JJBS

Volume 16, Number 2,June 2023
ISSN 1995-6673
Pages 207 – 221
https://doi.org/10.54319/jjbs/160205

Jordan Journal of Biological Sciences

Agronomic Characters and Quality of Fruit of Salak cv. Gulapasir Planted in Various Agro-Ecosystems

I Ketut Sumantra[1,2,*], I Ketut Widnyana[1,2], Ni Gusti Agung Eka Martingsih[3], I Made Tamba[3], Praptiningsih Gamawati Adinurani[4], Ida Ekawati[5], Maizirwan Mel[6,7], and Peeyush Soni[8]

[1]Department of Agrotechnology, Faculty of Agriculture and Business University of Mahasaraswati Denpasar Jl. Kamboja 11 A, Denpasar 80233, Bali, Indonesia; [2]Masters Program in Regional Development Planning and Environmental Management, University of Mahasaraswati Denpasar, Bali.; [3]Department of Agribusiness, Faculty of Agriculture and Business, University of Mahasaraswati, Denpasar, Bali, Indonesia; [4]Department of Agrotechnology, Faculty of Agriculture, Merdeka University of Madiun, Jl. Serayu No.79, Madiun 63133, East Java, Indonesia; [5]Department of Agribusiness, Faculty of Agriculture, Universitas Wiraraja, Jl. Raya Pamekasan KM. 05, Sumenep 69451, East Java, Indonesia; [6]Department of Chemical Engineering and Sustainability, Faculty of Engineering, International Islamic University Malaysia, 50728 Kuala Lumpur, Malaysia; [7]Postgraduate School, Program Study of Biology, Menara Universitas Nasional, Jl. RM. Harsono No.1, Special Region of Jakarta 12550, Indonesia ; [8]Department of Agricultural and Food Engineering, Indian Institute of Technology Kharagpur, 721302, Kharagpur, West Bengal, India

Received: Jan 29, 2023; Revised: Apr 2, 2023; Accepted Apr 4, 2023

Abstract

Salak [*Salacca zalacca* (Gaertn.) Voss] var. amboinensis cv. Gulapasir has been officially released by the Minister of Agriculture of the Republic of Indonesia since 1994. Salak 'Gulapasir 'is one of five types of fruit that have been designated as the superior fruit of the Bali Province. Salak 'Gulapasir' is preferred by consumers due to its specific fruit flesh taste. Salak 'Gulapasir' was propagated using seeds so that a new type of salak emerged. However, the characters of this new type of salak 'Gulapasir' are not yet known. The research objective was to obtain the superior products of Salak 'Gulapasir' both in quantity and quality. The research used a Randomized Block Design with three replications. The non-independent variable was the three of Salak 'Gulapasir' (SGP): SGP var. nangka (N), SGP var. nenas (NS), SGP var. gondok (G), and six sites, namely Karangasem: (K < 560 m asl, K 560 m to 650 m asl, and K > 650 m asl) and Tabanan: (T < 560 m asl, T 560 m to 650 m asl, T > 650 m asl). Observations were made on the agronomic characters and fruit quality. Data were analyzed using variance analysis, and if the planting location and varieties show a difference, then it is followed by the LSD test at the 5 % level. The results showed that different varieties caused different fruit weights, fruit bunches, TSS, and total acid ratio. In Karangasem and in Tabanan, SGP var. nangka grows ideally at an altitude of 560 m to 650 m asl with fruit weight per tree of 1.62 kg^{-1} and 1.29 kg^{-1}, respectively. SGP var. nenas and SGP var. gondok are ideal for cultivating at an altitude of < 560 m asl both in Karangasem and Tabanan, but the fruit production of SGP var. nenas and SGP var. gondok is higher, respectively 19.29 % and 15.31 % when planted in Karangasem, while the SGP var. nenas showed the highest number of fruit $bunches^{-1}$ in six locations. Further research can be applied using sustainable salak organic agriculture to maintain soil fertility.

Keywords: Altitude, Improve soil fertility, Organic potassium fertilizer, Organic salak, *Salacca zalacca* (Gaertn.) Voss, Salak sustainable agriculture, Snake fruit, Tropical fruit

1. Introduction

Salak [*Salacca zalacca* (Gaertn.) Voss] var. amboinensis cv. Gulapasir is one of the essensial fruits in Indonesia, and the plant can be found in most regions of Indonesia (Rai *et al*., 2016; Ritonga *et al*., 2018). The salak fruit belongs to the family Palmae or Arecaceae and is native to the Indonesian-Malaysian region (Hakim *et al.,* 2019; Zumaidar *et al*., 2014). One of the extraordinary strengths of this fruit commodity for Indonesia is the possession of high genetic diversity (Budiyanti *et al*., 2019). Also, the nutrition of salak fruit is rich in antioxidants, phenolics, vitamins, and minerals (Cepkova *et al.,* 2021; Mazumdar *et al*., 2019), and a good source of income and provides livelihood opportunities on seasonal days (Khan and Idrees, 2021). Furthermore fruit flesh and peel have shown tremendous anti-inflammatory, anticancer, antidiabetic (Saleh *et al*., 2018), and anti-aging agents (Girsang *et al*., 2019). Antioxidants are chemical compounds that play an essential role in protecting cells due to attacks against free radicals-induced damage to biomolecules (Damat *et al*., 2019, 2020; Puspitasari and Ningsih, 2016; Setyobudi *et al*., 2019). Despite its incredible food and medicinal benefits, salak fruit is still underutilized and unknown globally so that this underutilized fruit remains an issue for future sustainable utilization and commercial value enhancement market

* Corresponding author. e-mail: ketut.sumantra@unmas.ac.id

(Mazumdar *et al*., 2019). Fruit quality is an important issue, especially for products that are consumed raw and fresh. One of the problems is the lack of fruit quality because of inadequate information about superior salak (Budiyanti *et al*., 2019; Herawati *et al*., 2018). Therefore, it is necessary to select superior salak to meet market demand and serve community nutrition.

Salak 'Bali' is quite a lot, based on the shape, aroma, taste, and skin colour of the location where the plants are cultivated (Sumantra *et al*., 2012, 2014; Sumantra and Martiningsih, 2016, 2018). Under the Decree of the Minister of Agriculture of the Republic of Indonesia in 1994, Balinese zalacca was grouped into two superior zalacca: Salak 'Bali' (SK Mentan, 1994a) and Salak 'Gulapasir' (SK Mentan, 1994b). The second type, the salak 'Gulapasir' (SGP) is the most superior salak because of its sweet fruit taste; even though the age of the fruit is still young, thick fruit flesh and seeds are not attached to the fruit flesh (Rai *et al*., 2014; Sumantra *et al*., 2016). The nature of this fruit is ideal for meeting market demands for both the domestic and export markets (Martiningsih *et al*., 2018). Salak 'Bali' is monoecious, so crossing does not need human help (Herawati *et al*., 2018), and can quickly develop using seeds (Sumantra and Martiningsih, 2016). Another advantage of salak plants in Indonesia compared to other fruits is harvest 2 to 3 times a year if management is good (Rai *et al*., 2016; Warnita *et al.*, 2019). The expansion of salak 'Gulapasir' planting causes variations in phenotypic diversity. People can find two to three types of salak plants with a marker, fruit shape, aroma, flesh colour, and fruit weight (Martiningsih *et al*., 2018). The results of this study mean that the emergence of plant diversity due to plant propagation is done by seeds so that new varieties of salak 'Gulapasir' (SGP) appear, as reported by Sumantra and Martiningsih (2016). Based on the marker that can be used as a differentiator, salak farmers give it the name of SGP var. nenas, SGP var. gondok, and SGP var. nangka. The three varieties have not yet identified their advantages in meeting market needs in line with the results of research (Sumantra and Martiningsih, 2016). The performance and produce are influenced by the characteristics of the agricultural ecosystem, particularly microclimate and endogenic factors such as carbohydrate contents, nutrient status (Adelina *et al.,* 2021a; Kumar *et al*., 2020) and growth hormone (Prihastanti and Haryanti. 2022; Rai *et al.,* 2016).

The salak 'Gulapasir' plantation in the District of Bebandemis the main producer of salak 'Gulapasir' in Bali is located in the southern part of Mount Agung with an altitude of 450 m to 700 m above sea level (m asl). The effect of altitude on plant growth and production is related to plant adaptation to temperature (Sumantra, *et al*., 2014), full sunlight (Sukawijaya *et al*., 2009), water status and soil quality (Raharjo *et al*., 2022; Rai *et al*., 2014; Ritonga *et al.,*2018). Salak plants are not resistant to full sun but 50 % to 70 % enough, therefore it is necessary to have shade plants (Sukawijaya *et al*., 2009; Sumantra *et al*., 2012). The effect of altitude on plant growth and production is related to plant adaptation to plant tolerance to temperature (Fenech *et al*., 2019). Water status and soil quality really determine the fruit set on the salak 'Gulapasir'. Low rainfall reduces the Relative Water Content in leaves (RWC), leaf chlorophyll content, and plant nutrient uptake (Rai *et al*., 2014). Soil quality included the suitability of the physical, chemical and biological properties (Raharjo *et al*., 2022). Nuary *et al*. (2019) stated that the distribution of the salak 'Pondoh' plantation area in Sleman (Yogyakarta, Special Region) was greatly influenced by temperature and rainfall. The contribution of temperature in the modelling reached 38.6 % while the rainfall was 27.8 %. Furthermore, taking into account the probability of the temperature variable, the average temperature ranges from 17.41 °C to 25.65 °C, and the ideal month's rainfall ranges from 385.24 mm to 505.01 mm.

Ascorbate content is influenced by abiotic factors, especially temperature and light (Fenech *et al*., 2019; Setyobudi *et al.*, 2021, 2022). Therefore, variety differences may depend on growing requirements and cultivation techniques. Likewise, Puspitasari *et al*. (2016) stated that tannin content, fruit size and flesh colour of salak fruit are strongly influenced by where it grows. Other studies also explain that salak 'Gulapasir' var. nangka which is grown 570 m asl, would result in a higher quality of fruit that includes thickness of the mesocarpium, edible portion of fruit than compared to above and below 570 m asl (Sumantra *et al*., 2014; Sumantra and Martiningsih, 2016). Meanwhile, fruit weight and fruit quality of var. gondok and var. nenas have not been reported. Therefore, one way of handling salak quality is by undertaking severe studies for factors such as land and climate and adjusting agricultural patterns according to local climate conditions (Nassar *et al*., 2018). The success of each species to occupy the environment of an area is influenced by its ability to adapt optimally to all physical environmental factors (temperature, light, soil structure, humidity), biotic factors (interaction between species, competition, parasitism), and chemical factors including the availability of water, oxygen, pH, and nutrients (Nassar *et al*., 2018; Widyastuti *et al*., 2022). Moreover, a broad genetic variability would lead to wide phenotypic variability due to the effect of genetic-environment interaction (Ritonga *et al*., 2018). The research objective was to obtain several superior salak 'Gulapasir' both in production and fruit quality (sugar and acid ratio, vitamin C and tannins) in six different agricultural ecosystems in Bali. This research was important to do to get the suitability and adaptation of the types of salak based on the altitude where it grows so that in the future, its development will be able to provide maximum results according to existing agro-ecosystem conditions.

2. Materials and Methods

2.1. Experimental site

The research was conducted in Tabanan and Karangasem Regencies. Tabanan and Karangasem were selected as research locations because the domination of salak 'Gulapasir' in these two regencies was the highest. In 2021, the salak 'Gulapasir' population in Tabanan was 84 % of all salak species, while in Karangasem Regency the dominance of the salak 'Gulapasir' was more than 63 % (Sumantra *et al*., 2022).

The study was carried out in six different locations, three sites in Karangasem Regency and three sites in the district of Tabanan. Locations in Karangasem (K) are lowlands (K < 560 m asl) which include several places, namely Telaga, Dukuh, and Karanganyar. Karangasem in the moderate plains (K 560 m to 650 m asl) has several areas, namely Kecing and Kutabali and highlands (K > 650 m asl), namely Tanah Apo and Kresek (Figure 1).

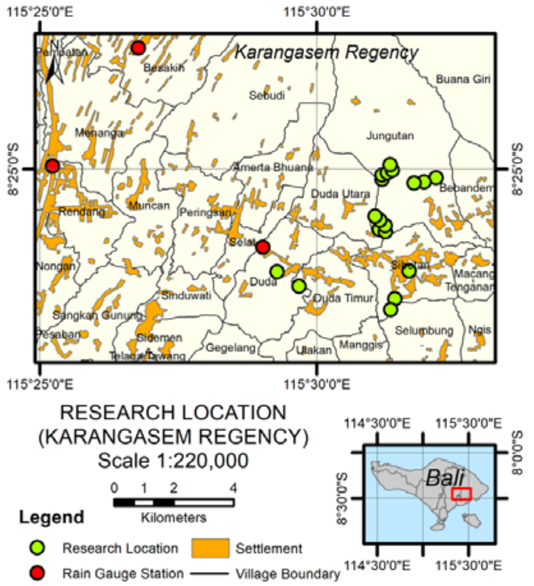

Fig. 1. Research map and sampling point in Karangasem (K)

The research location is in Tabanan (T) in the lowlands (T < 560 m asl), including Wanagiri, Sari Buana, and Mundeh Kauh. Tabanan in the medium lands (T 560 m to 650 m asl) includes several places, namely Pajahan, Kebon Jero, and Angseri. Tabanan in the highlands (T > 650 m asl), namely Munduk Temu, Pempatan, and Batungsel (Figure 2).

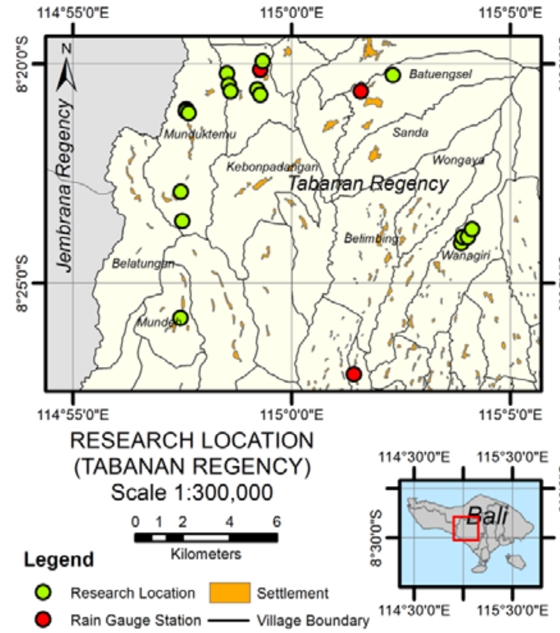

Fig 2. Research map and sampling point in Tabanan (T)

The non-independent variable was the three varieties of Salak 'Gulapasir' (SGP): SGP var. nangka (N), SGP var. nenas (NS), SGP var. gondok (G), and six sites, namely Karangasem (K): (K < 560 m asl, K 560 m to 650 m asl, and K > 650 m asl) and Tabanan (T): (T < 560 m asl, T 560 m to 650 m asl, T > 650 m). Repetition was carried out three times with the number of sample plants in each location, and cultivars were seven plants. The treatment tested is as shown in Table 1.

Table 1. Treatment of plant location and three varieties of 'Gulapasir' salak

No	Treatment	Explanation
1	NT < 560 m asl	Salak GP var. nangka Tabanan < 560 m asl.
2	NT 560 m to 650 m asl	Salak GP var. nangka Tabanan 560 m to 650 m asl.
3	NT > 650 m asl.	Salak GP var. nangka Tabanan > 650 m asl.
4	NK < 560 m asl.	Salak GP var. nangka Karangasem < 560 m asl.
5	NK 560 m to 650 m asl	Salak GP var. nangka Karangasem 560 m to 650m asl.
6	NK > 650 m asl.	Salak GP var. nangka Karangasem > 650 m asl.
7	GT < 560 m asl	Salak GP var. gondok Tabanan < 560 m asl.
8	GT.560 to 650 m asl	Salak GP var. gondok Tabanan 560 m to 650 m asl.
9	GT > 650 m asl	Salak GP var. gondok Tabanan > 650 m asl.
10	GK.< 560 m asl	Salak GP var. gondok Karangasem < 560 m asl.
11	GK 560 m to 650 m asl	Salak GP var. gondok Karangasem 560 m to 650 m asl.
12	GK >650 m asl	Salak GP var. gondok Karangasem > 650 m asl.
13	NST < 560 m asl	Salak GP var. nenas Tabanan < 560 m asl.
14	NST.560 m to 650 m asl	Salak GP var. nenas Tabanan 560 m to 650 m asl.
15	NST > 650 m asl	Salak GP var. nenas Tabanan > 650 m asl.
16	NSK .< 560 m asl	Salak GP var. nenas Karangasem < 560 m asl.
17	NSK 560 m to 650 m asl	Salak GP var. nenas Karangasem 560 m to 650 m asl..
18	NSK > 650 m asl	Salak GP var. nenas Karangasem > 650 m asl.

The study used a Composite Analysis of Variance (Andinurani, 2016, 2022) with the model determined using Equation (1) below:

$$Yjk = U + Li + \delta\, ik + Pj + (LP)\, ij + \varepsilon\, ijk \qquad (1)$$

Where:

Yijk = The observation value of the treatment (j) in the group (k), which is repeated at the location (i).

u = the actual average value

Li = additive effect from location i

δ ik = the error effect in group k at location i

Pj = additive effect of the next treatment

(LP) ij = the effect of treatment (j) atthe location (i)

Ɛ ijk = the effect of error from the treatment (j) in the group (k) which was carriedout at the location (i).

2.2. Preparation of study materials

The material used is the salak 'Gulapasir' plant with uniform growth; plants have been fruitful with uniform on morphological, age of plants and cultivation action. The intentional practice is that the plant only receives treatment in the midrib, tillers, and weed cleaning. In this study, the plants were not fertilized. The provision of water was only from rainfall following the habits applied by salak farmers. The sample plant was maintained by trimming unproductive leaf midribs and removing young shoots. Plant material was taken from the Salak Development Centre in six locations, namely at the Centre of Salak Development in the Bebandem sub-districts, Karangasem district (K-lowland < 560 m asl, K-medium 560 m to 650 m asl and K-highland > 650 m asl), Bajre, West Slemadeg and Pupuan sub-districts, Tabanan district (T-lowland < 560 m asl, T-medium 560 to 650 m asl and T-highland > 650 m asl).

2.3. Analysis of physicochemical properties of soil sample and climate

Soil analysis was carried out to determine the physical and chemical properties of the soil. Soil sampling was carried out under sample plant trees, in a composite manner at a depth of 0 cm to 40 cm. Chemical analysis was carried out on total N (Kjeldahl method), available P by Bray I method and K_2O by the Bray I method, organic C, pH, soil physical properties in the form of texture by pipette method (Eviati and Sulaeman. 2009; Hailu *et al*., 2015; Prasetyo *et al*., 2022a; Rzasa and Owczarzak, 2013).

Rainfall data was taken for 5 yr from 2015 to 2019. Rainfall data has been collected from six nearby stations to the research site (Figure 1 and Figure 2). Daily temperature data was obtained from the Denpasar Meteorology Climatology Agency.

2.4. Observation of fruit and fruit quality

Salak fruit can be harvested when it is ready for consumption. Consumable ripe fruit is a fruit that is ready to be consumed, characterized by a change in skin colour from dark brown to light brown, the thorns on the skin being reduced and not sharp, and in general, at this stage, the fruit easily falling when shaken.

Observation and measurement of agronomic characters follow the method that has been done by Sumantra *et al*. (2014) including fruit weight, number of fruit bunches, the thickness of fruit flesh and fruit shape. The fruit characters from six-observed locations include the numbers of fruits per bunch, which is calculated manually on the formed fruits. The fruit weight per fruit and the fruit weight per tree is weighed after the fruits were removed from the bunch. The thickness of the mesocarpium is obtained by measuring the mesocarpium after it is cut vertically. The length of the flower sheath is measured on the stem of the sheath from the base to the tip of the sheath.

While fruit quality includes sugar content, tannins, titrated acid, sugar content and vitamin C. Titrated acid was analyzed by titration (Sripakdee *et al*., 2015). The fruit which was weighed 10 g of sample was added to 100 mL of distilled water, then was homogenized using a slow spin blender, and filtered using an aseptic filter. The filtrate obtained was taken as much as 25 mL, then titrated with 0.1 N NaOH solution with phenolphthalein indicator until red colour appeared. The results obtained are calculated as the percentage tartaric acid as per Equation (2) below :

$$A = \frac{mL\ NaOH \times N\ NaOH \times P \times BM}{Y \times 1\,000 \times 2} \times 100\ \% \qquad (2)$$

where:

A = percentage of total acid
P = amount of dilution
BM = molecular weight of tartaric acid
Y = sample weight (g).

Tannins content was analyzed as done by Thakur *et al*. (2021), Setyobudi *et al*. (2022). Amount of 100 mg of the sample was homogenized by 2 mL of methanol, centrifuged for 10 min at 10 000 rpm (1 rpm = 1/60 Hz), and then the supernatant was collected. Amount of 1 mL of the aforementioned supernatant was mixed with 0.5 mL Folin's phenol reagent and 35 % Na_2CO_3 of 5 mL was added, and the mixture was kept at room temperature for 5 min. The blue colour of the reaction mixture was observed at 640 nm by UV/visible spectrophotometer (Shimadzu UV-1800, Japan). The content of tannins was calculated by calibration curve equation and determined using Equation (3) below:

$$Y = 0.007\,3 \times -0.007\,1 : R^2 = 0.997\,3 \qquad (3)$$

Vitamin C was determined by titration like the method used by Asamara (2016), Setyobudi *et al.* (2021a, 2022). The material is weighed as much as 10 g and crushed in mortal, then put into a 250 mL volumetric flask, set to the mark and filtered. Take 25 mL of the filtrate and titrate with 0.01 N Yod solution equivalent to 0.88 mg of ascorbic acid. The calculation of ascorbic acid content per 100 g of material is determined using Equation (4) below:

$$A = \frac{mL\ Yod\ 0.01\,N \times 0.88 \times P \times 100}{Y} \qquad (4)$$

where: A = mg of ascorbic acid per 100 g of material
P = amount of dilution
Y = gram sample weight

Sugar content as TSS is calculated using a hand refractometer (Bellingham and Stanley Ltd., London) at 20 °C (Adinurani *et al*., 2018). The ratio of sugar content (TSS) and total acid is calculated by the sugar content divided by the acid content multiplied by 100 %.

The materials used in this study were Folin-ciocalteu reagent (Pro Analytic, Merck), NaOH (pro analytic, Merck), Na_2CO_3 (pro analytic, Merck), Phenol reagent (pro analytic, Merck), Ascorbic acid (pro analytic, Merck), Phosphoric acid (Pro Analytic, Merck), Sodium phosphate (pro analytic, Merck) and Ammonium molybdate (pro analytic, Merck).

The tools used in this study were analytical balances (Shimadzu ATY224, Japan), centrifuge tubes, Erlenmeyer flasks (Pyrex), dropper pipettes (pyrex), volume pipettes (Pyrex), vortex (Maxi Mix II Type 367000), measuring flask (Pyrex), water bath (Memmert), blender (Miyako), and centrifuge (Damon /IEC Division). Whatman filter paper No 1 (Sigma – Aldrich, USA), measuring cup (Pyrex, USA), micropipette (Dragon Lab, Indonesia), spectrophotometer (Biochromsn 133467, UK), test tube (Pyrex¸ USA), vortex (Barnsteadl Thermolyne Type 37600 Mixer, USA), aluminum foil (Klin Pak, Indonesia).

2.5. Study design

This study used a randomized block design with the data analyzed using a Composite Analysis of Variance. If the variance test is significantly different, then it is continued with a different test with LSD at the 5 % level. Data analysis was performed using SPSS-IBM 18 (Adinurani, 2016, 2022). Each experimental treatment was repeated three times.

3. Results and Discussion

3.1. Agroclimate characteristic

The low production level and the quality of salak fruit are caused by environmental factors that do not support growth or because the physiological processes of the plant are not optimal due to insufficient nutrients and water. The suitability of climatic and soil conditions at six locations of the centres for the development of the 'Gulapasir' salak was evaluated. The evaluation results show that the air temperature decreases as the altitude increases. The average air temperature at the 'Gulapasir' salak plantation in Tabanan is 22.90 ^{o}C, while the air temperature at the Karangasem salak plantation is around 23.24 ^{o}C. (Tabel 2)

Table 2. Soil and climate characteristics of the research site in Tabanan and Karangasem in three subzones

Parameter	Tabanan (T)			Karangasem (K)		
	Lowlands (< 560 m asl)	Moderate ((560 m to 650 m asl)	Highlands (> 650 m asl)	Lowlands (< 560m asl)	Moderate (560 m to 650 m asl)	Highlands (> 650 m asl)
Temp. (^{o}C)	23.82	22.75	22.12	24.29	23.35	22.09
Rainfall (mm mo^{-1})	188.24	199.91	231.008	237.242	254.183	289.216
Soil texture	loamy clay	loamy clay	loamy clay	clay	Clay	sandy loam
pH (H_2O)	5.64 (sa)	5.75 (sa)	5.84 (sa)	6.08 (sa)	6.05 (sa)	6.03(sa)
C- organic (%)	2.94 (m)	3.40 (h)	3.25 (h)	2.77 (m)	3.63 (h)	3.32 (h)
Nutrients available						
N total (%)	0.18 (l)	0.16 (l)	0.18 (l)	0.24(m)	0.23 (m)	0.29 (m)
P_2O_5 (mg g^{-1})	9.38 (vl)	9.12 (vl)	13.50 (l)	22.55 (m)	24.18 (m)	23.04 (m)
K_2O (mg g^{-1}))	18.47 (vl)	22.05 (vl)	17.23 (vl)	24.17 (vl)	19.93 (vl)	18.37 (vl)

Notes: sa: slightly acidic; h: high; m: medium; l: low; vh: very high; h: high; asl: above sea level (The assessment criteria refer to Eviati and Sulaeman. 2009; PPT, 1983).

In addition to monthly rainfall, the average rainfall over 5 yr is presented in Figure 3. Annual rainfall in Tabanan (T < 560, T 560 to 650 and T > 650) is lower with an average of 2515.05 mm, while in Karangasem (K < 560, K 560 to 650 and K > 650) it is 3 122.05 mm. However, the six locations show a trend of increasing rainfall as altitude increases. The salak plantation area in Karangasem is in the southern part of Mount Agung. Meanwhile, in Tabanan, the dominant salak plantation area is behind Mount Batukaru with a lower elevation than Mount Agung. Mount Agung has an altitude of 3 142 m asl (Andaru and Rau, 2019), while Batukaru mountains area of 2 250 m asl (Asmiwyati *et al*., 2015). Mount Batukaru serves as a barrier from the rain, causing this area to be a rain shadow. Enyew and Steenveld (2014) state that rainfall in an area is influenced by topographical factors and mountain ranges. Decreasing the height of the mountains provides a reduction in the maximum level of rainfall over the mountains and foothills by 50 % (Flesch and Reuter, 2012). Topographical factors and regional weather systems have an important role in the amount and spatial pattern of rainfall in an area (Enyew and Steenveld, 2014).

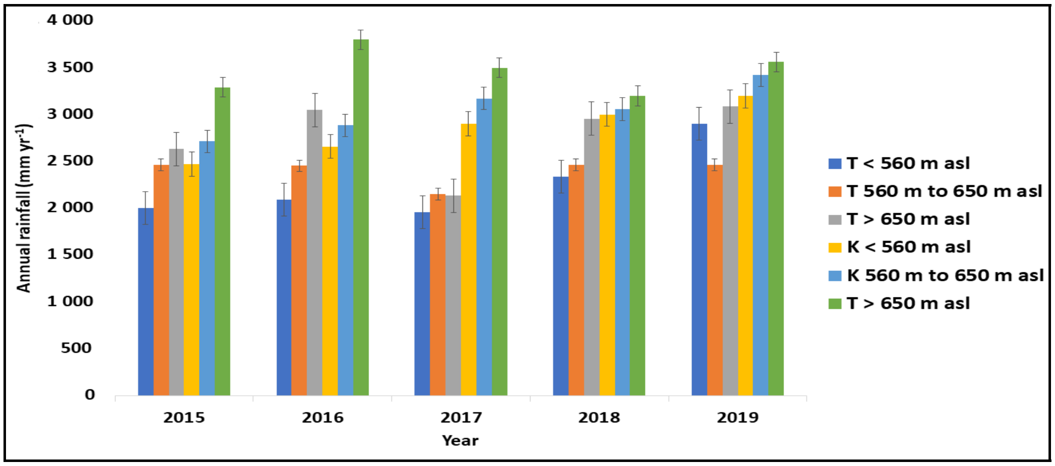

Fig. 3. The annual rainfall in the six study sites

Based on the growing requirements of salak plants, rainfall and air temperature in the six locations evaluated were in the very suitable range to support plant growth and development. A good air temperature for the growth of salak plants is between 20 °C to 30°C and an average rainfall of (200 to 400) mm mo^{-1} (Nuary *et al*., 2019).

Soil C-organic content in six planting sites was in the medium to high range. Availability of N and P nutrients in salak plantations in Tabanan in the lowlands, medium and highlands is of low to very low conditions. In salak planting land in Karangasem - both in the lowlands, medium and highlands - these two nutrients are available in moderate conditions (Table 3). The nutrient content of potassium available in the six planting locations that have been evaluated shows a very low value. The results of this study indicate that the cultivation techniques carried out by farmers are very low. Farmers do not apply fertilizers that only rely on litter from the pruning of salak midrib as reported by Ilmiah *et al*. (2021), Rai *et al.* (2014), and Warnita *et al.* (2019). To cultivate sustainable agriculture, especially in agroecosystems salak in Bali, the authors will discuss this issue more in the future research paragraph.

3.2. Fruit Characteristics of Salak 'Gulapasir'

The salak 'Gulapasir' his monoecius plant, namely male and female flowers arranged on the same bunches, the shape of the bunchesis compound, and the position of the flower is on the back of the midrib. The salak 'Gulapasir' is classified as special because of its sweet fruit taste and the price per unit weight is four times more expensive than the salak 'Bali' (Rai *et al*., 2014; Sumantra *et al*., 2012). The expansion of the cultivation of the salak 'Gulapasir' from its area of origin, Sibetan, Karangasem, has resulted in phenotypic diversity with a phenotypic similarity level of 58.62 % to 93.10 % (Sumantra and Martiningsih, 2016). In the same garden, more than one type of 'Gulapasir'salak appears, depending on fruit shape, aroma, color of fruit flesh and fruit weight (Sumantra and Martiningsih, 2016).The results of this study mean that the emergence of plant diversity due to plant propagation is done by seed, so new variants of salak 'Gulapasir' appear with local names such as salak 'Gulapasir' nenas, salak 'Gulapasir' gondok and salak 'Gulapasir' nangka. The striking difference between these three varieties lies in the shape and flesh of the fruit. The number of fruit branches of salak 'Gulapasir' nangka, 1 to 2 branches, salak 'Gulapasir' nenas amount of 2 to 4 branchesand salak 'Gulapasir' gondok the fruit bunches that do not form fruit branches. Salak 'Gulapasir', which is ready to harvest, has fruit flesh attached to the seed, and the fruit flesh is 0.63 cm thick. However, the flesh of the salak 'Gulapasir' nenas is the thinnest and the seeds are attached to the flesh. And when the salak 'Gulapasir' gondok is ready to harvest, the seeds make a sound when shaken (Figure 4 and Figure 5).

Fig. 4. The shape and the thickness of the fruit flesh of SGP.var.nenas, gondok and nangka

Figure 5. The shape of the bunch andthe number of fuits of SGPvar. gondok,nenas, and nangka

3.3. Agronomic characteristics of 'Gulapasir' Salak

Analysis of variance showed that the interaction between planting locations and varieties of 'Gulapasir' salak had significant effect on the number of fruits per bunch, fruit weight per tree, fruit weight per fruit, number of fruits per bunch, the ratio of sugar and acid and vitamin C content. Meanwhile, the thick fruit flesh and tannins content was not significant (Table 4)

Table 4. Recapitulation of the effects of varieties and growing locations on agronomic and fruits quality of 'Gulapasir' salak

No.	Character agronomic and fruits quality	Planting location	Varieties	Varieties x Location
1	Length of the flower sheath	**	**	*
2	Number of fruit bunches $^{-1}$	**	**	*
3	Fruit tree weight $^{-1}$	**	**	*
4	Fruit weight $^{-1}$	**	**	*
5	TSS ratio and total acid	**	**	**
6	Thick fruit flesh	**	**	Ns
7	Vitamin C	Ns	Ns	*
8	Tannins	Ns	Ns	Ns
9	Edible portion	**	**	Ns

Notes: *) significant $P < 0.05$, **) very significant $P < 0.01$ and Ns) not significantly different $P > 0.05$

The interaction of varieties and planting location had a significant effect on the length of the flower sheath and the number of fruit bunches^{-1}. Nenas variety grown in Tabanan (T < 560, T 560 to 650, and T > 650) and Karangasem (K < 560, K 560 to 650, and K> 650) showed higher sheath length and a number of fruit bunches^{-1} than with nangkaand gondok varieties (Table 5). Tabanan (T 560 to 650) and Karangasem (K < 560 m asl) are ideal conditions for flower sheath development and fruit development of nenas.

Table 5. Flower sheath length (cm) and a number of fruit bunches $^{-1}$ (fruit) of nangka, gondok and nenasvarieties at six locations.

Treatment	Sheath length (cm)	Amount fruit bunches $^{-1}$
NT< 560	27.50 ± 0.34 bcd	19.55± 0.82 hij
NT 560 to 650	28.83± 1.31 b	20.39± 1.00 g
NT > 650	27.17± 0.96 cde	19.02± 0.82 j
NK < 560	26.00± 0.82 e	21.13± 0.82 ef
NK 560 to 50	27.17± 0.14 cde	22.28± 2.45 c
NK > 650	26.67± 1.36 cde	21.13± 0.74 ef
GT<560	26.67± 2.18 cde	20.22± 0.31 gh
GT560 to 650	27.50 ± 1.22 bcd	20.55± 0.62 fg
GT>650	27.70 ± 1.98 bc	19.22± 0.74 ij
GK<560	25.83± 1.41 e	21.89± 0.82 cd
GK 560 to 650	26.83± 0.75 cde	20.5± 1.63 fg
GK >650	27.5± 0.82 bcd	21.28± 0.78 def
NST <560	27.5± 0.82 bcd	21.41± 0.91 de
NST560 to 650	27.67± 0.82 bc	22.00 ± 1.56 cd
NST >650	26.17± 2.16 de	19.91± 1.36 ghi
NSK <560	32.00 ± 1.63 a	25.27± 1.41 a
NSK560 to 650	30.90± 2.10 a	24.00 ± 0.82 b
NSK >650	27.00 ± 1.47 cde	21.86± 0.82 cde

Remarks : Numbers followed by the same letter in the samecolumn and parameter indicate a non-significant difference in LSD 5 %.

From Table 5 above, it can be explained that the three varieties planted in six locations produced a number of fruits between 19.02 to 25.27 fruits per bunch. The nenas variety planted in Karangasem at an altitude of < 560 m asl (treatment NSK < 560) produced the highest number of fruits of 25.27 per bunch, followed by NSK 560 to 650 and NST 560 to 650 with 24.00 and 22.00 fruits per bunch. In order for the salak plants to bear much fruit, the nangka variety is ideal in Karangasem 560 to 650 m asl (NK 560 to 650), while the gondok variety is very good when planted below 560 m asl (GK < 560) although the number of fruits is not significantly different from the same altitude for NT 560 to 650 and GT < 560.The results of this study are in line with the findings of Sumantra and Martiningsih (2016) that the 'Gulapasir' salak var. nenas produces the highest number of fruits both in the on season (*gadu* season) and -off-season (*sela* season).Sumantra *et al*. (2014) reported that the emergence of new sheaths occurred on the third or fourth leaf midrib from the growing point depending on the altitude and plant conditions. The time for new sheaths to appear ranges from 129.00 d to 145.10 d with the required heat units between (1 233.62 to 1 047.90) Degree-Day (DD). The higher altitude causes the longer the sheath appears as well as the harvest time.

The interaction of varieties and planting location had a significant effect on the fruit weigh (fruit tree^{-1} and fruit^{-1}). Nangka variety grown in Tabanan (T < 560, T 560 to 650, and T > 650) and Karangasem (K < 560, K 560 to 650, and K > 650) showed higher of weight of fruit tree^{-1} and fruit-^{1} than with nenas and gondok (Table 7).

Table 6. Fruit weight of nangka, gondok, and nenas varieties in six locations

Treatment	Fruit^{-1} (g)	Fruit tree-^{1} (kg)
NT < 560	45.32±1.08 cd	1.19± 0.08 def
NT 560 to 650	48.56±0.71 c	1.29± 0.07 cd
NT > 650	38.22±0.46 ef	1.03± 0.06 ghi
NK < 560	55.84±1.37 a	1.48 ± 0.02 b
NK 560 to 650	59.43±0.71 a	1.62 ± 0.07 a
NK > 650	49.4±1.65 b	1.34 ± 0.05 c
GT < 560	40.14± 0.11 e	1.11± 0.09 fg
GT 560 to 650	38.67± 0.55 ef	1.09 ± 0.07 fg
GT > 650	32.95± 0.73 gh	0.93 ± 0.10 i
GK <5 60	44.22± 0.18 d	1.27 ± 0.06 cde
GK 560 to 650	38.20 ± 0.78 ef	1.16 ± 0.05 defg
GK > 650	36.20 ± 0.75 fg	1.07 ± 0.11 fgh
NST < 560	39.00 ± 1.07 ef	1.14 ± 0.11 efg
NST560 to 650	37.79± 0.65 f	1.13 ± 0.06 g
NST >650	32.12± 0.11 h	0.94 ± 0.10 hi
NSK < 560	41.80 ± 0.65 de	1.36 ± 0.08 bc
NSK 560 to 650	36.57± 0.80 fg	1.18 ± 0.09 def
NSK > 650	37.10 ± 0.23 f	1.11 ± 0.07 fg

Remarks : Numbers followed by the same letter in the samecolumn and parameter indicate a non-significant difference in LSD 5 %.

From Table 6, it can be explained that the three varieties grown in six locations produced fruit weight per tree between 0.93 kg and 1.62 kg. The salak nangka variety planted in Karangasem at an altitude of 560 to 650 m asl (NK 560 to 650) produced the heaviest fruit weight of 1.62 kg tree^{-1}, followed by NK < 560 and NT 560 to 650 with fruit weights of 1.48 and 1.29 kg, while the nenas variety produces the best fruit at altitudes < 560 m asl (NSK < 560 and NT < 560). Salak 'Gulapasir' var.gondok is ideal when planted at altitudes < 560 m asl (GK < 560 and GT < 560), although the two growing locations showed different yields.

Nenas and gondok varieties showed a trend of decreasing fruit weight in line with increasing altitude, both planted in Karangasem and Tabanan. The reverse occurred in the salak Nangka variety, an increase in altitude from 550 m asl to 650 m asl caused an increase in fruit weight and after that the fruit weight decreased when planted at altitudes > 650 m asl. This finding is in line with the results of research that have been reported by Sumantra *et al*. (2014). However, for the gondok and nenas varieties, this is a new finding.

Apart from being influenced by environmental factors, the production of salak 'Gulapasir' fruit is also influenced by internal plant factors (Adelina *et al*., 2021b: Lestari *et al*. 2011). The effect of altitude on plant growth and production is related to plant adaptability and tolerance to temperature (Fenech *et al*., 2019) and rainfall (Ritonga *et al*., 2018). Altitude increases, the average daily air temperature decreases and monthly rainfall increases (Table 3). Nuary *et al.* (2019) stated that the distribution and adaptation of salak plants is strongly influenced by temperature and rainfall. It was further stated that the contribution of daily temperature accounts for nearly 38.6% while rainfall is 27.8 %. Kanzaria *et al.* (2015) reported that mango plants planted at an altitude of 229 m flowered slower than those at an altitude of 148 m and 81 m asl. The temperature regime at higher altitudes is colder than at lower altitudes. Lower temperatures accumulate less growing degree day (GDD) and may result in late flowering. Table 7 shows that the 'Gulapasir' salak planted in Karangasem produced a higher fruit weight in the three salak varieties tested. This is related to the level of soil fertility. The soil nitrogen and phosphate nutrient content at three locations in Karangasem was higher than at three locations in Tabanan. Meanwhile, the potassium content in the six research locations was low (Table 3). Therefore, it is necessary to make improvements by providing fertilizers containing elements of N, P and K to meet ideal conditions for growth, although more data is needed to fully support this conclusion (Hailu *et al.*, 2015).

3.4. Quality characteristics of salak varieties

The interaction between varieties and altitude significantly affected sugar/total acid and vitamin C content. The three varieties grown in Tabanan (T < 560, T 560 to 650 and T > 650) showed a lower TSS/acid ratio. The fruit flavour planted in three locations in Tabanan is more sour than the three locations in Karangasem. Sugar content is greatly affected by the geographical conditions. The geographical difference is usually followed by overall climate and weather differences, particularly temperature, humidity, and rainfall (Ritonga*et al*., 2018). Table 8 also shows that the increase in altitude from 550 m to 700 m asl in Tabanan and the addition in altitude from 550 to 650 m asl in Karangasem causes the sugar/acid ratio decrease in all three varieties, and the lowest sugar/acid value occurs in nenas variety in all locations. Each salak variety has an adaptation to an elevation closely related to plant tolerance to temperature (Sumantra and Martiningsih, 2016; 2018). Many factors influence fruit quality, but the most dominant are climate factors, especially temperature and rainfall. Rainfall has a negative correlation with fruit weight-1 (r = -0.991 **), TSS/acid ratio (r = -0.875 **) and vitamin C (r = -1.000**). However, the air temperature has a positive and significant correlation with fruit weight^{-1}, TSS/acid ratio, and vitamin C with correlations, respectively: r = 0.930 **, r = 0.733 **, and r = 0.964**. High rainfall and low air temperature during the fruit ripening phase can cause the dissolved solids in the fruit to become watery so that the TSS value is low (Singh *et al*., 2011).

Salak fruits from three different varieties grown in low lands in Karangasem (K < 560 m asl) showed the highest vitamin C content and were significantly different from the three cultivars when planted in other locations. In both areas, land increased by > 650 m asl effects to vitamin C decrease; nangka and gondok varieties showed higher levels of vitamin C between < 550 m to < 650 m asl. (Table 7).

Table 7. TSS/acid ratio and levels of vitamin C of nangka, gondok, and nenas varieties in six locations.

Treatment	TSS/T acid	Vit. C (mg 100 g-^{1})
NT < 560	56.20 ± 0.16 abc	27.50 ± 0.41 bde
NT 560 to 650	59.18± 0.82 a	25.45±0.37 defgh
NT > 650	37.89± 0.91 f	22.52± 0.39 j
NK < 560	51.41± 0.33 cde	27.74± 0.47 bd
NK 560 to 650	53.52± 0.82 abcd	29.61± 0.50 ab
NK > 650	47.76± 0.11 de	24.25± 0.20 fghij
GT<560	34.88±0.72 fg	25.50 ± 0.41 defgh
GT5 60 to 650	34.80 ± 0.65 fg	25.75± 0.20 defgh
GT > 650	30.24± 0.20 gh	23.34± 0.28 hij
GK< 560	51.28± 0.23 cde	30.31± 0.25 a
GK 560 to 650	58.44± 0.36 ab	27.63± 0.30 bd
GK > 650	53.04± 0.82 bcde	25.07± 0.33 efghi
NST < 60	31.50 ± 0.41 gh	26.71± 0.21 cdef
NST 560 to 650	30.44± 0.36 gh	25.88± 0.41 defg
NST > 650	26.13± 0.11 h	23.65± 0.29 ghij
NSK < 560	53.73± 0.60 abc	24.42± 0.34 fghij
NSK 560 to 650	52.63± 0.51 bcde	22.82± 0.15 ij
NSK > 650	47.60 ± 0.49 e	25.16± 0.13 efghi

Remarks : Numbers followed by the same letter in the samecolumn and parameter indicate a non-significant difference in LSD 5 %.

The results showed that the varieties of the ‘Gula pasir’salak need different environmental requirements to optimize yields. Ascorbate content is influenced by abiotic factors, especially temperature and light (Fenech *et al*., 2019; Setyobudi *et al*., 2021, 2022). Therefore, variety differences may depend on growing requirements and cultivation techniques. Vitamin C in the ‘Gula pasir’salak is strongly influenced by the altitude of the land. To produce high levels of vitamin C, the nangka and gondok varieties are ideal for planting at an altitude of 560 m to 650 m asl, while the nenas variety is ideal at a land altitude of < 560 m asl. However, changes in ascorbate levels during fruit ripening are species-dependent and environmental factors, especially temperature and light (Fenech *et al*., 2019).

There was no interaction between varieties and altitude to the flesh thickness, edible fruit portion, and fruit sugar content. The nangka salak variety showed fruit quality, including TSS, edible parts of the fruit, and higher flesh thickness (Table 8).

Table 8. The effect of a single factor of varieties on TSS, the portion of edible flesh, and the thickness of salak fruits

Treatment	TSS (° Brix)	Edible portion (%)	Flesh thickness (cm)
Nangka	16.59a	72.50a	0.63a
Gondok	16.42a	70.66ab	0.59b
Nenas	15.64b	69.22b	0.52c

Remarks : Numbers followed by the same letter in the same column and parameter indicate a non-significant difference in LSD 5 %.

Salak grown in Karangasem both from the lowlands and the middle lands produces fruit thickness, and the edible portion of fruits is higher than plants in the highlands. This study indicates that the ideal growing place for salak plants is between 450 m to 650 m asl (Tabel 9). This study is in line with several previous studies which explained that altitude affects the flowering process and fruit enlargement (Sophie *at al*., 2017; Spinardi *et al*., 2019; Widyastuti *et al*., 2022).

Table 9. The effect of a single factor of planting location on TSS, the portion of edible flesh, and the thickness of salak fruits

Treatment (m asl)	TSS (° Brix)	Edible portion (%)	Flesh thickness (cm)
T< 550	16.28a	73.13a	0.54c
T550 to 650	16.27a	69.89a	0.58bc
T >650	16.14a	63.87b	0.49d
K550	16.81a	73.15a	0.61b
K550 to 650	16.11a	72.29a	0.66a
K>650	15.69a	72.44a	0.61b

Remarks : Numbers followed by the same letter in the samecolumn and parameter indicate a non-significant difference in LSD 5 %.

The soil analysis results showed that the total N and P_2O_5 contents at three locations in Tabanan were very low to low, while the K_2O content at the six study sites was very low (Table 3). The low nutrient values of the three nutrients above are thought to be a factor causing the three types of salak planted in Tabanan at different altitudes to produce low fruit. The correlation results showed that N and P_2O_5 content negatively correlated with fruit weight (r = -0.855** and -0.992**), while K_2O content had a positive and highly significant correlation (r = 0.997**) with fruit weight. The quality of salak land is low because farmers practice very simple technique in salak cultivation, where most fertilization only uses buried salak midrib (Sumantra, *et al*., 2014; Tamba and Sumantra, 2022). Therefore, the utilization and processing of plant waste need to be optimized to improve land quality.

Further research can be applied using sustainable salak organic agriculture (Budiasa, 2014; Handayani, 2022; Nurhidayat *et al*., 2022; Rahmah *et al*., 2022; Sukewijaya *et al*., 2009; Wimatsari *et al*., 2019). Table 3 shows that salak cultivation in the research location still needs to implement sustainable farming (Prasetyo *et al*., 2022b; 2022a). There are indications on decrease in soil fertility, especially potassium availability, as the six planting locations came out with very low values. Potassium levels in Table 3 are lower than the observations of Ashari (2013) and Woran *et al.* (2018) in salak cultivation areas in Swaru – Malang (very high), Sleman – Yogyakarta (moderate), Bangkalan – Madura (very high), and Pangu – Minahasa (moderate).

The low availability of potassium (Table 3) in the nine study areas deserves attention, especially since the authors stated that the K_2O content had a positive and highly significant correlation (r = 0.997**) with fruit weight. Potassium helps produce good fruit quality, such as bigger, heavier, and sweeter fruit. Another benefit of the nutrient potassium in plants is to increase the growth of meristem tissue and regulate the movement of stomata. Potassium also helps the development of plant roots so that plant stems can stand upright and do not collapse easily (Adinurani *et al.,* 2018; Budiono *et al*., 2019). Therefore, Nasution (2022) recommends more K_20 fertilizer than P_20_5 fertilizer and N fertilizer. In addition, salak needs 70 kg of K_2O because this nutrient is found in the leaves at an amount (12.2 to 14.7) mg g^{-1} (Ashari, 2013).

The chemical fertilizers (*e.g*., KCl) are too expensive for Salak farmers and do not support the salak organic. Therefore, the application of sustainable farming should apply local wisdom including the use of the pruning of salak midrib. Consider this policy because C organic is essential to soil fertility (Budiono*et al*. 2021; Goenadi *et al*. 2021). The success of this midrib decomposition is demonstrated by the C organic in Table 3, which is classified as medium to high. This finding supports Faizah and Fauzan (2021), Saputra *et al.* (2018) in salak plantation of Purwosari District - Pasuruan Regency, and Wonosalam District – Jombang Regency.

But, in the next stage, some of the salak midribs should be burned into ashes which can be used as a source of potassium nutrients (Ekawati and Purwanto, 2012; Vincevica-Gaile *et al*., 2021a, 2021b). Another organic source of potassium is the pulp/husk of coffee cherries. Karangasem and Tabanan districts are coffee cultivation areas in Bali, so they should take advantage of this coffee processing waste. Several researchers stated that coffee pulp/husk contains higher potassium than nitrogen or phosphorus nutrients (Bahri *et al*., Falahuddin *et al*., 2016; Novita *et al.*, 2018; Setyobudi *et al*., 2018).

Several researchers (Analianasari *et al*. 2022; Ningsih, 2020; Wachisbu, 2020) recommend soaking the pulp/husk of coffee cherries and using it as liquid organic fertilizer, which is beneficial for various plants. To develop this idea, salak farmers in Karangasem and Tabanan Regency should create biogas as household or communal scale digesters (Prespa *et al*., 2020; Setyobudi *et al.* 2021b; Susanto *et al*., 2020a) or use digesters from used drums (Adinurani *et al*., 2013, 2017; Hendroko *et al*., 2013). All household organic waste is processed in the digester, including kitchen waste, leftover food, and human excrement from pit latrines and septic tank (Anukam and Nyamukamba, 2022; Somorin, 2020; Susanto *et al*., 2020b; Zhou *et al*., 2022). This action has various advantages, namely reducing global warming, obtaining clean - renewable energy, and two kinds of organic fertilizer, *i.e*., liquid and solid (Abdullah *et al*., 2020; Burlakovs *et al*., 2022; Hendroko *et al*., 2014; Prespa *et al*., 2020; Setyobudi, *et al*., 2018). In addition, many researchers have reported (among other things Benyahya *et al*., 2022; Baştabak and Koça, 2020; Li *et al*., 2021) the benefits of organic fertilizers from biogas digesters.

Another measure to increase and maintain land fertility is in salak cultivation, namely the application of Plant Growth Promoting Rhizobacteria (PGPR) or biological fertilizer (Afzal *et al*., 2017; Basu *et al*., 2021; Ekawati, *et al.,* 2019; Nguyen *et al.,* 2020; 2022, Sukorini *et al.*, 2023). Several researchers (Adinurani *et al*., 2021; Kumalawati *et al*., 2021; Muhammad *et al*. 2021) have reported using mycorrhiza, which positively impacts various plants, including salak cultivation (Amnah and Friska, 2018; Dewi *et al*., 2020; Rai *et al*., 2021). Multiplication of mycorrhiza is relatively simple (Sportes *et al*., 2021; Sukmawati *et al*., 2021) and can be done by farmer groups with initial guidance from universities.

4. Conclusion and Recommendation

The SGP var. nangka in Karangasem showed higher fruit weight, vitamin C content, and sugar/acid ratio. In Karangasem and Tabanan, SGP var. nangka grows ideally at an altitude of (560 to 650) m asl with fruit weight per tree of 1.62 kg^{-1} and 1.29 kg^{-1}, respectively, while the SGP var. nenas showed the highest number of fruit $bunches^{-1}$ in six locations. In contrast, SGP var. nenas and SGP var.gondok are ideal for cultivating at an altitude of < 560 m asl both in Karangasem and Tabanan, but the fruit production of SGP var. nenas and SGP var. gondok is higher, respectively, 19.29 % and 15.31 % when planted in Karangasem. In order to obtain ideal fruit production and quality, SGP var. nangka is very suitable to be planted at an altitude of 550 m to 650 m asl. In contrast, the SGP var. nenas and var.gondok are developed naturally at low altitudes < 550 m asl.

In order to enable all cultivars produce optimally, efforts to improve the cultivation system are needed through fertilization; mainly potassium is highly recommended. Further research can be applied using sustainable salak organic agriculture to maintain soil fertility.

Acknowledgements

The authors would like to thank the Head of the Regional Research and Innovation Agency of Bali Province for the funding provided for this research with contract number: B .17.027/3220/Bid.II/BaRI.

References

Abdullah K, Uyun AS, Soegeng R, Suherman E, Susanto H, Setyobudi RH., Burlakovs J and Vincēviča-Gaile Z. 2020. Renewable energy technologies for economic development. *E3S Web of Conf*., **188(00016)**: 1–8. https://doi.org/10.1051/e3sconf/202018800016

Adelina R, Suliansyah I,Syarif Aand Warnita. 2021a. Sulfate ammonium fertilizer on the off-season production of snake fruit (*Salacca sumatrana* Becc.). *Biotropia.,* **28(2)**: 156–164. https://DOI10.11598/btb.2021.28.2.1280

Adelina R, Suliansyah I, Syarif A and Warnita. 2021b. Phenology of flowering and fruit set insnake fruit (*Salacca Sumatrana* Becc.). *Acta Agrobotanica,* **74(742)**: 1–12. https://doi.org/10.5586/aa.742

Adinurani PG, Liwang T, Salafudin, Nelwan LO, Sakri Y, Wahono SK, Setyobudi RH. 2013. The study of two stages anaerobic digestion application and suitable bio-film as an effort to improve bio-gas productivity from *Jatropha curcas* Linn capsule husk. *Energy Procedia* **32**: 84–89. https://doi.org/10.1016/j.egypro.2013.05.011

Adinurani PG. 2016. **Design and Analysis of Agrotrial Data**: **Manual and SPSS**. Plantaxia, Yogyakarta, Indonesia.

Adinurani PG, Setyobudi RH, Wahono SK, Mel M, Nindita A, Purbajanti E, Harsono SS, Malala AR, Nelwan LO and Sasmito A. 2017. Ballast weight review of capsule husk Jatropha curcas Linn. on acid fermentation first stage in two-phase anaerobic digestion. *Proc. Pakistan Acad. Sci. B* **54(1)**: 47–57

Adinurani PG, Rahayu S, Budi LS, Nindita A, Soni P and Mel M. 2018. Biomass and sugar content of some varieties of sorghum (*Sorghum bicolor* L. Moench) on dry land forest as feedstock bioethanol. *MATEC Web Conf.* **164(01035)**: 1–5. https://doi.org/10.1051/matecconf/201816401035

Adinurani PG, Rahayu S, Purbajanti ED, Siskawardani DD, Stankeviča K and Setyobudi RH. 2021. Enhanced of root nodules, uptake NPK, and yield of peanut plant (*Arachis hypogaea* L.) using rhizobium and mycorrhizae applications. *Sarhad J. Agric.,***37(Special issue 1)**: 16–24. https://dx.doi.org/10.17582/journal.sja/2021/37.s1.16.24

Adinurani PG. 2022. **Agrotechnology Applied Statistics (compiled according to the semester learning plan).** Deepublish, Yogyakarta, Indonesia.

Afzal I, Iqrar I, ShinwariZK and Yasmin A, 2017. Plant growth-promoting potential of endophytic bacteria isolated from roots of wild *Dodonaea viscosa* L. *Plant Growth Regul*., **81**:399–408. https://doi.org/10.1007/s10725-016-0216-5

Amnah R and Friska M. 2018. The usage of *Arbuscular mycorrhiza* on the growth of salak Sidimpuan (*Salacca sumatrana* Becc.) seedling. *Jurnal Pertanian Tropik.* **5(3-59):** 455– 461

Analianasari A, Kenali EW, Berliana D and Yulia M. 2022. Liquid organic fertilizer development strategy based coffee leather and raw materials to increase revenue local coffee Robusta farmers. *IOP Conf. Ser.: Earth Environ. Sci*. **1012(012047)**: 1–9. https://doi.org/10.1088/1755-1315/1012/1/012047

Andaru R and Rau JY. 2019. Lava dome changes detection at Agung mountain during high level of volcanic activity using UAV photogrammetry. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci*., **XLII-2/W13**: 173–179.https://doi.org/10.5194/isprs-archives-XLII-2-W13-173-2019

Anukam A and Nyamukamba P. 2022. The chemistry of human excreta relevant to biogas production: A review. In: Meghvansi M., Goel AK (Eds) **Anaerobic Biodigesters for Human Waste Treatmen**t pp 29–38. *Environmental and Microbial Biotechnology*. Springer, Singapore. https://doi.org/10.1007/978-981-19-4921-0_2

Ashari S. 2013. **Salak: The Snake Fruit**. UB Press, Malang, Indonesia

Asmara AP. 2016. Analysis of vitamin C level contained in mango Gadung (*Mangifera indica* L.) with varied retension time. *Elkawnie***2(1):** 37–50. http://dx.doi.org/10.22373/ekw.v2i1.658

Asmiwyati, IG. Mahendra S, Arifin NHS and Ichinose T. 2015. Recognizing indigenous knowledge on agricultural landscape in Bali for micro climate and environment control. *Procedia Environ. Sci*., **28(07073)**: 623–629. https://doi.org/10.1016/j.proenv.2015.07.073

Bahri S, Pratiwi D and Zulnazri. 2020. Extraction of potassium from coffee seed waste (Coffea sp) using the reflux method. *Jurnal Teknologi Kimia Unimal,* **9(1):**24–31.

Baştabak B and Koça G. 2020. A review of the biogas digestate in agricultural framework. *J Mater Cycles Waste Manag.,* **22**: 1318–1327. https://doi.org/10.1007/s10163-020-01056-9

Basu A, Prasad P, Das SN, Kalam S ,Sayyed RZ, Reddy MS and Enshasy HE. 2021. Plant growth promoting rhizobacteria (PGPR) as green bioinoculants: Recent developments, constraints, and prospects. *Sustainability*, **13(3-1140)**:1–20. https://doi.org/10.3390/su13031140

Benyahya Y, Fail A, Alali A and Sadik M. 2022. Recovery of household waste by generation of biogas as energy and compost as bio-fertilizer—A review. *Processes.,* **10(81)**: 1–22. https://doi.org/10.3390/pr10010081

Budiasa IW. 2014. Organic farming as an innovative farming system development model toward sustainable agriculture in Bali., *Asian J Agric Dev*. **11(1)**: 65–76

Budiono R, Adinurani PG and Soni P. 2019. Effect of new NPK fertilizer on lowland rice (*Oryza sativa* L.) growth. *IOP Conf. Ser.: Earth Environ. Sci*. **293(012034):**1–10. https://doi.org/10.1088/1755-1315/293/1/012034

Budiono R, Aziz FN, Purbajanti ED, Turkadze T and Adinurani PG. 2021. Effect and effectivity of granular organicfertilizer on growth and yield of lowland rice.*E3S Web of Conf*., **226 (00039)**:1–7. https://doi.org/10.1051/e3sconf/202122600039

Budiyanti T, Hadiati S and Fatria D. 2019. Evaluation and selection of salacca hybrid population based on fruit characters. *IOP Conf. Ser.: Earth and Environ.* Sci., **497 (012005)**: 1–13. https://doi:10.1088/1755-1315/497/1/012005.

Burlakovs J, Vincevica-Gaile Z, Bisters V, Hogland W, Kriipsalu M, Zekker I, Setyobudi RH, Jani Y and Anne O. 2022. Application of anaerobic digestion for biogas and methane production from fresh beachcastbiomass. Proceedings EAGE GET2022– 3rd Eage Global Energy Transition,The Hague, Netherlands, pp. 1–5.

Cepkova PH, Jagr M, Janovska D, Dvoracek V, Kozak AK, and Viehmannova I. 2021.Comprehensive mass spectrometric analysis of snake fruit: Salak (*Salacca zalacca*). *J. Food Qual*., **Article ID 6621811**: 1–12. https://doi.org/10.1155/2021/6621811.

Damat D, Anggriani R, Setyobudi RH and Soni P. 2019. Dietary fiber and antioxidant activity of gluten-free cookies with coffee cherry flour addition. *Coffee Sci*., **14(4):**493–500.

Damat D., Setyobudi RH, Soni P, Tain A, Handjani H, Chasanah U. 2020. Modified arrowroot starch and glucomannan for preserving physicochemical properties of sweet bread. *Cienc. e Agrotecnologia.,* **44(e014820)**:1–9. https://doi.or10.1590/1413-7054202044014820

Dewi NMK, Rai IN and Wiraatmaja IW. 2020. Fertilization response to off-season production and fruit quality of Salak Gula Pasir (*Salacca zalacca* cv. Gula Pasir) and water and chlorophyll content of leaves. *Agrotrop*, **10(1):**88–99. https://doi.org/10.24843/AJoAS.2020.v10.i01.p10

EkawatiI and Purwanto Z. 2012. Potential of agricultural waste ash as an alternative source of potassium, calcium and magnesium nutrients to support sustainable crop production. Prosiding Seminar Nasional Kedaulatan Pangan dan Energi. **27**: 135–139. Universitas Trunojoyo, Bangkalan, Madura, Indonesia.

Ekawati.I. 2019. Smart farming: PGPR technology for sustainable dry land agriculture. Prosiding Seminar Nasional Ekonomi dan

Teknologi, pp 615–622. Universitas Wiraraja, Sumenep, Madura, Indonesia.

Enyew BD and Steeneveld GJ. 2014. Analysing the impact of topography on precipitation and flooding on the Ethiopian highlands. *Journal of Geology & Geosciences.,* **3(6)**: 1–6. https://doi.org/10.4172/2329-6755.1000173

Eviati and Sulaeman. 2009. **Technical Instructions - Chemical Analysis of Soil, Plant, Water, and Fertilizer, 2nd Edition.** Balai Penelitian Tanah, Badan Penelitian dan Pengembangan Pertanian, Departemen Pertanian Republik Indonesia.

Faizah M and Fauzan A. 2021. Biomass technology based on salak plantation waste (*Salacca zalacca*) as compost fertilizer in Sumber village, Wonosalam district, Jombang district. **Agrifor.**, **20(2)**: 235–246. https://doi.org.10.31293/agrifor.v20i2.5607

Falahuddin I, Raharjeng ARP and Harmeni L. 2016. The effect of coffee (*Coffea arabica*L.) waste organic fertilizer on the growth of coffee seeds. *Jurnal Bioilmi.,* **2 (2):** 108–120

Flesch TK and Reuter GW. 2012. WRF model simulation of two alberta flooding events and the impact of topography. *J. Hydrometeorol*, **13(2**), 695–708. https://doi.10.1175/JHM-D-11-035.1

Fenech M, Amaya I, Valpuesta V and Botella MA. 2019. Vitamin C content in fruits: biosynthesis and regulation. *Front. Plant Sci.* **9(2006**): 1–21. https://doi.org/ 10.3389/fpls.2018.02006

Girsang E, Lister INE, Ginting CN, Khu A, Samin B, Widowati W, Wibowo S and Rizal R. 2019. Chemical constituents of snake fruit (*Salacca zalacca* (Gaert.) Voss) peel and in silico anti-aging analysis. *Molecular and Cellular Biomedical Sciences*, **3(2)**: 122–128. https://doi10.21705/mcbs.v3i2.80.

Goenadi DH, Setyobudi RH, Yandri E, Siregar K, Winaya A, Damat D, Widodo W, Wahyudi A, Adinurani PG, Mel M, Zekker I, Mazwan MZ, Siskawardani DD, Purbajanti ED and Ekawati I. 2021. Land suitability assessment and soil organic carbon stocks as two keys for achieving sustainability of oil palm (*Elaeis guineensis* Jacq.). *Sarhad J. Agri*., **37(Special issue 1)**: 184–196. https://dx.doi.org/10.17582/journal.sja/2022.37.s1.184.196

Hailu H, Mamo T, Keskinen R, Karitun E and Gebrekidan H. 2015. Soil fertility status and wheat nutrient content in vertisol cropping systems of central highlands of Ethiopia. *Agric. Food Secur*. **4(19):** 1–10.https://doi.org/10.1186/s40066-015-0038-0

Hakim L, Widyorini R, Nugroho WD and Prayitno TA. 2019. Anatomical, chemical, and mechanical properties of fibrovascular bundles of salacca (snake fruit) frond. *Bioresources,* **14(4)**: 7943–7957. http://dx.doi.org/10.15376/biores.14.4.7943-7957.

Handayani A. 2022. Strategies to enhance the development of organic coffee to support local economic resource growth. The case of Wonokerso Village, Temanggung Regency, Central Java, Indonesia. In: Chaiechi T and Wood J. (Eds) **Community Empowerment, Sustainable Cities, and Transformative Economies.** Springer, Singapore. https://doi.org/10.1007/978-981-16-5260-8_35

Hendroko R, Liwang T, Adinurani PG, Nelwan LO, Sakri Y and Wahono SK. 2013. The modification for increasing productivity at hydrolysis reactor with *Jatropha curcas* Linn. capsule husk as bio-methane feedstocks at two-stage digestion. *Energy Procedia,* **32**:47–54. https://doi.org/10.1016/j.egypro.2013.05.007

Hendroko R, Wahono SK, Adinurani PG, Salafudin, Yudhanto AS, Wahyudi A and Dohong S. 2014 The study of optimization hydrolysis substrate retention time and augmentation as an effort to increasing biogas productivity from *Jatropha curcas* Linn. capsule husk at two stage digestion. *Energy Procedia.,* **47**: 255–262. https://doi.org/10.1016/j.egypro.2014.01.222

Herawati W, Amurwanto A, Nafi'ah Z, Ningrum AM and Samiyarsih S. 2018. Variation analysis of three Banyumas local salak cultivars (*Salacca zalacca)* based on leaf anatomy and genetic diversity. *Biodiversitas*, **19(1)**:119–125. https://doi.org/10.13057/biodiv/d190118.

Ilmiah E, Sulistyaningsih and Joko T. 2021. Fruit morphology, antioxidant activity, total phenolic and flavonoid contents of *Salacca zalacca* (Gaertner) Voss by applications of goat manures and *Bacillus velezensis* B-27. *Caraka Tani,* **36(2):** 270–282. https://dx.doi.org/10.20961/carakatani.v36i2.43798

Kanzaria RS, Chovatia DK, Varu ND, Polara RL, Chitroda HN and Patel DV. 2015. Influence of growing degree days (GDD) on flowering and fruit set of some commercial mango varieties under varying climatic conditions. *Asian J. Hort*., **10(1)**:130–133. https://doi10.15740/HAS/TAJH/10.1/130-133

Khan AA and Idrees M. 2021. Factors affecting the production of stone fruit (Apricot) in district Mansehra Khyber Pakhtunkhwa, Pakistan. *Sarhad J. Agric.,* **37(2)**: 475–483. https://dx.doi.org/10.17582/journal.sja/2021/37.2.475.483.

Kumar N, Kumar A, Jeena N, Singh R and Singh H. 2020. Factors influencing soil ecosystem and agricultural productivity at higher altitudes. In: Goel R, Soni R and Suyal D (Eds), **Microbiological Advancements for Higher Altitude Agro-Ecosystems & Sustainability**. Rhizosphere Biology. Springer Nature, Singapore. pp.55–70. https://doi.org/10.1007/978-981-15-1902-44

Kumalawati Z, Muliani S, Asmawati, Kafrawi and Musa Y. 2021. Exploration of *Arbuscular Mycorrhizal* fungi from sugarcane rhizosphere in marginal land. *Planta Tropika.,* **9(2):**126 – 135. https://doi.org/10.18196/pt.v9i2.4026

Lestari R, Ebert G and Keil SH. 2011. Growth and physiological responses of salak cultivars (*Salacca zalacca* (Gaertn.) Voss) to different growing media. *J. Agric. Sci*. **3(4)**: 261–271. http://doi10.5539/jas.v3n4p261

Li C, Wang Q, Shao S, Chen Z, Nie J, Liu Z, Rogers KM and Yua Y. 2021. Stable isotope effects of biogas slurry applied as an organic fertilizer to rice, straw, and soil. *J. Agric. Food Chem*. **69(29):** 8090–8097. https://doi.org/10.1021/acs.jafc.1c01740

Martiningsih EGAG, Sumantra IK and Sujana, P. 2018. The profile of salak gula pasir's farmer in Pajahan Village, Bali.. *Int. J. Contemp. Res. Rev*. **9(8)**: 20254–20256. https://doi.org/10.15520/ijcrr/2018/9/08/583.

Mazumdar P, Pratama H, Lau SE, Teo CH and Harikrishna JA. 2019. Biology, phytochemical profile and prospects for snake fruit: An antioxidant-rich fruit of South East Asia. *Trends Food Sci. Technol*., **91**: 147–158. https://doi.org/10.1016/j.tifs.2019.06.017

Muhammad M, Isnatin U, Soni P and Adinurani PG. 2021. Effectiveness of mycorrhiza, plant growth promoting rhizobacteria and inorganic fertilizer on chlorophyll content in *Glycine max* (L.) cv. Detam-4 Prida. *E3S Web Conf.* **226 (00031)**: 1–5. https://doi.org/10.1051/e3sconf/202122600031

Nassar JM, Khan SM, Villalva DR, Nour MM, Amani, Almuslem AS and Hussain MM. 2018. Compliant plant wearables for localized microclimate and plant growth monitoring. *npj Flex. Electron*, **2(24)**: 1–12. https://doi.org/10.1038/s41528-018-0039-8

Nasution Y. 2022. Application of N, P, K, fertilizer based on soil nutrient statussupport improving production and skills salak farmers and erosion prevention in the sub-district Padangsidimpuan Hutaimbaru, Padangsidimpuan city. *Jurnal Nauli*, **1(2**):7–11.

Nguyen NH, Trotel-Aziz P, Villaume S, Rabenoelina F, Schwarzenberg A, Nguema-Ona E, Clément C, Baillieul F and Aziz A. 2020. Bacillus subtilis and *Pseudomonas fluorescens* Trigger common and distinct systemic immune responses in

Arabidopsis thaliana depending on the pathogen life style. Vaccines, **8(503):** 1–18. https://doi.org/ 10.3390/vaccines8030503

Nguyen NH, Trotel-Aziz P, Clément C, Jeandet P, Fabienne Baillieul F and Aziz A. 2022. Camalexin accumulation as a component of plant immunity during interactions with pathogens and beneficial microbes. *Planta.,* **255**, 116. https://doi.org/10.1007/s00425-022-03907-1

Ningsih YC. 2020. The effect of Robusta coffee liquid organic fertilizer on red chili crily productivity (*Capsicum annuum* L.). Undergraduate Thesis. Universitas Islam Negeri Mataram, Indonesia.

Novita E, Fathurrohman A and Pradana HA. 2018. The utilization of coffee pulp and coffee husk compost block as growing media. *Jurnal Agrotek.,***2 (2)**: 61–72

Nuary RB, Sukartiko AC and Machfoedz MM. 2019. Modeling the plantation area of geographical indication product under climate change: Salak Pondoh Sleman (*Salacca edulis*cv Reinw). *IOP Conf. Ser.: Earth Environ. Sci.***365 (012020):** 1–10.https://doi10.1088/1755-1315/365/1/012020

Nurhidayat O, Andayani SA and Sulaksana J. 2022. Analysis of organic and inorganic Zalacca farming. *Journal of Sustainable Agribusiness* **1(1):**1–7. https://doi.org/10.31949/jsa.v1i1.2761

PPT (Pusat Penelitian Tanah). 1983. **Term of Fertility Capability Survey Reference Land**. Departemen Pertanian, Bogor, Indonesia

Prasetyo H, Setyobudi RH, Adinurani PA, Vincēviča-Gaile Z, Fauzi A, Pakarti TA, Tonda R, Minh NV and Mel M. 2022a. Assessment on soil chemical properties for monitoring and maintenance of soil fertility in Probolinggo, Indonesia*. Proc. Pak. Acad. Sci.: B*., **59(4):**99–113.http://doi.org/10.53560/PPASB(59-4)811

Prasetyo H, Karmiyati D, Setyobudi RH, Fauzi A, Pakarti TA, Susanti MS, Khan WA, Neimane L and Mel M. 2022b. Local rice farmers' attitude and behavior towards agricultural programs and policies. *Pakistan Journal of Agricultural Research*, **35(4):** 663–677. https://dx.doi.org/10.17582/journal.pjar/2022/35.4.663.677

Prespa Y, Gyuricza C and Fogarassy C. 2020. Farmers' attitudes towards the use of biomassas renewable energy a case study from south eastern Europe. *Sustainability*, **12(4009)**:1–18. https://doi.org/10.3390/su12104009

Prihastanti E and Haryanti S. 2022. The combination of plant growth regulators (GA3 and *Gracilaria* sp. extract) and several fertilisers in Salak Pondoh fruit production. *Hort. Sci*., **49(2**): 109–116.https://doi.org/10.17221/102/2021-HORTSCI

Puspitasari E and Ningsih IY. 2016. Antioxidant capacity of gula pasir variant of salak (*Salacca zalacca*) fruit extract using DPPH radical scavenging method. *Pharmacy*, **13(01)**: 116–126.

Puspitasari PD, Sukartiko AC and Mulyati GT 2016. Characterizing quality of snake fruit (*Salacca zalacca* var. zalacca) based on geographical origin. *Foreign Agricultural Economic Report*, **101**:101–105.

Raharjo G, Saidi D and Afany MR. 2022. Soil quality in cultivation land of snakefruit (*Salacca edulis*) in Ledoknongko, Bangunkerto Village, Turi, Sleman Yogyakarta Indonesia. *Int. J. Adv. Eng. Res. Sci*.**6(5)**: 27–31.

Rahmah DM, Putra AS, Ishizaki R, Noguchi R and Ahamed T. 2022. A life cycle assessment of organic and chemical fertilizers for coffee production to evaluate sustainability toward the energy–environment–economic nexus in Indonesia. *Sustainability*, **14(7),** 3912: 1–28. https://doi.org/10.3390/su14073912

Rai IN, Wiraatmaja IW, Semarajaya CGA and Astiari NKA. 2014. Application of drip irrigation technology for producing fruit of salak Gula Pasir (*Salacca zalacca* var. Gula Pasir) off season on dry land. *J. Degraded Min. Lands Manag*. **2(1)**: 219–222. https://doi.org/10.15243/jdmlm.2014.021.219

Rai IN, Semarajaya CGA, Wiraatmaja IW and Astiari KA. 2016. Relationship between IAA, sugar content and fruit-set in snake fruit (*Zalacca salacca*). *J. Appl. Hortic*., **18(3)**: 213–216. https://doi.org/10.37855/jah.2016.v18i03.37

Rai IN, Suada IK, Wiraatmaja IW and Astiari NKA. 2021. Effectiveness of indigenous endomycorrhizal biofertilizer prototype on organic salak leaves and fruits in Bali. *Biotropia* **28(3):** 214 –220. https://doi.org/10.1 1598/btb.2021.28.3.1333

Ritonga EN, Satria B and Gustian G. 2018. Analysis of phenotypic variability and correlation on sugar content contributing phenotypes of salak (*Salacca sumatrana* Reinw var. Sidempuan.) under various altitudes. *Int. J. Environ Agric. Biotech*. **3(6):**2103–2109.
https://dx.doi.org/10.22161/ijeab/3.6.18

Rzasa S and Owczarzak W. 2013. Methods for the granulometric analysis of soil for science and practice. *Pol. J. Soil Sci*. **(46)1:** 1–-50.

Saleh MS, Siddiqui MJ, Mediani A, Ismail NH, Ahmed QU, So'ad SZ and Saidi-Besbes S.2018. *Salacca zalacca:* A short review of the palm botany, pharmacological uses and phytochemistry. *Asian Pac J Trop Med*; **11(12):** 645–652. https://doi10.4103/1995-7645.248321.

Saputra DD, Putrantyo AR and Kusuma Z. 2018. Relationship between soil organic matter content and bulk density, porosity, and infiltration rate on salak plantation of Purwosari District, Pasuruan Regency. *Jurnal Tanah dan Sumberdaya Lahan.,* **5 (1)** : 647–654

Setyobudi RH, Wahono SK, Adinurani PG, Wahyudi A, Widodo W, Mel M, Nugroho YA, Prabowo B and Liwang T. 2018. Characterisation of Arabica coffee pulp – hay from Kintamani - Bali as prospective biogas feedstocks. *MATEC Web Conf.* **164 (01039):**1–13. https://doi.org/10.1051/matecconf/201816401039

Setyobudi RH, Zalizar L, Wahono SK, Widodo W, Wahyudi A, Mel M, Prabowo B, Jani Y, Nugroho YA, Liwang T and Zaebudin A. 2019. Prospect of Fe non-heme on coffee flour made from solid coffee waste: Mini Review. *IOP Conf. Ser. Earth Environ. Sci.,***293 (012035)**:1–24. https://doi.org/10.1088/1755-1315/293/1/012035.

Setyobudi RH, Yandri E, Nugroho YA, Susanti MS, Wahono SK, Widodo W, Zalizar L, Saati EA, Maftuchah M, Atoum MFM, Massadeh MI, Yono D, Mahaswa RK, Susanto H, Damat D, Roeswitawati D, Adinurani PG and Mindarti S. 2021a. Assessment on coffee cherry flour of Mengani Arabica Coffee, Bali, Indonesia as iron non-heme source. *Sarhad J. Agric*., **37(Special issue 1)**: 171–183.
https://dx.doi.org/10.17582/journal.sja/2022.37.s1.171.183

Setyobudi RH, Yandri E, Atoum MFM, Nur SM, Zekker I, Idroes R, Tallei TE, Adinurani PG, Vincēviča-Gaile Z, Widodo W, Zalizar L, Van Minh N, Susanto H, Mahaswa RK, Nugroho YA. Wahono SK and Zahriah Z. 2021b. Healthy-smart concept as standard design of kitchen waste biogas digester for urban households. *Jordan J. Biol. Sci*.,**14(3)**: 613 – 620. https://doi.org/10.54319/jjbs/140331

Setyobudi HS, Atoum MFM, Damat D, Yandri E, Nugroho YA, Susanti MS, Wahono SK, Widodo W, Zalizar L, Wahyudi A, Saati EA, Maftuchah M, Hussain Z, Yono D, Harsono SS, Mahaswa RK, Susanto H, Adinurani PA, Ekawati I, Fauzi A and Mindarti S. 2022. Evaluation of coffee pulp waste from coffee cultivation areas in Indonesia as iron booster. *Jordan J. Biol. Sci*., **15(3)**: 475–488.https://doi.org/10.54319/jjbs/150318

Singh D,Singh KVK, Ram RB and Yadava LP. 2011. Relationship of heat units (degree days) with softening status of fruits in Mango cv. Dashehari. *Plant Arch.***11(1):** 227–230.

SK Mentan 1994a. Decree of the Minister of Agriculture - No. 585/Kpts/TP.240/7/94, date 23 Juli 1994, on Bali salak

SK Mentan 1994b. Decree of the Minister of Agriculture No.584/Kpts /TP.240 /7/94, date 23 Juli 1994 on Gulapasir salak

Somorin TO. 2020. Valorisation of human excreta for recovery of energy and high-value products: A Mini-review. In: Daramola M, Ayeni A. (Eds) **Valorization of Biomass to Value-Added Commodities** pp 341–370. *Green Energy and Technology*. Springer, Cham. https://doi.org/10.1007/978-3-030-38032-8_17

Sophie F, Stöcklin J, Hamann E and Kesselring, H. 2017. High elevation plants have reduced plasticity in flowering time in response to warming compared to low-elevation congeners.*Basic Appl Ecol*.,**21**: 1–12. https://doi.org/10.1016/j.baae.2017.05.003.

Spinardi, A, Cola G, Gardana CS and Mignani I. 2019. Variation of anthocyanin content and profile throughout fruit development and ripening of highbush blueberry cultivars grown at two different altitudes. *Front. Plant Sci*. **10(1045)**: 1–14. https://doi.org/10.3389/fpls.2019.01045.

Sportes A, Hériché M, Boussageon R, Noceto PA, van Tuinen D, Wipf D and Courty PE. 2021. A historical perspective on mycorrhizal mutualism emphasizing arbuscular mycorrhizas and their emerging challenges. *Mycorrhiza.,* **31**:637–653.https://doi.org/10.1007/s00572-021-01053-2

Sripakdee T, Sriwicha A, Jansam N, Mahachai R and Chanthai S. 2015. Determination of total phenolics and ascorbic acid related to an antioxidant activity and thermal stability of the Mao fruit juice. *Int. Food Res. J.* **22(2)**:618–624

Sukewijaya IM, Nyoman R and Mahendra MS. 2009. Development of Salak Bali as an organic fruit. *As. J. Food Ag-Ind*. **Special Issue**: S37– S43

Sukmawati S, Adnyana A, Suprapta DN, Proborini M, Soni P and Adinurani PG. 2021. Multiplication arbuscular mycorrhizal fungi in corn (*Zea mays* L.) with pots culture at greenhouse. *E3S Web Conf.* **226(00044)**:1–10. https://doi.org/10.1051/e3sconf/202122600044

Sukorini H, Putri ERT, Ishartati E, Sufianto S, Setyobudi RH, Nguyen Huu NN and Suwannarat S. 2023. Assessment on drought stress resistance, salinity endurance, and indole acetic acid production potential of dryland-isolated bacteria. *Jordan J. Biol. Sci*. **16(1)**: 137–147. https://doi.org/10.54319/jjbs/160117

Sumantra K, Ashari S, Wardiyati T and Suryanto A. 2012. Diversity of shade trees and their influence on the microclimate of agro-ecosystem and fruit production of Gulapasir Salak (*Salacca Zalacca* var. Amboinensis) fruit. *Int. J. Basic Appl. Sci*.**12(06)**: 214–221.

Sumantra K, Labek SIN and Ashari S. 2014. Heat unit, phenology and fruit quality of salak (*Salacca zalacca* var. amboinensis) cv. Gulapasir on different elevation in Tabanan regency-Bali. *Agriculture, Forestry and Fisheries*. **3(2)**: 102–107. https://doi10.11648/j.aff.20140302.18.

Sumantra K and Martiningsih E. 2016. Evaluation of the superior characters of salak Gulapasir cultivars in two harvest seasons at the new development area in Bali. *Int. J. Basic Appl. Sci*. **16(06)**:19–22.

Sumantra K and Martiningsih E. 2018. The agroecosystem of salak Gulapasir (*Salacca zalacca* var. amboinensis) in new development areas in Bali. Proceedings of International Symposia on Horticulture (ISH), Kuta, Bali. Indonesian Center for Horticulture Research and Development pp. 19– 28.

Sumantra K, Tamba M, Partama Y, Sukerta M and Ariati PEP. 2022. Mapping potential for superior food in Bali: Sub-study of agro-ecosystem, post-harvest and marketing chain of salak commodity. Research Report**.**Bali Regional Research and Innovation Agency. Bali Province.

Susanto H, Setyobudi RH, Sugiyanto D, Nur SM, Yandri E, Herianto H, Jani Y, Wahono SK, Adinurani PA, Nurdiansyah Y and Yaro A. 2020a. Development of the biogas-energized livestock feed making machine for breeders. *E3S Web Conf*., **188 (00010**): 1–13. https://doi.org/10.1051/e3sconf/202018800010

Susanto H , Uyun, AS, Setyobudi, RH, Nur SM , Yandri E, Burlakovs J, Yaro A, Abdullah K, Wahono SK, and Nugroho YA. 2020b. Development of moving equipment for fishermen's catches using the portable conveyor system. *E3S Web Conf.***190(00014):** 1–10. https://doi.org/10.1051/e3sconf/202019000014

Tamba M and Sumantra K. 2022. Organic-based *Salacca zalacca* var. amboinensis farming development: An alternative to strengthening farmers' economy and food security. *IOP Conf. Ser: Earth Environ Sci*., **1107(012074)**: 1–7. https://doi:10.1088/1755-1315/1107/1/012074

Thakur A, Singh S and Puri S. 2021. Nutritional evaluation, phytochemicals, antioxidant and antibacterial activity of *Stellaria monosperma* Buch.-Ham. ex D. Don and *Silene vulgaris* (Moench) Garcke: Wild edible plants of Western Himalayas. *Jordan J. Biol. Sci.* **14(1)**: 83–90. https://doi.org/10.54319/jjbs/140111.

Vincevica-Gaile Z, Stankevica K, Klavins M, Setyobudi RH, Damat D, Adinurani PG, Zalizar L, Mazwan MZ, Burlakovs J, Goenadi DH, Anggriani R and Sohail A. 2021a. On the way to sustainable peat-free soil amendments. *Sarhad J. Agri*., **37(Special issue 1)**:122–135. https://dx.doi.org/10.17582/journal.sja/2021.37.s1.122.135

Vincevica-Gaile Z, Teppand T, Kriipsalu M, Krievans K, Jani Y, Klavins M, Setyobudi RH, Grinfelde I, Rudovica V, Tamm T, Shanskiy M, Saaremae E, Zekker I and Burlakovs J. 2021b. Towards sustainable soil stabilization in peatlands: Secondary raw materials as an alternative. *Sustainability,***13(126726**):1–24. https://doi.org/10.3390/su13126726

Wachisbu DR. 2020. Liquid organic fertilizer from coffee pulp/husk. http://cybex.pertanian.go.id/mobile/artikel/94356/Pupuk-Organik-Cair-Dari-Kulit-Kopi/

Warnita I, Suliansyah, Syarif A and Adelina R. 2019. Flowering induction and formation of salak (*Salacca sumaterana* Becc) fruit with potassium and boron fertilization. *IOP Conf. Ser. Earth and Environ. Sci.,* **347(012092)**:1–12. https://doi10.1088/1755-1315/347/1/012092

Widyastuti RAD, Budiarto R, Hendarto K, Warganegara A, Listiana I, Haryanto Y and Yanfika H. 2022. Fruit quality of guava *(Psidium guajava* 'kristal') under different fruit bagging treatments and altitudes of growing location*. J. Trop.Crop. Sci.***9(1)**: 8–14.

Wimatsari AD, Hariadi SS and Martono E. 2019. Youth of village attitudes on organic farming of snakefruit and it's effect toward their interest on farming organic. *Agraris* **5(1):**56–65. http://dx.doi.org/10.18196/agr.5175

Woran RF, Nangoi R and Lengkong JE. 2018. The study of physical and land chemical properties on the green plant area (*Salacca zalacca*) in Pangu village district Southeast Minahasa). *Cocos,* **1(1)**:1–15. https://doi.org/10.35791/cocos.v1i1.19180

Zhou X, Simha P, Perez-Mercado LF, Barton MA, Lyu Y, Guo S, Nie X, Wu F and Li Z. 2022. China should focus beyond access to toilets to tap into the full potential of its rural toilet revolution. *Resour Conserv Recycl*., **178**, 106100. https://doi.org/10.1016/j.resconrec.2021.106100

Zumaidar T, Chikmawati, Hartana A, Sobir, Mogea JP and Borchsenius F. 2014. Salacca acehensis (Arecaceae), A newspecies from Sumatra, Indonesia. *Phytotaxa,* **159 (4)**: 287–290. https://doi.org/10.11646/phytotaxa.159.4.5.