Morphology and fruit quality characters of Pineapple (*Ananas comosus* L. Merr) cv. Queen on three sites planting: freshwater peat, brackish peat and alluvial soil

Rosmaina1*, MA Almaktsur1, R Elfianis1, Oksana1, and Zulfahmi1.

1Department of Agrotechnology, Faculty of Agricultural and Animal Science
Universitas Islam Negeri Sultan Syarif Kasim Riau, Panam-Pekanbaru 28293, Riau
Indonesia
Corresponding author’s e-mail: rosmaina@uin-suska.ac.id

Abstract. The growth and fruit quality of the crop is strongly influenced by the environment in which it grows. The purpose of this study was to observe the growth and fruit quality of pineapple (*Ananas comosus* L. Merr) cv. *Queen* that cultivated in the three different ecosystems. Pineapple cv. *Queen* was planted in three different ecosystems, namely in freshwater peatlands, brackish water peatlands and Alluvial soils in Riau province. Morphology and fruit quality characters of pineapple were evaluated at each ecosystem. The result of this study displayed that pineapple cultivated in freshwater peatland having fruit weight (1540.64 g), fruit length (19.80 cm), sucker number (4.94 pieces), slip number (3.16 pieces), total dissolve content (14.19°Brix), titratable acidity (TA) (0.51%), and water content (85.94%) higher than others site. Morphology and fruit quality characters of pineapple that cultivated in brackish water peatlands and alluvial soils were not significantly different. Our finding of this study that pineapple grows well on three soil types and is adaptive in peatland so that pineapple can be selected as an alternative crop to be developed in the peatland in the future.

Keywords: pineapple, alluvial, peatland, fruit quality.

1. Introduction

Pineapple (*Ananas comosus* L. Merr.) is one of the most economically important tropical fruits after banana and mango. Pineapple has high nutrient contents, specific flavor so that people like to consume it's freshly. Besides, pineapple is often processed in various forms product such as canned fruit, juice, bromelin extract [1,2,3] fiber production [4] animal feed [5,6], and pineapple wine. Indonesia is one of the biggest pineapple producing countries in the world [7], reflected in Indonesia's total pineapple exports of around 193,948 tons in 2015 which continued to rise to 210,025 tons in 2017. Pineapple exports contribute around 82% of Indonesia's fruit exports [8]. The destination countries for Indonesian pineapple exports are the United Arab Emirates, Japan, Korea, Hong Kong, Saudi Arabia, and Singapore. In pineapple global trade, Indonesia's competitors are Brazil, Thailand, Philippines, Costa Rica, and China.

Riau province is one of the center productions of pineapple in Indonesia. In this region, the pineapples are commonly cultivated in peatland. Riau province has the biggest peatland in Sumatra, which is about 4.044 million hectares or 56.1% out of total peat land in Sumatra [9]. Most of the peatland in Riau are utilized by the farmer to plantation, crops and horticulture. The productivity of crops and horticulture in peatland was low, but the contribution of peatland in the crops and horticulture production around 50-60% from the total of crop production on the peatland [10].

One of the problems cultivation in the peatland is low soil fertility, acid soil reactions, and nutrient deficiency, mainly Cu and Zn [11]. This caused only a few plants able to produce well in the...
peatland, but instead, the pineapple is one of the crops that can grow and produce well in the peatland, 
not even using fertilizer until first harvesting. The utilization of peatland for pineapple cultivation is 
also reported in Malaysia, estimated about 90% of pineapple cultivation applied in the peatland 
[12],[13],[14]. According to [13] that the cultivation of pineapple in peatlands is more economically 
beneficial than cultivation in mineral soil, and is more environmental friendly [14] because the 
emissions of methane produced from peatland planted with pineapple are lower, which is 0.65% 
tons/ha/year compared to those on empty peat land which produces 0.75% tons/ha/year. Pineapple in 
Riau province has faster growth and harvesting age around 11-12 months. According to [15] and [16] 
stated that pineapple can flower at the age of six months after planting in tropical lowland areas and 
 faster harvesting, but pineapple planted at an altitude of 750 m above sea level started to flower in the 
age of 11-12 months. Other reports stated that altitude, season, duration and intensity of sunlight 
radiation effect growth and fruit quality of pineapple [15,17,18].

Based on the ecosystem or physiographic characteristics, peatland in Riau province can be 
divided into three types of peat, namely coastal peat swamp that is peat formed from marine water, 
brackish peat that is peat formed from brackish water (river and sea) and freshwater peat swamp that is 
formed from rainwater or freshwater. Each type of peat has different physical, chemical and biological 
properties [19,20,11] so that it will produce differentiation vegetation that grows on it [21,22]. They 
are widely used for pineapple cultivation in Riau so pineapple might produce differences in fruit 
growth and quality, depending on genotype, environment, and interactions between genotype and 
environment. According to [23] that different pineapple genotypes and different growing 
environments require different fertilization to produce optimal fruit, in other words, different soil types 
will produce different fruit quality product. The purpose of this study was to observe the growth and 
fruit quality of pineapple (Ananas comusus L. Merr) cv. Queen that cultivated in the three different 
locations, namely in freshwater peatlands, brackish water peatlands and alluvial soils.

2. Materials and Methods

The research conducted from March 2017 to February 2018. Plant materials that are used are 
pineapple cv. Queen. The research design used a randomized complete design (RCD) with land type 
as treatment. The plant sampled is taken from in three locations, e.g. freshwater peatland (101° 15’58” 
E and 0° 25’44” N), brackish peatland (102° 50’56.47” E and 0° 33’16.49” N) and alluvial soil 
(101°16’34.4” E and 0°24’53.7” N). Thirty plants sampled were randomly selected from each 
population and then carried out to the laboratory to be analysed.

The qualitative and quantitative characters of the sampled were observed. The measurement of 
quantitative characters of pineapple included plant height (cm), leaf length (cm), leaf width (cm), 
number of leaves, stem diameter (cm), number of slips, number of shoot, number of suckers, fruit 
weight with crown (g), fruit weight without crown (g), peduncle diameter (cm), fruit height (cm), fruit 
diameter (cm), eye (berry) depth (cm), core diameter (cm), crown height (cm), crown weight (g), total 
soluble solid (TTS °Brix), titratable acidity (TA), vitamin C content, TTS/TA ratio, and water content. 
Observations on qualitative characters were carried out on the character of plant habit, leaf color, bract 
color, petal colour, sepal color, fruit shape, fruit color when unripe, fruit color when ripe, fruit color 
homogeneity when ripe, eye profile, eye relative surface, flesh color, flesh aroma, and crown shape. 
The observation technique for all characters refers to the Descriptor for Pineapple guidelines, issued 
by the International Board for Plant Genetic Resources [24]. The analysis of variance was carried out 
to quantitative characters from three locations.

3. Results and Discussions

3.1. Qualitative Characters

The result observed the qualitative characters of pineapple at three sites planting are presented at Table 
1. The results of this study showed that there is no difference in the qualitative character of pineapple 
(cv. Queen on three types of cultivation land tested. This may be closely related to qualitative 
characters controlled by simple genes, so they are not influenced by environmental factors. It is
different from quantitative characters which are strongly influenced by many genes and are strongly influenced by genotype and environmental interaction [25],[26]

Table 1. Qualitative characters of pineapple cv. Queen planted in freshwater peatland, brackish peatland and alluvial soil in Riau Province.

| Characters                  | Freshwater peatland | Brackish peatland | Alluvial soil |
|-----------------------------|---------------------|-------------------|--------------|
| Plant habit                 | Erect               | Erect             | Erect        |
| Leaf color                  | Greenish/green      | Greenish/green    | Greenish/green|
| Bract color,                | Silver- white       | Silver- white     | Silver- white|
| Petal colour,               | White-purple        | White-purple      | White-purple |
| Sepal color,                | Greenish-green      |                   |              |
| Fruit shape,                | Long-conical        | Long-conical      | Long-conical |
| Fruit color when unripe     | Silvery green       | Yellow with green mottling | Yellow with green mottling |
| Fruits color when ripe      | Good                | Good              | Good         |
| Fruit color homogeneity when ripe | Prominent        | Prominent         | Prominent    |
| Eyes profile                | Medium              | Medium            | Medium       |
| Eyes relative surface       | Golden yellow       | Golden yellow     | Golden yellow|
| Crown shape                 | Long conical        | Long conical      | Long conical |

Based on the level of peat maturity, freshwater peatland and brackish peatland in this study were belong to hemic peat with a pH of 3.23-3.50 and 2.60-3.20, respectively, while alluvial mineral soils planted have a pH of 5.00-6.00. Pineapple grown on freshwater peatlands and brackish peatlands has a more vigorous initial growth than pineapple planted in alluvial soils. Pineapple has facultative photosynthetic pathways, namely C3/CAM [25,26,27,28,29,30]. At the beginning of growth (age 2 months), pineapple has a C3 photosynthetic pathway, but when plants experience abiotic stress such as low soil water content, high light intensity, and deficiency of soil nutrient cause changes and transitions of metabolism from C3 to CAM [25,27,28,30]. Changes in photosynthetic pathways from C3 to CAM cause pineapple to be efficient in water use due to stomata closure during the daylight [31]. Besides, pineapple also has a leaf anatomical structure that is capable of storing water and has a dense trichome and mushroom-shaped in the below leaves surface (usually silvery colored) thereby reducing evaporation [18].

3.2. Quantitative Characters

The average values of pineapple quantitative characters in three different soil types are presented in Table 2. There are differences in the character of growth and quality of pineapple at different locations, except for the character of leaf width, fruit diameter, and heart diameter. Pineapple that grows on brackish peatlands and mineral soils has a higher plant height and leaf length than pineapple which grows on freshwater peatlands. The highest number of leaves is found in mineral soil which is 61.90 leaves/plants. The plant height of pineapple in brackish peatland and alluvial soil is higher than the pineapple in freshwater peatland. The plant height of pineapple in this study is higher than pineapple of Mahkota Bogor and Palembang pineapple which has an average plant height of 60.30 cm [33]. The stem diameter of pineapple in brackish peatland and freshwater is higher than pineapple in alluvial soil, and this character is also higher than the stem diameter of pineapple of Mahkota Bogor (4.46 cm), and Palembang pineapple (4.04 cm) [33,34]. Differences in plant morphology are strongly influenced by the environment and genotype. According to [35] that plant height of pineapple ranged from 39.00 cm to 171.00 cm with an average of 91.09 cm. Furthermore, [36] explained that plant
height and the number of leaf correlated to fruit size. Pineapple planted on peatlands has a higher plant height and number of leaf in which resulted in the larger fruit size. The positive correlation between the number of leaves and the stem diameter with fruit size is closely related to the efficiency of light absorption so that photosynthates are produced more [37].

Table 2. The Average value of morphological characters of pineapple cv. Queen planted in freshwater peatland, brackish peatland and alluvial soil in Riau Province.

| Characters                        | Freshwater peatland | Brackish peatland | Alluvial soil |
|-----------------------------------|---------------------|-------------------|---------------|
| Plant height                      | 82.48b              | 106a              | 110a          |
| Leaf length                       | 66.00b              | 83.10a            | 87.50a        |
| Leaf width                        | 4.99a               | 5.27a             | 4.84a         |
| Leaf number                       | 36.00b              | 30.84b            | 61.90a        |
| Stem diameter                     | 9.97a               | 8.97a             | 4.92b         |
| Fruit weight with crown           | 1540.64a            | 1091.05b          | 999.00b       |
| Fruit weight without crown        | 1380.32a            | 926.84b           | 865.00b       |
| Fruit height                      | 19.80a              | 17.52b            | 16.30b        |
| Fruit diameter                    | 9.97a               | 8.97a             | 8.95a         |
| Eye (berry) width                 | 1.08b               | 1.58a             | 1.58a         |
| Core diameter                     | 2.37b               | 2.20a             | 2.14a         |
| Crown height                      | 15.33b              | 19.89a            | 16.20b        |
| Leaf number of crown              | 126.06b             | 139.15a           | 107.10c       |
| Crown weight                      | 129.97b             | 162.21a           | 128.00b       |
| Number of suckers                 | 4.93a               | 1.21b             | 0.80b         |
| Number of shoots                  | 0.96ab              | 1.21a             | 0.40b         |
| Number of slips                   | 3.16a               | 0.10b             | 0.55b         |

The average value of fruit weight with crown, fruit weight without crown, fruit height, number of sucker, and number of slip of the pineapple planted on freshwater peatlands is higher and significantly different than pineapple grown on brackish peatland and alluvial soil, while the character of crown as crown height, leaf number of crown, crown weight, and number of shoot on brackish peatlands is higher and significantly different compared to freshwater and alluvial soil (Table 1). The weight of pineapple fruit in alluvial soils in this study was higher than the fruit weight reported by [38] in Bogor pineapple, [39] in Palembang pineapple and Blitar pineapple, and by [26] in many pineapple accessions cv. Queen. This showed that even though there was a decrease in the fruit size of pineapple grown in mineral soil but fruit size was not lower than another pineapple cv. queen that has been reported, even fruit size (as fruit weight, fruit diameter, and fruit length) and growth characters of the pineapple planted in alluvial soil higher compared to various accession of Bangka pineapple reported by [40].

The character of fruit weight is not only influenced by genetic factor but also is strongly influenced by the size of population/ha, plant spacing, in which the closer of spacing used is the smaller the size of fruit produced [41,42], but production/ha will increase with increasing plant population [41,43]. Furthermore, [44] also stated that giving organic matter can increase fruit size. Other studies also reported that the addition of nitrogen (N), phosphate (P) and potassium (K) increased plant growth, fruit weight, fruit size, and productivity [45,46,47]. Other factors that caused differences in fruit size included fertilization, uneven seedling size, and plant size when induction of flowering is carried out.

The character of fruit weight, fruit length, number of shoots, and the number of the slip of pineapple growing on freshwater peatland have higher compared to another, this was probably closely
correlated to the nutrient content of freshwater peatlands that supported to pineapple growth well. The same has been reported by [48] that the pineapple growth in peatland is better than alluvial soil. The author explained that it closely related nutrient uptake in pineapple plant tissue that grows in peatlands in which higher N, P, and K contents, ie 1.01%, 0.22 %, and 0.71% compared to alluvial soils with N, P, and K contents of 0.85%, 0.13%, and 0.69%, respectively. Furthermore, [49] reported the results of microscopic studies on peatland containing very high N, P, K, Ca, and Mg elements. This nutrient content is estimated to increase more vigorous the growth of pineapple in peatland, both in the character of growth in vegetative phase and in yield characters such as fruit weight, fruit diameter, and fruit length. In another study, [50] reported that the macronutrient content of N, P, K, Ca, and Mg on peatland planted with pineapple was higher than that of empty peat soil. This is related to changes in organic matter in peatland, besides the increase of temperature will also accelerate the decomposition in peatland [51]. Macro-nutrient deficiencies cause a decrease in fruit size and fruit weight [52].

One of peat soil characteristic is high organic matter content. According to [53] reported that the addition of organic matter to pineapple crops significantly increased the growth and number of leaves. It is also lined with reported by [54]. The same has been reported by [55] and [56] also found that the growth of Brassica oleracea was significant differences when planted in two different soil types, it occurred due to differences in the symbiosis of soil microorganisms against Brassica oleracea plants. According to [53] reported that differences in the growing environment and soil nutrient content caused differences in plant height, number of leaves, root length, plant dry weight in two pineapple genotypes.

Soil water content, nutrient content, and carbon assimilation have also influenced the growth of pineapple [52,57]. Nutrient content in peatlands is strongly influenced by the water that forms the peat (freshwater, brackish and seawater) [19,11], the type of organic matter forming, peat maturity, and peat acidity level [49]. Peat that is formed from tidal runoff/flooding of water river and seawater contained a lot of minerals, so it was relatively more fertile [58]. The differences in growing environments, techniques cultivation and genotypes caused differences in phenotypes in pineapple [53,1].

3.3. Fruit Quality

The quality of fruit is not only observed from the size of the fruit, but also the total soluble solid contents (TSS), titratable acidity (TA), Vitamin C content, TSS/TA ratio, and water content. Total dissolved solids (TSS) are an important component in determining the quality of pineapple. The TSS of pineapple in the freshwater and brackish peatlands is higher and significantly different compared to pineapple planted in alluvial soil (Table 3), the value of TA on brackish peatland is higher (0.78%) and is significantly different from pineapple which grows in freshwater peatlands (0.51%) and mineral soils (0.50%), while TSS/TA ratio is 25.86 in alluvial soil and 27.82 in freshwater peatland, and that values are higher and significantly different than TSS/TA ratio in brackish peatland (19.92) (Table 1). The ratio of TSS/TA is one of the indicators that are widely used in flavor evaluation because it describes the balancing between sugar levels and acid levels in the fruit. The higher the TSS/TA ratio usually the sweeter the fruit tastes. TSS/TA ratio in this study was higher than that reported by [59] (16) in smooth cayenne pineapple (23.78-25.58), [60] in Vitória pineapple (17.50-21.29), Maeda et al. (2011) in Smooth Cayenne Pineapple (15.35-18.01), but it was lower than the TSS/TA ratio (30.47-34.82) that reported by [41]. The value of TSS, TA, and TSS/TA ratio of pineapple in this study have met market standards for fresh fruit which requires TSS, TA, and TSS/TA ratio were 13, 0.5-0.7, 20-40, respectively.

The character of TSS, and TA, the ratio of TSS/TA, and the content of Vitamin C are influenced by several factors including fertilization [61,44,46,47,52], induction flowering [62,63] in which carbide use at high doses increases the TA level of fruit [64], fruit maturity [65,66], and the harvesting season [67], while the spacing, size of the population/ha, source of planting material, and size of seedling used did not affect the value of TSS and TA of the fruit [41,68,62].
Table 3. The Average value of fruits quality of pineapple cv. Queen planted in freshwater peatland, brackish peatland and alluvial soil in Riau Province.

| Characters       | Freshwater peatland | Brackish peatland | Alluvial soil |
|------------------|---------------------|-------------------|--------------|
| Total soluble solids (TSS) | 14.19<sup>a</sup> | 14.10<sup>a</sup> | 12.93<sup>b</sup> |
| Titratable acidity (TA)     | 0.51<sup>b</sup>   | 0.78<sup>b</sup>   | 0.50<sup>b</sup>   |
| Vitamin C content         | 17.92<sup>a</sup>  | 11.14<sup>b</sup>  | 8.56<sup>c</sup>  |
| TSS/TA Ratio             | 27.82<sup>a</sup>  | 19.92<sup>b</sup>  | 27.51<sup>a</sup> |
| Water content            | 85.94<sup>a</sup>  | 77.59<sup>b</sup>  | 80.20<sup>b</sup> |

Some researchers stated that addition of organic matter has been reported able to increase TSS content and TSS/TA ratio and significantly different from pineapple plants that are given chemical fertilization, while TA and Vitamin C content increases with giving of chemical fertilizers [61, 44, 69]. According to [47] that the addition of Nitrogen fertilizer caused a decrease in TSS, TA, and Vitamin C. It was inlined with reports [52] that explained lack of Nitrogen caused an increase in the TA, TSS, and vitamin C content, but TSS/TA ratio decreased. The results of this study indicated that TTS and TSS/TA ratio of the pineapple in peatland is higher than that in mineral soils, this is presumably because peat is very rich in organic matter, compared to mineral soils. The content of vitamin C and moisture content of pineapple which grows in freshwater peat is higher and significantly different from brackish peatland and alluvial soil. The vitamin C content of pineapple in this study was almost similar to vitamin C content in pineapple (9.44-16.86%) that is reported by [59], but lower than reported [61] that is 31.15% -32.81%.

4. Conclusion
The results of this study indicated that pineapple which grows in peatlands has a higher plant vigor and fruit size, but no difference in the qualitative character of pineapple plants both those grown on peatlands and mineral soils.

References
[1] M. Hossain, “World Pineapple Production: An Overview,” African J. Food, Agric. Nutr. Dev., vol. 16, no. 4, pp. 11443–11456, 2016.
[2] F. Hossain, S. Akhtar, and M. Anwar, “Nutritional Value and Medicinal Benefits of Pineapple,” vol. 4, no. 1, pp. 84–88, 2015.
[3] S. Ketnawa, P. Chaiwut, S. Rawdkuen, and F. Science, “Food Science and Technology International,” 2011.
[4] M. Asim et al., “A Review on Pineapple Leaves Fibre and Its Composites,” Int. J. Polym. Sci., vol. 2015, pp. 1–16, 2015.
[5] E. O. Omwango, E. N. M. Njagi, G. O. Orinda, and R. N. Wanjau, “Nutrient Enrichment of Pineapple Waste using Aspergillus niger and Trichoderma viride by Solid State Fermentation,” African J. Biotechnol., vol. 12, no. 43, pp. 6193–6196, 2013.
[6] A. J. Omole, F. O. Ajasin, A. D. Adejuyigbe, and A. Soetan, “Effects of feeding snails with pineapple waste on feed consumption, growth and cost benefits,” Arch. Zootec., vol. 60, no. 229, pp. 53–56, 2011.
[7] FAO, “Food and Agriculture Organisation Satistics of word production,” 2019.
[8] Ministry of Agriculture, “Kementerian Pertanian Republik Indonesia,” 2019. [Online]. Available: http://www.pertanian.go.id/home/?show=page&act=view&id=6.
[9] Wahyunto, W. Supriatna, and F. Agus, “Land use change and recommendation for sustainable development of peatland for agriculture: Case Study at Kubu Raya and Pontianak Districts, West Kalimantan,” Indones. J. Agric. Sci., vol. 11, no. 1, pp. 32–40, 2010.
[10] Masganti, K. Anwar, and M. A. Susanti, “Potensi dan Pemanfaatan Lahan Gambut Dangkal
untuk Pertanian,” *J. Sumberd. Lahan*, vol. 11, pp. 43–52, 2017.

[11] Riwandhi, “Riwandhi, 2000.pdf.” Program Pascasarjana Institut Pertanian Bogor, Bogor, p. 36, 2001.

[12] O. H. Ahmed, H. M. H. Ahmad, H. M. Musa, A. A. Rahim, and S. O. S. Rastan, “Applied K Fertilizer Use Efficiency in Pineapples Grown on a Tropical Peat Soil Under Residues Removal,” *Sci. world J.*, no. 5, pp. 42–49, 2005.

[13] R. M. Lin and A. A. Rahman, “Status and impact of pineapple technology on mineral soil,” *Econ. Technol. Manag. Rev.*, vol. 5, no. 11–19, pp. 11–19, 2010.

[14] L. Nuriati, K. L. Choo, and O. H. Ahmed, “Methane Emission from Pineapple Cultivation on a Tropical Peatland at Saratok, Malaysia,” *Sustain. Agric. Res.*, vol. 6, no. 3, pp. 64–74, 2017.

[15] O. H. Ahmed, H. M. H. Ahmad, H. M. Musa, A. A. Rahim, and S. O. S. Rastan, “Applied K Fertilizer Use Efficiency in Pineapples Grown on a Tropical Peat Soil Under Residues Removal,” *Sci. world J.*, no. 5, pp. 42–49, 2005.

[16] R. M. Lin and A. A. Rahman, “Status and impact of pineapple technology on mineral soil,” *Econ. Technol. Manag. Rev.*, vol. 5, no. 11–19, pp. 11–19, 2010.

[17] O. H. Ahmed, H. M. H. Ahmad, H. M. Musa, A. A. Rahim, and S. O. S. Rastan, “Applied K Fertilizer Use Efficiency in Pineapples Grown on a Tropical Peat Soil Under Residues Removal,” *Sci. world J.*, no. 5, pp. 42–49, 2005.
[33] Malihah, “Karacterisasi Morfologi dan Kualitas Buah Nenas (Ananas comosus L.Merr) dari Empat Populasi di Kecamatan Cijeruk Kabupaten Bogor,” Institut Pertanian Bogor, 2006.

[34] E. Mulyati, “Simulasi Uji BUSS (Baru, Unik, Seragam, Stabil) tiga Varietas Nenas (Ananas comosus L.Merr.),” Institut Pertanian Bpgor, 2008.

[35] M. A. Nasution, “Analisis Parameter Genetik dan Pengembangan Kriteria Seleksi Bagi Pemuliaan Nenas (Ananas comosus (L.) Merr.) di Indonesia,” Institut Pertanian Bogor, 2008.

[36] M. A. Nasution, “Analisis Korelasi dan Sidik Lintas Antara Karakter Morfologi dan Komponen Buah TanamanNenas (Ananas comosus L. Merr.),” *Crop agro*, vol. 3, no. 1, pp. 1–8, 2010.

[37] R. Nitrisari and Sobir, “Analisis keragaan morfologi dan kualitas buah populasi nenas (Ananas comosus (L.) Merr) queen di empat desa kabupaten Bogor,” in *Prosiming Seminar Akademik Buah-buahan*, 2002, pp. 171–175.

[38] P. A. Aryawati and Sobir, “Simulasi Uji BUSS (Baru, Unik, Seragam Stabil) Enam Varietas Nenas (Ananas comosus L.Merr),” *Bulentin Agron.*, vol. 1, no. 4, pp. 83–93, 2013.

[39] Sobir and Triatikaduri, “Karacterisasi Sifat Fisik dan Kimia serta Perubahannya selama Penyimpanan Empat Kultivar Nenas,” *Enviagro, J. Pertan. dan Lingkung.*, vol. 2, no. 1, pp. 15–18, 2008.

[40] A. Lanoviadi, E. . Mustikarini, and U. Widyaastuti, “Daya Adaptasi dan Produksi Tujuh Aksesi Nenas Lokal Bangka di Lahan Tailing Pasca Penambangan Timah,” *Enviagro, J. Pertan. dan Lingkung.*, vol. 4, no. 1, pp. 1–48, 2011.

[41] V. Valleser, “Planting Density Influenced the Fruit Mass and Yield of ‘Sensuous Pineapple,” *Int. J. Sci. Res. Publ.*, vol. 8, no. 7, pp. 113–119, 2018.

[42] A. Hepton, “Cultural System,” in *The Pineapple, Botany, Production*, D. . Bartholomew, R. . Paull, and K. . Rohrbach, Eds. CABI Publishing, 2003, pp. 109–142.

[43] E. Dorey, T. Cambournac, T. Michels, M. Rothe, and P. Tixier, “Designing new management sequences for pineapple production using the SIMPIÑA model,” *Agric. Syst.*, vol. 159, no. 2018, pp. 50–56, 2018.

[44] C. H. Liu and Y. Liu, “Influences of organic manure addition on the maturity and quality of pineapple fruits ripened in winter,” *J. soil Sci. plant Nutr.*, vol. 12, no. 2, pp. 211–220, 2012.

[45] R. A. Bhugaloo, “Effect of different levels of nitrogen on yield and quality of pineapple variety Queen Victoria,” in *Proceedings of the Third Annual Meeting of Agricultural Scientists, 17-18 November 1998*, 1998, pp. 75–80.

[46] S . Omotoso and E . Akinrinde, “Effect of nitrogen fertilizer on some growth , yield and fruit quality parameters in pineapple ( Ananas comosus L.Merr.) plant at Ado-Ekiti Southwester, Nigeria,” *Int. Res. J. Agric. Sci. Soil Sci.*, vol. 3, no. 1, pp. 11–16, 2013.

[47] A. Spironello, J. A. Quaggio, L. A. J. Teixeira, P. R. Furlani, and J. M. M. Sigrist, “Pineapple yield and fruit quality effected by NPK fertilization in a tropical soil,” *Rev. Bras. Frutic.*, vol. 26, no. 1, pp. 155–159, 2004.

[48] E. Gunawan, “Kajian pertumbuhan dan produksi nenas pada lahan gambut dan lahan aluvial di Kalimantan Barat.” Pascasarjana Institut Pertanian Bogor, Bogor, p. 79, 2007.

[49] Q. N. B. Kassim and A. Yaacob, “Chemistry and Microstructure of Surface Peat Soils : Implications of Pineapple Cultivation,” *Nat. Resour.*, vol. 05, pp. 359–366, 2014.

[50] J. . Orluchukwu and O . . Adedokun, “Response of Growth and Yield of Pineapple ( Ananas comosus ) on Spent Response of Growth and Yield of Pineapple ( Ananas comosus ) on Spent

---

Dev. Biol., vol. 41, no. November-Desember, pp. 832–837, 2005.

[33] Malihah, “Karacterisasi Morfologi dan Kualitas Buah Nenas (Ananas comosus L.Merr) dari Empat Populasi di Kecamatan Cijeruk Kabupaten Bogor,” Institut Pertanian Bogor, 2006.

[34] E. Mulyati, “Simulasi Uji BUSS (Baru, Unik, Seragam, Stabil) tiga Varietas Nenas (Ananas comosus L.Merr.),” Institut Pertanian Bpgor, 2008.

[35] M. A. Nasution, “Analisis Parameter Genetik dan Pengembangan Kriteria Seleksi Bagi Pemuliaan Nenas (Ananas comosus (L.) Merr.) di Indonesia,” Institut Pertanian Bogor, 2008.

[36] M. A. Nasution, “Analisis Korelasi dan Sidik Lintas Antara Karakter Morfologi dan Komponen Buah TanamanNenas (Ananas comosus L. Merr.),” *Crop agro*, vol. 3, no. 1, pp. 1–8, 2010.

[37] R. Nitrisari and Sobir, “Analisis keragaan morfologi dan kualitas buah populasi nenas (Ananas comosus (L.) Merr) queen di empat desa kabupaten Bogor,” in *Prosiming Seminar Akademik Buah-buahan*, 2002, pp. 171–175.

[38] P. A. Aryawati and Sobir, “Simulasi Uji BUSS (Baru, Unik, Seragam Stabil) Enam Varietas Nenas (Ananas comosus L.Merr),” *Bulentin Agron.*, vol. 1, no. 4, pp. 83–93, 2013.

[39] Sobir and Triatikaduri, “Karacterisasi Sifat Fisik dan Kimia serta Perubahannya selama Penyimpanan Empat Kultivar Nenas,” *Enviagro, J. Pertan. dan Lingkung.*, vol. 2, no. 1, pp. 15–18, 2008.

[40] A. Lanoviadi, E. . Mustikarini, and U. Widyaastuti, “Daya Adaptasi dan Produksi Tujuh Aksesi Nenas Lokal Bangka di Lahan Tailing Pasca Penambangan Timah,” *Enviagro, J. Pertan. dan Lingkung.*, vol. 4, no. 1, pp. 1–48, 2011.

[41] V. Valleser, “Planting Density Influenced the Fruit Mass and Yield of ‘Sensuous Pineapple,” *Int. J. Sci. Res. Publ.*, vol. 8, no. 7, pp. 113–119, 2018.

[42] A. Hepton, “Cultural System,” in *The Pineapple, Botany, Production*, D. . Bartholomew, R. . Paull, and K. . Rohrbach, Eds. CABI Publishing, 2003, pp. 109–142.

[43] E. Dorey, T. Cambournac, T. Michels, M. Rothe, and P. Tixier, “Designing new management sequences for pineapple production using the SIMPIÑA model,” *Agric. Syst.*, vol. 159, no. 2018, pp. 50–56, 2018.

[44] C. H. Liu and Y. Liu, “Influences of organic manure addition on the maturity and quality of pineapple fruits ripened in winter,” *J. soil Sci. plant Nutr.*, vol. 12, no. 2, pp. 211–220, 2012.

[45] R. A. Bhugaloo, “Effect of different levels of nitrogen on yield and quality of pineapple variety Queen Victoria,” in *Proceedings of the Third Annual Meeting of Agricultural Scientists, 17-18 November 1998*, 1998, pp. 75–80.

[46] S . Omotoso and E . Akinrinde, “Effect of nitrogen fertilizer on some growth , yield and fruit quality parameters in pineapple ( Ananas comosus L.Merr.) plant at Ado-Ekiti Southwester, Nigeria,” *Int. Res. J. Agric. Sci. Soil Sci.*, vol. 3, no. 1, pp. 11–16, 2013.

[47] A. Spironello, J. A. Quaggio, L. A. J. Teixeira, P. R. Furlani, and J. M. M. Sigrist, “Pineapple yield and fruit quality effected by NPK fertilization in a tropical soil,” *Rev. Bras. Frutic.*, vol. 26, no. 1, pp. 155–159, 2004.

[48] E. Gunawan, “Kajian pertumbuhan dan produksi nenas pada lahan gambut dan lahan aluvial di Kalimantan Barat.” Pascasarjana Institut Pertanian Bogor, Bogor, p. 79, 2007.

[49] Q. N. B. Kassim and A. Yaacob, “Chemistry and Microstructure of Surface Peat Soils : Implications of Pineapple Cultivation,” *Nat. Resour.*, vol. 05, pp. 359–366, 2014.

[50] J. . Orluchukwu and O . . Adedokun, “Response of Growth and Yield of Pineapple ( Ananas comosus ) on Spent Response of Growth and Yield of Pineapple ( Ananas comosus ) on Spent

---
Mushroom Substrates and Inorganic Fertilizer in South – South , Nigeria,” Int. J. Plant Soil Sci., vol. 8, no. 6, pp. 1–5, 2015.

[55] R. W. Nusantara, Sudarmadji, T. S. Djoohan, and E. Haryono, “KAJIAN KARBON DAN HARA TANAH GAMBUT AKIBAT ALIH FUNGSI LAHAN GAMBUT DI KALIMANTAN BARAT,” J. Pedon Trop., vol. 3, no. 1, pp. 97–105, 2016.

[56] Y. Sripontan, M. Huang, C.-C. Young, and S.-Y. Hwang, “Effects of Soil Type and Plant Growth Promoting Microorganism on Cabbage and Spodoptera litura Performance,” J. Agric. For., vol. 63, no. 3, pp. 153–161, 2014.

[57] P. V de Azevedo, C. B. de Souza, B. B. da Silva, and V. P. R. da Silva, “Water requirements of pineapple crop grown in a tropical environment , Brazil,” Agric. Water Manag., vol. 88, pp. 201–208, 2007.

[58] S. Ritung and Sukarman, “Kesesuaian Lahan Gambut untuk Pertanian,” in Lahan Gambut Indonesiapembentukan, Karakteristik, dan Potensi Mendukung Ketahanan Pangan, Edisi Revi., no. March, F. Agus, M. Anda, A. Jamil, and Masganti, Eds. Balai penelitian dan pengembangan Pertanian, 2018, pp. 61–74.

[59] T. Suwandi, K. Dewi, and P. Cahyono, “Pineapple harvest index and fruit quality improvement by application of gibberellin and cytokinin,” Fruits, vol. 71, no. 4, pp. 209–214, 2016.

[60] A. V. Amorim, D. dos S. Garruti, C. F. de Lacerda, C. F. H. Moura, and E. Gomes-Filho, “Postharvest and sensory quality of pineapples grown under micronutrients doses and two types of mulching,” African J. Agric. Res., vol. 8, no. 19, pp. 2240–2248, 2013.

[61] M. Darnaudery, F. P. A. M., and M. Lèchaudel, “Low-Input Pineapple crops with hight quality fruit: Promising impacts of locally integrated and organic fertilisation compared to chemical fertilisers,” Exp. Agric., vol. 54, no. 2, pp. 286–302, 2016.

[62] V. N. F. Hotegni, W. J. Lommen, E. K. Agbossou, and P. C. Struik, “Trade-offs of flowering and maturity synchronisation for pineapple quality,” PLoS One, vol. 10, no. 11, pp. 1–28, 2015.

[63] Y. E. S. Salomé, K. K. Laurent, B. J. Pierre Irénée, K. Patrice, and K. T. Hilaire, “Comparison of Pineapple Fruit Characteristics of Plants Propagated in Three Different Ways: By Suckers, Micropropagation and Somatic Embryogenesis,” J. Nutr. Food Sci., vol. 01, no. 04, pp. 1–8, 2011.

[64] E. Asare-Bediako, F. . Showemimo, J. . Buah, and A. . Ntow-Manu, “Quality of Pineapple Fruits as Influence by Floral Induction in Ghana,” Am. J. Food Technol., vol. 2, no. 2, pp. 100–103, 2007.

[65] S. . Kamol, J. Howlader, G. . S. Dhar, and M. Aklimuzzaman, “Effect of different stages of maturity and postharvest treatments on quality and storability of pineapple,” J. Bangladesh Agric. Univ., vol. 12, no. 2, pp. 251–260, 2014.

[66] N. Ersoy, Ş. Gözlekçi, and L. Kaynak, “Changes in Sugar Contents of Fig Fruit ( Ficus carica l . Cv . Bursa Siyahı ) During Development,” Süleyman Demirel Üniversitesi Ziraat Fakültesi Derg., vol. 2, no. 2, pp. 22–26, 2007.

[67] A. Joomwong and J. Sornsrivichai, “Morphological Characteristic, Chemical Composition and Sensory Quality of Pineapple Fruit in Different Seasons,” C. J., vol. 4, no. 2, pp. 149–164, 2005.

[68] V. N. F. Hotegni, W. J. M. Lommen, J. G. A. J. Van Der Vorst, and E. K. Agbossou, “Analysis of Pineapple Production Systems in Benin,” pp. 47–58, 2012.

[69] S. Omotoso and E. Akinrinde, “Effect of nitrogen fertilizer on some growth , yield and fruit quality parameters in pineapple ( Ananas comosus L . Merr .) plant at Ado-Ekiti Southwestern , Nigeria,” no. November 2014, 2013.