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Research Article

The Effect of the Taro Corm Type and Storage on Morphophysiological Deterioration and Early Growth in the Field

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Corm type correlates with corm size, which affects longevity and early growth in the field. Seed storage after harvesting is important to preserve viability and vigor. This study was conducted to determine the correlation between the corm type and storage period on corm deterioration, storage, vigor, and growth in the field. A factorial randomized complete block design (RCBD) with three replications was arranged, with the corm size (i.e., corm and cormels) and the storage period (i.e., 0, 2, 4, and 6 weeks). Corms undergo color changes faster than cormels do. The weight and diameter decreased by more than 10–30% after 4 weeks, while the length decreased by more than 10% after 6 weeks, and even the hardness decreased by 50% compared to that at 0 weeks. Corms were stored for 6 weeks, when the weight loss was lower than that of cormels. The corm sprouted after 2 weeks of storage. Corm resulted in a higher sprouting percentage than cormels. The corm type did not have a significant effect on growth vigor, but corm resulted in higher growth vigor than cormels after storage. The storage period leads to growth vigor loss. Weight, length, and diameter loss were positively correlated with sprouting and negatively correlated with hardness and growth vigor. This research recommends that the storage period of taro tubers before planting should be less than six weeks to optimize growth in the field.

1. Introduction

Taro is a tropical plant grown primarily for its edible corms, roots, and vegetables [1] and is widely cultivated in high rainfall areas under flooded conditions, usually by small farmers [2]. It is one of the oldest crops with important edible, medicinal, nutritional, and economic value [3]. The crop has been largely maintained by smallholder farmers, and the species' genetic resources have largely remained within local communities [4]. Taro contains approximately 35 g of total carbohydrates per 100 g of corm, which is twice that of potatoes [5]. It also contains 11% protein by dry weight and is rich in minerals, vitamin C, thiamine, riboflavin, and niacin [6]. This crop is important for supporting food security in the future.

The taro plant consists of a central corm lying just below the soil surface, with leaves growing from the apical bud at the top of the corm and roots growing from the lower portion, whereas cormels, daughter corms, and runners grow laterally [7]. The optimum productivity of taro can exceed 30 tons per hectare [8]. The productivity of green taro in year 1996 in Hawaii had reached 37 tons/ha and in Nigeria 21.9 tons/hectare [9]. The productivity of green taro in Indonesia only reached 9.52 tons/hectare in 2011 [10]. The productivity of crops, taro in particular, in farmers' fields depends on several factors, including the type of planting material, the size of planting material, and population density [5].

Traditionally, taro is propagated using corms, cormels, suckers, and tops (huli, a Hawaiian vernacular term used to describe plant parts) [5]. The use of tops and suckers is preferred because the growing season from planting to harvest is shorter than that for cormels, corms, or corm pieces (setts), although cultivars with many suckers produce smaller corms [10]. The use of different types of planting materials or propagules, such as stolon/suckers, corms, and cormels, results in a higher intraclonal variation in the growth rate although plants from stolons usually grow faster [11]. The larger cormel size consistently improves almost all morphological traits and yields components in taro plants [12].

The looming challenge for storing taro planting material after harvesting is their highly perishable characteristics. Postharvest losses in taro are caused mainly by mechanical damage during harvesting and physiological factors, such as respiration, transpiration, sprouting, and microbial attack [13]. Storing planting materials under poor conditions of high temperature and relative humidity or at high moisture content accelerates their deterioration and reduces their quality [14]. High temperature and low humidity in ambient storage resulted in maximum morphophysiological deteriorations, followed by evaporative cooled room and refrigerated conditions [13]. The morphological deterioration of taro corm is marked by changes in the color of the tuber flesh to brown (browning process), and fungal growth is accompanied by changes in the hardness and odor of the taro [15]. Deterioration during storage is caused by oxidative processes [16] and damage to protein enzymes [17], cell membrane lipids [18], RNA [19], and DNA [20], all of which reduce cell integrity and metabolism [21].

The storage conditions after procurement (harvesting or purchase) are essential for maintaining the quality of the planting material. Inadequate storage can lead to resource and economic losses when low-quality planting materials are used. This is expected to maintain the quality of the taro planting material for a certain period until they are ready to be planted. This study aimed to determine the effects of the taro corm type and storage on morphophysiological deterioration and early growth in the field.

2. Materials and Methods

2.1. Site and Experimental Design. The research was conducted at the Seed Science Laboratory, Leuwikopo Experimental Station, Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University, Indonesia, from May to August 2022. The research was arranged in a factorial randomized complete block design (RCBD) with three replications. The factors were the corm type, that is, corm and cormels, and the storage period, that is, 0, 2, 4, and 6 weeks.

2.2. Corm Deterioration and Sprouting Storage. One hundred corms and cormels were stored in a plastic box (60 cm × 42 cm × 37 cm) for 0, 2, 4, and 6 weeks and placed at ambient room temperature. The temperature and relative humidity in the plastic boxes were measured daily using a thermohygrometer. Corm deterioration, including color, length loss, weight loss, diameter loss, and hardness loss, was observed. Color was measured using an RHS Mini Color Chart. Weight loss was observed by weighing the corm and cormels. The length and diameter were measured using Vernier calipers. The hardness was observed using a rheometer (Sun Rheometer) that was arranged with mode 20, maximum load of 10 kg, stabbing depth of 10 mm, needle drop speed of 60 mm minutes^{-1}, and needle diameter of 5 mm.

2.3. Growth Vigor Evaluation. Corm and cormels were collected from the Collection Station, Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University. The corm and cormel sizes are listed in Table 1. The corm was planted in a plot (1 m × 10 m), planting distance (1 m × 1 m), and planting depth ± 5–8 cm. The pests and diseases were controlled by the application of carbofuran during planting and mankozeb. Growth vigor was observed at a week after planting (WAP).

2.4. Data Analysis. Data were analyzed by the *F* test using SAS on Demand for Academics (https://welcome.oda.sas.com/), followed by Duncan's multiple range test at a level of 0.05. Correlation analysis was performed by Pearson's correlation using the R software.

3. Results and Discussion

3.1. Color Degradation. Color change is a clear indicator of maturity [22]. Surface color is a visual indicator of quality that closely relates to taro corm [13, 14]. After harvesting, the corm color was light brown and changed to dark brown after 2–6 weeks of storage (Figure 1). Cormel color was grey brown until 2 weeks of storage and changed to dark brown after 4–6 weeks of storage. An increase in the respiration rate can cause weight loss. The increase in the respiration rate causes a reshuffle of compounds such as carbohydrates and produces CO_2, energy, and water that evaporates through the surface of the surface and causes weight loss [23]. A high respiration rate also accelerates ripening, which affects color and texture degradation during storage [24].

3.2. Corm Deterioration. Tuber damage during storage is an indicator of deterioration in taro tuber quality. Tuber damage can be indicated by weight loss, length and diameter reduction, and changes in corm hardness (Table 2). The corm type had a significant effect on weight loss and corm diameter, with corm showing a greater reduction in weight and diameter than cormels. The storage period was shown to significantly affect all observed tuber reduction variables. After 4 weeks of storage, the weight and diameter of the corm decreased by 10–30%, while the length of corm decreased by more than 10% after 6 weeks of storage (WAS). Corms can be kept up to 6 WAS with less weight loos about 17%, while cormels about more than 40%.

Table 1: The size of corm and cormels.

Corm types	Length (cm)	Diameter (cm)	Weight (g)
Corm	4.7–7.6; 6.0	2.4–3.7; 3.1	19.2–36.2; 27.4
Cormels	2.6–4.5; 3.5	2.4–3.4; 2.8	9.4–19.8; 14.4

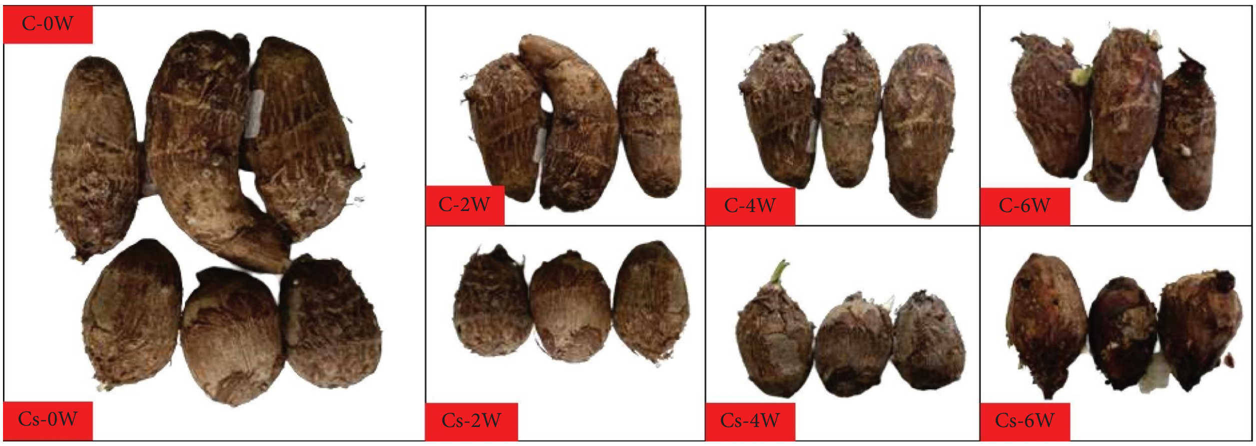

Figure 1: Color degradation and conditions of taro corm and cormels during storage. C-0W, corm-0 weeks after storage, light brown; C-2W, corm-2 weeks after storage, dark brown; C-4W, corm-4 weeks after storage, dark brown; C-6W, corm-6 weeks after storage, dark brown; Cs-0W, cormels-0 weeks after storage, grey brown; Cs-2W, cormels-2 weeks after storage, grey brown; Cs-4W, cormels-4 weeks after storage, dark brown; Cs-6W, cormels-6 weeks after storage, dark brown.

Table 2: The effect of corm types and the storage period on corm deterioration.

Corm types	Storage periods (weeks)				
	0	2	4	6	
Weight loss (%)					
Corm	0.0d	4.6d	11.1c	17.5c	13.8A
Cormels	0.0d	3.8d	10.9c	40.6a	8.3B
	20.8; 0.0D	4.2C	11.0B	29.0A	
Corm types			0.0011^{*}		
Storage period			$<0.0001^{*}$		
Corm type * storage period			$<0.0001^{*}$		
Coefficient variance			10.16%		
Length loss (%)					
Corm	0.0	4.4	7.7	12.7	6.2
Cormels	0.0	5.2	7.5	17.5	7.5
	4.8; 0.0D	4.8C	7.6B	14.9A	
Corm types			0.1544^{tn}		
Storage period			$<0.0001^{*}$		
Corm type * storage period			0.2319^{tn}		
Coefficient variance			4.90%		
Diameter loss (%)					
Corm	0.0	8.1	13.2	22.6	10.9A
Cormels	0.0	3.6	8.5	18.1	7.6B
	2.9; 0.0D	5.8C	10.8B	20.4A	
Corm types			0.0252^{*}		
Storage period			$<0.0001^{*}$		
Corm type * storage period			0.5776^{ns}		
Coefficient variance			3.87%		
Hardness (lbs)					
Corm	14.2	13.2	12.3	8.7	12.1
Cormels	14.7	13.5	13.0	5.4	11.6
	14.5A	13.4A	12.7A	7.0B	

Table 2: Continued.

Corm types	Storage periods (weeks)			
	0	2	4	6
Corm types			0.4440^{ns}	
Storage period			$<0.0001^{*}$	
Corm type ∗ storage period			0.0011^{ns}	
Coefficient variance			12.40%	

Note. Means followed by the same letters are not significantly different ($p < 0.05$) according to Duncan's multiple range test. * = significant; ns = not significant.

Table 3: The effect of corm types and the storage period on sprouting.

Corm sizes	Storage periods (weeks)				
	0	2	4	6	
			(%)		
Corm	0.0a	2.3cd	11.7a	11.7a	6.4a
Cormels	0.0a	0.7d	4.7bc	5.3b	2.7b
	0.0a	1.5a	8.2b	8.5b	
Corm types			$<0.0001^{*}$		
Storage period			$<0.0001^{*}$		
Corm type ∗ storage period			0.0018^{*}		
Coefficient variance			30.00%		

Note. Means followed by the same letters are not significantly different ($p < 0.05$) according to Duncan's multiple range test. * = significant; ns = not significant.

Table 4: The effect of corm types and the storage period on growth vigor.

Corm sizes	Storage periods (weeks)				
	0	2	4	6	
			(%)		
Corm	100.0a	73.3b	37.8cd	22.2d	58.3
Cormels	100.0a	48.9c	37.8cd	20.0d	51.7
	100.0a	61.1b	37.8c	21.1d	
Corm types			0.2042^{ns}		
Storage period			$<0.0001^{*}$		
Corm type ∗ storage period			0.2797^{ns}		
Coefficient variance			22.40%		

Note. Means followed by the same letters are not significantly different ($p < 0.05$) according to Duncan's multiple range test. * = significant; ns = not significant.

Table 5: The correlation of corm deterioration, sprouting, and germination of taro corm.

	Weight loss	Length loss	Diameter loss	Hardness	Sprouting	Germination
Weight loss	1.0000					
Length loss	0.9071	1.0000				
Diameter loss	0.7066	0.7855	1.0000			
Hardness	−0.8233	−0.8329	−0.7551	1.0000		
Sprouting	0.4059	0.5922	0.7728	−0.5260	1.0000	
Germination	−0.7017	−0.8396	−0.8307	0.7083	−0.7006	1.0000

3.3. Sprouting. Corm and cormels sprouted at 2 WAS, with corm sprouting at a greater rate throughout storage. Cormels sprouted less than 10% WAS, whereas corms sprouted by more than 10% (Table 3). The corm size has a significant effect on sprout elongation [25]. Larger corms result in more sprouting, whereas smaller corms lower the rate and amount of sprouting [26].

Tuber dormancy is an indispensable method for adjusting tubers to survive in their natural environments [27]. Fresh tubers are harvested, and tuber dormancy is required for shelf life. Long tuber dormancy is desirable for tuber storage [28]. This improves storage and makes it easier to transfer planting materials between locations. Farmers might exploit the "tuber dormancy" phase to fine tune their production in response to climatic, agronomic, or economic circumstances [29]. The effective suppression of sprouting is critical for controlling the quality of corm planting material during storage.

3.4. Growth Vigor. Tuber vigor when planted is affected not only by the storage period but also by size [25]. The vigor trend following storage differed among the cultivars. By carefully regulating storage conditions, a cultivar's growth vigor at a specific time can be maximized. Optimal storage conditions vary according to cultivar [30].

The type of corm had no significant effect on growth vigor in the field. The growth vigor of both types of corm before storage was 100%. The storage period had a significant effect on growth vigor, as indicated by the growth vigor, which continued to decrease with increasing storage period. Initially, both types of growth vigor were approximately 100%, and the storage period led to a decrease in the growth vigor (Table 4). Two weeks after storage, the corm still had a growth vigor of more than 70%, whereas the cormel growth vigor decreased by less than 50%. Furthermore, at 4 and 6 weeks after storage, both types had growth vigor of less than 40%.

4. Relation of Corm Deterioration and Early Growth

The degree of closeness of the relationship between the observed components can be determined using correlation analysis. Changes in other components in the same or opposite directions can be interpreted as a correlation between two components [31]. The decrease in corm dimensions (weight, length, and diameter) was positively correlated with sprouting and negatively correlated with hardness and growth vigor in the field (Table 5). Hardness was positively correlated with growth vigor and negatively correlated with sprouting, while sprouting was negatively correlated with growth vigor.

Sprouting causes an increase in corm weight loss and a decrease in corm quality and inhibits air movement through the corm pile [32]. The control of sprouting is essential for tuber storage because sprouting causes changes in weight, texture, nutritional value, softening, shrinkage, and the formation of toxic alkaloids [33]. Increased sprouting during storage reduces tuber growth in the field.

5. Conclusion

Corms can be stored for up to 6 WAP, with lower corm deterioration than cormels. Growth vigor continues to decrease with an increasing storage period. Corms showed higher growth vigor than cormels after storage. The decrease in corm dimensions (weight, length, and diameter) was positively correlated with sprouting and negatively correlated with hardness and growth vigor in the field. This research recommends that the storage period of taro tubers before planting should be less than six weeks to optimize growth in the field.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

Authors' Contributions

All authors had an equal contribution in this article.

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