GROWTH PERFORMANCE OF PINEAPPLE (*ANANAS COMOSUS VAR.* MD2) WITH DIFFERENT APPLICATION OF GRANULAR FERTILIZER ON TROPICAL PEAT SOIL

Mohd Nizam Zubir
Horticulture Research Centre,
Malaysia Agriculture Research and Development Institute, 82000 Pontian, Johor.
Email: znizam@mardi.gov.my

Nor Syahida Md Sam
Soil Science, Water and Fertilizer Research Centre,
Malaysia Agriculture Research and Development Institute, 42400 Serdang, Selangor.
Email: nsyahidah@mardi.gov.my

Nurul Shamimi Abdul Ghani
Horticulture Research Centre,
Malaysia Agriculture Research and Development Institute, 82000 Pontian, Johor.
Email: nshamimi@mardi.gov.my

Ahmad Arif Ismail
Industrial Crop Research Centre,
Malaysia Agriculture Research and Development Institute, 21810 Ajil, Terengganu.
Email: amdarif@mardi.gov.my

ABSTRACT

Cultivation of pineapple crop in Malaysia started on tropical peat soil. At present time, the industry slowly shifting pineapple cultivation to mineral soil yet it still exists on tropical peat soil due to the robustness of pineapple plant on acidic peat soil. In this study, commonly used fertilizer on peat soil, Pineapple Mixed Fertilizer, PMF (30:1:32) was compared with NPK fertilizer (15:15:15 and 12:12:17) and RH Growpine Compacted Fertilizer, GCF (12:8:16). Pineapple treated with no fertilizer treatment was included as checked treatment. Growth performance of MD2 pineapple on 3, 6 and 9 months after planting (MAP) was evaluated. Application of 20 gram fertilizer for each application per tree was made on 3, 6 and 9 MAP. Based on vegetative data collection, there was significant difference measured for NPK and GCF compared to PMF in terms of plant height, D-leaf width and stem circumference on 6 MAP. The difference was also showed on 9 MAP for NPK and GCF compared to PMF in terms of plant height, D-leaf length and D-leaf width. There was no significant difference observed on number of leaves on 6 and 9 MAP between fertilizer treatments except treatment without fertilizer. For fresh weight of pineapple leaves, no difference can be seen between NPK, GCF and PMF on 6 MAP except for dry weight of leaves where GCF leaves dry weight was higher compared to NPK. The trend was not followed for fresh and dry weight of pineapple stem between each fertilizer treatments. Fresh weight of pineapple root for PMF and no fertilizer treatment were higher compared to NPK and GCF while no significant difference on root dry weight on every treatment except between GCF and PMF. Altogether, granular fertilizer of GCF and NPK affected greatly on growth performance of MD2 pineapple as compared to PMF.

Key words: pineapple, fertilizer, peat soil, growpine compacted fertilizer

INTRODUCTION

Pineapple (Ananas comosus) cultivation in Malaysia initially intended for canning industry but later this industry shifted to fresh fruit market. Typically, pineapple cultivation in Malaysia is associated with tropical peat soil however introduction of new variety of pineapple; MD2 moved Malaysia's pineapple cultivation to mineral soil in which this variety produced high quality and sweeter fruit. Yet, the cultivation still continues to exist on tropical peat soil and still popular among pineapple growers especially for pineapple varieties of Moris, Josapine and N36. The used of Pineapple Mixed Fertilizer, PMF (30:1:32) is common for pineapple planted on peat soil while NPK fertilizer (15:15:15 and 12:12:17) is recommended for pineapple planted on mineral soil (MPIB, 2020). Introduction of RH Growpine Compacted Fertilizer, GCF (12:8:16) by MARDI increases pineapple productivity on mineral soils and this fertilizer was tested suitable for commercial pineapple varieties such as Josapine, Morris, MD2, N36, Gandul, Maspine and Sarawak (Abbas et al., 2015). Pineapple farmers claimed the usage of NPK fertilizer for pineapple on peat soil did increased plant vigor and fruit quality compared to PMF yet the usage of PMF still practiced among farmers.

MD2 pineapple is newly introduced pineapple hybrid that is highly demanded for export market in Malaysia. This variety is chosen because of its high-quality characteristics which are sweeter fruit, cylinder in shape, golden flesh color and longer shelf life (Sanewski et al., 2018). Preferably, MD2 pineapple is cultivated on mineral soil however the cultivar is also planted on peat soil in which the fruit quality is reported less sweet and high in acidity. This variety may respond differently with fertilizers input as compared to other varieties when cultivated on peat soil. The other factor causing lower fruit quality of MD2 could be the properties of peat soil itself which is acidic soil. Pineapple variety Josapine (cross between Johor and Sarawak) released by MARDI on 1996 was developed on peat soil in Johor. This variety is popular for fresh fruit market with relatively high soluble solid content in range of 17 - 22% (Sanewski et al., 2018). While pineapple varieties of N36 and Morris were commonly planted on peat soil in southern region of Peninsular Malaysia (MPIB, 2019). Since Josapine, N36 and Moris were commonly cultivated on peat soil, problem

regarding fruit quality is less likely reported for these varieties. In addition, the price for MD2 pineapple fruit produced on peat soil was reported to be lower than MD2 pineapple fruit produced on mineral soil. Therefore, this study will provide some information regarding the use of different fertilizer on improving plant vigor consequently impacting fruit quality afterward.
Nutrient leaching is a common problem for pineapple cultivation on peat soil which is infrequently reported on mineral soils (Balasundram et al., 2018). Fertilization program is the key to ensure optimum growth of pineapple to increase crop yield. Pineapple plants require large nutrient demand mostly potassium, nitrogen, calcium and magnesium (Vásquez-Jiménez & Bartholomew, 2018). Micronutrient of nitrogen is known to be essential during vegetative stage while potassium is important for formation of high quality and sweeter fruit. Given these circumstances, this study will show an insight on suitability of NPK fertilizer and GCF for pineapple cultivation on tropical peat soil as compared to PMF in supplying optimum amount of nitrogen during vegetative stage which afterward could influence fruit quality. Thus, the objective of this study was to observed growth performance of MD2 pineapple with the application of three different type of granular fertilizer; PMF, NPK and GCF with checked treatment of pineapple without any application of fertilizer on tropical peat soil.

MATERIALS AND METHODS

Field Preparation
A field study was conducted at Malaysian Agricultural Research and Development Institute (MARDI) Pontian, Johor, Malaysia (1°30' N latitude, 103°27' E longitude) from August 2019 until Jun 2020. Mean monthly precipitation on this area ranging from 160 mm to 320 mm all year round. Application of 7.5 metric ton ground magnesium lime, GML per hectare was made into the soil before it was ploughed with rotary tiller. This study was conducted using a randomized complete block design (RCBD) with four treatments; control plants with no fertilizer, plants applied with NPK fertilizer (15:15:15 and 12:12:17), plants applied with RH Growpine Compacted Fertilizer, GCF (12:8:16) and plants applied with Pineapple Mixed Fertilizer, PMF (30:1:32). The plot was divided into four blocks with each containing four individual plots. Each subplot with size 3.6 m X 3.6 m was planted with 81 (9 X 9) plants per plot with plant-to-plant planting distance of 30 cm. Each individual plot was separated with a spacing of 1.5 m and metal flat sheet G030 was placed with depth of 30 cm into soil between each subplot to prevent sideways movement of fertilizer during heavy precipitation season.

Pineapple suckers with average length of 30 cm were obtained from Kulim Pineapple Farm, Ulu Tiram Johor where the pineapple suckers were treated with fungicide with active ingredient of fosetyl-aluminium before shipment to planting site. All type of fertilizers were applied to the soil approximately 5 cm close to the plant on 3, 6 and 9 months after planting (MAP) with rate of 20 gram per plant for each application. For NPK fertilizers, NPK 15:15:15 was applied on 3 and 6 MAP while on 9 MAP, NPK 12:12:17:2 was used instead. Application of foliar fertilizer was made on 1.5 MAP and 4.5 MAP for 100 mL per plant with mixture of 32 g/L of hydrated lime, 2.1 g/L of copper sulfate, 2.1 g/L zinc sulfate and 2.1 g/L of iron sulfate. Urea with rate of 32g/L was added into foliar fertilizer mixture on 4.5 MAP. For checked plot without fertilizer, neither application of granular nor foliar fertilizer was made. The plot was not irrigated and water level was maintained approximately 1.0 m throughout the study. Weeds on the plot were controlled through hand weeding without any application of herbicide.

Vegetative Growth of Pineapple Plants
Twenty plants from each treatment; five plants per replication of treatment were chosen randomly within second line (7 X 7) of each subplot (9 X 9) for vegetative growth data collection. Data collection included plant height, D-leaf length and width, stem circumference and number of leaves on 3, 6 and 9 MAP. D-leaf is the longest leaf on the plant (Vásquez-Jiménez & Bartholomew, 2018). The plant height was measured using a meter ruler; D-leaf length and width were measured with a 30 cm ruler and stem circumference was measure with a meter of sewing tape. For number of leaves, the count only included functional leaves only through manual counting.

Plant Biomass Determination
Twelve plants from each treatment; three plants per replication of treatment were chosen from second line of each subplot for fresh and dry weight determination. The plant was pulled carefully from the soil to avoid unnecessary lost of plant roots. The plants were washed and air dried before the leaves were separated from the stem. Then, the stem was divided to upper part as pineapple stem and lower part or underground portion as pineapple roots (Coppens d'Eeckenbrugge & Leal, 2018). The samples were dried in the oven at 70°C until constant mass was obtained. The fresh and dry weight of leaves, stem and roots were determined with electronic balance (FX-3000i, A&D, Tokyo, Japan).

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

Data Analysis
Data for vegetative growth and plant biomass were analyzed by one-way analysis of variance (ANOVA). The results are express as mean ± standard error of mean. The differences between means were separated using Duncan's multiple range test (DMRT) at 5% significance level. Statistical analysis was completed using SAS software version 9.3.

RESULT AND DISCUSSION

Vegetative growth and plant mass

Table 2 shows vegetative growth of MD2 pineapple was not significant during early growth of plant on 3 MAP. This was happened due to no application of fertilizer during early growth of pineapple. Application of first foliar fertilizer was indeed without addition of any macro elements of N, P and K except microelements of copper, zinc and iron. The same trend was observed for number of leaves and stem circumference between each fertilizer treatments throughout the study except checked treatment. On 6 MAP, the only difference of pineapple plants supplied with fertilizer was observed between PMF as compared to NPK and GCF in term of plant height and D-leaf width. While on 9 MAP, plant growth of GCF and NPK were better as compared to PMF in term of plant height, D-leaf length and D-leaf width. Generally, plant growth performance of pineapple applied with PMF was lower compared to NPK fertilizer and GCF.

Based on Table 3, generally checked plant without any addition of fertilizer was statistically differed than other treatment especially on 6 and 9 MAP. In term of leaf fresh weight, significant difference was observed on pineapple plant with GCF, 3589 g which was heavier as compared to PMF, 2319 g on 9 MAP while for leaf dry weight, the difference was observed only on 6 MAP between GCF, 202.5 g and NPK, 142.5 g. For stem fresh and dry weight, the difference was only shown on 9 MAP between GCF and PMF. There was no significant difference on fresh and dry weight of roots for all treatments except on 6 MAP where root of plants with GCF was lighter compared to PMF. Based on total biomass of plant, the different was observed on 9 MAP on fresh weight between GCF as compared to PMF but the trend was not followed on total dry weight of plant. In general, GCF produced heavier pineapple plant, 4038-gram follower by NPK fertilizer, 3175 g, PMF 2583 g and unfertilized pineapple 1767 g. Based on Table 4, pineapple leaves comprised close to 90% of total biomass of pineapple plant and the rest was divided between root and stem. The ratio of root to total biomass of plants in all treatments was getting lesser throughout plant development. However, the trend was increasing for ratio of stem to total biomass of plant. The ratio of leaves nevertheless was almost the same throughout the experiment.

Nitrogen and potassium are the main macro elements needed for optimum pineapple plant development. Nitrogen is important during vegetative growth stage of pineapple in order to maintain high vegetative growth rate while potassium is more important during fruit development stage for high quality and sweeter fruit (Vásquez-Jiménez & Bartholomew, 2018). The main problem with pineapple cultivation on tropical peat soil would be nutrient leaching due to peat soil properties that is less likely to retain nutrients, low in cation exchange capacity and prone to washout during high precipitation season on tropical climate region (Balasundram et al. 2018). Nitrogen and potassium ratio in PMF is higher compared to NPK and GCF at 30% N and 32% K_2O ratio respectively. However, application of this fertilizer to pineapple on peat soil did not improved growth rate as good as NPK fertilizer or GCF. Increased application of nitrogen certainly will increase plant growth rate and fruit yield as reported by Mohammed Selamat and Ramlah (1993), Omotoso & Akinrinde (2013) and Spironello et al. (2004). Nonetheless, application of high nitrogen in PMF still not guaranteed vigorous plant growth of MD2 in this study. Potassium deficient pineapple produced fruit with reduced fruit mass, less aromatic flesh and lower number of planting materials (Hawkesford et al., 2012). High rate of K may reduce absorption of other crucial micronutrients during vegetative growth. Large amount of potassium applied before planting could bring advantages to the plant but it also could caused nutrients imbalance that interfere with micronutrients absorption such as Mg, Ca, or Zn (Vásquez-Jiménez & Bartholomew, 2018). High ratio of K on PMF starting from early vegetative growth on 3 MAP could disrupt nutrient absorption from soil to plant roots. Lower total plant biomass of plant supplied with PMF observed as early on 6 MAP and significantly on 9 MAP was the evidence of lower nutrients supplied to the plant for vegetative growth. While for the case of phosphorus, low phosphorus of PMF may not causing lower growth rate. This factor could be rule out due to insignificant interaction of low phosphorus to pineapple growth vigor as suggested by Mohammed Selamat and Ramlah (1993) on deep peat soil and Spironello et al. (2004) on sandy and low fertility Alfisol. Valleser (2019) finding on interaction of phosphorus certainly described there are positive correlation between increasing amount of phosphorus to MD2 pineapple plant growth yet phosphorus starved plant still produced good quality fruit without diminished physico-chemical properties. Thus, lower ratio of P on PMF could not be the factor that causing low plant vigor on pineapple plant.

Pineapple mix fertilizer, PMF is made up of three single fertilizers; ammonium sulfate, christmas island rock phosphate (CRIP) and muriate of potash (MOP). NPK fertilizer is a fertilizer that is very homogenous in their chemical analysis and contain superior nutrient combinations both fast-acting and slow-acting nitrogen and phosphorus sources (Behn Meyer, 2020). RH Growpine Compacted Fertilizer, GCF contained zeolite to ensure efficient control nutrient release to the plant (Abbas et al., 2015). The properties of GCF which releases nutrients at slower rate as compared to NPK and PMF could be the main factor contributes to high growth rate of pineapple plant and heavier plant biomass. This statement was supported by Sakimin et al. (2017) where the application of Kamila, a type of slow release fertilizer in form of nugget increased plant height significantly. Small size particles of single fertilizer used for PMF increased surface area for granule degradation for nutrients released. As result, the rate of nutrient release for PMF will be faster compared to NPK fertilizer and GCF. The usage of combination of single fertilizers of PMF to supply nitrogen and potassium as granular fertilizer proved to be not suitable on peat soil due to nutrient leaching. Hence, combination factor of small size particle of PMF and nutrients' leaching of tropical peat soil resulted with low plant vigor and lighter plant biomass of pineapple plant. The usage of controlled release fertilizer such as GCF is more suitable in order to supply nutrients optimally to pineapple plant throughout its life cycle on tropical peat soil. Long interval between fertilizer applications could lead to temporary nutrients deficit during plant growth. Stretching continuous supply of nutrients using slow release fertilizer should adequately supply optimum amount of nutrients to pineapple plant. Instead of supplying large amount of nutrients at one time in this case observed on PMF, gradual release of nutrients from GCF or NPK fertilizer show vigorous plant growth.

Accumulation of dry matter before pineapple flowering induction mostly will be on the leaves as agreed by Hanafi & Razzaque (2003) where more than 80% of total biomass contributed by pineapple leaves portion. Usage of 872 $kg.ha^{-1}$ of N and 400 $kg.ha^{-1}$ of K_2O produced heaviest stem and leaves dry matter compared to 600 $kg.ha^{-1}$ of N and 798 $kg.ha^{-1}$ of K_2O followed by 750 $kg.ha^{-1}$ of N and 266 $kg.ha^{-1}$ of K_2O (Hanafi & Halimah, 2004). High ratio of nitrogen to potassium unnecessarily resulted to high accumulation of biomass where ratio of 2:1 of N to K_2O showed heavier dry matter mass compared to ratio of 3:1 of N to K_2O (Hanafi & Halimah, 2004). In regard to this experiment, the ratio of N to K_2O for PMF (30:31), NPK fertilizer (15:15 & 12:17) and GCF (12:16) were relatively close to 1:1 ratio. From the ratio for all type of granular fertilizers, the result of plant vigor and plant biomass were expected to be not too different between each treatment but the result confirmed differently. Therefore, it is not necessarily supplying high amount of nitrogen and potassium will ensure optimum plant growth but rather supplying good ratio of nutrients will guarantee higher plant vigor.

Cost of Fertilizer

A cost analysis was conducted to determine the profitability and relationship of using different granular fertilizers to plant growth performance discussed in this study. Cost of pineapple suckers, foliar fertilizers, manpower for field maintenance was not included since these costs were similar for every fertilizer treatments. Based on table 5, the cost of fertilizer application was the highest for NPK fertilizer which is RM 6,090 per hectare followed by GCF at RM 4,698 per hectare and PMF at RM4,541.40 per hectare. Based on plant growth rate and plant biomass analysis, the application of GCF to MD2 pineapple on peat soil is more profitable compared to NPK fertilizer since both fertilizers showed insignificant results. Both NPK fertilizer and GCF produced heavier plant biomass and vigorous plant growth. Since, the cost for GCF is lower than NPK fertilizer by 23%, pineapple farmers could benefit more on using GCF rather than applying NPK fertilizer. Farmers could save up to 35% on cost of fertilizer and 29% on cost of fertilizer programme by using RH Growpine Compacted Fertilizer as compared to NPK Fertilizer for pineapple cultivated on mineral soil (Abbas et al., 2015). Even the cost of PMF is the lowest as compared to NPK fertilizer and slightly lower than GCF, PMF did not resulted with good growth rate and heavy plant biomass unfulfilled the reason of fertilizer application to increase plant growth rate. The benefits of GCF compensate the cost in which GCF was indeed producing more vigorous plant and heavier plant biomass. Pineapple farmers always thrive to lower production cost without affecting crop yield afterward. Consequently, GCF is proven resulting more vigorous pineapple plant growth and plant biomass with optimum cost of.

Table 2. Growth performance of MD2 pineapple applied with different type of granular fertilizers.

Morphology	MAP	No fertilizer	Pineapple Mix Fertilizer, PMF	NPK fertilizer	Growpine Compacted Fertilizer, GCF
Plant height (cm)	3	48.9 ± 1.8 ^{a}	46.3 ± 0.9 ^{a}	48.6 ± 1.1 ^{a}	47.2 ± 2.1 ^{a}
	6	69.1 ± 3.1 ^{c}	85.9 ± 1.3 ^{b}	93.1 ± 1.7 ^{ab}	94.3 ± 2.9 ^{a}
	9	81.7 ± 2.5 ^{c}	103.1 ± 1.7 ^{b}	117.5 ± 2.6 ^{a}	122.0 ± 3.6 ^{a}
D-leaf length (cm)	3	47.9 ± 1.2 ^{a}	45.5 ± 0.5 ^{a}	48.2 ± 1.1 ^{a}	46.4 ± 1.9 ^{a}
	6	65.9 ± 3.0 ^{b}	81.3 ± 1.3 ^{a}	86.6 ± 1.2 ^{a}	88.3 ± 3.3 ^{a}
	9	77.0 ± 3.0 ^{c}	93.3 ± 2.5 ^{b}	104.6 ± 1.9 ^{a}	109.0 ± 2.6 ^{a}
D-leaf width (cm)	3	2.9 ± 0.1 ^{a}	2.7 ± 0.1 ^{a}	3.0 ± 0.1 ^{a}	3.1 ± 0.1 ^{a}
	6	3.6 ± 0.1 ^{c}	5.0 ± 0.4 ^{b}	6.1 ± 0.4 ^{a}	5.8 ± 0.3 ^{a}
	9	4.2 ± 0.3 ^{c}	5.4 ± 0.3 ^{b}	6.5 ± 0.1 ^{a}	6.5 ± 0.2 ^{a}
Stem circumferenc e (cm)	3	23.5 ± 1.4 ^{a}	21.7 ± 2.2 ^{a}	23.8 ± 1.3 ^{a}	23.0 ± 1.7 ^{a}
	6	27.4 ± 1.1 ^{b}	30.9 ± 1.5 ^{ab}	34.4 ± 0.9 ^{a}	31.9 ± 1.2 ^{a}
	9	30.2 ± 0.7 ^{b}	35.5 ± 2.2 ^{ab}	38.0 ± 0.2 ^{a}	35.2 ± 2.1 ^{ab}
Number of leaves	3	18 ± 1 ^{a}	20 ± 2 ^{a}	20 ± 1 ^{a}	19 ± 1 ^{a}
	6	25 ± 1 ^{a}	27 ± 2 ^{a}	28 ± 2 ^{a}	26 ± 1 ^{a}
	9	26 ± 1 ^{b}	29 ± 1 ^{ab}	31 ± 1 ^{a}	31 ± 1 ^{a}

Note: Mean ± standard error of mean was analyzed by ANOVA. The different letter within each row indicates significant difference at $p \leq 0.05$ based on Duncan's multiple range test (DMRT).

Table 3. Plant biomass of different plant parts of MD2 pineapple applied with different type of granular fertilizers.

	MAP	No fertilizer	Pineapple Mix Fertilizer, PMF	NPK fertilizer	Growpine Compacted Fertilizer, GCF
Leaf Fresh Weight (g)	3	332.1 ± 32.6 ^{a}	394.7 ± 38.0 ^{a}	336.2 ± 32.9 ^{a}	324.0 ± 30.0 ^{a}
	6	640.3 ± 45.0 ^{b}	1063 ± 139 ^{a}	1153 ± 114 ^{a}	1222 ± 96 ^{a}
	9	1572 ± 275.0 ^{c}	2319 ± 199 ^{bc}	2820 ± 379 ^{ab}	3589 ± 385 ^{a}
Leaf Dry Weight (g)	3	45.27 ± 6.42 ^{a}	51.83 ± 5.96 ^{a}	41.88 ± 3.58 ^{a}	39.28 ± 3.58 ^{a}
	6	87.69 ± 6.76 ^{c}	155.7 ± 21.8 ^{ab}	142.5 ± 9.9 ^{b}	202.5 ± 17.6 ^{a}
	9	249.0 ± 57.8 ^{b}	293.0 ± 39.4 ^{ab}	316.0 ± 52.2 ^{ab}	378.0 ± 23.6 ^{a}
Stem Fresh Weight (g)	3	19.03 ± 1.94 ^{ab}	25.68 ± 2.75 ^{a}	18.59 ± 1.49 ^{ab}	17.61 ± 2.14 ^{b}
	6	38.04 ± 3.24 ^{b}	62.63 ± 9.12 ^{a}	77.73 ± 7.34 ^{a}	80.63 ± 6.99 ^{a}
	9	89.75 ± 19.90 ^{c}	154.8 ± 18.5 ^{bc}	238.3 ± 46.1 ^{ab}	314.8 ± 51.8 ^{a}
Stem Dry Weight (g)	3	1.94 ± 0.31 ^{ab}	2.70 ± 0.38 ^{a}	1.66 ± 0.42 ^{b}	1.80 ± 0.46 ^{ab}
	6	4.01 ± 0.40 ^{b}	6.36 ± 0.93 ^{ab}	7.09 ± 1.05 ^{a}	6.87 ± 0.83 ^{a}
	9	11.25 ± 2.02 ^{c}	18.50 ± 1.94 ^{bc}	22.50 ± 5.24 ^{ab}	29.00 ± 4.51 ^{a}
Root Fresh Weight (g)	3	29.84 ± 2.64 ^{a}	35.99 ± 6.83 ^{a}	28.84 ± 4.40 ^{a}	27.18 ± 3.62 ^{a}
	6	45.30 ± 2.19 ^{a}	50.38 ± 11.83 ^{a}	35.63 ± 4.51 ^{a}	30.84 ± 3.76 ^{a}
	9	105.5 ± 22.6 ^{a}	109.8 ± 15.1 ^{a}	116.8 ± 22.0 ^{a}	134.0 ± 17.2 ^{a}
Root Dry Weight (g)	3	5.37 ± 0.72 ^{a}	6.04 ± 1.55 ^{a}	5.20 ± 0.71 ^{a}	5.98 ± 1.47 ^{a}
	6	10.11 ± 0.27 ^{a}	10.34 ± 2.12 ^{a}	6.22 ± 1.04 ^{ab}	5.85 ± 0.83 ^{b}
	9	17.00 ± 4.42 ^{a}	19.25 ± 1.89 ^{a}	17.50 ± 3.38 ^{a}	23.00 ± 3.34 ^{a}
Total Fresh Weight (g)	3	380.9 ± 36.9 ^{a}	456.3 ± 48.2 ^{a}	383.7 ± 38.0 ^{a}	368.8 ± 35.5 ^{a}
	6	723.6 ± 48.8 ^{b}	1176 ± 160 ^{a}	1266 ± 124 ^{a}	1334 ± 106 ^{a}
	9	1767 ± 315 ^{c}	2583 ± 230 ^{bc}	3175 ± 438 ^{ab}	4038 ± 449 ^{a}
Total Dry Weight (g)	3	52.58 ± 7.37 ^{a}	60.58 ± 6.65 ^{a}	48.73 ± 4.62 ^{a}	47.06 ± 5.36 ^{a}
	6	101.8 ± 6.85 ^{c}	172.4 ± 24.8 ^{ab}	155.8 ± 11.1 ^{bc}	215.2 ± 18.8 ^{a}
	9	277.3 ± 63.3 ^{b}	330.8 ± 42.3 ^{ab}	356.0 ± 60.5 ^{ab}	430.0 ± 30.9 ^{a}

Note: Mean ± standard error of mean was analyzed by ANOVA. The different letter within each row indicates significant differences at $p \leq 0.05$ based on Duncan's multiple range test (DMRT).

Table 4. Ratio of different parts of plant compared to total biomass during vegetative growth of pineapple with application of different granular fertilizer.

	MAP	No fertilizer	Pineapple Mix Fertilizer, PMF	NPK fertilizer	Growpine Compacted Fertilizer, GCF
Ratio of leaf fresh	3	87.2	86.5	87.6	87.9
weight	6	88.5	90.4	91.0	91.6
(%)	9	89.0	89.4	88.8	88.9
Ratio of leaf dry	3	86.1	85.6	85.9	83.5
weight	6	86.1	90.3	91.5	94.1
(%)	9	89.8	88.6	88.8	87.9
Ratio of stem fresh	3	5.00	5.56	4.84	4.77
weight	6	5.26	5.33	6.14	6.05
(%)	9	5.08	5.99	7.51	7.80
Ratio of stem dry	3	3.69	4.46	3.40	3.83
weight	6	3.93	3.69	3.19	3.19
(%)	9	4.06	5.59	6.74	6.74
Ratio of root fresh	3	7.83	7.89	7.52	7.37
weight	6	6.26	4.29	2.81	2.31
(%)	9	5.97	4.25	3.68	3.32
Ratio of root dry	3	10.2	9.98	10.7	12.7
weight	6	9.93	5.99	3.99	2.72
(%)	9	6.13	5.82	4.92	5.35

Table 5. Cost analysis of MD2 pineapple grown with different granular fertilizer.

Fertilizer	Composition	Cost (RM)	
		Per plant	**Per hectare**
No fertilizer	-	0.000	0.00
Pineapple Mix Fertilizer, PMF	30:1:32	0.104	4,541.40
NPK fertilizer	15:15:15 12:12:17:2	0.140	6,090.00
Growpine Compacted Fertilizer, GCF	12:8:16	0.108	4,698.00

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

CONCLUSION

The result showed that the application of GCF as compared to NPK fertilizer and PMF produced more vigorous plant growth rate and heavier plant biomass. It confirmed GCF and NPK fertilizers supplied optimum amount of nutrients during vegetative stage of pineapple. In comparison of fertilizer control; pineapple mix fertilizer, PMF which is commonly used fertilizer on pineapple plantation on peat soil in Malaysia, the usage of either NPK fertilizer or GCF is more profitable to the farmers. Thus, recommendation of usage of Growpine Compacted Fertilizer, GCF could transform Malaysia's pineapple industry further. Although, large scale study is required in order to reaffirm the suitability and profitability of using GCF for pineapple cultivated on peat soil.

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