

Cultivar responses to daylength and stem descent in aeroponic seed potato

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Abstract: Extending daylength during vegetative growth may improve aeroponic potato (*Solanum tuberosum* L.) growth but yield responses may depend on cultivar and canopy disturbance. Two cultivars, cvs. Atlantic Malang and Chipita, were grown under a natural 12 h day or a 16 h day created by 4 h supplemental LED lighting until 6 weeks after planting (WAP), combined with no stem descent or stem descent at 2 or 4 WAP. A split-plot randomised complete block design with five blocks was used; daylength was the main-plot factor and six cultivar-stem descent combinations were subplots. Data were analysed by split-plot ANOVA followed by Tukey's test and principal component analysis. At 6 WAP, 16 h increased canopy, root, stolon, and early tuber growth. In cv. Atlantic Malang without stem descent, 16 h increased final tuber weight per plant by 55%. In cv. Chipita, 16 h combined with stem descent at 4 WAP reduced final tuber number and weight by 71% and 59%, respectively. Cv. Chipita without stem descent or with descent at 2 WAP produced the greatest plot-level yields. Thus, daylength extension should be matched to cultivar and stem-descent timing.

Keywords: minituber; crop architecture; soilless cultivation; source-sink; tropical highland

Reliable multiplication of healthy potato seed is essential for crop productivity, and aeroponic propagation is a promising option because roots and stolons develop in an oxygen-rich chamber supplied with recirculating nutrient mist, water and nutrient delivery can be controlled, and tubers can be harvested repeatedly without destroying the plant (Garzón et al. 2023, Rajendran

et al. 2024). In a three-year experiment, Čížek and Komárková (2022) reported 2.4–41.0 tubers/plant in aeroponic units, depending on cultivar and year, and confirmed the production advantage of successive harvesting. The absence of soil also reduces exposure to soil-borne constraints, which is particularly useful for early-generation seed production.

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Potato tubers develop from stolon tips, so practices that alter stolon initiation, extension, and the balance between canopy growth and tuber growth can change both tuber number and size (Zierer et al. 2021, Abeytilakathna 2022). A longer day during the vegetative phase may prolong shoot growth and support stolon development, whereas a return to the natural shorter day may favour tuberisation (Kondhare et al. 2021). Stem descent is a canopy-management practice adapted from hilling: lower leaves and lateral shoots are removed, and part of the stem is lowered into the aeroponic chamber so that additional nodes are positioned below the bed surface. In soil-grown potato, hilling can alter tuber-size distribution without necessarily increasing total yield (Van Dijk et al. 2021). In aeroponics, stem descent may also prevent stolons from emerging above the bed, where exposed tubers are unsuitable as seed.

The response to daylength is not uniform among potato cultivars and can change with developmental stage (Van Dam et al. 1996, Falcon et al. 2006, Ai et al. 2021, Southern et al. 2025). This issue is especially relevant in tropical highlands, where the natural day is close to 12 h throughout the year. A 16 h day created by supplemental lighting may increase early vegetative growth, but any benefit may depend on whether the canopy remains intact and on the cultivar's capacity to convert additional vegetative growth into tubers. Previous studies have examined photoperiod, cultivar, hilling, or aeroponic management separately; evidence on their combined effects across successive growth stages in a tropical aeroponic system remains limited.

This study evaluated two contrasting cultivars, cvs. Atlantic Malang and Chipita, under a natural 12 h day and a 16 h day during the vegetative phase, combined with no stem descent or stem descent at 2 or 4 weeks after planting (WAP). We hypothesised that extending the day to 16 h would increase canopy and stolon growth, but that its effect on tuber production would depend on cultivar and stem-descent timing: early descent would be less disruptive than descent at 4 WAP, whereas late descent would reduce yield because the canopy would have less time to recover before tuber bulking. The objective was to quantify these cultivar-specific responses before light termination, after light termination, and at final harvest.

MATERIAL AND METHODS

Experimental site and design. The experiment was conducted in a greenhouse aeroponic facility at

UPTD Balai Benih Kentang, Bandung Regency, West Java, Indonesia, at approximately 1 500 m a.s.l. The experiment was arranged as a split-plot randomised complete block design with five blocks. Daylength was assigned to the main plots: a natural-day control of approximately 12 h and an extended day of 16 h. The subplot factor comprised six cultivar-stem-descent combinations: cvs. Atlantic Malang (AM) or Chipita (CP), each with no stem descent (SD0), stem descent at 2 WAP (SD2), or stem descent at 4 WAP (SD4).

Each subplot contained 15 plants arranged in a 5 × 3 pattern at 20 cm × 20 cm spacing. Before treatments began, plants were assigned to specific sampling purposes so that selection was not based on plant vigour. One plant per subplot was destructively sampled at 6 WAP and one at 11 WAP. Three centrally located plants were designated for repeated per-plant harvest measurements, and the remaining 10 plants were used to calculate plot-level tuber number and weight.

Lighting and stem-descent treatments. The 12 h treatment received only natural daylight. In the 16 h treatment, commercial blue LED strips supplied 4 h of supplemental lighting from 18:00 to 22:00, extending the intended daily lighting period to 16 h. Supplemental lighting was applied from planting until 6 WAP, then discontinued so that both treatments received natural daylight during the tuber-bulking period. The controller could also activate the lamps during cloudy periods when measured illuminance was below 1 000 lux. LED strips were mounted approximately 50 cm above the aeroponic bed surface and directed downwards. A post-hoc engineering estimate based on the electrical power of the blue LED system, an estimated photon-flux conversion for blue LEDs, and the lamp-to-bed distance indicated a nominal photosynthetic photon flux density (PPFD) of approximately 360 $\mu\text{mol}/\text{m}^2/\text{s}$ at bed level.

To limit light spill, the 12 h and 16 h main plots were separated by thick, black, light-proof curtains installed vertically to a height of approximately 2 m. The curtain was positioned about 50 cm from the aeroponic bed, deployed only while the supplemental lamps were operating, and rolled up after the lamps were switched off. This arrangement isolated the control plots from the additional evening light.

For stem descent, leaves and lateral shoots were removed from the lowest stem nodes, and the stem was gently lowered into the aeroponic chamber until approximately 20 cm of the shoot remained above the bed surface. The procedure was performed at 2 or 4 WAP according to treatment; SD0 plants were

not lowered. The same procedure and target shoot height were used in both cultivars.

Aeroponic system and plant material. Aeroponic beds were lined with polystyrene and covered with silver-black plastic mulch; bed edges were insulated with bubble insulation. Each bed measured 1.0 m wide, 13.0 m long, and 0.6 m high. Fertilisation was supplied through the aeroponic nutrient solution. The nutrient solution was pumped from a 1 000 L reservoir through two 13 mm pipelines fitted with misting nozzles at 60 cm intervals and sprayed directly onto the plant roots. After contacting the roots, the nutrient solution returned to the reservoir by gravity and was recirculated in a closed system. Electrical conductivity was maintained at 1–2 mS/cm and pH at 6.0–7.0 according to crop stage. A nano-bubble generator operated for 30 min each morning (07:30–08:00) as described by Dianawati et al. (2026), and 3% hydrogen peroxide was added at 2 mL/L to sanitise the nutrient solution. The AB-mix nutrient programme followed the aeroponic seed-potato protocol reported by Dianawati et al. (2025).

Plantlets were acclimatised for 4 weeks and propagated to the third cutting generation in a sterile 1:1:1 (v/v/v) mixture of soil, sheep manure, and rice-husk charcoal. Shoot-tip cuttings from the mother plants were grown in trays for 10 days and transplanted when they were at least 15 cm tall and had healthy roots. Leaves were reduced to three or four apical leaves at transplanting. Plants were tied as required. Before transplantation into the aeroponic system, rooted cuttings were immersed for 10 min in a microbial consortium containing *Pseudomonas fluorescens* and *Bacillus subtilis*, as described by Dianawati et al. (2024). After transplanting, plants were regularly monitored for disease symptoms. Chemical control was not applied routinely but only when disease symptoms occurred.

Measurements and harvest. Destructive observations were made at 6 WAP, immediately before supplemental lighting was terminated, and at 11 WAP, five weeks after termination. At 6 WAP, measurements included plant height, chlorophyll index, leaf area, fresh weights of upper stover, leaves, lower stover, roots, stolons, and tubers, primary stolon length, and numbers of primary stolons, secondary stolons, and tubers. At 11 WAP, stem number, root length, and tuber numbers by weight class were added. The chlorophyll index was measured with a Konica Minolta SPAD-502 Plus meter (Tokyo, Jepang). Leaf area was determined from images captured with an OPPO A76 smartphone and analysed using ImageJ (Dongguan, China).

Primary stolons were defined as stolons emerging directly from stem nodes, and secondary stolons as branches arising from primary stolons. Stolon and root length were measured on the longest primary stolon or root of the sampled plant. Tubers were classified as large (> 10 g), medium (5–10 g), or small (< 5 g) following the aeroponic seed-potato grading scheme used by Dianawati et al. (2025).

Repeated tuber harvest began at 11 WAP and was conducted four times at 2-week intervals. For the three preassigned sample plants, tuber number and weight were recorded at each harvest and summed to obtain total tubers and total tuber weight per plant. Tuber number and weight from the remaining 10 plants were summed across harvests to obtain plot-level totals. Plants removed for the two destructive samplings and the three designated sample plants were not included in the plot-total denominator.

Statistical analysis. Data were analysed with a split-plot ANOVA in which block and the block × daylength term provided the main-plot error, and cultivar-stem descent combination and its interaction with daylength were tested at the subplot level. Residual normality and homogeneity of variance were examined. Variables that did not meet the assumptions were transformed before analysis; reported means are on the original measurement scale. When an effect was significant at $P < 0.05$, means were separated using Tukey's honestly sig-

Table 1. Tukey-adjusted means for the main effect of day length at 6 and 11 WAP

Variable	12 h	16 h
6 WAP		
Plant height (cm)	29.54 ^b	36.43 ^a
Upper stover weight (g)	24.46 ^b	33.98 ^a
Leaf weight (g)	10.15 ^b	15.19 ^a
Lower stover weight (g)	17.63 ^b	24.84 ^a
Stolon weight (g)	6.14 ^b	10.70 ^a
Root weight (g)	6.37 ^b	8.87 ^a
Total tuber weight (g)	0.05 ^b	4.95 ^a
Chlorophyll index (SPAD unit)	48.50 ^b	49.39 ^a
11 WAP		
Number of secondary stolons	9.26 ^b	11.13 ^a
Root weight (g)	8.51 ^a	6.59 ^b

Within each row, means followed by the same lowercase letter are not significantly different according to Tukey's test ($P < 0.05$). Means are reported on the original scale. WAP – weeks after planting

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nificant difference (*HSD*) test. Lowercase letters in the interaction table compare cultivar-stem descent combinations within a daylength treatment, whereas uppercase letters compare 12 h and 16 h within the same combination.

Principal component analysis (PCA) was additionally used as an exploratory multivariate analysis to summarise treatment patterns at 6 WAP, 11 WAP, and final harvest. Sampling adequacy was evaluated with the Kaiser-Meyer-Olkin statistic, which ranged from 0.70 to 0.79, and Bartlett's tests of sphericity were significant ($P < 0.05$). PCA was used only to visualise multivariate relationships; treatment inference remained based on the split-plot ANOVA and Tukey comparisons. All statistical analyses, Tukey comparisons, and PCA were performed in RStudio version 4.4.3 (Boston USA).

RESULTS AND DISCUSSION

Responses before supplemental lighting was terminated. At 6 WAP, the main effect of daylength showed broad stimulation under 16 h (Table 1). Across cultivar-stem descent combinations, 16 h increased plant height from 29.54 to 36.43 cm and increased upper-stover, leaf, lower-stover, stolon, root and tuber weights; early tuber weight increased from 0.05 to 4.95 g. The daylength × cultivar-stem descent interaction then showed that the magnitude of this response differed among combinations (Table 2). In AM-SD0 and AM-SD4, stolon length increased from 23.37 to 67.31 cm and from 16.81 to 64.94 cm, respectively. No tubers were recorded in any cv. Atlantic Malang combination under 12 h, whereas 1.72–5.90 tubers were present under 16 h;

Table 2. Tukey-adjusted means for the daylength × cultivar-stem descent interaction at 6 WAP, 11 WAP, and final harvest

Variable	Daylength	AM-SD0	AM-SD2	AM-SD4	CP-SD0	CP-SD2	CP-SD4
6 WAP							
Stolon length (cm)	12 h	23.37 ^{bB}	41.45 ^{ab}	16.81 ^{bB}	58.75 ^a	42.07 ^{ab}	33.12 ^{ab}
	16 h	67.31 ^{aA}	41.99 ^a	64.94 ^{aA}	46.32 ^a	55.95 ^a	57.14 ^a
Number of tubers	12 h	0.00 ^{aB}	0.00 ^{aB}	0.00 ^{aB}	0.64 ^a	0.00 ^{aB}	0.18 ^a
	16 h	5.90 ^{aA}	2.28 ^{abA}	1.72 ^{abA}	2.47 ^{ab}	2.84 ^{abA}	1.38 ^b
11 WAP							
Upper stover weight (g)	12 h	116.55 ^b	54.22 ^c	42.48 ^{cB}	258.74 ^{aA}	201.46 ^a	117.24 ^{bA}
	16 h	108.07 ^{ab}	72.10 ^b	77.15 ^{bA}	163.51 ^{aB}	157.81 ^a	72.10 ^{bB}
Stolon weight (g)	12 h	9.02 ^c	2.66 ^c	7.79 ^c	93.47 ^{ab}	98.05 ^{aA}	44.85 ^b
	16 h	20.03 ^b	13.15 ^b	15.32 ^b	61.36 ^a	58.30 ^{aB}	35.26 ^{ab}
Stolon length (cm)	12 h	79.60 ^a	62.50 ^a	40.00 ^{aB}	76.00 ^a	81.20 ^a	59.50 ^{aB}
	16 h	84.00 ^{ab}	70.25 ^b	91.00 ^{abA}	94.40 ^{ab}	93.75 ^{ab}	118.40 ^{aA}
Number of tubers	12 h	7.00 ^{bB}	6.25 ^b	6.60 ^b	24.20 ^{aA}	22.20 ^{aA}	17.25 ^{aA}
	16 h	12.40 ^{abcA}	7.00 ^c	10.20 ^{bc}	17.80 ^{aB}	17.00 ^{abB}	12.00 ^{abcB}
Tuber weight (g)	12 h	100.80 ^a	48.00 ^b	29.80 ^b	142.00 ^{aA}	116.80 ^{aA}	46.00 ^b
	16 h	84.00 ^a	57.50 ^{ab}	53.40 ^{ab}	87.20 ^{aB}	79.75 ^{aB}	21.60 ^b
Final harvest							
Total tubers per plant	12 h	19.24 ^{bcd}	10.02 ^d	14.66 ^{cd}	25.96 ^{ab}	33.07 ^a	20.26 ^{abcA}
	16 h	20.07 ^{ab}	14.02 ^b	11.56 ^{bc}	29.66 ^a	25.29 ^a	5.90 ^{cB}
Total tuber weight per plant (g)	12 h	168.84 ^{cB}	106.05 ^c	118.64 ^c	279.08 ^{ab}	331.78 ^a	171.32 ^{bcA}
	16 h	261.16 ^{aA}	146.24 ^b	95.93 ^{bc}	320.92 ^a	250.49 ^a	70.14 ^{cB}

Lowercase letters compare cultivar-stem descent combinations within the same daylength treatment; uppercase letters compare 12 h and 16 h within the same combination. Means sharing the same letter are not significantly different according to Tukey's test ($P < 0.05$). WAP – weeks after planting; AM – cv. Atlantic Malang; CP – cv. Chipita; SD0 – no stem descent; SD2 and SD4 – stem descent at 2 and 4 WAP

in cv. Chipita, CP-SD2 increased from 0.00 to 2.84 tubers. When averaged across daylength treatments, CP-SD0 and CP-SD2 had the greatest early canopy and below-ground biomass, whereas SD4 generally reduced biomass in both cultivars (Table 3), consistent with leaf and lateral-shoot removal only two weeks before sampling.

The broad early stimulation by 16 h agrees with the role of extended daylength in maintaining vegetative growth and stolon development (Van Dam et al. 1996, Kondhare et al. 2021). However, tuber initiation under 16 h shows that long days did not completely suppress tuberisation. Photoperiod acts together with developmental status, assimilate avail-

ability, temperature and mobile signals such as StSP6A (Zierer et al. 2021, Qin et al. 2026), and tubers have also formed under long photoperiods in controlled LED studies (Rahman et al. 2024). Because plant source and physiological age influence aeroponic production potential (Buckseth et al. 2024), the established cuttings used here may have been sufficiently advanced to initiate tubers despite the extended day.

Responses five weeks after supplemental lighting was terminated. At 11 WAP, the daylength main effect was limited to two traits (Table 1): the previous 16 h treatment increased secondary-stolon number from 9.26 to 11.13 but reduced root weight from 8.51 to 6.59 g. The daylength $\times$ cultivar-stem descent in-

Table 3. Tukey-adjusted means for cultivar-stem descent combinations averaged across daylength treatments at 6 WAP, 11 WAP, and final harvest

Variable	AM-SD0	AM-SD2	AM-SD4	CP-SD0	CP-SD2	CP-SD4
6 WAP						
Plant height (cm)	34.90 ^{bc}	28.87 ^{cd}	21.00 ^{de}	50.20 ^a	43.98 ^{ab}	18.97 ^e
Number of primary stolons	6.00 ^b	9.00 ^{ab}	6.10 ^b	8.10 ^{ab}	11.28 ^a	7.10 ^b
Upper stover weight (g)	39.48 ^{ab}	23.54 ^{bc}	13.79 ^c	64.27 ^a	46.96 ^a	14.37 ^c
Leaf weight (g)	19.46 ^{ab}	11.76 ^{bc}	7.12 ^{cd}	22.44 ^a	18.25 ^{ab}	5.15 ^d
Lower stover weight (g)	24.73 ^{ab}	14.40 ^c	15.49 ^{bc}	33.81 ^a	29.77 ^a	14.93 ^{bc}
Stolon weight (g)	6.14 ^{bc}	5.08 ^c	3.97 ^c	17.53 ^a	15.57 ^{ab}	5.71 ^{bc}
Root weight (g)	6.02 ^b	3.57 ^b	5.22 ^b	13.70 ^a	11.88 ^a	5.34 ^b
Total tuber weight (g)	2.80 ^{ab}	1.42 ^{ab}	0.44 ^b	3.22 ^a	0.97 ^{ab}	1.10 ^{ab}
Chlorophyll index (SPAD unit)	47.61 ^{bc}	46.02 ^c	46.98 ^{bc}	51.79 ^a	53.26 ^a	48.40 ^b
11 WAP						
Plant height (cm)	52.28 ^{bc}	40.43 ^c	39.64 ^c	93.86 ^a	91.84 ^a	67.25 ^b
Number of primary stolons	5.60 ^{ab}	6.50 ^{ab}	3.80 ^b	6.40 ^{ab}	7.65 ^a	5.67 ^{ab}
Number of secondary stolons	10.10 ^a	4.75 ^b	9.50 ^a	12.50 ^a	12.15 ^a	12.17 ^a
Upper stover weight (g)	72.53 ^b	44.53 ^b	44.03 ^b	129.68 ^a	143.94 ^a	74.60 ^b
Leaf weight (g)	41.00 ^{abc}	28.00 ^{bc}	26.30 ^c	43.90 ^{ab}	49.45 ^a	32.38 ^{bc}
Root weight (g)	4.94 ^b	4.17 ^b	3.08 ^b	15.00 ^a	14.56 ^a	11.03 ^a
Stolon length (cm)	100.70 ^c	87.38 ^c	110.70 ^{bc}	143.00 ^{ab}	120.75 ^{abc}	158.25 ^a
Number of large tubers	4.80 ^a	2.62 ^{abc}	1.10 ^{bc}	3.70 ^{ab}	2.12 ^{bc}	0.88 ^c
Number of medium tubers	0.88 ^b	2.33 ^b	2.96 ^b	7.40 ^a	8.91 ^a	0.70 ^b
Number of small tubers	2.76 ^{bc}	0.96 ^c	2.90 ^{bc}	9.10 ^a	7.36 ^{ab}	11.84 ^a
Chlorophyll index (SPAD unit)	43.97 ^b	42.93 ^b	43.50 ^b	48.63 ^a	50.24 ^a	50.89 ^a
Leaf area (cm ²)	2 456.73 ^{bc}	1 470.02 ^c	2 270.06 ^{bc}	3 747.95 ^{ab}	4 295.10 ^a	2 212.12 ^{bc}
Final harvest						
Total tubers per plot	68.42 ^b	73.40 ^b	51.52 ^b	240.12 ^a	272.57 ^a	184.61 ^a
Total tuber weight per plot (g)	962.54 ^b	733.48 ^{bc}	466.72 ^c	3003.27 ^a	3246.28 ^a	1165.82 ^b

Within each row, means followed by the same lowercase letter are not significantly different according to Tukey's test ($P < 0.05$). WAP – weeks after planting; AM – cv. Atlantic Malang; CP – cv. Chipita; SD0 – no stem descent; SD2 and SD4 – stem descent at 2 and 4 WAP

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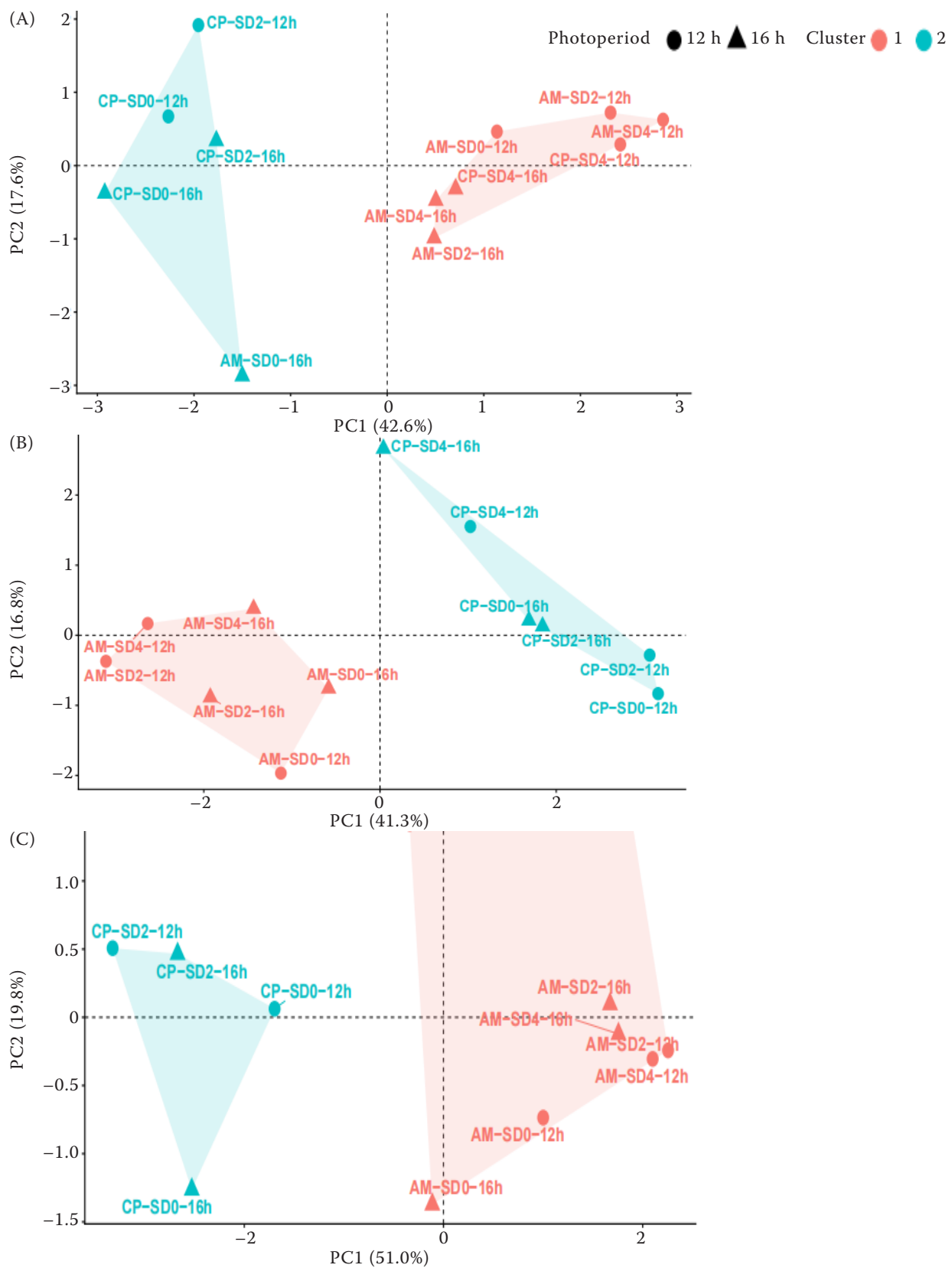


Figure 1. Principal component analysis (PCA) score plots at (A) 6 WAP; (B) 11 WAP, and (C) final harvest. Circles indicate 12 h and triangles indicate 16 h. WAP – weeks after planting; AM – cv. Atlantic Malang; CP – cv. Chipita; SD0 – no stem descent; SD2 and SD4 – stem descent at 2 and 4 WAP

teraction showed a much stronger cultivar-specific carry-over response (Table 2). AM-SD0 produced more tubers after 16 h than after 12 h (12.40 vs. 7.00), whereas all cv. Chipita combinations produced fewer tubers after 16 h: CP-SD0 declined from 24.20 to 17.80, CP-SD2 from 22.20 to 17.00, and CP-SD4 from 17.25 to 12.00. Tuber weight also declined in CP-SD0 (from 142.00 to 87.20 g) and CP-SD2 (from 116.80 to 79.75 g). Averaged across daylength treatments, CP-SD0 and CP-SD2 remained the most vigorous combinations, with plant heights above 91 cm and high canopy and root biomass (Table 3).

These contrasting responses indicate that the value of early supplemental lighting depended on cultivar development rather than on additional light alone. Photoperiod sensitivity and tuberisation thresholds vary with genotype and developmental phase (Van Dam et al. 1996, Falcon et al. 2006, Ai et al. 2021, Southern et al. 2025). In cv. Atlantic Malang, the larger early vegetative capacity under 16 h may subsequently have supported tuber production, whereas cv. Chipita already had a large canopy and high tuber number under 12 h and gained no comparable advantage from the extended day. The longer stolons observed in some SD4 treatments therefore did not translate into greater tuber production.

Final tuber production. At final harvest, the daylength × cultivar-stem descent interaction was agronomically clear (Table 2). In AM-SD0, 16 h increased total tuber weight per plant from 168.84 to 261.16 g or by 55% without changing final tuber number, indicating improved bulking rather than increased tuber set. In contrast, CP-SD4 under 16 h declined from 20.26 to 5.90 tubers per plant by 71% and from 171.32 to 70.14 g tuber weight by 59%. Final per-plant yield of CP-SD0 and CP-SD2 did not differ significantly between daylength treatments. Averaged across daylength treatments, CP-SD0 and CP-SD2 produced the highest plot-level tuber weights (3 003.27 g and 3 246.28 g) and tuber numbers, whereas CP-SD4 produced much lower tuber weight and all cv. Atlantic Malang combinations produced fewer tubers per plot (Table 3).

Stem descent at 2 WAP was therefore tolerated by cv. Chipita but did not improve yield relative to no descent, whereas descent at 4 WAP was consistently risky, especially after the extended day. Late removal of photosynthetic tissue can restrict carbon supply during canopy recovery (Hu et al. 2020, Louis and Neilson 2026), and hilling-type manipulations may alter stolon position or tuber-size distribu-

tion without increasing total yield (Van Dijk et al. 2021). The poor CP-SD4 response under 16 h is thus consistent with a mismatch between a large stolon system and insufficient recovered canopy, although this source-sink interpretation remains inferential because photosynthesis, sugars, starch and assimilate transport were not measured.

Multivariate response patterns. The first two principal components explained 59.6% of the total variation at 6 WAP (PC1 42.0%, PC2 17.6%), 58.1% at 11 WAP (PC1 41.3%, PC2 16.8%), and 70.8% at final harvest (PC1 51.0%, PC2 19.8%) (Figure 1). At 6 WAP, CP-SD0 and CP-SD2 treatments were positioned on the negative side of PC1, and AM-SD0 under 16 h shifted toward the same region, consistent with its strong early stolon and biomass response. At 11 WAP, the score pattern separated the two cultivars largely along PC1. At final harvest, the high-yielding CP-SD0 and CP-SD2 treatments were clearly separated from CP-SD4 and most cv. Atlantic Malang treatments. The PCA therefore supported the univariate results by showing that cultivar and stem-descent timing structured the overall multivariate response, while daylength modified selected treatment combinations.

Overall, the 16 h vegetative day accelerated early canopy, root, stolon and tuber growth, but its yield value depended on cultivar and canopy management. In cv. Atlantic Malang, supplemental lighting increased final tuber weight when stems were not descended, whereas cv. Chipita obtained no consistent final-yield advantage from the extended day. Stem descent was therefore not necessary as a general management practice; early stem descent was tolerated in cv. Chipita, whereas descent at 4 WAP was detrimental, particularly when combined with supplemental lighting. These results indicate that supplemental lighting and stem descent should be considered cultivar- and timing-specific management options rather than universally recommended practices in tropical aeroponic seed potato production. Future studies should evaluate a broader range of cultivars across seasons, directly assess photosynthesis and carbohydrate partitioning, and analyse the basic chemical composition and quality attributes of the harvested tubers.

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