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Evaluation of the Growth and Yield of Hydroponically Grown Bell Pepper at Low Altitudes

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ABSTRACT

Bell pepper cultivation in low-altitude regions of Indonesia holds significant promise because of increasing domestic and international demand. However, domestic production is not sufficient to meet market needs. This study investigated hydroponic cultivation as a potential solution to low-altitude agriculture. Conducted from November 2023 to January 2024 at the University of Bengkulu Greenhouse (10 meters above sea level), the research evaluated the performance of nine bell pepper cultivars using a single-factor completely randomized design (CRD) with three repetitions. The cultivars tested were Red Star F1, Cardinal Star, Hercules, Merah, Yellow Star F1, Golden Star F1, Polaris F1, Orange Bell F1, and Kuning. Results indicated that the Cardinal Star and Polaris F1 cultivars outperformed the others under low-altitude conditions, demonstrating superior growth and yield components. Cardinal Star exhibited the highest fruit weight per plant, whereas Polaris F1 had the highest weight per fruit or fruit size. .

INTRODUCTION

Bell pepper cultivation has promising prospects because of high domestic and international demand, driven by an increasing number of foreign nationals in Indonesia and changing lifestyles and consumption patterns (Andriyani, 2018; Nursidiq et al., 2019). Despite rising demand, farmers have struggled to meet market needs, with bell pepper production in Indonesia decreasing from 17,822 tons in 2020 to 12,665 tons in 2021. East Java and West Java are the largest producers, contributing 7,781 tons and 4,737 tons, respectively (BPS, 2022).

Traditionally, bell peppers grow and yield well at altitudes above 1000 meters above sea level with around 80% humidity (Moekasan et al., 2008) and are predominantly grown hydroponically in highland greenhouses (Oktavianti and Kartika, 2019). To increase production, exploring hydroponic cultivation in low-altitude regions could be effective.

Low-altitude cultivation presents challenges such as high temperatures, intense light, and high humidity, which can reduce productivity (Noor et al., 2005). While bell peppers are sensitive to high light intensity, Tonny et al. (2008) found that high light intensity can en-

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hance yield, whereas high temperatures can significantly decrease yield (Noor et al., 2005).

The low yield of bell peppers in low-altitude areas is attributed to high temperatures, elevated humidity, and increased pest and disease susceptibility. Developing cultivars specifically adapted to low-altitude conditions could mitigate these issues and enhance crop production.

MATERIALS AND METHODS

The research was conducted from November 2023 to January 2024 at the Screen House of the Agroecotechnology Laboratory, Faculty of Agriculture, The University of Bengkulu, at an altitude of 10 meters above sea level. The study used a Single Factor Completely Randomized Design (CRD) with 9 bell pepper cultivars and 3 replications. The tested cultivars were Red Star F1, Cardinal Star, Hercules, Merah, Yellow Star F1, Golden Star F1, Polaris F1, Orange Bell F1, and Kuning.

The parameters observed were as follows: plant height (cm), stem diameter (mm), number of leaves, number of fruits, fruit weight per plant (g), fruit weight per fruit (g), fruit diameter (mm), fruit length (cm), fruit flesh thickness (mm), leaf greenness (SPAD), stomatal density (mm^2), fresh shoot weight (g), dry shoot weight (g), fresh root weight (g), and dry root weight (g). The data were analyzed using ANOVA at a significance level of 5%. If significant effects were observed, further testing was conducted using the LSD at a significance level of 5%.

The research was conducted using a drip irrigation hydroponic system with a growing medium containing rice husk charcoal and AB mix nutrient solution. Bell pepper seeds were soaked in warm water for 30 min before sowing. After soaking, the seeds were drained and placed in seedling trays using tweezers, with one seed per hole. The seedlings were watered daily in the morning and evening. The seedling medium used was rice husk charcoal soaked in boiling water for 24 h to ensure no microorganisms were present.

The growing medium consisted of 1 kg rice husk charcoal placed in poly-bags measuring 30 cm × 40 cm. Bell pepper seedlings were transplanted 30 days after sowing when they had developed 5-7 leaves. The seedlings were transferred from the seedling medium to the prepared polybags in the evening.

The AB mix nutrient stock solution was prepared at 250,000 ppm for each nutrient (A and B) by dissolving 250 g of nutrient A in 1000 ml of water and 250 g of nutrient B in 1000 ml of water. Nutrient solutions were applied from the beginning of transplanting to the end of the growing period to meet plant nutrient requirements and maintain soil moisture. Nutrient application was adjusted according to the plant's growth phase to optimize growth. During the vegetative phase (approximately 1-6 weeks after transplanting), 600 ppm of nutrients were provided, and during the generative phase (approximately 7-12 weeks after transplanting), 1500 ppm of nutrients were provided (Gunadi et al., 2006).

In the drip irrigation system, water and nutrients are supplied simultaneously, a process known as fertigation, to facilitate and optimize water and nutrient usage according to plant needs. Nutrient application was automated with a digital timer set to irrigate three times a day every four hours, with an average of 400 ml per irrigation session, resulting in a daily total of 1200 ml per polybag.

The non-viable or suboptimal plants were replaced 7 days after transplantation by replacing them with new plants. Pruning was conducted from 1 to 3 weeks after transplantation to maintain the leaves on the main stem. This process involved removing new shoots at plant nodes to ensure adequate nutrient distribution to fruits. Support strings were installed to help the plants grow upright by tying nylon strings to the base of the plant stems and hanging them above the plants.

Pest and disease control was done both chemically and mechanicallyconducted once a week to prevent pest infestation. Insecticides with the active ingredient of profenos were used to prevent fruit fly, thrips, and aphid attacks. Propineb fungicides were used to prevent black spot, rust, fruit rot, and fusarium wilt diseases. Abamectin acaricides were used to prevent mite infestations. Surfactant was also used to improve the pesticide effectiveness during spraying. Mechanically, pests were removed manually or with the aid of tools.

Harvesting was done when the fruits met the harvest criteria, indicated by bright and uniform color changes according to the bell pepper variety, such as from green to red, green to yellow, or green to orange (Savaringga, 2013).

RESULTS AND DISCUSSION

Results

This study was conducted in a screen house using a drip irrigation hydroponic system with rice husk charcoal as the growing medium. According to the Meteorology, Climatology, and Geophysics Agency of Bengkulu, the air temperatures in November and December 2023 and January 2024 were 28.3°C, 29.4°C, and 29.2°C, respectively. Humidity levels during the same period were 82%, 77%, and 79%, respectively. Sebayang (2014) reported that the optimal temperature for bell pepper growth is between 21°C and 27°C. Bell peppers can grow at 30°C; however, when the temperature reaches 38°C, all flowers and young fruits will drop (Sebayang, 2014).

During the study, bell pepper plants showed good growth. However, during the generative phase at 10 weeks after planting (WAP), blossom-end rot with an intensity of 12% was observed in the Yellow Star F1 cultivar. Blossom-end rot is a physiological disorder caused by calcium deficiency (Srivastava et al., 2022) and is influenced by environmental factors, genetic factors, and cultivation practices (Kumar et al., 2023). Environmental factors such as altitude significantly affect the growth rate of bell peppers. Plants grown at unsuitable altitudes will experience physiological disorders (Mandagi, 2023). Genetic factors also play a role in determining plant susceptibility to blossom-end rot (Kumar et al., 2023). Additionally, nutrient imbalance, humidity stress, temperature fluctuations, and hormonal irregularities increase the risk of blossom-end rot. These factors can disrupt the normal growth and development of plants.

Blossom-end rot typically affects young fruits, and its symptoms include small, round, and brown spots at the fruit's blossom end. These spots enlarge, turn black, and eventually spread over the entire flesh and skin of the fruit, leading to decay and rendering the bell pepper harvestable (Supriatna and Azzahra, 2021). Control measures for blossom-end rot include maintaining the nutrient solution pH within the optimal range and applying calcium, which can reduce the intensity of blossom-end rot in bell pepper plants.

The variance analysis results showed that bell pepper cultivars significantly influenced various growth parameters, including plant height at 6 weeks after planting (WAP), leaf greenness, number of leaves, stomatal density, fresh shoot weight, dry shoot weight, fresh root weight, dry root weight, number of fruits, fruit weight per plant, fruit weight per fruit, fruit diameter, fruit length, and fruit flesh thickness. However, there was no significant effect on stem diameter. The tallest plants were found in the Polaris F1 cultivar, and the shortest plants were in the Merah cultivar (Table 1).

The highest leaf greenness was recorded in the Polaris F1 cultivar, which did not differ significantly from the Cardinal Star, Yellow Star F1, Golden Star F1, Merah, Red Star F1, and Hercules cultivars. However, the yield was significantly higher than the Kuning cultivar. The lowest leaf greenness was observed in the Orange Bell F1 cultivar, which had significantly lower leaf greenness than the other cultivars (Table 1).

The Polaris F1 cultivar also had the highest number of leaves, which was not significantly different from the Cardinal Star, Hercules, and Yellow Star F1 cultivars. However, the yield was significantly higher than the Golden Star F1, Red Star F1, Orange Bell F1, and Kuning cultivars. The Merah cultivar had the lowest number of leaves and was significantly different from the other cultivars (Table 1).

The highest stomatal density was recorded in the Polaris F1 cultivar, which was not significantly different from the Cardinal Star, Hercules, Red Star F1, and Kuning cultivars

Table 1. Growth of hydroponically grown bell pepper cultivars in low altitudes

Cultivar	Plant Height (cm)		Leaf Greenness (SPAD)		Number of Leaves		Stomatal Density (stomata/mm^2)	
Red Star F1	40.98	b	56.49	ab	50.00	bc	182.43	ab
Cardinal Star	41.13	b	62.37	a	52.33	ab	187.67	a
Hercules	48.23	a	56.01	abc	52.16	ab	186.62	ab
Merah	35.15	c	57.06	ab	42.66	d	159.36	e
Golden Star F1	40.63	b	58.76	ab	50.50	bc	176.14	bcd
Yellow Star F1	41.35	b	60.92	a	52.16	ab	170.90	cd
Polaris F1	52.35	a	63.10	a	54.16	a	189.77	a
Orange Bell F1	37.33	bc	46.76	c	49.83	bc	163.55	de
Kuning	39.21	bc	50.30	bc	45.83	c	179.29	abc

Note: Numbers followed by the same letter in the same column are not significantly different according to LSD at a=5% .

but significantly higher than the Golden Star F1, Yellow Star F1, and Orange Bell F1 cultivars. The Merah cultivar had the lowest stomatal density, which was significantly different from the other cultivars (Table 1).

In terms of fresh shoot weight, the Polaris F1 cultivar had the highest value, which was not significantly different from the Golden Star F1, Yellow Star F1, Hercules, and Red Star F1 cultivars but significantly higher than the Cardinal Star, Orange Bell F1, and Kuning cultivars. The Merah cultivar had the lowest fresh shoot weight, which was significantly different from the other cultivars (Table 2).

The Polaris F1 cultivar also had the highest shoot dry weight, significantly different from the Yellow Star F1, Hercules, Red Star F1, Golden Star F1, Cardinal Star, and Orange Bell F1 cultivars. The Kuning cultivar had the lowest dry shoot weight and was not significantly different from the Merah cultivar (Table 2).

For fresh root weight, the Polaris F1 cultivar again had the highest value, which was significantly higher than the Yellow Star F1, Hercules, Red Star F1, Cardinal Star, Kuning, and Orange Bell F1 cultivars. The Merah cultivar had the lowest fresh root weight, which was significantly different from the other cultivars (Table 2).

The highest dry root weight was observed in the Polaris F1 cultivar, which was not significantly different from the Yellow Star F1, Hercules, Golden Star F1, Red Star F1, and Cardinal Star cultivars, but was significantly higher than the Orange Bell F1 and Kuning cultivars. The Merah cultivar had the lowest dry root weight, which was significantly different from the other cultivars (Table 2).

Table 2. Accumulated biomass of hydroponically grown bell pepper at low altitudes

Cultivar	Shoot fresh weight (g)		Shoot dry weight (g)		Root fresh weight (g)		Root dry weight (g)	
Red Star F1	61.83	ab	8.20	cd	7.71	bc	2.93	abc
Cardinal Star	60.09	b	7.86	cd	7.60	bc	2.80	abcd
Hercules	62.49	ab	8.61	c	8.38	bc	3.12	ab
Merah	46.89	c	6.65	e	6.41	c	2.26	d
Golden Star F1	63.64	ab	8.05	cd	8.29	bc	3.00	ab
Yellow Star F1	62.95	ab	9.93	b	8.68	b	3.28	a
Polaris F1	73.01	a	11.26	a	11.33	a	3.35	a
Orange Bell F1	54.48	bc	7.52	de	6.78	bc	2.66	bcd
Kuning	52.76	bc	6.89	e	6.86	bc	2.41	cd

Note: Numbers followed by the same letter in the same column are not significantly different according to LSD at α=5%

The highest numbers of fruits were found in the Red Star F1 and Cardinal Star cultivars, which were not significantly different from the Hercules cultivar but were significantly higher than the Merah, Golden Star F1, Yellow Star F1, Polaris F1, and Orange Bell F1 cultivars. The highest fruit weight per plant was recorded in the Cardinal Star cultivar, which was significantly higher than the Red Star F1, Hercules, Polaris F1, Merah, Golden Star F1, and Yellow Star F1 cultivars. The Orange Bell F1 cultivar had the lowest fruit weight per plant and was not significantly different from the Kuning cultivar (Table 3).

The highest fruit weight per fruit was found in the Polaris F1 cultivar, which was not significantly different from the Cardinal Star cultivar but significantly higher than the Yellow Star F1, Merah, Red Star, Hercules, Kuning, and Orange Bell F1 cultivars. The Golden Star F1 cultivar had the lowest fruit weight per fruit, which was significantly different from the other cultivars (Table 3).

The Cardinal Star cultivar had the highest fruit diameter, which was not significantly different from the Polaris F1 and Golden Star F1 cultivars but significantly higher than the Yellow Star F1, Hercules, Merah, Orange Bell F1, and Kuning cultivars. The Red Star F1 cultivar had the lowest fruit diameter (Table 3).

The Yellow Star F1 cultivar produces the longest fruits and is significantly different from the Polaris, Hercules, Red Star F1, Golden Star F1, Cardinal Star, and Kuning cultivars. Orange Bell F1 had the shortest fruit length and was not significantly different from the Merah cultivar (Table 3).

The highest fruit flesh thickness was observed in the Cardinal Star F1 cultivar, which was not significantly different from the Polaris F1, Yellow Star F1, Kuning, and Hercules cultivars but significantly higher than the Golden Star F1, Merah, and Red Star F1 cultivars (Table 3).

Discussion

The growth and yield were influenced by both genetic and environmental factors (Lagiman and Supriyanta, 2021). In pepper plants, environmental factors such as temperature, air humidity, soil moisture, and water pH significantly affect plant growth and production outcomes (Pamungkas, 2020).

The fruit weight of pepper exhibits significant differences among cultivars, as indicated in Table 4. It was observed that the Polaris F1 cultivar had the highest average fruit weight per fruit, 89.23 g, which was significantly different from the description. This difference is presumed to be influenced by the genetic factors of each cultivar and environmental factors, such as temperature, humidity, and water availability. Mastaufan (2011) showed that fruit weight is influenced by the interaction between genetic and environmental factors. Inardo et al. (2014) explained that genetic factors play a role in determining fruit weight, as each plant has unique genetic characteristics that result in different fruit weights. Astutik et al. (2017) also found that fruit diameter correlates

Table 3. The yield and fruit quality 9 bell pepper cultivars grown hydroponically at low altitudes

Cultivar	Fruit weight per plant (g)		Weight per fruit (g)		Fruit diameter (mm)		Fruit length (cm)		Thickness of Fruit Flesh (mm)	
Red Star F1	117.66	b	70.48	bc	54.02	d	7.04	d	5.37	b
Cardinal Star	147.26	a	89.03	a	66.71	a	6.75	de	6.94	a
Hercules	93.00	bc	69.72	bc	61.17	bcd	7.44	c	5.73	ab
Merah	83.15	cd	71.03	b	60.65	bcd	5.76	f	5.57	b
Golden Star F1	72.52	cd	61.85	d	65.36	ab	6.82	de	5.72	b
Yellow Star F1	71.07	cd	71.07	b	62.65	bc	8.90	a	5.92	ab
Polaris F1	89.22	cd	89.22	a	70.49	a	7.98	b	5.99	ab
Orange Bell F1	63.71	d	63.71	cd	57.03	cd	6.08	f	5.56	b
Kuning	65.59	d	65.59	bcd	56.45	cd	6.53	e	5.94	ab

Note: Numbers followed by the same letter in the same column are not significantly different according to LSD at α=5%

positively with fruit weight; the larger the fruit diameter, the higher the fruit weight.

Generally, peppers grown at high altitudes have larger fruit weights than those grown at low altitudes due to differences in environmental conditions. Aviantara and Sarjana (2019) demonstrated that pepper cultivation at high altitudes in Candikuning Village, Bali, resulted in an average fruit weight of 250 g. Pepper fruit weights are divided based on quality standards; Grade 1 fruit weighs between 220 and 350 g, Grade 2 fruit weighs between 150 and 200 g, and Grade 3 fruit weighs between 80 and 140 g (Aviantara and Sarjana, 2019). Based on these standards, peppers grown at low altitudes generally fall into Grade 3 because of their smaller size compared to peppers grown at high altitudes.

The results indicated that the Polaris F1 cultivar excels in growth and yield components compared to eight other pepper cultivars grown in low-altitude areas. In terms of growth, Polaris F1 plants have optimal plant height, high chlorophyll content, and numerous leaves, all of which support efficient photosynthesis and high fruit production. In terms of yield components, Polaris F1 showed high harvest potential with good fruit quality, as evidenced by its highest weight, diameter, and flesh thickness. Therefore, Polaris F1 is the best cultivar for pepper cultivation in low-altitude.

The results of this study highlight significant differences in the growth and yield characteristics of nine bell pepper cultivars grown under low altitude conditions. Notably, the Polaris F1 cultivar exhibited superior performance in several key parameters, including plant height, leaf greenness, number of leaves, stomatal density, and yield components, such as fruit weight, fruit diameter, and fruit flesh thickness.

The Polaris F1 cultivar's outstanding performance might be attributed to its genetic traits, which confer adaptability to specific environmental conditions in low-altitude areas. This finding is consistent with recent studies that have highlighted the critical role of genetic factors in determining plant growth and yield potential under varying environmental conditions (Liu et al., 2019; Kumar et al., 2023).

The occurrence of blossom-end rot in the Yellow Star F1 cultivar highlights the need for adequate calcium supplementation to prevent physiological disorders. Calcium deficiency, intensified by environmental stressors such as high humidity and temperature fluctuations, can significantly affect fruit quality (Srivastava et al., 2022; Kumar et al., 2023). Effective management practices, including the maintenance of optimal calcium levels in nutrient solutions, are crucial for minimizing these issues.

The positive correlation between vegetative growth traits (plant height, leaf greenness, and number of leaves) and yield components (data not presented) emphasizes the importance of robust vegetative growth for enhancing fruit yield. Enhanced vegetative growth increases photosynthetic capacity, thereby improving fruit development and yield (Gómez-García et al., 2021). This finding is consistent with recent studies that highlighted the role of vegetative vigor in supporting higher yields in bell peppers (Kumar et al., 2023).

Interestingly, although stem diameter did not differ significantly among the cultivars, other parameters did, indicating that stem diameter alone is not a reliable indicator for overall plant health or yield potential. These discoveries provide valuable insights for bell pepper growers, especially in regions with similar environmental conditions, and highlight the importance of selecting cultivars with genetic traits that confer adaptability to specific environments.

CONCLUSION

This study underscores the significant impact of cultivar selection on the growth and yield of bell peppers. Cardinal Star and Polaris F1 consistently outperformed others in several growth traits, yield, and fruit quality, making them promising candidates for hydroponic production in low-altitude areas. Future research should focus on further elucidating the genetic mechanisms underlying these traits and their interactions with various environmental factors to optimize bell pepper production.

REFERENCES

Andriyani, C. N. 2018. Analisis biaya budidaya paprika hidroponik dengan sistem irigasi tetes kelompok tani Gg Lembang. Karya Ilmiah Mahasiswa 2(2): 1–8.

Astutik, W., Rahmawati, D., and N. Sjamsijah. 2017. Uji daya hasil galur MG1012 dengan tiga varietas pembanding tanaman cabai keriting (*Capsicum annuum* L.). Agriprima: Journal of Applied Agricultural Sciences 1 (2): 163–173. https://doi.org/10.25047/agriprima.v1i2.30.

Aviantara, I. G. N. A., and P. Sarjana. 2019. Kajian sistem jaminan mutu pada budidaya paprika di greenhouse di desa Candikuning, kecamatan Baturiti, kabupaten Tabanan, Bali. Jurnal Ilmiah Teknologi Pertanian Agrotechno 3(2): 338. https://doi.org/10.24843/jitpa.2018.v03.i02.p04.

Badan Pusat Statistik. 2022. Indikator hortikultura komoditas paprika 2018-2021. In Badan Pusat Statistik dan Kementrian Pertanian. p. 23. https://www.bps.go.id/indicator/55/61/1/produksi-tanaman-sayuran.html.

Fonseca, J. M., C. M. Rush, and A. E. McClean. 2020. Fruit yield and quality responses of jalapeño, serrano, and tabasco pepper to herbicides. Agronomy Journal 112(4): 2561–2570.

Gómez-García, J. G., N. Ochoa-Alejo, and M. L. Miranda-Ham. 2021. Capsaicinoid and phenolic compound levels in chile pepper fruits during different growth stages. HortScience 56(1): 93–99.

Inardo, D., Wardati, and Deviona. 2014. Evaluasi daya hasil 8 genotipe cabai (*Capsicum annuum* L.) di lahan gambut. Jom Faperta 1(2).

Kumar, A., R. Bhattacharya, and S. Prakash. 2023. Role of calcium in preventing blossom-end rot in bell peppers. Journal of Plant Nutrition and Soil Science 186(3): 450-462.

Lagiman, and B. Supriyanta. 2021. Karakterisasi morfologi dan pemuliaan tanaman cabai. LPPM UPN "Veteran" Yogyakarta.

Liu, Z., T. Chen, and J. He. 2019. Differentially expressed genes and pathways associated with seedling and fruit traits in *Capsicum annuum* L. identified by comparative transcriptome analysis. BMC Plant Biology 19(1): 343.

Mandagi, L. P. S. 2023. Teknik budidaya tanaman paprika (*Capsicum annuum* var. *Grossum* L.) di kelompok tani A'makalendong kelurahan Rurukan kecamatan Tomohon Timur kota Tomohon. Laporan Kerja Praktek. Universitas Katolik De La Salle Manado.

Mastaufan, A. 2011. Genetic and environmental interaction in determining fruit weight in bell peppers. Journal of Horticultural Science 136(4): 270-279.

Mastaufan, S. A. 2011. Uji daya hasil 13 galur cabai IPB pada tiga unit lingkungan. Skripsi. Institut Pertanian Bogor.

Moekasan, T., L. Prabaningrum, and G. Nikardi. 2008. Budidaya paprika di dalam rumah kasa berdasarkan pengendalian hama terpadu (PHT). Balai Penelitian Tanaman Sayuran.

Noor, Z., B. Simatupang, and Y. Koesmaryono. 2005. Pertumbuhan dan produksi paprika pada berbagai intensitas radiasi surya di dataran rendah, Batam. Jurnal Agromet 19(2): 57–67.

Nursidiq, A., T. I. Noor, and L. Trimo. 2019. Analisis keberlanjutan agribisnis paprika di Bandung Barat. Jurnal Penelitian Pertanian Terapan 19(3): 184. https://doi.org/10.25181/jppt.v19i3.1317.

Oktavianti, F., and J. G. Kartika. 2019. Penerapan good agricultural practices (GAP) pada budidaya paprika kerucut mini (*Capsicum annuum* var. Tribeli) dalam greenhouse di V.O.F MdanW Van Paassen, Belanda. Buletin Agrohorti 7(3): 255–262. https://doi.org/10.29244/agrob.v7i3.30172.

Pamungkas, S. 2020. Smart greenhouse system on paprican plants based on internet of things. Telekontran: Jurnal Ilmiah Telekomunikasi, Kendali dan Elektronika Terapan 7(2): 197–207. https://doi.org/10.34010/telekontran.v7i2.2277.

Sebayang, L. 2014. Berocok tanam paprika. In Balai Pengkajian Teknologi Pertanian Sumatera Utara.

Srivastava, A., R. Singh, and D. Pathak. 2022. Managing calcium nutrition to prevent physiological disorders in horticultural crops. International Journal of Agricultural Sciences 98(2): 112-120.

Srivastava, S., L. Singh, B. Debnath, M. Shukla, S. Kumar, Gaurav, M. Rana, and S. Meshram. 2022. Blossom end-rot (BER): an abiotic devastating disorder of tomato. Climate Change and Environmental Sustainability 10(1): 15–22. https://doi.org/10.5958/2320-642x.2022.00002.3.

Supriatna, J., and I. D. Azzahra. 2021. Budidaya tanaman paprika (*Capsicum annuum* var. *Grossum*) secara hidroponik dengan sistem irigasi tetes di P4S tottal cantigi farm. Community Empowerment 6 (8): 1545–1556. https://doi.org/10.31603/ce.5214.