PROPAGATION TECHNIQUES FOR RAPID ESTABLISHMENT AND PRODUCTION OF COCOYAM (*Xanthosoma sagittifolium* (L.) Schott)

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ABSTRACT

Corm, cormel and corm setts of cocoyam (*Xanthosoma sagittifolium* L. Schott) were tested to determine the most practical and efficient propagation technique for its multiplication. The study for evaluating corm and cormel used whole corm, top half, bottom half, and cormel. Corms and its parts showed that all planting materials have comparable sprouting percentage at 8 weeks after planting (WAP) except for cormel which had significantly lower sprouting. Whole corm and top half of corm produced significantly longer corm and higher corm yield than other treatments. The study for sett used small sett with 15 and 30 cm petiole, big sett with 15 and 30 cm petiole and small sett with intact shoots. The result showed that all treatments gave comparable percent survival at 4 WAP except for small corms with intact shoots. Big sett with 30 cm petiole showed higher plant height, stem girth, petiole length, and number of leaves than other treatments. Small setts with 15 and 30 cm petiole and big sett with 30 cm petioles have comparable corm length, girth and yield. All treatments except for those with small setts with intact shoots have comparable number and length of cormel. Cormel yield from small sett with 15 cm petiole is comparable with big sett with 30 cm petiole.

Keywords: Takudo, Gabing San Fernando, cocoyam, *tannia*, propagation techniques, rapid multiplication

INTRODUCTION

Cocoyam *(Xanthosoma sagittifolium)* (L.) Schott is locally known in the Philippines *as Gabing San Fernando, Galiang, Takudo,* and *Butig*. It is a perennial crop belonging to the family *Araceae* (Aroid), and has a corm where the cormels are attached. Corm is the pseudo stem of the plant while sett is the top portion of the main plant including about 5 mm of corm and the leaves cut off about 20-30 cm above the base, but leaving the newly formed leaf at the center of the plant (Kay 1987) (Fig. 1). Cormels are the parts that grow from the corm. Several large leaves sprout from the main stem and the leaves are sagittate and erect with long, ribbed petioles (Bermejo and de Leon 1994; Pardales1997). They are grown for their edible corms or cormels which are used as food (boiled as snack food), yam substitute in yam jam (*Halayang ube*), and additional vegetables for meat or fish sour broth (*sinigang).* The young leaves of cocoyam are also used sometimes as vegetable similar to spinach (Bermejo and De Leon 1994). Ohaemenyi (1993) reported that cocoyam corms can be cooked and used to some extent in the diets of growing pigs.

Xanthosoma sagittifolium grows in hot and humid areas of the world and is cultivated extensively throughout West Africa (Onwueme 1982). It is also common anywhere on the dryland environment of the Philippines. In the past, it, was mainly cultivated and consumed by the less privileged small scale farmers. A study conducted by the Farming Systems and Soil Resources Institute (FSSRI) and the Institute of Animal Science (IAS) in Dolores, Quezon used corms of cocoyam as substitute for corn in swine feeds (Villancio et al. 2001). For Philippine farmers, the cormels are marketed for human consumption while the main corms (*sakwa*) are used as planting material and as feeds (Villancio et al. 2001; Bulatao et al. 2010).

The use of cocoyam as a raw material for brewing is reported by Onwuka and Eneh 1996. It is a staple crop in parts of Ghana, Nigeria, Japan, and Hawaii. In South Pacific Island countries, edible aroids, principally taro (*Colocasia esculenta L. Schott*), form a high proportion of the root crops. However, in the Caribbean and West Africa, tannia (*X. sagittifolium*) dominates (Owuso –Darko et al. 2014). Cocoyam is now gaining more importance due to the superiority of their corms and cormels in terms of energy, proteins and mineral elements (Mwenye 2009). Cocoyam cormel ranks second to sweet potato in terms of nutritive value and digestibility, having a nutritional value comparable to potato, containing 15 - 39% of carbohydrates, 2-3% of protein and 70-77% of water (Bermejo and Leon 1994).

In spite of its growing importance, the production of cocoyam has been stagnant for many years owing mainly to low productivity (Schafer 1999), the limited availability of traditional planting material (corm cuttings), as well as viral and fungal infections (Xu et. al. 1995; Mbouobda, et. al. 2007). Planting material acquisition is a big challenge especially for commercial or large scale production due to the inherent low multiplication ratio of the corms (Owusu-Darko 2014). The production technologies for cocoyam for large scale production are not yet well established in the Philippines and are greatly based on small-scale production. There is a need to develop the component technologies for large scale planting to get the potential benefits from this crop. Thus, this study was conducted to determine the most practical and effective propagation technique using different plant parts of cocoyam as planting materials that will give early establishment and higher yield.

MATERIALS AND METHODS

Two separate trials (Trial A and B) were conducted from August 2015 to April 2016 to determine the best propagation technique to rapidly multiply cocoyam planting materials using the following: corm and its parts, cormel and setts (Fig. 1).

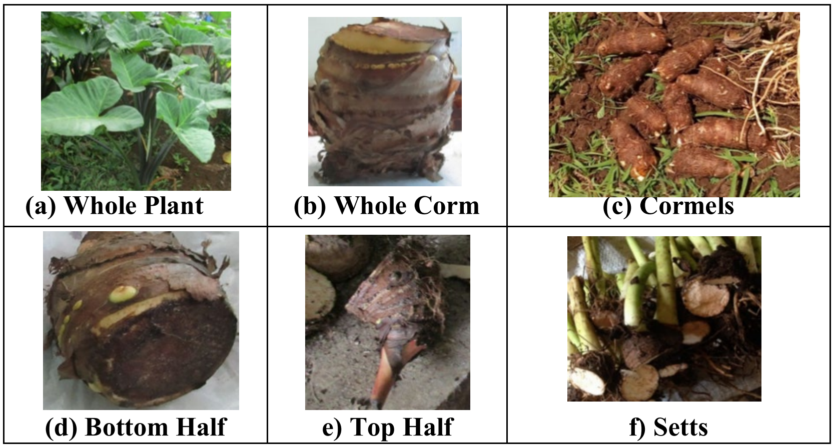

Fig. 1. Cocoyam (*Xanthosoma sagittifolium)* plant showing the whole plant and the different parts used as planting materials, (a) whole plant, (b) whole corm, (c) cormels, (d) bottom half corm, (e) top half corm and (f) setts.

The planting materials were cleaned, sorted according to sizes of corm's and sett's girths. They were then cut into sizes according to the proposed treatments (Fig. 1). The planting materials were treated with fungicide (Mancozeb 80WP) to prevent corm and sett rot which may affect the sprouting and development of the cocoyam plants.

Corm parts and cormel as planting material. For the trial using corm and cormel, four (4) treatments; b) whole corm, c) whole cormel, d) bottom half corm, and e) top half corm (Fig. 1) were laid in Randomized Complete Block Design with 4 replications. This experiment was established at the Agricultural Systems Institute (ASI) screen house using the 16 concrete enclosed, volcanic soil-filled plots of 4m x 4m. Cocoyam was planted at a distance of 50cm x 50cm apart.

Different types of setts as planting material. Similarly, for the trial involving setts, 5 treatments; a) small sett with 15 cm petiole, b) small sett with 30 cm petiole, c) big sett with 15 cm petiole, d) big sett with 30 cm petiole, and e) small sett with intact shoots, were arranged in a Randomized Complete Block Design with 4 replications. The corm size of the small sett was 29-32 mm girth while big sett was 42-59 mm. This was established at Block C8 of the Central Experiment Station of the University of the Philippines Los Banos. Plot size was 10 m x 5 m and 50 planting materials were planted in each plot at a distance of 1 m x 1 m. The total experimental area was 1,560 m^2 including the 2 m alley way between treatments and replicates.

The plants were fertilized at the rate of 30-30-30 kg NPK/ha using complete fertilizer (14-14-14) as basal application and urea (46-0-0) as side dress at 3 and 6 months after planting. Weeds were controlled regularly through using grass cutter and hand weeding. Insect pests were controlled by spraying bio-con agent, Nuclear Polyhedrosis Virus (NPV) to control cutworm, which were observed during the early establishment of the plants. For both trials, data collection started after planting (4 WAP) until harvest (28 WAP). The experimental area was irrigated as needed using perforain irrigation system.

a) big sett with 15 cm petiole

b) big sett with 30 cm petiole

c) small sett with 15 cm petiole

d) small sett with 30 cm petiole

e) small sett with intact shoots

Fig. 2. Sett planting material treatments, (a) big sett with 15cm petiole, (b) big set with 30cm petiole, (c) small sett with 15cm petiole, (d) small sett with 30 cm petiole, (e) small sett with intact shoots.

Data were collected from 10 sample plants per replicate per treatment for the following: a) number of plants that have sprouts b) plant height, c) petiole length, and d) girth size. The following yield and yield parameters were also gathered: number of cormels per plant, cormel yield per plant (g), cormel length and girth (cm), corm yield per plant (g), and corm length and width (cm). Observations on the sprouting started when the shoots became evident, i.e. around 0.5 -1.0 inch above the ground. The number of plants that have sprouts was counted every week until 9 WAP. The collected data were statistically analyzed for significance using ANOVA and comparison of means.

RESULTS AND DISCUSSION

Corm parts and cormel as planting material. Sprouting of propagules started 3 WAP which is close to the findings of Osundare (2010) where corm, cormel and split corm of cocoyam emerged in 2 to 3 WAP. Whole corm gave a 100% sprouting after the 8 weeks of observation. All treatments showed statistically similar sprouting percentage at 5WAP (Table 1). The percent sprouting of cormel was statistically comparable with the whole corm and top half corm on the 5 WAP but statistically lower than the former treatments starting 6 up to 8 WAP and never attained 100% sprouting even on the 8 WAP. No noticeable sprouting was observed on the 9-10 WAP in all treatments. The result is consistent with the findings of Tsedalu et al. (2014) who found out that corms achieved 50% emergence earlier than cormels. The delay in the sprouting of bottom half corms and cormel at 3 WAP to 5 WAP could be due to the dormancy of cut corms. Wilson (1984) attributed the delay in sprouting to the dormancy period of aroids from cutting portions of corm or cormels of approximately 5 weeks. The results showed that it is better to use whole corm, top half and bottom half of corm as planting material compared to cormels. This is especially critical when planting materials are scarce where the whole corm could be divided into two parts (top and bottom) without affecting its sprouting percentage.

Table 1. Weekly sprouting percentage of corm, cormels and corm setts as planting materials.

Treatment	Percentage sprouting in weeks after planting (WAP)					
	3 WAP	4 WAP	5 WAP	6 WAP	7 WAP	8 WAP
Whole corm	86.0^{a}	90.5^{a}	94.0^{a}	97.5^{a}	99.5^{a}	100.0^{a}
Top half corm	74.0^{a}	81.0^{ab}	90.0^{a}	94.5^{a}	99.5^{a}	99.5^{a}
Bottom half corm	30.0^{b}	56.0^{b}	75.0^{a}	86.0^{ab}	95.5^{ab}	99.0^{a}
Cormel	55.5^{ab}	64.0^{ab}	68.0^{a}	69.0^{b}	78.0^{b}	80.0^{b}

Whole corm and top half of corm had significantly higher plant height and petiole length than bottom half of corm and cormel from 12 WAP to 24 WAP (Fig. 3 and 4). Petiole girth of whole corm is significantly higher than top half, bottom half and cormel at 12 WAP (Fig. 5). At 16 WAP and 20 WAP, whole corm, and top half corm had significantly higher petiole girth than bottom half of corm and cormel at 16 WAP and 20 WAP. Whole corm, top half of corm and cormel had significantly higher number of leaves compared to bottom half of corm from 12 WAP to 20 WAP (Fig. 6). On the 24 WAP and 28 WAP, number of leaves of whole corm is significantly higher compared to the other 3 treatments.

These results could be attributed to the age of the corm parts. Primary corm of cocoyam is the main stem of the plant and the secondary 'corms' are its branches (Enyi 1967). The age of the planting sett where the main stems are cut to produce setts will depend on its position on the corm, the top being the youngest and those from the bottom the oldest. Also found out in their study on *Xanthosoma mafafa* that better growth and yield performance of cormels than that of the corm and split corm can be attributed to the new and fast growing root system produced from the stolons of the planted cormels (Osundare and Fajinmi 2013). Cormels were active in utilizing available soil nutrients compared to the old roots of corms with worn out buds and split corm. When transferred to the field, the latter two uses more period to rejuvenate and establish its old root system. A study conducted by Lebot (2008) stated that taro and cocoyam can be grown from suckers split longitudinally in halves or quarters with their attached pieces of corms but would result in a reduced leaf area per plant.

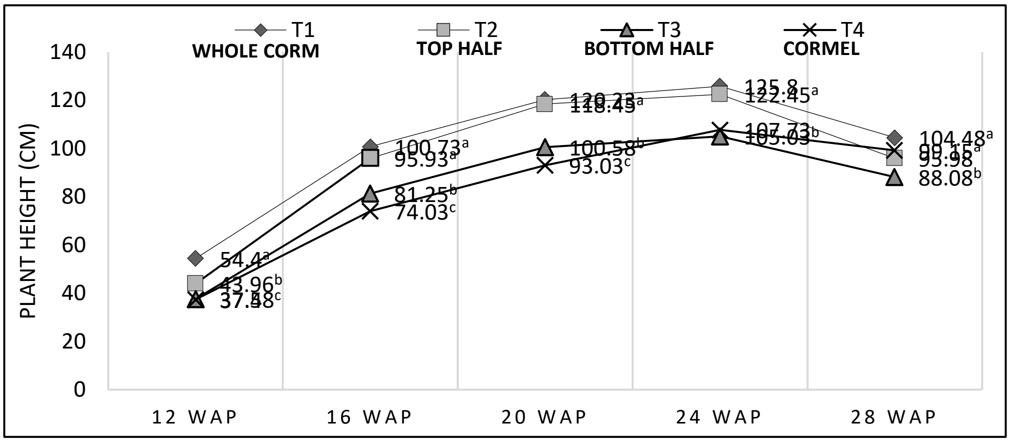

Fig. 3. Plant height of cocoyam using corm parts and cormel as planting materials from 12 WAP to 28WAP.

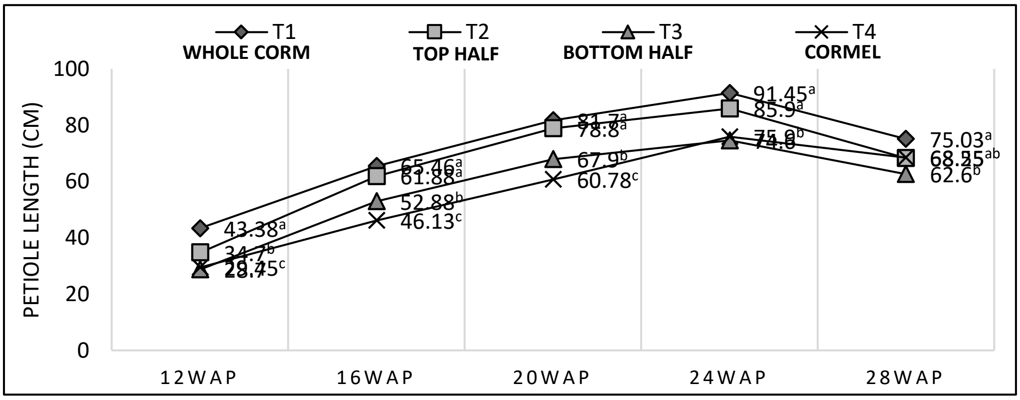

Fig. 4. Petiole length of cocoyam using corm parts and cormel as planting materials from 12 WAP to 28WAP.

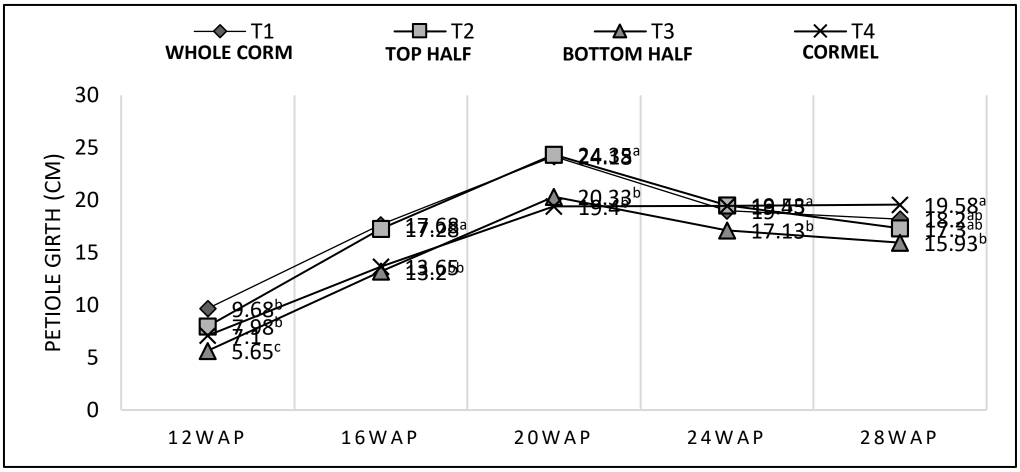

Fig. 5. Petiole girth of cocoyam using corm parts and cormel as planting materials from 12 WAP to 28WAP.

The early establishment of the plants demonstrated by the use of whole corm and top half corm have full advantage over the other treatments on the initial plant growth in terms of plant height, plant girth, and petiole length at the start of the growing period while the plants became less advantageous on these parameters at maturity.

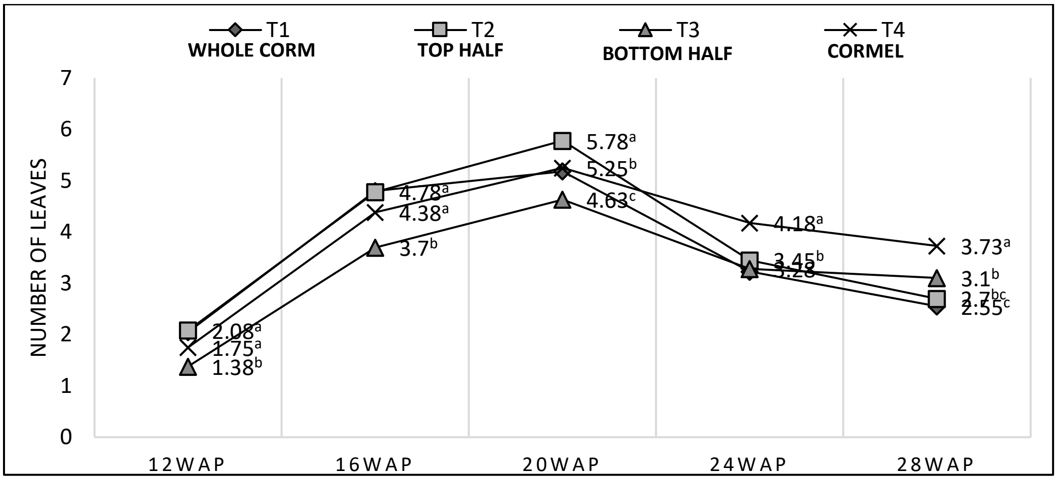

Fig. 6. Number of leaves using corm parts and cormel as planting materials from 12 WAP to 28WAP.

Yield of corms and cormel as planting material. Yield and yield parameters of cocoyam planted using whole corm, top half and bottom half of corm and cormel are presented in Table 2. Using whole corm and top half of corm produced significantly longer corm than bottom half of corm and cormel. Corm weight is significantly higher when using whole corm than bottom half of corm. Corm weight of whole corm as planting material is comparable to using top half of corm. No significant difference in corm girth was observed using different types of planting materials. No significant difference was also observed in the cormels produced and the corresponding parameters, e.g. cormel number, length, width and weight using different types of planting materials (Table 2).

Table 2. Yield (number of corms and cormels harvested) and yield parameters of cocoyam using whole corm, split corms and cormel.

Treatment	**Corm Length** (cm)	**Corm girth** (cm)	**Corm yield** (g/plant)	**Number of cormel per plant**	**Cormel length** (cm)	**Cormel girth** (cm)	**Cormel yield** (g/plant)
Whole corm	15.71^a	22.58^a	442.88^a	3.85^a	5.80^a	10.60^a	170.11^a
Top half	13.93^a	23.75^a	393.00^{ab}	3.58^a	6.71^a	11.33^a	190.95^a
Bottom half	11.63^b	22.30^a	237.25^c	4.45^a	6.56^a	12.06^a	240.45^a
Cormel	12.03^b	28.43^a	321.50^{bc}	4.35^a	6.00^a	11.00^a	196.18^a

In a field experiment using corm as planting material, produced plants have higher mean height, leaf number, shoot number, leaf area, corm weight and corm diameter per plant as well as higher total and marketable yield (Tsedalu et al. 2014). It is consistent with the results of study conducted by Edossa et al. (1995) as cited by Ivancic and Lebot (2000) who found that using corm produced higher mean corm weight per plant than cormel. Their results also showed that the use of corm as planting material markedly increased total corm yield per unit area than using cut corm and cormel. This can be ascribed to a greater number of buds per given area compared to split corm (Ivancic and Lebot 2000). Central corms give greater yields than the cormels which are also sometimes used especially when planting materials are scarce (Bermejo and Leon 1994). In another study in taro conducted by Gonzales et al. (1992), the use of big cormels (30-39 g) as planting material produced higher corm and cormel yields compared to using smaller cormels. Bigger cormels have more reserved nutrient (bigger sink) for growth and development. This indicates that the size of the corm and cormels affect yield of the cocoyam.

Establishment performance of different setts as planting material. All treatments gave a high percent sprouting of the propagules on the 4 WAP except for small sett with intact shoots (Table 3). Percent survival using small sett with 15 and 30 cm petiole are significantly higher compared to small sett with intact shoots. Small sett with 15 to 30 cm petiole showed greater sprouting percentage than other treatments and are statistically significant compared to all treatments. The size of the corm may be one factor for higher sprouting percentage. High sprouting percentage of the youngest sections of the corm was attributed to both greater bud number per given area and to the short period of their dormancy (Enyi 1967). Better establishment in the field was achieved by using setts from the oldest section of the corm, probably because they were less vulnerable to decomposition by soil micro-organisms. Setts from the oldest sections of the corm produced plants with the greatest leaf blade area, total dry weight and dry weight of various organs and it is recommended that planting setts should be obtained from the less succulent section of the corm.

Table 3. Percent survival of cocoyam plants using different corm sett planting materials at 4 WAP.

Treatment	Percentage of surviving cocoyam (%)
Small sett with 15cm petiole	97.50[a]
Small sett with 30cm petiole	100.00[a]
Big sett with 15cm petiole	87.50[ab]
Big sett with 30cm petiole	95.00[ab]
Small sett with shoots intact	80.00[b]

Although the small sett with 30 cm petiole achieved a better head start in its plant height, petiole length and girth at 8 WAP up to 16 WAP, the big sett with 30 cm petiole had higher plant height and girth size at 16-18 WAP up to 20 WAP (Figures 7, 8 and 9). The use of small sett with 30 cm petiole obtained significantly higher plant height and petiole length during the first 8-16 WAP compared with other treatments. Petiole girth is significantly lower for treatments with intact shoots from 8 WAP up to 28 WAP (Figure 9). The poor performance of sett with intact shoots may be due to transplanting shock. With already photosynthetically active shoots, the plant may not have adjusted to the nutrient and acclimatization demand for its sustained growth. The loss of root tips and root hairs due to root pruning at transplanting disturbs the roots affecting the root and shoot ratio. This induces a "recovery phase" during which shoot growth is suppressed until the previous root and shoot ratio is restored (Kerbiriou et al. 2013). In this experiment, the setts are cut with only 5-10cm of the corm retained although protruding young buds are still visible. The results suggest that the size of the corm as well as the length of the petioles are important in the production of cocoyam.

Yield performance of different setts as planting material. Yield and yield parameters using different sett sizes and petiole lengths are presented in Table 4. Using small setts with 15 cm petiole as planting material produced significantly higher corm length, corm girth and corm weight than using big setts with 15 cm petiole and small sett with intact shoots. Corm length, corm girth and corm weight using small setts with 15 cm petiole is comparable to using small setts with 30 cm petiole and big setts with 30 cm petiole. Significantly higher number of cormels were harvested, with longer sized cormel and higher corm girth were produced using small sett at 15 cm petiole and big sett at 30 cm petiole contrary to small sett with intact shoots. Cormel weight was significantly higher using big sett with 30cm petiole as compared to all other treatments. However, small sett with 15cm petiole ranked second highest in yield. This was corroborated by the study conducted by Gebre, et al. (2015) where increase in corm yield per hectare was attributed to bigger corm size as having more food reserve that lead to early canopy closure, maximum leaf area and leaf area index which help for the production of bigger weight of corms and cormels. In this experiment however, big corm gave higher yield only with longer petiole but not with shorter petiole. Another study by Ameyaw et al. (1994) also reported that larger sett size produced heavier tuber weight per hectare than the smaller sett size for yam, also a rootcrop. The results suggest that the size of the corm as well as the length of petioles are important in the propagation of yam. In this study, it is recommended that planting material to be used for cocoyam should have petiole length and corm girth of at least 15 to 30cm and 30.6 to 50.5mm, respectively.

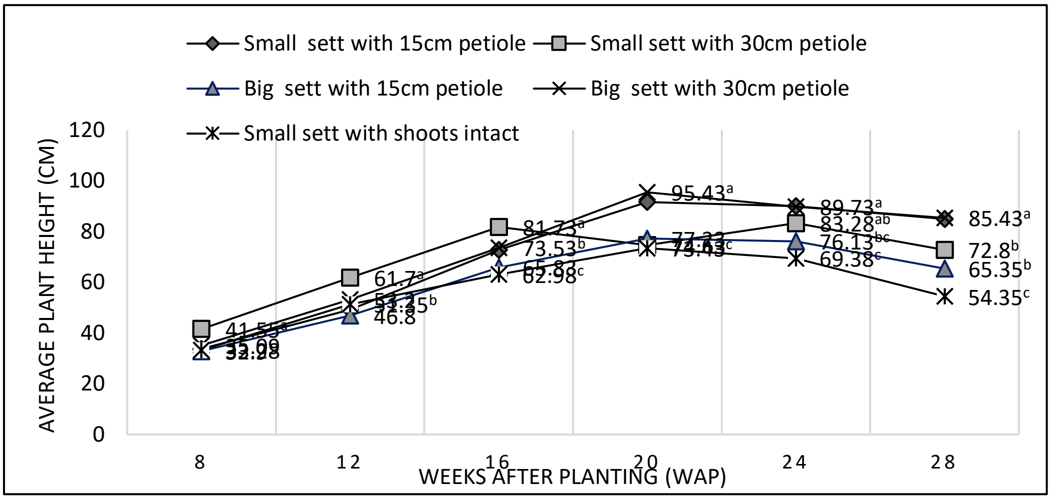

Fig. 7. Plant height of different sett sizes and petiole lengths as planting materials from 8 WAP to 28 WAP.

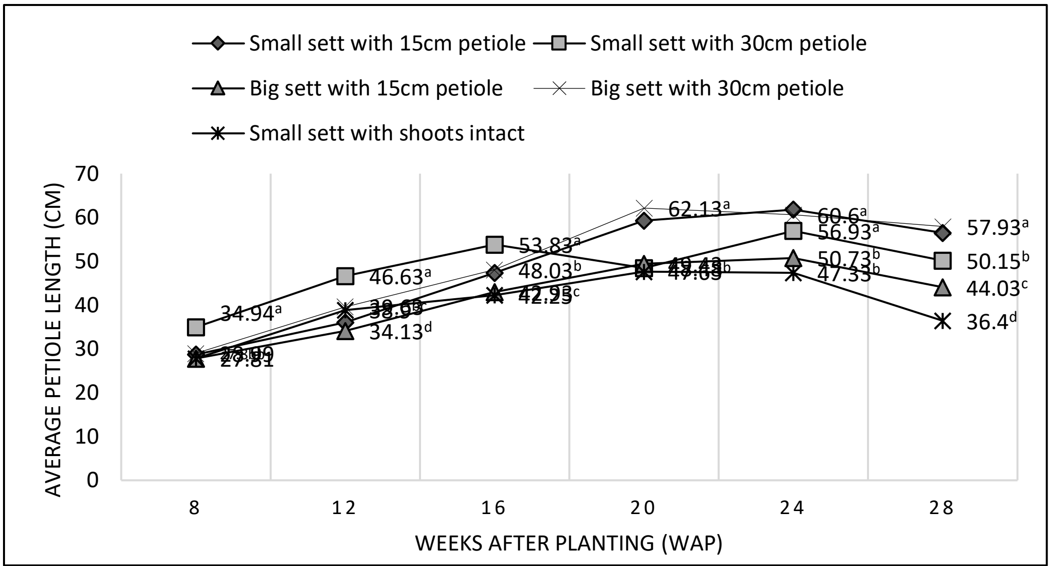

Fig. 8. Petiole length of different sett sizes and petiole lengths as planting materials from 8 WAP to 28 WAP.

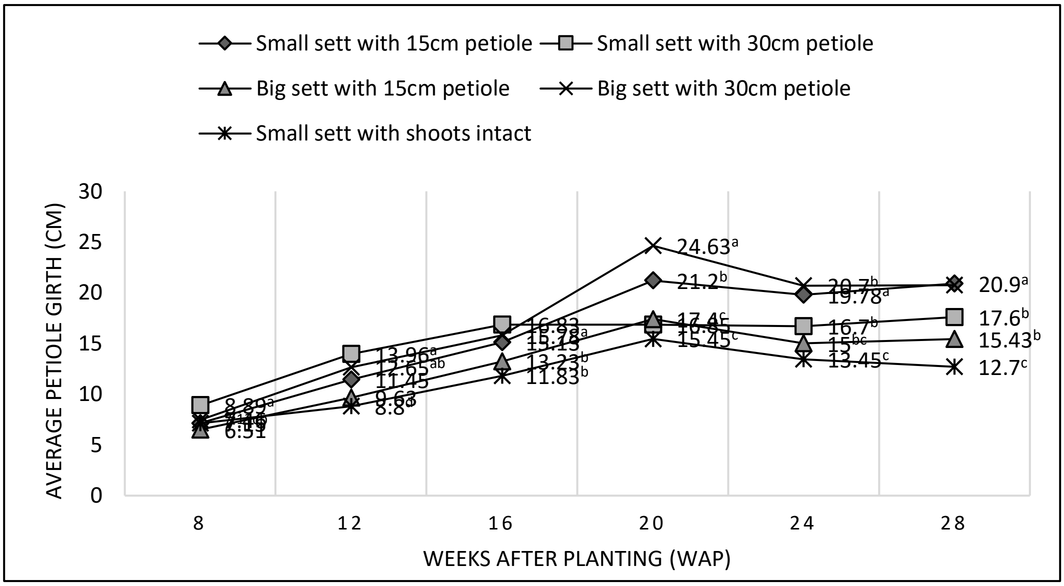

Fig. 9. Petiole girth of different sett sizes and petiole lengths as planting materials from 8 WAP to 28 WAP.

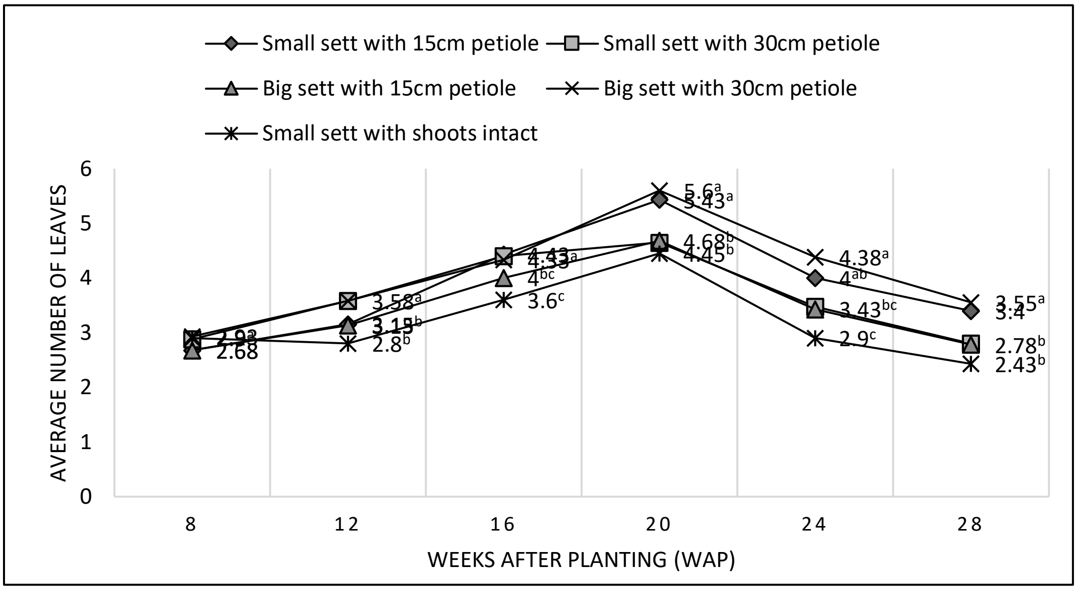

Fig. 10. Number of leaves using different setts sizes and petiole lengths as planting materials from 8 WAP to 28 WAP.

Table 4. Yield (corm and cormel) and yield parameters of cocoyam using different sett size and petiole length.

Treatment	**Corm length** (cm)	**Corm girth** (cm)	**Corm yield** (g/plant)	**Number of cormel per plant**	**Cormel length** (cm)	**Cormel girth** (cm)	**Cormel yield** (g/plant)
Small sett, 15cm petiole	11.00[a]	25.00[a]	366.75[a]	7.45[a]	5.75[a]	11.48[a]	333.85[ab]
Small sett, 30 cm petiole	10.70[ab]	23.00[ab]	318.13[a]	5.68[ab]	5.30[ab]	9.06[abc]	249.00[b]
Big sett, 15 cm petiole	9.18[bc]	20.51[bc]	198.75[c]	5.20[ab]	5.10[ab]	8.68[bc]	225.73[b]
Big sett, 30 cm petiole	10.64[ab]	23.13[ab]	316.00[ab]	6.63[a]	6.67[a]	10.16[ab]	454.40[a]
Small setts with intact shoots	8.63[c]	19.48[c]	200.25[bc]	4.00[b]	3.57[b]	6.44[c]	179.20[b]

CONCLUSION AND RECOMMENDATION

For rapid establishment of GSF, corm or sett could be used. Whole corm is the most effective as it will sprout early and gives the highest sprouting percentage. However, for practicality, both top half corm and bottom half corm can also be used. Although they will sprout later than the whole corm, they are able to catch up with the whole corm in the latter stages of crop growth without significant differences in other crop parameters from the whole corm except corm yield. The use of cormel is less effective as it has low percent sprouting and may result in high quantities of non-marketable cormels. Use of cormel is also less practical because this is the part highly marketed for food in the Philippines. It is recommended that the cocoyam planting material to be used should at least have a 15 to 30cm petiole length and the corm size should be within a girth size of 30.6 to 50.5mm. The use of sett as planting material is also effective regardless of the size of the sett and length of petiole. However, retaining the shoots in the sett would reduce the percent sprouting of the planting materials.

For corm production, whole corm and top half of corm are the best planting materials as these produced longer corm and higher corm yield as well as sprouted earlier with higher sprouting percentage. For cormel production, all these types of planting materials can be used. Cormel, which is the more economically important part of cocoyam can be marketed while corm (whole corm, top and bottom half of corm) can be used as planting materials.

Multi-location trial using bigger plot sizes is being recommended for further verification of the results of this study. Nutrient management for this crop is also recommended for large-scale production. Value addition like feeds for animals other than pigs and use of cocoyam flour in food products can be explored.

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