Journal of Tropical Crop Science Vol. 11 No. 2, June 2024
www.j-tropical-crops.com

Received 15/01/2024; Revised 27/05/2024; Accepted 10/06/2024
https://doi.org/10.29244/jtcs.11.02.137-146

Quality and Production Potentials of Various Types of Taro Cormel

Rafi Fauzan[A], Eny Widajati[B]*, Endah Retno Palupi[B], Edi Santosa[B]

[A] Graduate School of Seed Science and Technology, IPB University, Bogor 16680, Indonesia
[B] Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University, Bogor 16680, Indonesia

*Corresponding author; email: eny_widajati@apps.ipb.ac.id

Abstract

Taro is a promising food crop that can be developed as a significant source of carbohydrates; however, a major obstacle is the unavailability of high-quality planting materials. Due to the difficulty in obtaining seeds, taro cultivation generally relies on vegetative propagation materials such as cormels, cormlets, and stolons. The advantage of using vegetative propagation material is that it retains the same characteristics as the parent plant. This research aimed to evaluate the quality of various types of cormels as taro planting material, study the potential of different types of cormels on the growth and production of taro plants, and investigate the growth, development, and time required to produce cormels from various types of cormels and their potential in cormel seed production. The research consisted of two experiments: the first experiment evaluated the quality of several types of cormels from two taro accessions (S24 and S28) using a completely randomized design with two factors (accession and types of cormels—primary, secondary, and tertiary), while the second experiment studied the growth and development of cormels from various types of cormels. The best quality seeds were obtained from primary cormels directly attached to the main tubers, with the germination rate highest for primary cormels at 53.25%, followed by secondary cormels at 51.59%, and tertiary cormels at 39.42%. Accession S24 showed a faster emergence rate (30.26 days) compared to S28 (58.08 days), and in S24, there was no significant difference between types of cormels for this parameter. In contrast, in S28, primary cormels had a significant emergence advantage (33.65 days) over secondary and tertiary cormels (62.57 and 78.02 days, respectively). Additionally, primary cormels were formed 8 weeks after planting, while secondary and tertiary cormels appeared 12 weeks after planting. These findings suggest that primary cormels should be prioritized for use in taro propagation to improve growth, development, and yield, highlighting their potential in cormel seed production and offering a viable solution to the challenge of seed availability in taro cultivation.

Keywords: bud emergence, germination rate, leaves emergence, vigor

Introduction

Taro (*Colocasia esculenta* L. Schott) is widely cultivated as a staple food in many countries due to its high carbohydrate content of around 24% (Laenggeng and Nurdin, 2018). It has a low glycemic index, making it suitable for diabetics (Sari et al., 2013). Additionally, taro contains beneficial compounds such as alkaloids, flavonoids, tannins, saponins, phenols, terpenoids, and steroids (Chakraborty et al., 2015), which contribute to its health benefits. The stems and leaves of the taro plant can also be used for animal feed.

Taro is categorized into two types based on tuber structure: *Colocasia esculenta* var. esculenta (dasheen taro), which has a single, medium to large tuber with no cormlets, and *Colocasia esculenta* var. Antiquorum (Eddoe taro), which has a medium-sized mother tuber with side-forming tiller tubers (Ladeska et al., 2021). In Indonesia, Eddoe taro cultivation is less popular but has significant economic potential, particularly for export to Japan, reaching USD 15,000 (Amelia et al., 2016).

The high demand for taro necessitates the production of sustainable, high-quality planting material. However, a major challenge is the low availability of planting material, especially for Eddoe taro (Maretta et al., 2016). This is partly due to taro's reproductive challenges, as female flowers become receptive 1-2 days before pollen release (Ivancic and Lebot, 2000). Additionally, taro often has sterile flowers, preventing seed formation (Ghani, 1984).

Using cormels as planting material is more effective and productive than other vegetative organs such

Received 15/01/2024; Revised 27/05/2024; Accepted 10/06/2024
https://doi.org/10.29244/jtcs.11.02.137-146

as cormlets and stolons, particularly in Eddoe taro, which produces many tubers (Zelin and Setyawan, 2019). Cormels vary in shape and weight, ranging from 95 g to 932 g, and can be conical, round, or oval (Setyowati et al., 2007). The weight and shape of cormels affect plant growth and production, with heavier cormels typically resulting in higher growth capacity (Singh et al., 2016).

Given the limited research on taro seed quality criteria, this study aims to evaluate the quality of various types of cormels as taro planting material, assess their potential on the growth and production of taro plants, and study the growth, development, and time required to produce cormels from different types of cormels, as well as their potential in cormel seed production.

Materials and Methods

The research consisted of two experiments. The first experiment was quality of several types of cormel from two accessions of taro as planting material, and the second experiment was growth and development of cormel from various types of cormel.

Experiment 1. Quality Evaluation of Several Types of Cormel as Planting Materials

Seed Source

This study used two taro accessions, S24 (Talas “Oshikawa”) and S28 (“Bentul”). The accessions were selected because they represent type-1 (S24), an imported taro with a light gray tuber color, and type-2 (S28), a local taro with a dark gray and black tuber color (Maretta, 2022). A clear difference between accession S24 and accession S28 is the color of the petiole. S24 (Talas “Oshikawa”) color of petiole is green whereas S28 (“Bentul”) is red.

Experimental Procedure

The research was conducted from May to September 2022 at Leuwikopo Experimental Farm of IPB, Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University.

The bed size is 10 m x 1 m x 20 cm. The planting distance is 70 cm x 70 cm, one cormel per planting hole. The cow manure 20 kg per bed was applied one week before planting. Each planting hole was given Furadan (carbofuradan 3%) as much as 5 mg. NPK fertilizer (N: P_2O_5: K_2O = 15:15:15) 12 g per plant was applied in two stages, namely at the time of seed planting and the second stage at 12 weeks after planting (Andani et al., 2018). Maintenance is weeding weeds and watering at intervals of three days (Maretta et al., 2020). Dursban insecticide is sprayed once in the third month (Azzahra et al., 2020). Harvesting was carried out at 16 weeks after planting (WAP).

Measurements were conducted on the growth capacity of cormels (16 weeks after planting), the percentage of fresh seeds, dead seeds by measuring all plants in the bed and the number of leaves (have petioles and leaves have opened completely). Measurements on seed vigor includes the day of the first bud emergence (minimum 2 cm shoots emerge on the surface of the soil), and the day of the first leaves emergence (leaves have opened completely), which are carried out every day until shoots and leaves are formed since the beginning of planting (Susiyani et al., 2014). Seed production observations included the number and weight of all primary, secondary and tertiary cormels produced at 16 weeks after sowing.

Experimental Design

The experiment was arranged using two-factor randomized complete block design. The first factor was two taro accessions consisting of S24 and S28, and the second factor was three types of cormels consisting of primary cormels (attached directly to the main tuber), secondary cormels (attached to primary cormels), tertiary cormels (attached to secondary cormels) (Figure 1 and 2). The experiment was repeated three times, so there were 18 experimental units.

Experiment 2. Growth and Development of Cormel from Different Seed Sources

Seed Source

This study used seed sources from primary, secondary, and tertiary cormel of taro accession S24.

Trial Design and Experimental Procedure

The research was conducted from January to May 2023 at Leuwikopo Experimental Farm of IPB, Department of Agronomy and Horticulture, Faculty of Agriculture, IPB University. The planting medium used was a mixture of sand and biochar 1:1. The experiment used a 50-liter planter bag for one cormel per bag. The manure was applied as much as 1 kg per planter bag and NPK fertilizer (15:15:15) were given in two stages, namely at the time of seed planting and the second stage at 12 WAP as much as 12 grams per planter bag (Andani et al., 2018).

Journal of Tropical Crop Science Vol. 11 No. 2, June 2024
www.j-tropical-crops.com
Received 15/01/2024; Revised 27/05/2024; Accepted 10/06/2024
https://doi.org/10.29244/jtcs.11.02.137-146

Figure 1. Types of cormels: primary cormel accession S24 (a), secondary cormel accession S24 (b), tertiary cormel accession S24 (c), primary cormel accession S28 (d), secondary cormel accession S28 (e), tertiary cormel accession S28 (f)

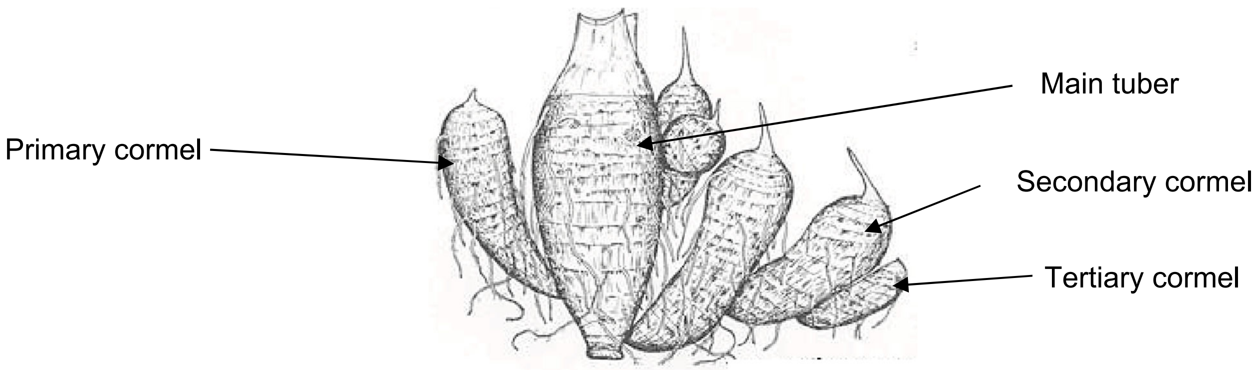

Figure 2. Tuber and cormel structure of taro var Antiquorum (Sukal, 2014)

Received 15/01/2024; Revised 27/05/2024; Accepted 10/06/2024
https://doi.org/10.29244/jtcs.11.02.137-146

The experiment was arranged using a completely randomized design with one factor namely cormel type consisting of 3 levels: primary cormel, secondary cormel, and tertiary cormel. The experiment was repeated five times, with each replicate consisting of 5 cormels. Growth measurements consisted of the development of the cormel at 4, 8, 12, and 16 WA includes diameter and the number of primary, secondary, and tertiary cormels.

Data Analysis

All data were analyzed using analysis of variance at the 95% confidence interval. If there was a significant effect on the treatments tested, further tests were carried out using the Duncan Multiple Range Test (DMRT). Data processing was done with SAS 9.0 and STAR (Statistical Tool for Agricultural Research) programs.

Results and Discussion

Experiment 1. Quality Evaluation of Several Types of Cormel as Planting Materials

Cormel Physical Quality

Planting material derived from primary and secondary cormels is significantly better in seed weight than tertiary cormels in accession S24 (Table 1). In contrast, in accession S28, secondary and tertiary cormels are significantly smaller than primary cormels. Meanwhile, in terms of cormel diameter, tertiary cormels are significantly smaller than primary and secondary cormels in both accessions, with accession S24 having a larger cormel diameter than S28 in all types of planting materials. Singh et al. (2016) stated that cormels with heavier weights have a better growth ability compared to lighter ones.

The differences in seed weight between accessions and cormel types are closely related to the process of assimilation filling and the duration of cormel formation (Duaja, 2012). Primary and secondary cormels form earlier than tertiary cormels, impacting the accumulation of food reserves, resulting in larger and heavier primary and secondary cormels. Physical observations show that the sizes of primary, secondary, and tertiary cormels of accession S24 are significantly larger than those of S28.

Cormel Growth Capacity

The growth capacity of cormels from both S24 and S28 accessions is similar, as illustrated by the percentage of growth capacity, which is not significantly different between the two accessions. However, tertiary cormels, which are the lowest in weight and size, have a significantly higher mortality rate (Table 2).

In the fresh seed percentage parameter, Accession S28 has a significantly higher percentage of fresh seeds than S24. The high level of fresh seeds shows that the cormel is still dormant. Ravi et al. (2009) The results of Ravi's research show that several Araceae families have dormancy properties 3-4 months after harvest (Ravi et al., 2009).

Primary, secondary, and tertiary cormels have a similar percentage of growth capacity and fresh seeds. However, the percentage of dead seeds of tertiary cormels is higher than that of primary and secondary cormels. This difference is due to different food reserves because primary and secondary seeds are larger than tertiary. The size of the cormel reflects the amount of accumulated food reserves. In bulbous plants, cormel size influences plant growth and development as well as plant production (Uke et al., 2015; Rahayu et al., 2018).

Table 1. Physical quality of cormel used as planting materials

Accession	Primary cormel	Secondary cormel	Tertiary cormel
		Cormel weight (g)	
S24	33.48 Ba	34.87 Aa	14.39 Ab
S28	41.53 Aa	11.90 Bb	16.41 Ab
		Cormel diameter (mm)	
S24	33.52 Aa	32.65 Aab	26.29 Ab
S28	28.36 Ba	26.69 Bab	25.55 Bb
		Cormel perimeter (cm)	
S24	11.11 Aa	10.92 Aa	8.88 Aa
S28	9.11 Ba	8.80 Ba	8.78 Ba

Notes: values followed by the same capital letter in the same column and numbers followed by the same lowercase letter in the same row are not significantly different according to the DMRT at α= 0.05.

Journal of Tropical Crop Science Vol. 11 No. 2, June 2024
www.j-tropical-crops.com
Received 15/01/2024; Revised 27/05/2024; Accepted 10/06/2024
https://doi.org/10.29244/jtcs.11.02.137-146

Table 2. Growth capacity of different taro accession and types of cormel.

Accession	Growth capacity (%)	Percentage of fresh seed (%)	Percentage of dead seeds (%)
S24	58.9	11.67 b	29.4 a
S28	52.2	31.11 a	16.7 b
Type of cormel			
Primary	65.0	14.2	20.8 b
Secondary	60.8	25.8	13.3 b
Tertiary	40.8	24.2	35.0 a

Notes: values followed by the same capital letter in the same column and numbers followed by the same lowercase letter in the same row are not significantly different according to the DMRT at α= 0.05. Data was *arcsin* transformed.

The two accessions had no significant difference in leaf number until the 16th week (Table 3). The research results of Hidayatullah et al. (2020) showed the same result, that the number of leaves on taro accessions S24 and S28 was not significantly different. At the beginning of growth (4th week) the number of leaves growing from the primary cormel was significantly higher. In subsequent developments (8th week to 16th week) the number of leaves increased, and the number did not differ between cormel types.

The number of leaves is significantly lower in tertiary cormels at the 4th week (Table 3) presumably due to slower leaf emergence in the tertiary cormel (Table 4).

Cormel Vigor

Accession S24, in all types of planting materials used, and primary planting materials in accession S28, have the same ability to emerge buds, ranging from 26 to 36 days after sowing (DAS). In accession S28, secondary and tertiary cormel showed a slower rate of bud emergence, ranging from 62 to 78 days. The same trend was observed in the rate of emergence of the first leaves (Table 4).

Hattu et al. (2018) suggested that earlier bud and leaf emergence significantly impact taro production, as it influences the photosynthesis process and the accumulation of food reserves in the tubers, ultimately

Table 3. The leaf number of various taro accessions and types of cormel.

Accession	Observation period (weeks)			
	4	8	12	16
S24	1.58	6.74	13.32	14.49
S28	1.74	7.59	10.39	12.25
Type of cormel				
Primary	2.00 a	7.20	12.43	13.12
Secondary	1.84 a	8.53	13.25	15.74
Tertiary	0.64 b	5.78	9.88	11.26

Notes: values followed by the same capital letter in the same column and numbers followed by the same lowercase letter in the same row are not significantly different according to the DMRT at α= 0.05.

Table 4. The bud and first leaf emergence of various taro accessions and types of cormel.

Accession	First bud emergence (days)		
	Cormel primer	Secondary cormel	Tertiary cormel
S24	28.48 Aa	26.21 Ba	36.10 Ba
S28	33.65 Ab	62.58 Aa	78.02 Aa
Accession	First leaf emergence (days)		
	Cormel primer	Secondary cormel	Tertiary cormel
S24	35.51 Aa	34.86 Ba	41.54 Ba
S28	40.29 Ab	66.13 Aa	83.88 Aa

Notes: values followed by the same capital letter in the same column and numbers followed by the same lowercase letter in the same row are not significantly different according to the DMRT at α= 0.05.

Received 15/01/2024; Revised 27/05/2024; Accepted 10/06/2024
https://doi.org/10.29244/jtcs.11.02.137-146

affecting total production.

The variations in growth rates observed among different types of cormels, particularly in accession S28, can be attributed to differences in weight between primary, secondary, and tertiary cormels (Table 1). Larger cormel weights have the capacity to store more nutrients during growth and development (de Chavez et al., 2019). Arifin et al. (2014) noted that larger corm weights (55-70 g) tend to yield greater production compared to smaller corm weights (15-30 g), although they do not significantly differ from corm weights with medium weights (35-50 g).

Regarding cormel production, the number of cormels produced at 16 weeks after planting (WAP) by accession S24 using primary, secondary, and tertiary cormel planting materials did not significantly differ (Table 5). The three types of planting materials exhibited similar outcomes to the primary cormel planting material in accession S28. However, a notable difference was observed in the primary cormel type in accession S28 compared to the number of seeds produced by secondary and tertiary cormels.
According to Wulandari (2012), the weight of large tubers has a direct impact on the number of plant tubers produced, a notion consistent with the findings regarding the average measurements of cormel types in accession S28. Here, the primary cormel exhibited a significantly higher average weight of 41.53 g compared to the secondary cormel (11.90 g) and the tertiary cormel (6.41 g, Table 1).

Both the accession treatment and the type of planting material significantly influenced the number of primary and secondary cormels produced by taro plants. Accession S24 yielded significantly more primary and secondary cormels compared to accession S28 (Table 6). Additionally, primary cormels emerged as the optimal planting material for producing primary and secondary seeds. However, the number of primary seeds was similar between primary and secondary planting materials. Conversely, seeds derived from tertiary planting material yielded the lowest number of primary and secondary seeds, though the outcome was comparable to the number of seeds produced by secondary seeds from planting materials.

The tertiary corm from accessions S24 and S28 did not differ significantly between accessions and the type of cormel used as seed. This could be due to the low seed weight in tertiary cormels, as also reported by Arifin et al. (2014).

Cormel Weight

The results presented in Table 8 indicate that the total cormel production in accessions S24 and S28 at 16 weeks after planting did not show significant differences. This trend was consistent across treatments involving similar primary, secondary, and tertiary cormel planting materials. These findings align with the research conducted by Arifin et al. (2014), which suggests that both large and medium-sized tubers exhibit similar yield potential.

Table 5. Number of cormel produced from different types of planting material.

Accession	Type of planting material		
	Primary cormel	Secondary cormel	Tertiary cormel
S24	29.17 Aa	26.37 Aa	21.16 Aa
S28	31.49 Aa	10.79 Bb	6.20 Bb

Notes: values followed by the same capital letter in the same column and numbers followed by the same lowercase letter in the same row are not significantly different according to the DMRT at α= 0.05.

Table 6. Average number of primary, secondary, and tertiary cormels produced from different sources of planting material.

Accession	Seed production (number of cormel)		
	Primary cormel	Secondary cormel	Tertiary cormel
S24	29.57 a	37.11 a	8.44
S28	16.30 b	25.70 b	6.49
Planting material			
Primary	17.83 a	33.58 a	6.96
Secondary	16.28 ab	17.06 b	4.36
Tertiary	11.77 b	12.16 b	3.60

Notes: values followed by the same capital letter in the same column and numbers followed by the same lowercase letter in the same row are not significantly different according to the DMRT at α= 0.05.

Received 15/01/2024; Revised 27/05/2024; Accepted 10/06/2024
https://doi.org/10.29244/jtcs.11.02.137-146

Moreover, Table 7 reveals that accession S24 significantly outperformed accession S28 in primary cormel production. Interestingly, there were no discernible differences in the weight of seed yields derived from primary, secondary, or tertiary cormel planting materials. This observation corresponds with the findings of Maretta's research (2022), which indicates that the harvest weight of accession S24 exceeds that of accession S28. Additionally, there were no significant variations in secondary cormel production between accession treatments and the type of cormel used as planting material. According to Duaja (2012), seed production is contingent upon the duration of filling in the tuber, a factor intricately linked to the growth rate and weight of the harvested tuber. The absence of significant differences between the accession treatment and the treatment of the type of cormel used in the overall harvest weight is in line with Husen et al. (2018), which stated that the nutrients in large, medium, and small corm seeds are sufficient so that they can be used as planting material. There was no significant difference between the accessions and planting materials used in tertiary cormel production.

Table 7. Cormel production 16 weeks after planting.

Accession	Total cormel production (g)	Primary cormel production (g)	Secondary cormel production (g)	Tertiary cormel production (g)
S24	885.81	506.22 a	273.12	59.94
S28	635.38	276.11 b	196.21	44.44
Planting material				
Primary	603.05	297.70	188.17	47.35
Secondary	511.96	286.20	164.42	30.71
Tertiary	406.17	198.43	116.74	26.32

Notes: values followed by the same lowercase letter in the same column are not significantly different according to the DMRT at α= 0.05.

Experiment 2. Cormel Growth and Development

Main Tuber Development

Throughout the growth process, the main tuber experiences development concurrent with the formation of cormels on its surface (Figure 2). Primary cormels utilized as seeds exhibit significantly larger sizes compared to secondary and tertiary cormels, with secondary cormels also being notably larger than tertiary ones. This disparity arises from variations in the assimilate accumulation during cormel formation (Duaja, 2012). Four weeks after planting, there was a reduction in tuber diameter across all cormel treatments. This phenomenon was attributed to the utilization of assimilates, which serve as food reserves for bulb growth, to support root and shoot development. The shrinkage persisted until eight weeks after planting, likely due to the initial adjustment period for plants observed four weeks after planting, necessitating adaptation to the provided treatment.

At 8th WAP, it was observed that the secondary cormel was notably larger than the primary cormel, although not significantly different from the tertiary cormel, while the tertiary cormel did not significantly differ from the primary cormel. Changes in the diameter of primary cormels are anticipated due to their substantial weight and high-water content, resulting in increased susceptibility to shrinkage and damage (Wawo, 2011). The consistent diameter and perimeter values of the secondary cormel indicate its resilience to the applied dismantling treatment, resulting in the largest value at 16 weeks after planting, albeit not significantly different from the primary and tertiary cormels.

Cormel Formation

Observations regarding the number of cormels formed indicate that four weeks after planting, no cormels had developed regardless of the type of cormel. This phenomenon is likely attributed to the initial shrinkage of the cormel size upon planting, suggesting that the plants require an initial adaptation period. Cormel formation data are presented in Table 8.

The formation of new cormels at 8 WAP indicated that planting material derived from secondary cormel types yielded more total cormels compared to primary and tertiary cormels, even though statistically the differences were not significant. Secondary and tertiary cormels were observed to form 12 weeks after planting, suggesting a delayed physiological response in the plants.

Further examination of secondary cormel formation demonstrated that tertiary cormel planting material resulted in a higher number of secondary cormels compared to primary and secondary planting materials at both 12 and 16 weeks after planting, although

Journal of Tropical Crop Science Vol. 11 No. 2, June 2024
www.j-tropical-crops.com

Received 15/01/2024; Revised 27/05/2024; Accepted 10/06/2024
https://doi.org/10.29244/jtcs.11.02.137-146

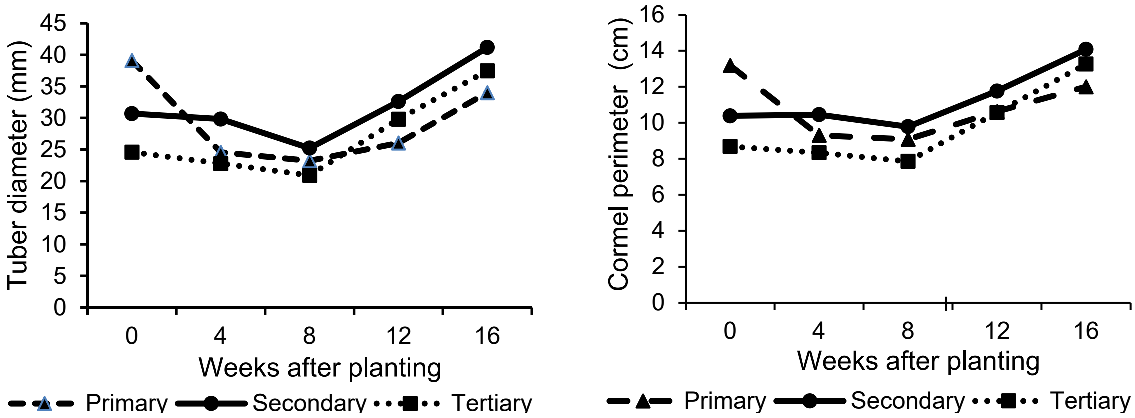

Figure 3. Tuber diameter and cormel perimeter during 16 weeks after planting; * = significantly different according to the DMRT at α= 0.05.

Table 8. The average number of cormel at 8, 12 and 16 weeks after planting.

	Planting materials			
Cormel types	Primary	Secondary	Tertiary	
8 WAP				
Primary	2.73	4.97	3.68	
Secondary	0	0	0	
Tertiary	0	0	0	
Total	2.73	4.97	3.68	ns
12 WAP				
Primary	5.32	7.13	6.24	
Secondary	1.69	1.80	1.92	
Tertiary	0.37	0.79	0.80	
Total	7.38	9.72	8.96	ns
16 WAP				
Primary	6.67	8.93	7.44	
Secondary	1.98	2.62	2.71	
Tertiary	0.84	1.76	1.01	
Total	9.49	13.31	11.16	ns

Notes: ns = values on the same row show no significant differences according to DMRT at α=0.05.

not significantly different. This trend is attributed to the maximum filling in tertiary cormels. Moreover, the number of tertiary cormels formed at 12 and 16 weeks did not significantly differ based on the type of cormels, indicating a consistent process of cormel formation regardless of the initial cormel type. This finding is consistent with Onwueme's (1999) study, which suggests that cormels typically begin forming well in the third month after planting.

Conclusions

Primary, secondary, and tertiary cormels can be utilized as planting material for the S24 accession, as evidenced by variables such as bud and leaf emergence and cormel production. However, for the S28 accession, the use of primary cormel as planting materials yielded superior results compared to secondary and tertiary cormels. While the effect of different accessions and cormel types was similar in terms of growth capacity and cormel production weight, tertiary cormels exhibited higher percentages of dead seeds. Therefore, tertiary cormels, particularly from the S28 accession, are not recommended for use as planting material. Cormel formation typically begins around the 8^{th} week after planting for all types of planting materials, followed by the formation of secondary and tertiary cormels 12^{th} week after planting.

Received 15/01/2024; Revised 27/05/2024; Accepted 10/06/2024
https://doi.org/10.29244/jtcs.11.02.137-146

References

Amelia, D.D., and Yumiati, Y. (2016). Analysis of Satoimo taro (*Colocasia esculenta* var. Antiqourum) farming (a case study in Suka Sari Village, Kabawetan District, Kepahiang Regency). *Agricultural Science and Technology Journal* **3**, 188-198

Andani, S.P., Ginting, J., and Hasanah, Y. (2018). Growth response of taro (*Colocasia esculenta* L.) seedlings to various compositions of planting media and doses of NPK fertilizer. *Agroecotechnology Online Journal* **6**, 845-853.

Arifin, M.S., Nugroho, A., and Suryanto, A. (2014)." Study of Shoot Length and Seedling Tuber Weight on the Production of Potato (*Solanum tuberosum* L.) Granola Variety". Faculty of Agriculture, Brawijaya University.

Azzahra, H., Lubis, Y. D. M., Hartanti, S.D., and Purnaningsih, N. (2020). Taro (*Colocasia esculenta* Scho) cultivation techniques as an effort to increase taro production in Situgede Village. *Center for Community Innovation Journal (PIM)* **2**, 412-416.

Chakraborty, P., Deb, P., Chakraborty, S., Chatterjee, B., and Abraham, J. (2015). Cytotoxicity and antimicrobial activity of *Colocasia esculenta*. *Journal of Chemical and Pharmaceutical Research* **7**, 627-635.

De Chavez, H. D., Villavicencio, E. B., Villancio, V. T., Garcia, J. N. M., Bulatao, M. J. G., Villavicencio, M. L. H., and Bondad, J. J. B. (2019). Propagation techniques for rapid establishment and production of cocoyam (*Xanthosoma sagittifolium* L. Schott). *Journal of International Society of Southeast Asian Agriculture* **25**, 83-94.

Duaja, M. D., (2012). Growth analysis of potato (*Solanum tuberossum* L.) tubers in the lowlands. *Bioplantae* **1**, 88-97s

Ghani, F. D. (1984). Preliminary studies on flowering in taro cultivars in Malaysia *In* "Edible Aroids" (S. Chandra, ed.). Malaysia.

Hattu, W., Parera, D. F., and Raharjo, S. H. (2018). Use of adenine sulfate in micropropagation of Japanese taro. *Agrologia* **7**, 59-70.

Hidayatullah, C. S. R., Santosa, E., and Sopandie, D. (2020). Response of taro genotypes *Colocasia esculenta* Esculenta and Antiquorum to different water application intervals. *Indonesian Journal of Agronomy* **48**, 249-257. DOI: https://dx.doi.org/10.24831/jai.v48i3.33136

Husen, S., Ruhiyat, M., Siskawardani, D. D., and Ela, D. (2018). Differences in tuber size and media on growth and yield of potato mini tuber seeds. *Conference on Innovation and Application of Science and Technology (CIASTECH)* **1**, 419-426.

Ivancic, A., and Lebot, V. (2000). "The Genetics and Breeding of Taro". Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement (CIRAD).

Ladeska, V., Am, R. A., and Hanani, E., (2021). *Colocasia esculanta* L (taro): pharmacognosy, phytochemical and pharmacological activity studies. *Science and Health Journal* **3**, 351-358. DOI: 10.22271/phyto.2020.v9.i4s.11937

Laenggeng, A. H., and Nurdin, M. (2018). Carbohydrate content in taro tubers (*Colocasia esculenta*) in Ombo Village, Sirenja District, and their application as a learning medium. *Biology Science and Education Journal* **6**, 207-211.

Maretta, D., Handayani, D.P., Rosdayanti, H., and Tanjung A. (2016). Shoot multiplication and induction of satoimo (*Colocasia esculenta* (L.) Schott) micro tubers at several concentrations of sucrose and benzylaminopurine. *Indonesia Biotechnology and Biosciences Journal* **3**, 81-88.

Maretta, D., Sobir, S., Helianti, I., Purwono, P., and Santosa, E. (2020). Genetic diversity in Eddoe taro (*Colocasia esculenta* Antiquorum) from Indonesia based on morphological and nutritional characteristics. *Journal of Biological Diversity* **21**, 3525-3533.

Maretta D. 2022. "Conservation Studies and Diversity Analysis Based on Morphology, Metabolites and Molecular of Taro Plants". Faculty of Agriculture, IPB University.

Onwueme, I. 1999. Taro cultivation in Asia and the Pacific. *RAP Publication* **16**, 1-9.

Ravi, V., Ravindran, C. S., Suja, G. 2009. Growth and productivity of elephant foot yam (*Amorphophallus paeoniifolius* Dennst.

Received 15/01/2024; Revised 27/05/2024; Accepted 10/06/2024
https://doi.org/10.29244/jtcs.11.02.137-146

Nicolson): an overview. *Root Crops Journal* **35**, 131-142.

Rahayu, D., Marveldani, F. N. U., and Andini, S. N. (2018). The use of three tuber sizes and growth regulator (atonic) in night sedge (*Polianthes tuberosa* L.). *Journal of Applied Agricultural Sciences* **2**, 163-170.

Sari, I. P., Lukitaningsih, E., Rumiyati, Setiawan, I. M. (2013). Glycemic index of uwi gadung and taro given to rats. *Traditional Medicine Magazine* **18**, 127-131.

Setyowati, M., Hanarida, I., and Sutoro. (2007). Characteristics of taro (*Colocasia esculenta*) germplasm tubers. *Germplasm* **13**, 49-55

Singh, H., Khurana, D. S., Nedunchezhiyan, M., and Mukherjee, A. (2016). Effect of seed cormel weight on growth and yield of taro (*Colocasia esculenta* L. Schott.) in Punjab conditions. *Journal of Root Crops* **42**, 95-97.

Sukal, A. C. (2014). “In Vitro Virus Elimination from Taro (*Colocasia esculenta* (L.) Schott) for Conservation and Safe International Exchange”. University of the South Pacific. Fiji.

Susiyani, S., Lestari, W., and Fatonah, S. (2014). “In-vitro Shoot Induction from Fruit Shoot Explants (slips) of Pineapple (*Ananas comosus* (l.) Merr.) Plants Kampar Origin with the Addition of 6-benzylaminopurine (BAP)”. Faculty of Agriculture, Riau University.

Uke, H. Y., Barus, H., and Madauna, I. S. (2015). Effect of bulb size and potassium dosage on growth and yield of shallot (*Allium ascalonicum* L.) Hammer Valley variety. *Agrotekbis Journal* **3**, 655-661.

Wawo, A. H. (2011). Study on propagation and growth of arrowroot (*Maranta arundinaceae* L.) in different light condition. *Environmental Engineering Journal* **7**, 127-136

Wulandari, A. N., Heddy, S., and Suryanto, A. (2014). “The Use of Seed Tuber Weight to Increase the Yield of Potato Plants (*Solanum tuberosum* L.) G3 and G4 Granola Varieties”. Faculty of Agriculture, Brawijaya University

Zelin, O., and Setyawan, H. B. (2019). Effect of planting materials on growth and yield of three varieties of taro (*Colocasia esculenta* L.). *Berkala Ilmiah Pertanian Journal* **2**, 122-126.