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THE EFFECTS OF PINEAPPLE CAPSULAR AND MICROBIAL FERTILISERS WITH DIFFERENT APPLICATION RATES ON FRUIT MORPHOLOGY, BIOCHEMICAL CHANGES, AND SOIL NUTRIENTS IN PEAT SOILS

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Abstract: The MD2 variety of pineapple exhibits a substantial level of demand from both China and the Middle East, emphasising the significance of this crop in these regions. Most pineapple cultivation in Malaysia occurs in peat soil, requiring substantial fertiliser application throughout growth. Peat soil exhibits limited productivity and does not adequately facilitate optimal plant growth. A research investigation was undertaken to mitigate the reliance on traditional fertilisers by utilising capsular fertilisers and microbes to improve the growth of pineapple crops in peat soil. Seven treatments and four replications were performed using conventional pineapple fertiliser and capsule fertiliser with microbes at various fertiliser application rates. The pineapple cultivar employed in this study is MD2. The findings indicate no statistically significant impact on pineapple morphology when comparing capsule fertiliser and microbes to conventional fertiliser. However, the fruit weight of conventional fertiliser is slightly heavier. Nevertheless, in terms of flavour, pineapple cultivated with capsule and microbial fertiliser exhibits a more pronounced sweetness than conventional fertiliser. The observed nutrient content in the soil did not demonstrate a statistically significant impact across all treatment conditions. Nevertheless, utilising capsule fertilisers containing microbes with lower application rates than conventional fertilisers proves to be a viable approach in mitigating the overreliance on chemical fertilisers while concurrently fostering the growth of pineapple plants..

Keywords: fertiliser, beneficial microorganisms, peat soil

Introduction

Pineapple (*Ananas comosus* L.) plays a vital role in the agricultural and food industries because pineapple fruit is highly appreciated for its unique aroma and sweet taste. It ranks second among four major fresh tropical fruits, which comes after mango and is followed by papaya and avocado (FAO 2017). In 2021, the total number of pineapple plantations in Malaysia was 16,204 hectares. Most pineapples in Malaysia are grown in peat soil, though they can be grown in various other soil types.

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This is because pineapples thrive in acidic soil with a pH 5. Peat soil comprises semi-decomposed organic matter derived primarily from plant material but has a low planting productivity.

The high water content is one reason peat soils usually refer to problematic soils (Kazemian et al. 2011). The decomposition or humification process in peat soils involves the loss of organic matter in the form of gas or solution, the physical structure disappears, and the chemical state changes, finally releasing carbon dioxide and water (Huat et al. 2014). The agricultural practices developed in peat soils have modified the structural components related to organic matter decomposition and carbon emission, which further alter its physiochemical characteristics (Azmi & Kassim 2022).

Soil has been degraded globally, resulting in lower fertility as agricultural practices such as pesticides and chemical fertilisers have become more prevalent (Harman et al. 2020). Using biofertilisers presents a potential strategy for enhancing soil microbial composition, thereby promoting the activity of indigenous soil microorganisms and impacting nutrient availability and organic matter decomposition (Chaudhary et al. 2021). Soil microbes interact with one another and with plant roots in various ways, providing a wide range of essential acts important for maintaining soil ecological balance (Kumar et al. 2021c). Plant-microbial interactions are favourable since they improve plant survival, nutritional status, and crop productivity (Vishwakarma et al. 2020). Microorganisms solubilise phosphorus and zinc, fix nitrogen, and provide other macro and micronutrients that promote plant growth under biotic stress conditions (Singh et al. 2022). This study aimed to determine the efficacy of capsule fertiliser and microbes on the morphology of pineapple fruit, the biochemical properties of pineapple fruit, and the effect on soil nutrients.

Materials and Methods

The field trial was conducted on peat soil at the MARDI Pontian, Johor (1.5077° N, 103.4457° E) from July 2021 until October 2022. The experimental design was arranged in a randomised complete block design (RCBD) with seven treatments and four replicates consisting of chemical fertiliser (T1), chemical fertilizer+microbes (T2), capsular fertiliser (60g x 1 application)+microbes (T3), capsular fertiliser (50g x 1 application)+microbes (T4), capsular fertiliser (30g x 2 application)+microbes (T5), capsular fertiliser (25g x 2 application)+microbes (T6) and capsular fertiliser (15g x 3 application)+microbes (T7). The pineapple cultivar employed in this study is MD2.

Microbes were applied before transplanting and spraying 3, 6, and 9 months after planting (MAP). The NPK fertiliser granules were used at different rates of the treatments at 1, 3, 6 and 9 MAP. Individual plot size was 3.0 m × 2.0 m. The beds and blocks were separated with a spacing of 1.0 m to ensure uninterrupted irrigation flow for each plot. An average of fifteen plants were planted in double rows for each plot with the plant-to-plant spacing of 60 cm × 30 cm. Flowering was induced after 10 MAP based on the crop development stage by spraying with 50 ml Ethrel (2-chloroethyl phosphonic acid) solution (which mix with 160 g urea with 18 L water) at the centre of the pineapple plants. Flowering induction is carried out in the morning. Then, the fruits were harvested when they were one-third ripe (about 145 days after flowering was successfully induced).

For morphological analysis, plant weight and diameter were measured after harvesting. All pineapple fruits were weighed before the biochemical analysis. Soil analysis was outsourced to determine the CEC, total N, P, K, Mg and Ca content.

Results and Discussions

The fertilisation effect on the pineapple morphology is shown in Table 1. Pineapple fresh weight shows no significant differences among the treatments between conventional fertiliser and capsular fertiliser with microbes. The average pineapple fresh weight is 1.65 to 2.08 kg per plant. The crown weight was also uniform among the treatments with no significant differences, as well as pineapple diameter for all treatments. In contrast, the length of the pineapples shows a significant difference between T1 (conventional fertiliser) and T3 (capsular fertiliser with microbes). T1 shows the highest fruit length, 19.2±0.49 cm, compared to T3, which is 16.3±0.52 cm.

Table 1. Morphological characteristics of MD2 pineapple plants supplemented with different capsular and microbes fertilisers rates.

Parameters	Samples						
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**
Fruit weight (fresh) (g)	2.08±0.10a	2.04±0.12a	1.65±0.08a	1.72±0.07a	1.74±0.07a	1.95±0.09a	1.83±0.08a
Crown weight (dry) (g)	0.06a	0.05a	0.05a	0.05a	0.05a	0.06a	0.05a
Diameter of fruit (cm)	13.10±0.33a	12.37±0.35a	12.29±0.33a	12.49±0.37a	11.88±0.20a	12.88±0.31a	12.16±0.21a
Length of fruit (cm)	19.2±0.49ab	17.6±0.76a	16.3±0.52ab	16.9±0.69a	17.0±0.48a	18.6±0.50a	17.1±0.43a

Means ± standard error followed by different letters in a row are significant at $p < 0.05$

For biochemical results, all treatments had no significant differences in fruit pH (Table 2). The pH ranges from 4.94 to 5.15 among treatments. Regarding sweetness or total soluble solid (TSS), treatment with capsular fertiliser and microbes (T4, T5, T6 and T7) has higher TSS values, which is more than 14% than treatment with conventional fertiliser (T1, T2) and T3 (1x application capsular fertiliser with microbes). For the export market, the TSS value of the harvested MD2 fruit must reach 12% or above.

A simple titration process is used to measure the percentage of acid in the pineapple to test its acidity. Pineapples contain sugars and are generally acidic (pH below 7) (Table 2). pH value and total titratable acid (TTA) also differed significantly among treatments. The balance between the sugar-to-acid ratio helps determine the pineapple's use, i.e., canned, fresh or as juice. The sugar-to-acid ratio did not differ significantly among the treatments regarding taste. Ascorbic acid content showed significant differences among the treatments. T7 has the highest ascorbic acid (vitamin C) content, 45.73 mg/100 g fresh weight, while T3 shows the lowest at 28.19 mg/100 mg fresh weight.

Table 2. Biochemical changes of MD2 pineapple plants supplemented with different capsular and microbes, fertiliser rates

Parameters	Samples						
	T1	**T2**	**T3**	**T4**	**T5**	**T6**	**T7**
pH	5.14a	5.07b	5.15a	5.07b	4.94c	5.01b	5.04b
Total soluble solid (%)	12.39b	12.91b	13.07b	14.72a	14.80a	15.14a	14.25a
Titratable acidity (%)	0.34c	0.37bc	0.34bc	0.38b	0.45a	0.44a	0.42a
Sugar:acid ratio	37.10	34.98	38.14	38.95	32.76	34.20	33.68
Ascorbic acid (mg/100 g FW)	26.42d	37.10c	28.19d	39.42bc	38.59c	41.43b	45.73a

Means followed by different letters in a row are significantly different at $p < 0.05$

According to Table 3, all treatments show soil pH at an average of 5.2, which is the typical pH for peat soil. The soil CEC in all treatments was consistent with soil pH. Soil CEC recorded readings between 14 to 22.9 meg/100 g of soil, where the highest CEC was in the T7 treatment. Soil texture is also crucial in affecting soil moisture content as well as the chemical properties of the soil, such as its cation exchange capacity (CEC) or the ability of the soil to hold positively charged ions (Delgado et al. 2016). Data on the soil nutrient content (N, P, K, Mg, Ca) taken after harvesting are presented in Table 3. Soils total N, P, K, Mg and Ca nutrient contents showed no significant difference for all treatments except the T1, which shows the highest available phosphorus (32.25%) compared to other treatments which majorities are below 15%.

Table 3 Soil nutrient analysis of MD2 pineapple plants supplemented with different capsular and microbes, fertilisers rates

pH/Total Elements	Samples						
	T1	T2	T3	T4	T5	T6	T7
pH	5.3a	5.2a	5.2aa	5.1a	5.2a	5.3a	4.9a
CEC (meq/100g)	14.05a	16.88a	20.26a	16.73a	21.57a	19.46a	22.90a
Total N (%)	1.37a	1.42a	1.34a	1.39a	1.42a	1.39a	1.38a
Avail. P (%)	32.25a	15.5a	12.5a	9.5a	9.25a	10.75a	8.5a
K (meq/100 g)	0.061a	0.015a	0.027a	0.018a	0.027a	0.021a	0.033a
Mg (meq/100 g)	5.23a	1.73a	4.02a	2.26a	4.73a	4.61a	3.85a
Ca (meq/100 g)	6.65a	2.52a	4.99a	3.29a	5.98a	5.99a	4.93a

Means followed by different letters in a row are significantly different at $p < 0.05$

Conclusion

Across all treatment conditions, the observed pineapple morphology and nutrient content in the soil had no statistically significant impact. Regarding flavour, pineapple grown with capsule and microbial fertiliser has a stronger sweetness than conventional fertiliser. However, using capsule fertilisers containing microbes at lower application rates than conventional fertilisers proves viable in reducing reliance on chemical fertilisers while promoting pineapple plant growth. There are significant and non-significant differences between the use of conventional fertilisers and capsule fertilisers with microbes. Since using microbes is the first time for this pineapple cultivation, the more effective effect has yet to be seen.

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Declaration of Interest Statement

The authors declare no conflict of interest.

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