

OPTIMIZATION OF VEGETATIVE GROWTH FOR ENHANCING THE YIELD OF SWEET POTATO (*IPOMOEA BATATAS* L.) – A STUDY OF TRAILING AND PRUNING IN THREE GENOTYPES

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Abstract

Sweet potato (*Ipomoea batatas* L.) is one of the reliable crops for the agriculture system in Sri Lanka. In a previous study carried out using eighteen different *I. batatas* accessions and improved varieties demonstrated that vegetative parameters did not effectively contribute to the per-plant yield. When the vegetative parts grow excessively, they can consume a larger share of resources, leaving less available to develop storage roots. By managing vegetative growth, such as through appropriate pruning, the allocation of resources can be optimized to enhance storage root development in *I. batatas*. When *I. batatas* vines are trailed, they are spread out, allowing more leaves to be exposed to sunlight. The main objective of the present study was to see the effect of pruning and trailing on yield of two improved *I. batatas* varieties, Ranwanbathala and Wariyapola-red, and one promising line TJ4. The experiment was carried out using pots (35 cm X 35 cm) filled with a potting mixture of topsoil, cow dung, and compost in a 1:1:1 ratio, weighing 10 kg, in a randomized complete block design with three replicates. In the pruning experiment, 25% of the total branch length was pruned on the 45th day after planting. In the trailing experiment, *I. batatas* branches were trailed using twine threads. The control experiment was carried out without pruning and trailing. Agronomic parameters, yield per plant, storage tuber characteristics, and yield per pot were evaluated at the end of the experiment. Data was analyzed using SPSS. All three genotypes produced significantly higher per pot yield in the trailing experiment (Ranwanbathala-577.58 kg/pot, TJ4-432.50 g/pot, Wariyapola-red- 365.19 g/pot), while pruned plants did not produce greater yield than in control plants. Compared to the control experiment, total vine length (753.86 cm), leaf area (52.74 cm²), vine diameter (4.44 mm), and storage root girth (14.40 cm) were significantly higher in trailed plants in Ranwanbathala, and these parameters would positively influence storage root yield in trailed plants. The most extended vine length, storage root girth, and number of tubers per pot in TJ4, as well as leaf area and number of tubers per pot in Wariyapola-red, were significantly different in treatments. These traits would positively affect the yield increment in trailing plants in these genotypes. Trailing is one of the effective techniques for yield increment in pot cultivation of *I. batatas* that can be implemented in the cultivation.

Keywords: *Ipomoea batatas*, Pruning, Trailing, Yield increment

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Introduction

Sweet potato (*Ipomoea batatas* L.) belongs to the family Convolvulaceae. *I. batatas* is cultivated in at least eight million hectares in 114 different countries in tropical and subtropical regions, producing 106.569 million tons with an average productivity of 13.147 tons per hectare (FAO Statistics, 2012). Asia leads in area of 60.75% and 86.89% production of *I. batatas* in worldwide (Nedunchezhiyan *et al.*, 2012). China is the main *I. batatas*-producing country (Leite *et al.*, 2020). *I. batatas* is a significant root crop that holds both economic and nutritional importance, particularly in economically disadvantaged areas of many developing nations (Otalora *et al.*, 2024). *I. batatas* are traditionally cultivated in the wet and intermediate zones in Sri Lanka. The present overall production of *I. batatas* was approximately 70,000 t/year, with a national yield of 10–12 t/ha (De Silva and Jayawardene, 1989). However, according to present data, the sweet potato yield has reached 15-25 t/ha (Department of Agriculture, n.d).

Even under low fertilizer conditions, *I. batatas* can produce some yield, and root crops, including *I. batatas* give per acre yield more than almost any other crop (Martin, 1998). Excessive vegetative growth, characterized by abundant leaves and stems, diverts a significant portion of photosynthates towards maintaining the above-ground parts (Blecharczyk *et al.*, 2023). Excessive shoot growth reduces

the assimilate distribution to the storage roots (An and Lindberg 2003; Safwa *et al.*, 2024). This reduces the sugars available for tuber bulking and ultimately decreases tuber yield (Eldlgamony *et al.*, 2022). Low levels of light due to excessive leaves minimise the amount of chlorophyll (Senevirathna *et al.*, 2003), leaf structural and physiological changes between high-light and low-light conditions (Baldi *et al.*, 2012; Hu *et al.*, 2011). Mutual shading inhibits storage root growth, reducing *I. batatas* yield (Iseki *et al.*, 2022). Trailing is a method to overcome the impact of mutual shading in crop growth.

Under favourable conditions, *I. batatas* exhibits vigorous growth and generates a greater number of vines (Nedunchezhiyan and Byju, 2012). However, when both vegetative and reproductive stages are in equilibrium results in a balanced assimilation of resources (Zhu and Jiang, 2014). Widaryanto and Saitama (2017) found that the Leaf Area Index (LAI) has a negative correlation with tuber production in sweet potatoes. Leaves differ greatly in structure and physiology under high- and low-light conditions (Baldi *et al.*, 2012; Hu *et al.*, 2011). Shading reduces photosynthetic capacity, endogenous hormones, and root yield in purple-fleshed *I. batatas* (Wang *et al.*, 2013). Consequently, photosynthesis for large amounts (proportion) of foliage proceeds under non-saturating light conditions (Dohleman and Long, 2009). Crop yield is significantly influenced by

the production of assimilates in the leaves (source) and their accumulation in the harvested organs (sink) (Jiang *et al.*, 2024). Growth analysis is widely used to examine factors affecting yield and plant development by evaluating net photosynthate accumulation over time (Li *et al.*, 2024).

The low productivity in tuber plant cultivation is mostly attributed to the plant's dominance of vegetative development (Saitama *et al.*, 2017). When the vegetative and reproductive stages are in balance, consumption and accumulation are also in balance, resulting in a balanced assimilation of resources that are both used and stored (Zhu and Jiang, 2014). There is a research gap in identifying a method to minimize the excessive vegetative growth of *I. batatas* to overcome the impact of excessive vegetative growth on storage root yield (Ranawake *et al.*, 2022).

Research indicates that using vine cuttings with leaves as planting material, with an optimal length of 25 to 30 cm, enhances the yield of *I. batatas* (Mkhatshwa *et al.*, 2021). Shoot pruning at 12 weeks after planting had a major impact on the production of tubers, particularly the amount and quality of *I. batatas* tubers. Plant growth is influenced by the timing of shoot pruning, particularly for the *I. batatas* harvest (Aniekwe, 2014). Shoot pruning during the early vegetative phase results in an increase in the number of vegetative organs, while pruning during the late

vegetative phase accelerates the production of generative organs that eventually be distributed to the tubers (Nedunchezhiyan *et al.*, 2012). Therefore, studies are required to establish the ideal pruning time and intensity of pruning of *I. batatas* (Saitama *et al.*, 2017).

Morphological modifications to regulate the balance between vegetative and storage root development stages ensure that assimilates produced by vegetative growth are controlled and efficiently transferred to the sink (Rahmiana *et al.*, 2015). Agronomic practices, including adjusting the plant canopy, effectively alter plant morphology (Esmailpour *et al.*, 2011). In the study of Soplanit, *et al.* (2021), the use of different staking angles in order to facilitate the sunlight interception of the lower leaves of the *I. batatas* vines has been tested. The results of this study show that using stakes of 60° had shown the most efficient in utilizing the solar energy, leading to a 34.15 t ha⁻¹ of tuber production. The apical and the middle portion of the vine are proven to be the best for obtaining higher tuber yield while accelerating shoot growth, leading to early canopy closure, which helps in reducing weeds (Eronico *et al.*, 1981); Villamayor and Perez (1988). Trailing would help maximizing light capturing in these parts of *I. batatas*. Therefore, our study aimed to evaluate the effect of trailing on the yield of *I. batatas*.

Varieties also play an important role in determining the high yield in *I. batatas* production (Nedunchezhiyan *et al.*, 2012). The vegetative growth and storage root weight must be optimized in *I. batatas* varieties based on their performances under pruning and staking. However, there is limited research on trailing practices of *I. batatas* to optimize the yield. The objectives of the present study were to evaluate the effect of trailing on the final storage root yield in three genotypes of *I. batatas*, to assess the impact of pruning 25% of vegetative branches on the final storage root yield of the same three genotypes of *I. batatas*, and to assess the growth parameters' effect on the storage root yield of *I. batatas* under trailing and pruning conditions. Three recommended varieties of *I. batatas* (Two improved *I. batatas* varieties; *Wariyapola Red*, *Ranwan Bathala*, and one selected line; *TJ4*, collected from Thelijjawila research station) were used for the study.

Materials and methods

Three *I. batatas* accessions were collected from the Thelijjawila research station in Sri Lanka. In 2024, the experiment was conducted using plastic pots at the Faculty of Agriculture, University of Ruhuna, Matara, Sri Lanka (6°01'04.5"N, 80°30'15.5"E).

Field establishment

Plastic pots measuring 35 cm in height and 35 cm in diameter were filled with a

potting mixture consisting of topsoil, cow dung, and compost in a 1:1:1 ratio, with a total weight of 10 kg. Cuttings of three *I. batatas* accessions, each with 03 nodes long, were planted. Four cuttings were planted in each plastic pot. Spacing was adjusted to 0.6m x 0.6 m. Cuttings were collected from the field-established germplasm collection at the research station, Thelijjawila.

Experimental Design and Treatments

The experiment was carried out using a Randomized Complete Block Design with three replicates. Each replicate consisted of ten plastic pots. There were two separate experiments for the trailing and pruning treatment.

For the pruning experiment, 25% of the vegetative parts of the treatment group were pruned on the 45th day after planting, and the control experiment was left without pruning. For the trailing experiment, all elongated branches in the experimental group were trailed using ropes, and the control experiment was carried out without trailing.

Field Management Practices

Irrigation was practiced daily during the first week. The plants were established with the onset of the northeast monsoon. Weed management was done manually. Fertilization was carried out in accordance with the recommendations provided by the Department of Agriculture in Sri Lanka

Table 1: Fertilizer recommendation by the Department of Agriculture (DOA), Sri Lanka for *I. batatas*.

Fertilizer application	Time	Urea (Kg/ha)	TSP (Kg/ha)	MOP (Kg/ha)
Basal dressing	2 WAP	60	120	120
Top dressing	6 WAP	60	—	60

WAP: Weeks after planting

Crop Maturity and Harvesting

Secretions from damaged parts of the vine indicate the maturity of *I. batatas*. Harvesting was done 3.5 months after planting. Mature *I. batatas* vines and tubers generally have higher levels of latex and other compounds that are more actively secreted when damaged. Further, the older leaves at the base of the plant start to turn yellow and die off as the tubers reach maturity.

Studied Parameters

Length (cm) and fresh weight of pruned branches (g/branch), Dry weight of pruned branches (g/plant), total vine length (cm), longest vine length (cm), 3rd internodal length (cm), vine diameter at the 3rd internode, number of branches per plant, number of leaf per plant, petiole length (cm), leaf area (cm²), fresh weight (g/plant), dry weight (g/plant), storage root length (cm), storage root diameter (cm), storage root girth (cm), root cortex thickness (mm), number of tuber per plant, number of tuber per pot, total yield per plant (g/plant), total yield per pot (g/plant). The experiment was conducted inside a protected house to minimize the pest problems (*Supplementary Figure 1*).

Data Collection and Data Analysis

All the quantitative data were collected according to the Descriptors for *I. batatas* (Huaman, 1991), developed by the International Potato Center (CIP), Asian Vegetable Research and Development Center (AVRDC), and International Board for Plant Genetic Resources (IBPGR). Data were analyzed using variance analysis using SPSS.

Results and Discussion

According to DMRT, trailing increased per pot yield in *Ranwanbathala*, *TJ4*, and *Wariyapola-red* (Tables 2, 3, and 4), and pruning was not effective in yield increment compared to control plants. Mutual shading can reduce storage root yield, especially during the later growth phase of *I. batatas*, when the plant biomass is established; The elongated and tangled vines can increase the mutual shading effect (Iseki and Matsumoto, 2022) under the control conditions. In the present study, trailing likely provided optimal conditions for photosynthesis and growth by allowing the vines to spread and maximize light capture, leading to the highest yield per plant. Previous studies of Soplanit et al. (2021) support the current study, as staking *I.*

batatas at 60° and 90° angles has increased the crop growth rate, energy conversion efficiency, and tuber yield. Altering the branches of *I. batatas* can overcome the lower reception of sunlight intensity and low duration of radiation by reducing mutual shading.

The yield in the studied *I. batatas* genotypes did not significantly differ at 25% pruning (Tables 2, 3, and 4). According to Netsai and Moses (2019). A 25% vine pruning level can significantly affect the tuber yield more than the 0% and 50% vine pruning levels, justifying 25% pruning as an optimum level of pruning to gain the maximum yield. According to them, a 50% pruning level results in the lowest storage root girth compared to the controls. Hence, the

exact pruning level and pruning time must be optimized in future studies.

Ranwanbathala

An ANOVA test was performed to determine the significant differences among treatments for the *Ranwanbathala* variety, followed by Duncan's Multiple Range Test (DMRT) for the mean separation. According to DMRT, significant differences were observed in the parameters of total vine length, vine diameter, the number of leaves per plant, leaf area, fresh weight, storage root diameter, storage root girth, and tuber yield per pot in *Ranwanbathala*. The per-pot yield (577.58 g) of *Ranwanbathala* was significantly higher in the trailing experiment compared to pruning (443.08 g) and control (397.67 g) plants (Table 2).

Table 2: Comparison of multiple parameters of the *Ranwanbathala* variety using Duncan's Multiple Range Test

Parameter	TVL	LVL	VIL	VD	NBPP	NLPP	PL	LA	FW
Control	1054.19 ^a	166.31 ^a	1.77 ^a	0.43 ^b	11.48 ^a	130.14 ^a	14.41 ^a	4474 ^b	273.29 ^{ab}
Pruning	1022.57 ^a	160.55 ^a	1.69 ^a	0.49 ^a	7.52 ^a	118.25 ^{ab}	14.42 ^a	3068 ^c	291.94 ^a
Trailing	753.86 ^b	219.32 ^a	1.61 ^a	0.47 ^{ab}	7.5 ^a	114.72 ^b	13.60 ^a	6053 ^a	223.92 ^b
Parameter	DW	SRL	SRD	SRG	RCT	NTPP	NTPPOT	TYPP	TYPPOT
Control	27.62 ^a	15.08 ^a	3.94 ^{ab}	13.38 ^b	2.76 ^a	2.01 ^a	3.33 ^a	240.43 ^a	397.67 ^b
Pruning	27.75 ^a	14.24 ^a	3.59 ^b	11.16 ^b	2.52 ^a	1.85 ^a	3.25 ^a	252.74 ^a	443.08 ^b
Trailing	28.89 ^a	15.72 ^a	4.44 ^a	14.40 ^a	2.68 ^a	1.81 ^a	3.33 ^a	313.98 ^a	577.58 ^a

TVL: total vine length, LVL: Longest vine length, VIL: Vine internodal length, VD: Vine diameter, NBPP: Number of branches per plant, NLPP: Number of leaves per plant, PL: Petiole length, LA: leaf area, FW: Fresh weight, DW: Dry weight, SRL: Storage root length, SRD: Storage root diameter, SRG: Storage root girth, RCT: Root cortex thickness, NTPP: Number of tuber per plant, NTPPOT: Number of tuber per pot, TYPP: Tuber yield per plant, TYPPOT: Tuber yield per pot

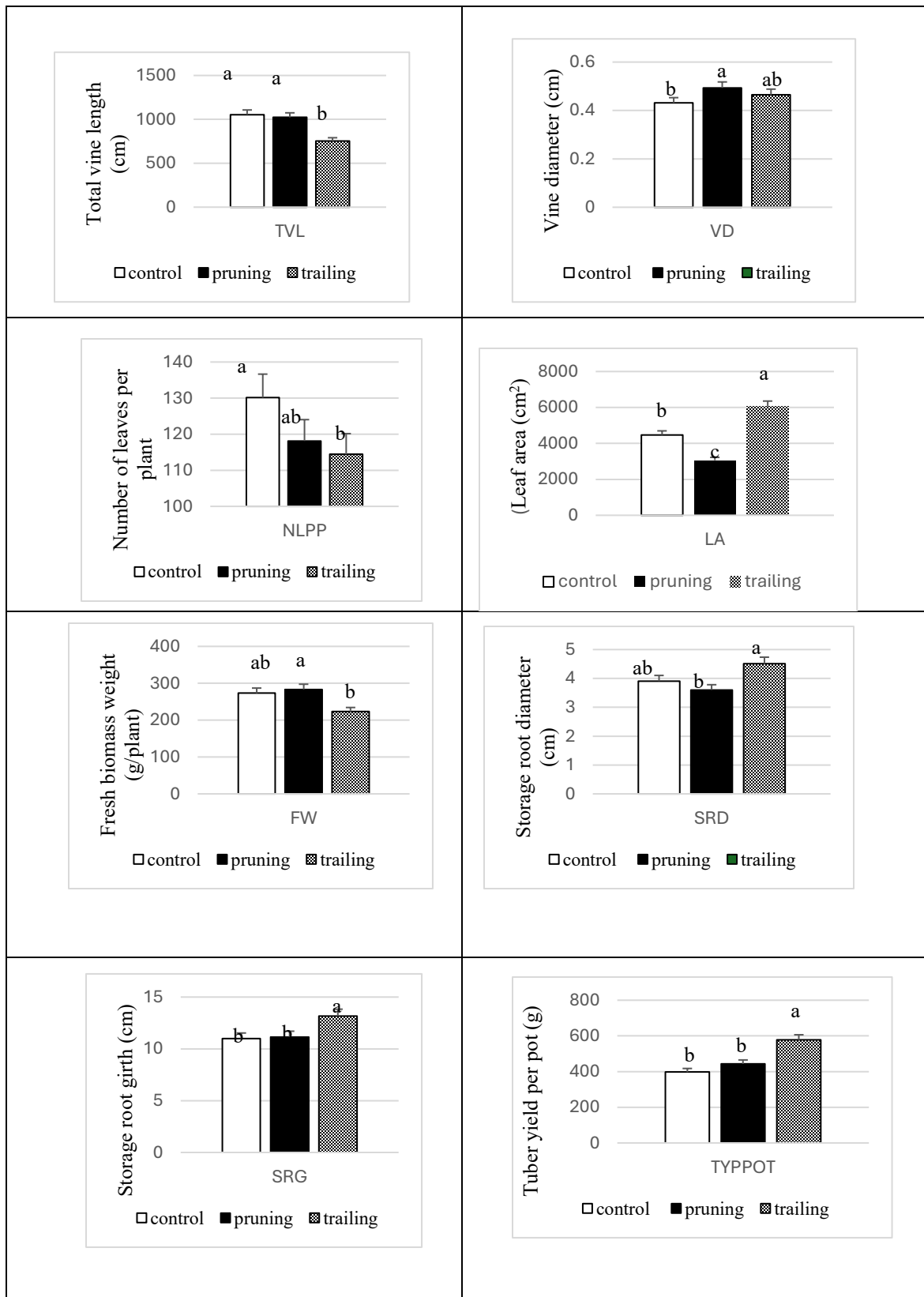


Figure 1. Parameters significantly different according to DMRT in the *Ranwanbathala* variety.

TVL: Total vine length, VD: Vine diameter, NLPP: Number of leaves per plant, LA: Leaf area, FW: Fresh biomass weight, SRD: Storage root diameter, SRG: Storage root girth, TYPPOT: Total yield per pot

However, per plant yield in *Ranwanbathala* did not exhibit significant differences among the treatments; this might be the competition between the two plants in one pot. Compared to *TJ4* and *Wariyapola-red*, per plant yield of *Ranwanbathala* was higher (Tables 2, 3, and 4). This might lead to competition for yield in individual plants in a pot. Leaf area (52.74 cm²), and storage root girth (14.40 cm) were significantly higher in trailed plants in *Ranwanbathala* variety. Total vine length (753.86) was significantly lower in trailed plants than in the control and pruned plants. These parameters would positively influence storage root yield in

the *TJ4* variety. Total vine length, vine diameter, number of leaves per plant, leaf area, fresh biomass weight, storage root diameter, storage root girth, and tuber yield per pot significantly differed in trailing, pruning, and control plants in different ways in *Ranwanbathala*, while other parameters remained unchanged (Figure 1).

TJ4

The trailing treatment in *TJ4* resulted in the highest total yield per plant and total yield per pot, while other parameters did not exhibit statistically different values (Table 3).

Table 3: Duncan's Multiple Range Test (DMRT) for different parameters for *TJ4* variety

Parameter	TVL	LVL	VIL	VD	NBPP	NLPP	PL	LA	FW
Control	1028.25 ^a	222.12 ^{ab}	1.58 ^a	0.55 ^a	11.25 ^a	142.97 ^a	16.30 ^a	6440 ^a	423.57 ^a
Pruning	981.18 ^a	147.80 ^b	1.40 ^a	0.47 ^a	13.69 ^a	141.59 ^a	18.44 ^a	6031 ^a	409.77 ^a
Trailing	968.77 ^a	228.23 ^a	1.56 ^a	0.47 ^a	10.95 ^a	140.28 ^a	14.87 ^a	6803 ^a	401.85 ^a
Parameter	DW	SRL	SRD	SRG	RCT	NTPP	NTPPOT	TYPP	TYPPOT
Control	51.59 ^a	11.47 ^a	3.34 ^a	10.74 ^{ab}	2.14 ^a	1.59 ^a	2.50 ^b	137.86 ^b	219.28 ^b
Pruning	43.20 ^a	12.95 ^a	3.01 ^a	9.74 ^b	2.28 ^a	1.71 ^a	3.00 ^{ab}	141.81 ^b	253.58 ^b
Trailing	53.53 ^a	13.08 ^a	3.76 ^a	11.99 ^a	2.10 ^a	1.82 ^a	3.50 ^a	228.19 ^a	432.50 ^a

TVL: total vine length, LVL: Longest vine length, VIL: Vine internodal length, VD: Vine diameter, NBPP: Number of branches per plant, NLPP: Number of leaves per plant, PL: Petiole length, LA: leaf area, FW: Fresh weight, DW: Dry weight, SRL: Storage root length, SRD: Storage root diameter, SRG: Storage root girth, RCT: Root cortex thickness, NTPP: Number of tuber per plant, NTPPOT: Number of tuber per pot, TYPP: Tuber yield per plant, TYPPOT: Tuber yield per pot

According to DMRT, significant differences were observed in the parameters of the longest vine length, storage root girth, number of tubers per pot, total yield per plant, and total yield per pot (Figure 2). These traits collectively determined the significant difference in the yield increment in trailed plants in *TJ4*.

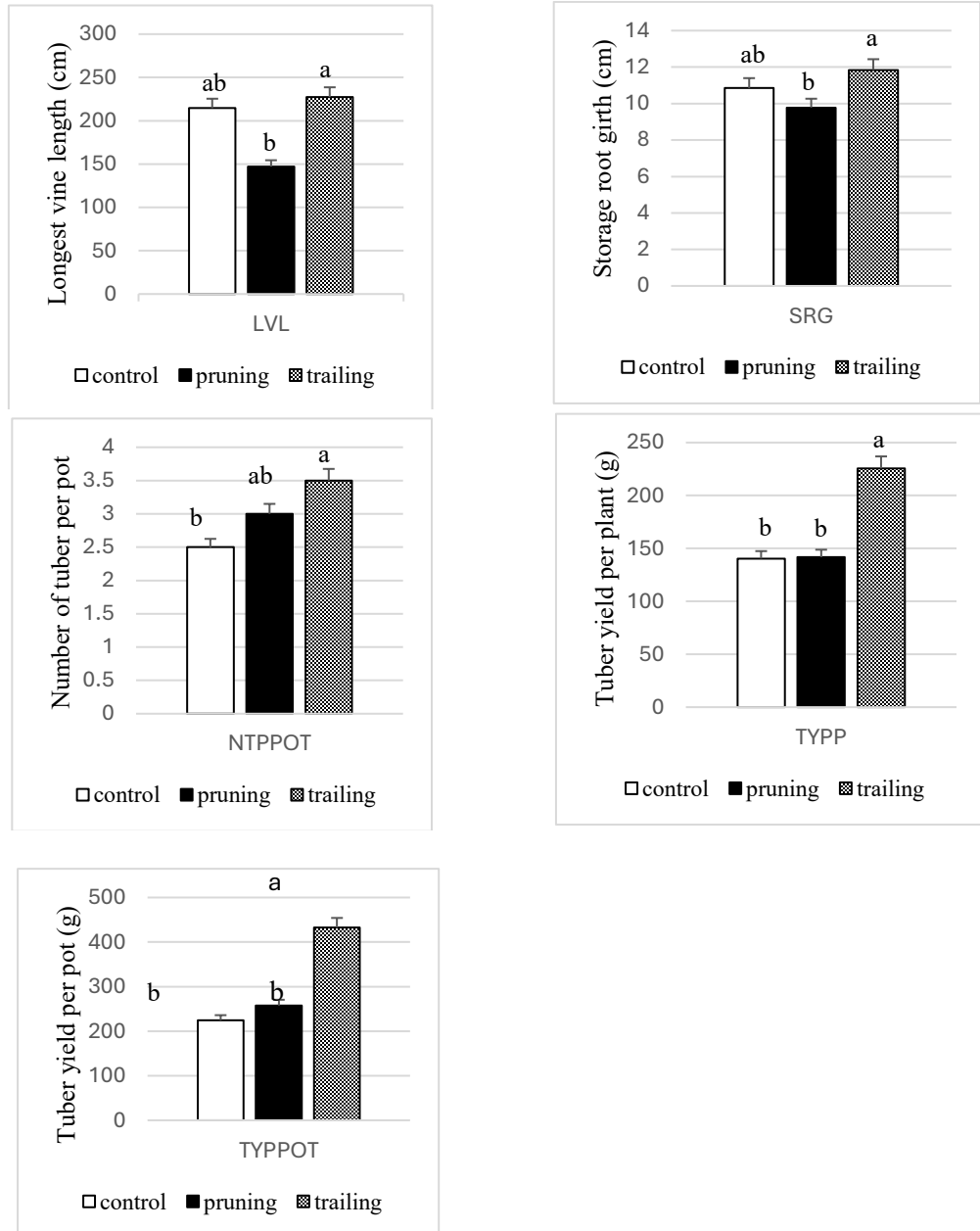


Figure 2. Parameters significantly different according to DMRT in *TJ4*

LVL: Longest vine length, SRG: Storage root girth, NTPPOT: Number of tubers per pot, TYPP: Total yield per plant, TYPPOT: Total yield per pot

Wariyapola-red

In the variety *Wariyapola-red*, the total yield per pot was significantly highest in the trailing treatment (Table 4). The trailing treatment allowed the plants to spread their vines, optimizing light capture and photosynthetic activity and contributing to the highest yields like *Ranwanbathala* and *TJ4* varieties. The leaf area was significantly highest in the

trailing treatment, compared to the control, and pruning. Maximum leaf area with minimum mutual shading would yield a higher trailing treatment yield in *Wariyapola-red*. In the control plants, the overall leaf area was reduced compared to the trailing treatment, but was still the same as the pruning treatment since pruning intensity, time, or both didn't create a significant difference.

Table 4: Duncan's Multiple Range Test (DMRT) for different parameters of *Wariyapola-red* variety

Parameter	TVL	LVL	VIL	VD	NBPP	NLPP	PL	LA	FW
Control	702.5 ₄ ^a	136.73 _a	2.13 _a	0.52 _a	8.97 _a	85.01 _a	19.07 _a	6100 _b	407.44 _a
Pruning	771.64 ^a	141.16 _a	1.83 _a	0.51 _a	11.35 _a	103.80 _a	18.80 _a	6031 _b	467.87 _a
Trailing	870.9 ₇ ^a	182.10 _a	1.85 _a	0.58 _a	11.02 _a	118.16 _a	18.21 _a	13290 _a	522.15 _a
Parameter	DW	SRL	SRD	SRG	RCT	NTPP	NTPPOT	TYPP	TYPPOT
Control	44.68 _a	13.58 _a	3.24 _a	10.56 _a	2.18 _a	1.17 _a	1.33 _b	108.14 _a	219.92 _b
Pruning	47.98 _a	12.07 _a	3.51 _a	11.38 _a	2.35 _a	1.22 _a	1.61 _{ab}	128.62 _a	245.03 _b
Trailing	52.11 _a	13.40 _a	4.07 _a	13.08 _a	2.34 _a	1.49 _a	1.92 _a	178.34 _a	365.19 _a

TVL: total vine length, LVL: Longest vine length, VIL: Vine internodal length, VD: Vine diameter, NBPP: Number of branches per plant, NLPP: Number of leaves per plant, PL: Petiole length, LA: leaf area, FW: Fresh weight, DW: Dry weight, SRL: Storage root length, SRD: Storage root diameter, SRG: Storage root girth, RCT: Root cortex thickness, NTPP: Number of tuber per plant, NTPPOT: Number of tuber per pot, TYPP: Tuber yield per plant, TYPPOT: Tuber yield per pot

In the mean separation, leaf area, number of tubers per pot, and total yield per pot showed significant differences among treatments (Figure 3). In *Wariyapola-red*,

these parameters would positively enhance the yield in trailed plants compared to control plants and pruned plants.

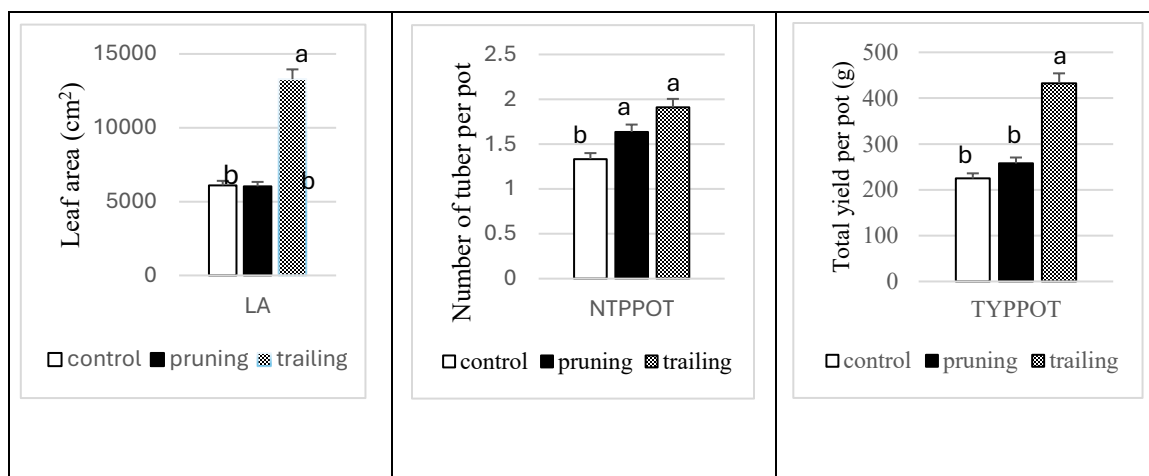


Figure 3. Parameters significantly different according to DMRT in the *Wariyapola-red* variety

LA: Leaf area, NTPPOT: Number of tubers per pot, TYPPOT: Total yield per pot

Conclusions

Trailing effectively increased per-pot yield for *Ranwanbathala*, *TJ4*, and *Wariyapola-red*. Pruning was not effective in terms of the applied pruning intensity and time. The effective pruning intensity and time must be experimentally tested in future. Trailing is an effective method to increase per-pot yield in pot cultivation of *I. batatas*, for tested genotypes. The trait contribution for yield increment in trailed plants was not the same across the three *I. batatas* genotypes. The same experiment must be tested under field conditions in future.

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Supplementary Figure 1: Different stages of the cultivation
Upper panel: Trailed plants, Middle panel: Pruned plants, Bottom panel: Field appearance