JUATIKA
JURNAL AGRONOMI TANAMAN TROPIKA
VOL. 7 NO. 1 January 2025

DOI :https://doi.org/10.36378/juatika.v7i1.3908
eissn 2656-1727
pissn 2684-785X
pages : 175 – 180

RESEARCH ARTICLE Open Access

Growth and Yield of Sweet Corn Plants (*Zea mays* L Var saccharata.) Effect of Providing Various Nitrogen Sources and Pruning Techniques

Laila Nazirah[1,*]

Abstract

Corn is a vital food component primarily due to its high carbohydrate content. This research examines the effects of various nitrogen sources and pruning methods on the growth and yield of sweet corn. The investigation occurred in Tambon Tunong Village, located in the Dewantara District of North Aceh Regency, and in the Laboratory of the Faculty of Agriculture at Malikussaleh University from February to May 2024. A randomized block design (RAK) was employed for the experimental setup, incorporating two main factors: nitrogen sources (ZA fertilizer, HX Nitro fertilizer, and Urea fertilizer) and pruning methods (No Pruning, Pruning at 45 days after sowing (HST), and Pruning at 55 HST). Nine treatment combinations were evaluated, each replicated three times, resulting in 27 experimental units with 15 plants per unit, culminating in 405 plants. The findings indicated that urea fertilizer at 300 kg/ha produced the most favorable results regarding plant height, stem diameter, cob weight, and overall corn yield (10.79 tons/ha). Additionally, pruning at 45 HST resulted in the highest measurements for stem diameter, leaf count, and corn yield (7.81 tons/ha).

Keywords: Growth, Nitrogen Source, Pruning Technique, Sweet Corn, Yield

1. Introduction

Corn is a significant food ingredient, the second carbohydrate source after rice (Hadianto et al., 2024; Asridawati & Febriyanti, 2019). It is also used in animal feed and various industries. As the 17th largest corn importer in the world during the 2012-2016 period, Indonesia accounted for approximately 1.8% of total world imports (Sulaiman et al., 2017). These statistics indicate the potential for increasing sweet corn productivity. Sweet corn cultivation is more profitable than regular corn due to its high economic value and shorter production cycle.

Nitrogen (N) is crucial for fruit development in corn plants. Adequate nitrogen supply ensures optimal fruit development and timely ripening. Proper fertilization with nitrogen during corn growth stages can significantly increase corn yields (Saragih et al., 2013). Research by Aliansyah et al. (2022) demonstrated that 300 kg/ha of N fertilizer resulted in the highest cob weight of 16.39 tons/ha.

Enhancing corn crop yields requires more than mere fertilization; it necessitates additional interventions to modify plant growth, such as pruning. Pruning minimizes competition for light among plants and between leaves and flowers, thereby enhancing the efficiency of photosynthesis and ultimately improving harvest outcomes. Without pruning, the effectiveness of nutrient uptake and the photosynthetic process may be significantly diminished.

Pruning can be applied to the plant's upper and lower leaves. The younger, upper leaves play a less critical role in supplying photosynthate to the cob than the middle leaves surrounding it. By pruning the upper leaves, the objective is to maximize light capture by the middle leaves, facilitating optimal photosynthesis. Research indicates that pruning the upper leaves can lead to increased light interception in the middle leaves of corn compared to unpruned plants (Herlina & Fitriani, 2017).

*Correspondence: lailanazirah@unimal.ac.id
1) Universitas Malikussaleh - Kampong, Reuleut Tim., Muara Batu Distric, Aceh Utara Regency, Aceh, Indonesia

2. Material and Methods

This study was carried out in Pulo Rungkom Village, located in the Dewantara District of North Aceh Regency, as well as in the laboratory of the Faculty of Agriculture at Malikussaleh University, situated at the coordinates 4°55′00″N 97°00′00″E (4.9167 °N 97°). The research spanned from February to May 2024. The materials utilized in this investigation included Bonanza variety sweet corn seeds, ZA fertilizer, urea, HX Nitro fertilizer, cow manure, and Virtako 300 SC, which contains the active ingredients Chlorantraniliprole and Thiametoksam. The tools employed comprised hoes, machetes, rakes, knives, scissors, plastic ropes, diggers, watering cans, nameplates, measuring tapes, analytical scales, stationery, and calculators.

The experimental design adopted for this research was a randomized block design (RAK). Two primary factors were examined: the first being the application of nitrogen sources to the corn plants, and the second being the pruning techniques applied. For the nitrogen sources (Factor 1), the treatments included N1: ZA fertilizer at 1.6g/plant (200 kg/ha), N2: HX Nitro fertilizer at 2.6g/plant (250 kg/ha), and N3: Urea fertilizer at 5.52g/plant (300 kg/ha). The pruning techniques (Factor 2) were categorized as P0: No Pruning, P1: Pruning of 3 lower leaves at 45 days after planting (HST), and P2: Pruning of 3 lower leaves at 55 HST. This resulted in 9 treatment combinations, each replicated 3 times, culminating in 27 experimental units. Each unit consisted of 15 plants, leading to 405 plants. The data collected from the study were subjected to statistical analysis using the F test via SAS V9 12 software. If the analysis of variance indicated significant differences at the 5% level, a subsequent Duncan test was performed.

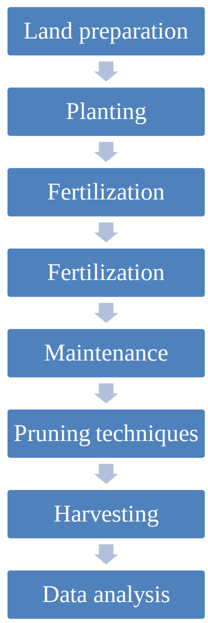

Figure 1. Research flow diagram

3. Results and Discussion

3.1. Plant Height (cm)

The results of the variance analysis demonstrated that the provision of nitrogen sources significantly affected plant height from 50 HST until harvest age. Conversely, pruning techniques did not demonstrate a significant effect on plant height. However, an interaction was observed between the provision of nitrogen sources and pruning techniques. The effect of the provision of nitrogen sources and pruning techniques on plant height can be observed in Table 1.

The data presented in Table 1 indicates that at 50 days after sowing (HST), 60 HST, and at the time of harvest, the tallest sweet corn plants were observed in the N3 treatment group (300 kg/ha), measuring 101.23 cm, 137.04 cm, and 210.87 cm, respectively. Conversely, the shortest plants were recorded in the N1 treatment group (200 kg/ha), with heights of 90.86 cm, 107.54 cm, and 176.32 cm at the same intervals. This variation in plant height can be attributed to the essential role of nitrogen in the growth of sweet corn. Adequate nutrient uptake is crucial for optimal plant height development; insufficient absorption can hinder growth. The effectiveness of nitrogen fertilizer application is also influenced by the inherent fertility of the soil and the specific growth stage of the sweet corn plants. Furthermore, the growth response of sweet corn to increased organic fertilizer application may be limited by the duration of the growth period. When plants receive adequate amounts of all nutrients except for one, their growth tends to be directly proportional to the quantity of the available nutrients. Additionally, nutrients limiting growth are classified as growth-limiting (Hapsani & Basri, 2017).

Table 1. The average height of sweet corn plants with a nitrogen source and pruning technique.

Plant Age (HST)	Nitrogen (N) Sources	Pruning (P)			Average
		P0 (No Trimming)	P1 (45 HST pruning)	P2 (55 HST pruning)	
50 HST	N1 (200kg/ha)	91.19 ± 2.07	90.90 ± 1.42	90.49 ± 3.56	90.86 ± 0.20 b
	N2 (250kg/ha)	100.06 ± 8.35	91.21 ± 0.98	84.32 ± 1.51	91.86 ± 4.56 b
	N3 (300kg/ha)	96.21 ± 1.16	108.32 ± 4.63	99.16 ± 8.57	101.23 ± 3.65 a
	Average	95.82 ± 2.57 a	96.81 ± 5.76 a	91.32 ± 4.30 a	
60 HST	N1 (200kg/ha)	107.18 ± 1.67	106.17 ± 2.32	109.28 ± 1.48	107.54 ± 0.92 c
	N2 (250kg/ha)	118.70 ± 3.07	124.48 ± 1.33	125.74 ± 1.39	122.97 ± 2.17 b
	N3 (300kg/ha)	133.94 ± 1.25	152.49 ± 8.39	124.70 ± 13.51	137.04 ± 8.17 a
	Average	119.94 ± 7.75 a	127.71 ± 13.47 a	119.91 ± 5.32 a	
70 HST	N1 (200kg/ha)	174.11 ± 1.41	174.70 ± 2.46	180.15 ± 2.30	176.32 ± 1.92 c
	N2 (250kg/ha)	200.43 ± 3.83	196.81 ± 1.86	195.46 ± 0.79	197.57 ± 1.49 b
	N3 (300kg/ha)	205.52 ± 3.72	219.17 ± 3.32	207.91 ± 0.62	210.87 ± 4.21 a
	Average	193.35 ± 9.73 a	198.89 ± 12.84 a	194.51 ± 8.03 a	

Note: Numbers followed by the same letter in the same column are not significantly different according to the 5% DMRT test.

3.2. Stem Diameter

The results of the variance analysis demonstrated that the provision of nitrogen sources exerted a highly significant effect on stem diameter across all observation days. Pruning techniques exhibited a highly significant impact on stem diameter across all observation days. However, the interaction between the provision of nitrogen sources and pruning techniques was not statistically significant. The combined impact of these factors on stem diameter is elucidated in Table 2.

Table 2. Average diameter of sweet corn stalks with nitrogen source provision and pruning technique.

Plant Age (HST)	Nitrogen (N) Sources	Pruning (P)			Average
		P0 (No Pruning)	P1 (45 HST Pruning)	P2 (55 HST Pruning)	
50 HST	N1 (200kg/ha)	12.92 ± 0.38	13.80 ± 0.26	11.89 ± 0.19	12.87 ± 0.55 c
	N2 (250kg/ha)	18.10 ± 0.45	19.97 ± 0.14	18.21 ± 0.08	18.76 ± 0.60 b
	N3 (300kg/ha)	21.21 ± 0.31	21.50 ± 0.51	19.80 ± 0.12	20.84 ± 0.52 a
	Average	17.41 ± 2.42 b	18.42 ± 2.35 a	16.63 ± 2.42 a	
60 HST	N1 (200kg/ha)	20.29 ± 0.25	20.93 ± 0.82	19.30 ± 0.12	20.17 ± 0.47 c
	N2 (250kg/ha)	21.85 ± 0.10	22.75 ± 0.34	20.41 ± 0.10	21.67 ± 0.68 b
	N3 (300kg/ha)	25.11 ± 0.20	25.33 ± 0.31	23.35 ± 0.34	24.60 ± 0.63 a
	Average	22.42 ± 1.42 b	23.00 ± 1.28 a	21.02 ± 1.21 c	
70 HST	N1 (200kg/ha)	22.77 ± 0.41	22.89 ± 0.19	21.78 ± 0.24	22.48 ± 0.35 c
	N2 (250kg/ha)	25.90 ± 0.28	26.69 ± 0.08	25.27 ± 0.30	25.95 ± 0.41 b
	N3 (300kg/ha)	29.09 ± 0.22	30.47 ± 0.50	27.59 ± 0.23	29.05 ± 0.83 a
	Average	25.92 ± 1.82 b	26.68 ± 2.19 a	24.88 ± 1.69 c	

Note: Numbers followed by the same letter in the same column are not significantly different according to the 5% DMRT test.

Table 2 shows that the highest average stem diameter at 50 HST is in N3 (300 kg/ha) at 20.84 mm, while the lowest stem diameter is in N1 (200 kg/ha) at 12.87 mm. At 60 HST and harvest age, the highest diameter is in N3 (300 kg/ha) at 24.59 mm and 29.04 mm, respectively, whereas the lowest stem diameter at 60 HST and harvest age is in N1 at 20.17 mm and 22.47 mm. N fertilizer enhances soil fertility physically, chemically, and biologically, increasing stem diameter. Adding N fertilizer promotes plant fertility, resulting in larger stem diameters due to enhanced nutrient absorption and continued development in the generative phase. The growth stages of corn plants involve germination, vegetative growth, and, eventually, the generative phase, where growth slows down (Hapsani & Basri, 2017).

The pruning technique treatment significantly impacted the stem diameter variable on each observation day, indicating that leaf pruning techniques are crucial in stem diameter variation. Genetic traits, environmental conditions, and nutrient availability influence stem diameter. Sumajow et al. (2016) highlighted that genetic and environmental factors can affect corn plants, and better environmental conditions allow plants to express their genotypic traits and thrive.

3.3. Number of Leaves

The results of the variance analysis demonstrated that the provision of nitrogen sources did not significantly affect the number of leaves on any of the observation days. However, the pruning technique significantly impacted the number of leaves on all observation days. However, the interaction between the provision of nitrogen sources and pruning techniques was not statistically significant. The impact of these variables on the number of leaves is elucidated in Table 3.

Table 3. Average number of sweet corn leaves with a nitrogen source and pruning technique.

Plant Age (HST)	Nitrogen (N) Sources	Pruning (P)			Average
		P0 (No Pruning)	P1 (45 HST Pruning)	P2 (55 HST Pruning)	
50 HST	N1 (200kg/ha)	12.78 ± 0.29	9.00 ± 0.67	11.33 ± 1.02	11.04 ± 1.10 a
	N2 (250kg/ha)	11.78 ± 0.45	8.33 ± 051	10.33 ± 0.69	10.15 ± 1.00 a
	N3 (300kg/ha)	12.44 ± 0.29	13.78 ± 0.40	13.00 ± 0.51	13.07 ± 0.39 a
	Average	12.33 ± 0.29 a	13.37 ± 1.72 b	11.55 ± 0.78 c	
60 HST	N1 (200kg/ha)	13.78 ± 0.49	9.55 ± 0.91	10.67 ± 0.19	11.33 ± 1.26 a
	N2 (250kg/ha)	13.22 ± 0.29	9.89 ± 0.44	11.00 ± 0.51	11.37 ± 0.98 a
	N3 (300kg/ha)	13.67 ± 0	10.44 ± 0.11	10.22 ± 0.40	11.45 ± 1.11 a
	Average	13.56 ± 0.17 a	9.96 ± 0.26 b	10.63 ± 0.23 b	
70 HST	N1 (200kg/ha)	10.66 ± 0.33	10.44 ± 0.11	11.00 ± 0.51	10.70 ± 0.16 a
	N2 (250kg/ha)	12.66 ± 0.33	12.11 ± 0.29	12.00 ± 0.19	12.26 ± 0.20 a
	N3 (300kg/ha)	12.44 ± 0.29	13.78 ± 0.40	13.00 ± 0.51	13.07 ± 0.39 a
	Average	11.92 ± 0.63 a	12.11 ± 0.96 b	12.00 ± 0.58 b	

Note: Numbers followed by the same letter in the same column are not significantly different according to the 5% DMRT test.

The data presented in Table 3 indicates that at 50 days after sowing (HST), the treatment N3 (300 kg/ha) resulted in the highest average leaf count, measuring 13.07 strands, while the treatment N2 (250 kg/ha) recorded the lowest at 10.15 strands. At 60 HST, N3 again exhibited the highest leaf count with 11.45 strands, closely followed by N1 (200 kg/ha) at 11.33 strands. By 70 HST, N3 maintained the highest leaf count at 11.33 strands, although the lowest count at harvest was also recorded in N3, which had a value of 13.07 strands. Regarding pruning techniques, the highest leaf count at 50 HST was observed in P1 (pruning at 45 HST) with 13.37 strands, while P2 recorded the lowest at 11.55 strands. At both 60 HST and 70 HST, the highest average leaf counts were found in P0 (no pruning) at 13.56 strands and P1 at 12.11 strands, respectively. Conversely, the lowest leaf count at 60 HST was noted in P1 at 9.96 strands, and the lowest at harvest was in P0 at 11.92 strands. This observation aligns with the findings of Sirajuddin and Lasmini (2014), who emphasized the critical role of nitrogen fertilizer in enhancing the growth of sweet corn plants, as it significantly promotes the development of roots, stems, leaves, and overall plant height.

The treatment of pruning techniques on the variable number of leaves has a significant effect because pruning 3 leaves on sweet corn plants is more effective in the assimilation process for cob formation. Leaf pruning needs to be done to reduce plant competition in the use of nutrients. This follows the opinion of Lubis (2019) that plants that are not pruned produce low yields. This is because the photosynthate produced during the vegetative phase is used not only for seed development but also for plant organs that are not pruned so that competition occurs within the plant body itself. Therefore, leaf pruning at the age of 55 and 60 HST tends not to differ from the treatment without pruning.

3.4. Weight of Corn Husk

The results of the variance analysis demonstrated that the provision of nitrogen sources exerted a highly significant effect on the weight of the corn cobs. Conversely, the pruning technique treatment did not demonstrate a statistically significant impact on the weight of the corn cobs. However, a notable interaction was observed between providing nitrogen sources and pruning techniques. The impact of the interaction is elucidated in Table 4.

Table 4. Average weight of corn cobs with nitrogen source provision and pruning technique.

Nitrogen (N) Sources	Pruning (P)			Average
	P0 (No Pruning)	P1 (45 HST Pruning)	P2 (55 HST Pruning)	
N1 (200kg/ha)	434.89 ± 31.44 ab	358.89 ± 23.39 cd	408.11 ± 10.05 cd	400.63 ± 22.26 a
N2 (250kg/ha)	317.33 ± 25.58 d	417.78 ± 7.29 b	435.55 ± 7.78 ab	390.22 ± 36.80 b
N3 (300kg/ha)	463.33 ± 1.93 ab	482.89 ± 3.47 a	440.00 ± 10.00 ab	462.07 ± 12.40 b
Average	405.18 ± 44.69 a	419.85 ± 35.81 a	427.89 ± 9.97 a	

Note: Numbers followed by the same letter in the same column are not significantly different according to the 5% DMRT test.

According to the data presented in Table 4, the highest average weight of cob with husk is recorded in the N3 treatment (300 kg/ha), which yields an average of 462.07 g. Conversely, the N2 treatment (250 kg/ha) exhibits the lowest average weight, measuring 390.22 g. Regarding pruning techniques, the P2 treatment (pruning at 55 days after sowing) achieves the highest average weight at 427.89 g, while the P0 treatment (no pruning) results in the lowest average weight at 405.18 g.

According to the data presented in Table 4, it is evident that the combined effects of nitrogen source treatment and pruning technique significantly influence the weight of the corn cob. This observation suggests a significant interaction between these two factors. The optimal value is obtained from the application of N3P0 (urea at a rate of 300kg/ha without pruning) at 417.78, while the least desirable value is observed from the application of N2P0 (hx nitro at a rate of 250kg/ha without pruning) at 300.33. The weight of the maize cob is significantly impacted by the process of seed formation and the availability of adequate nutrients post-pollination. Supplying adequate nitrogen during growth is thought to enhance plant metabolic processes. According to the findings of Made's study (2020), it was concluded that the application of 300 kg ha-1 of Urea fertilizer, or its equivalent of 184 kg N ha-1, resulted in the development of larger maize cobs and heavier fresh cob weight, which was statistically distinct from the outcomes of other treatment methods. The weight of corn cobs, particularly the seeds, is influenced by the presence of nutrients, as the absorbed nutrients are utilized by the plants for the synthesis of proteins, carbohydrates, and fats, culminating in an increase in the weight of the cobs due to the accumulation of these substances in the seeds.

3.5. Length of Corncob Without Husk (cm)

The results of the variance analysis demonstrated that the provision of nitrogen sources exerted a highly significant effect on the length of the cob devoid of husks. Conversely, the pruning technique treatment did not significantly affect the weight of the cob with husks. The interaction between providing nitrogen sources and pruning techniques was not statistically significant. The findings of this study are elucidated in Table 5.

Table 5. Average length of corn cob without husk with given source nitrogen and pruning techniques

Nitrogen (N) Sources	Pruning (P)			Average
	P0 (No Pruning)	P1 (45 HST Pruning)	P2 (55 HST Pruning)	
N1 (200kg/ha)	19.63 ± 0.22	19.69 ± 0.39	19.47 ± 0.17	19.60 ± 0.07 b
N2 (250kg/ha)	19.95 ± 0.44	19.43 ± 0.32	20.52 ± 0.26	19.97 ± 0.31 b
N3 (300kg/ha)	20.75 ± 0.34	20.93 ± 0.13	20.01 ± 0.39	20.57 ± 0.28 a
Average	20.11 ± 0.33 a	20.02 ± 0.46 a	20.00 ± 0.30 a	

Note: Numbers followed by the same letter in the same column are not significantly different according to the 5% DMRT test.

The data presented in Table 6 indicates that the nitrogen treatment N3 (300 kg/ha) yields the greatest average cob length without husks, measuring 20.57 cm, whereas the treatment N1 (200 kg/ha) results in the shortest average length of 19.60 cm. In terms of pruning techniques, the highest average cob length is observed in the P0 treatment (no pruning), which records a value of 20.11 cm, while the lowest average is noted in the P2 treatment (pruning at 55 days after planting), with a measurement of 20.00 cm. Applying different nitrogen sources significantly influences the length of cobs without husks. This effect is likely attributed to the optimal availability of nutrients provided by the nitrogen sources, which ensures a proper balance of macro and micronutrients essential for plant health. Effective fertilization practices can enhance both growth and yield's qualitative and quantitative aspects. Kresnatita (2019) emphasized that adequate nitrogen fertilization leads to optimal development of plant organs and an increase in photosynthate production, ultimately enhancing overall plant productivity.

3.6. Number of Rows of Seeds Per Cob

The results of the variance analysis demonstrated that the provision of nitrogen sources exhibited a highly significant effect on the number of rows of seeds per ear. Conversely, the pruning technique treatment exhibited no statistically significant impact on the weight of the ear devoid of husks. The interaction between providing nitrogen sources and pruning techniques was not statistically significant. The findings of this study are elucidated in Table 6.

Table 6. Average number of rows of seeds per cob with nitrogen source provision and pruning technique.

Nitrogen (N) Sources	Pruning (P)			Average
	P0 (No Pruning)	P1 (45 HST Pruning)	P2 (55 HST Pruning)	
N1 (200kg/ha)	36.33 ±019	36.33 ±0.69	36.34 ± 0.67	36.33 ± 0.00 c
N2 (250kg/ha)	38.00 ± 0.33	38.22 ± 0.49	39.00 ± 0.19	38.41 ± 0.30 b
N3 (300kg/ha)	41.78 ± 1.28	41.56 ± 0.87	40.11 ± 0.95	41.15 ± 0.52 a
Average	38.70 ± 1.61 a	38.71 ± 1.53 a	38.48 ± 1.12 a	

Note: Numbers followed by the same letter in the same column are not significantly different according to the 5% DMRT test.

According to the data presented in Table 6, it can be observed that the greatest mean number of seed rows per cob is found in N3 (300kg/ha) at 41.15, whereas the lowest average value of 36.33 is obtained in N1 (200kg/ha). The pruning technique treatment showed the highest average in P1 (pruning 45 HST) with a value of 38.71 and the lowest in the P2 treatment (pruning HST) with a value of 38.48. This is attributable to the significant impact of the genetic composition of the seeds utilized in determining the number of rows on the cob. According to Saputra and colleagues (2018), genetic factors significantly influence the number of seed rows, resulting in consistent production of the same number of seed rows within a specific variety of sweet corn. According to Marliah et al. (2020), plants will not yield optimum results without access to the necessary nutrients. Fertilization can potentially enhance both the qualitative and quantitative growth and yields of crops. According to Kresnatita (2019), adequate nitrogen fertilization is essential for optimizing the growth of plant organs and increasing photosynthate formation, ultimately contributing to enhanced plant production.

4. Conclusion

Applying a nitrogen source (urea 300 kg/ha) yielded the most favorable outcomes regarding plant height at 50, 60 days after sowing (HST) and at harvest and stem diameter at 50, 60 HST, and at harvest. Additionally, it positively impacted the weight of cobs with husks. As a result, corn production was recorded at 10.79 tons per hectare. Applying the pruning technique (specifically, removing the 3 lower leaves at 45 days after sowing) resulted in the most favorable outcome, as indicated by the highest values observed in both stem diameter and number of leaves. The yield of corn production is 7.81 tons per hectare. The interaction of nitrogen source provision and pruning technique influences the growth and yield of sweet corn plants. The most effective interaction was observed in the N3P1 treatment, which consists of applying a nitrogen source at 300 kg/ha in combination with a pruning technique 45 days after planting (HST).

References

Avianto, Y., & Susila, W. A. (2024). Application techniques of photosynthesis bacteria and its effect on the growth and yield of local Bantul shallot variety (*Allium cepa var. aggregatum* cv. Crok Kuning). *Jurnal Agronomi Tanaman Tropika, 6*(2), 185–198. https://doi.org/10.36378/juatika.v6i2.3577

Elliott, S., & Brimacombe, J. (1987). The medicinal plants of Gunung Leuser National Park, Indonesia. *Journal of Ethnopharmacology, 19*(3), 285–317. https://doi.org/10.1016/0378-8741(87)90006-7

Catalano, C., Ciacciulli, A., Salonia, F., Russo, M. P., Caruso, P., Caruso, M., Russo, G., Distefano, G., & Licciardello, C. (2020). Target-genes reveal species and genotypic specificity of anthocyanin pigmentation in citrus and related genera. *Genes, 11*(7), 807. https://doi.org/10.3390/genes11070807

Cooper, S. M., & Owen-Smith, N. (1986). Effects of plant spinescence on large mammalian herbivores. *Oecologia, 68*(3), 446–455. https://doi.org/10.1007/BF01036753

Darusman, L. K., Sari, D. R., & Siregar, U. J. (2020). Eksplorasi plasma nutfah jeruk di kawasan hutan produksi dan hutan lindung Provinsi Aceh. *Jurnal Penelitian Sains & Teknologi Lingkungan, 8*(2), 135–146.

Duddek, P., Ahmed, M. A., Javaux, M., Vanderborght, J., Lovric, G., King, A., & Carminati, A. (2023). The effect of root hairs on root water uptake is determined by root-soil contact and root hair shrinkage. *New Phytologist*. https://doi.org/10.1111/nph.19144

Febrianti, D., Harisandy, M., & Suwardi, A. (2022). The diversity of plant species in the ecotourism zone of Gunung Leuser National Park, Tangkahan, Indonesia. *Jurnal Biologi Tropis*. https://doi.org/10.29303/jbt.v22i2.3367

Fichtner, F., Barbier, F., Stephanie, C., Kerr, C., Dudley, P., Cubas, P., Colin, G., Turnbull, N., Philip, B., Brewer, P., & Beveridge, A. C. (2021). Different plasticity of bud outgrowth at cauline and rosette nodes in *Arabidopsis thaliana*. *bioRxiv*. https://doi.org/10.1101/2021.09.26.461886

Jian-peng, D., Hang, L., Xiao-Ling, P., Chao-Ni, Z., Tian-Huai, Y., & Xian-Min, J. (2019). Research progress of quantum memory. *Acta Physica Sinica*. https://doi.org/10.7498/APS.68.20190039

Kandowangko, N. Y., & Febriyanti, F. (2023). Genetic diversity of the genus Citrus in Tomini Bay coastal areas, Indonesia based on morphological characters. *Biodiversitas, 24*(5). https://doi.org/10.13057/biodiv/d240549

Laurance, W. (2018). Taman Nasional Gunung Leuser di Sumatera menghadapi ancaman serius. *Mongabay-Indonesia*.

Li, X., Chen, Y., Zhao, L., Wang, Q., & Liu, H. (2021). Structural characteristics of leaf cuticles across different citrus species. *Journal of Plant Biology, 64*(3), 275–285.

Mazzini, R. B., & Pio, R. M. (2010). Morphological characterization of six citrus varieties with ornamental potential. *Revista Brasileira De Fruticultura, 32*(2), 463–470. https://doi.org/10.1590/S0100-29452010005000043

Murtando, H., Sahiri, N., & Madauna, I. (2016). Identifikasi karakter morfologi dan anatomi tanaman jeruk lokal (*Citrus sp.*) di Desa Karya Agung dan Karya Abadi Kecamatan Taopa Kabupaten Parigi Moutong. *Jurnal Agrotekbis, 4*(6), 642–649.

Nazari, A. A., & Karyadi, B. (2024). Morphological characterization and conservation of Nagami Citrus (*Citrus japonica*) as an antioxidant and nutrient source. *Jurnal Agronomi Tanaman Tropika*. https://doi.org/10.36378/juatika.v6i2.3472

Purnomo, H., & Hendrajaya, H. (2021). Keanekaragaman plasma nutfah jeruk di Indonesia. *Jurnal Hortikultura Indonesia, 12*(2), 156–163. https://doi.org/10.29244/jhi.12.2.156-163

Rai, M. R., Chawla, R., & Mirza, A. (2020). Study on different extraction methods and antimicrobial potential of citrus peel and leaf. *International Journal of Current Microbiology and Applied Sciences*, 9(11), 246–254. https://doi.org/10.20546/IJCMAS.2020.911.029

Rezkianti, V., Maemunah, & Lakani, I. (2016). Identifikasi morfologi dan anatomi jeruk lokal (*Citrus sp.*) di Desa Hangira dan Desa Baleura Kecamatan Lore Tengah Kabupaten Poso. *Jurnal Agrotekbis, 4*(6), 412–418.

Sari, R. K., Nurfauzi, I., & Muhtadi, A. (2020). Keanekaragaman plasma nutfah jeruk (*Citrus spp.*) pada kebun percobaan Balai Penelitian Tanaman Jeruk dan Buah Subtropika Pasuruan. *Jurnal Hortikultura Indonesia, 11*(3), 219–227.

Sato, M., & Tanaka, K. (2018). Comparative analysis of petiole development in lime and kaffir lime leaves. *Botanical Studies, 59*(4), 312–318.

Solikin. (2012). Eksplorasi buah lokal Madura Jawa Timur. *Prosiding Seminar Nasional Perhorti Kerjasama dengan UPN "Veteran" Jatim 2012*.

Suwardi, A., Navia, Z., Harmawan, T., Syamsuardi, S., & Mukhtar, E. (2020). Wild edible fruits generate substantial income for local people of the Gunung Leuser National Park, Aceh Tamiang Region. *Ethnobotany Research and Applications, 20,* 1–13. https://doi.org/10.32859/era.20.11.1-13

Tjitrosoepomo, G. (2009). *Morfologi tumbuhan* (Cetakan ke-17, revisi). Gadjah Mada University Press.

Zamzamiyah, I., Nabila, & Ashar, S. (2020). Eksplorasi dan karakterisasi tanaman jeruk purut (*Citrus hystrix*) di Kabupaten Tulungagung. *Jurnal Agrotekbis, 8*(11), 1041–1049.