratio. Although there is a slight increase in fertilizer cost by 14%, the benefits outweigh this cost. Given that fertilizer represents only 20% of the total production cost, the 14% increase in fertilizer cost translates just a 2.8% increase in the overall production cost. Research on other soil types, such as mineral soil, is important as the cultivation of MD2 pineapple shifts toward this soil type which offers better fruit quality and facilitates foliar fertilizer application as tractors can be effectively used on this type of soil.

REFERENCES

[1]. Balasundram, S.K., Chong, Y.M. & Husni, M.H.A. (2018), Monitoring potassium levels in peat-grown pineapple using selected spectral ratios, Papers presented at 14th International Conference on Precision Agriculture, held at Montreal, Quebec, Canada, June 24 – June 27, 2018.

[2]. Coppens d'Eeckenbrugge, G. & Leal, F. Morphology, Anatomy and Taxonomy. In The Pineapple: Botany, Production, and Uses. Second Edition. Sanewski, G.M., Bartholomew, D.P. & Paull, R.E.; CAB International: Wallingford, UK, 2018; pp. 11–31.

[3]. Jabatan Pertanian Negeri Kedah, Manual Pengurusan Teknologi Tanaman Padat Nanas Moris di Tanah Mineral. http://www.doa.gov.my/index/resources/aktiviti_sumber/sumber_awam/maklumat_pertanian/teknologi_inovasi/manual_pengurusan_teknologi_nanas.pdf

[4]. Malezieux, E. & Bartholomeew, D.P. (2003). Plant Nutrition. In D.P. Bartholomew, R. E. Paull & K. G. Rohrbach (eds.) *The Pineapple: Botany, Production and Uses.* (pp 143-165) Wallingford, UK: CAB International.

[5]. Nur Syahidah, A.J., Salwa A., Asmah A., Shampazuraini S., Nor Azma Y. and Nordiana I., (2021), Conf. Ser.: Earth Environ. Sci. 685, 012025.

ISSN: 2455-6939

Volume: 10, Issue: 05 "September-October 2024"

[6]. Programme PIP COLEACP (2011) Crop Production Protocol Pineapple MD2 (Ananas Comosus) (2011), Rue du Trone, 130-B-1050 Brussels-Belgium.

[7]. Vásquez-Jiménez, J., & Bartholomew, D. P. (2018). Plant nutrition. In The pineapple: botany, production and uses (pp. 175-202). Wallingford UK: CAB International.

[8]. Soil Information System (Geotanih), Jabatan Pertanian Malaysia. 2017 – 2024.

