Developing Low Input Technology for Rapid Multiplication of Taro *(Colocasia esculenta)* Planting Material

R. Sagoe,* B. Dzomeku, A. S. Osman, K. Agyeman, E. L. Omenyo and J. N. L. Lamptey
CSIR - Crops Research Institute, P.O.Box 3785, Kumasi-Ghana.

***Corresponding author: rsagoe50@gmail.com**

Abstract
Taro (Colocasia esculenta (L) Schott) is mainly propagated vegetatively using suckers and corms. This practice is characterised by low multiplication ratio (1:1) which reduces yield and seedling quality and favours the accumulation of pest and pathogens. Availability of clean planting material is essential for sustained high production of taro in Ghana. Demand for high quality planting materials of the newly released of taro varieties will increase; and this makes such study very significant. This paper presents the preliminary observations on the development of a farmer friendly system to produce quality and healthy planting materials. It describes a protocol developed for the rapid multiplication of taro and establishes that some parts of the crop sprout spontaneously and grow well in river sand as a growth medium. A multiplication ratio of 6 to 10 per corm has been established. Sprouts count from river sand (1237) was higher than that of sawdust (1170). Seedlings from these growth chambers when established in the field were able to withstand Taro leaf blight disease attack with an incidence of 82%, severity of disease score was 2.6, recording yields ranging from 7.5 to 12.3 t/ha which was very hgh compared with yields from a mix of locals planted direct from daughter suckers (5 .5 7t/ha). So far the study has supported the notion that nutritional predisposition of the planting material as a result of the early yellowing of the leaves of the seedlings, thus influencing low or high yield. Supplementary nutrients will have to be applied to plantlets to boast its growth at the nursery stage.

Key words: Colocasia esculenta, planting material, rapid multiplication, multiplication ratio

Développement d'une technologie à faible niveau d'intrants pour la multiplication rapide du matériel de végétal de taro *(Colocasia esculenta)*

Résumé
Le taro (Colocasia esculenta (L) Schott) est principalement multiplié par voie végétative à l'aide de drageons et de cormes. Cette pratique est caractérisée par un faible ratio de multiplication (1: 1) qui réduit le rendement et la qualité de la culture, tout en favorisant l'accumulation de ravageurs et de pathogènes. La disponibilité de matériel végetal propre est essentielle pour une production élevée soutenue de taro (Taro) au Ghana. La demande de matériel de plantation de haute qualité pour les variétés de taro nouvellement homolognées augmentera; et ceci rend cette étude très significative. Cet article présente les observations

préliminaires sur le développement d'un système favorable aux agriculteurs pour produire du matériel végetal sain et de qualité. Il décrit un protocole développé pour la multiplication rapide du taro et établit que certaines parties de la culture poussent spontanément et poussent bien dans le sable de la rivière comme milieu de croissance. Un rapport de multiplication de 6 à 10 par corme a été établi. Le nombre de pousses provenant du sable de la rivière (1237) était plus élevé que celui de la sciure de bois (1170). Les plantules issues de ces chambres de croissance ont pu résister à la maladie de la brûlure helminthosporienne (incidence: 82%, sévérité: 2,6), avec des rendements variant de 7,5 à 12,3 t / ha comparés aux rendements d'un mélange de populations locales (5,5 - 7t/ha). Jusqu'à présent, l'étude a soutenu la notion que la prédisposition nutritionnelle du matériel végetal à la suite du jaunissement précoce des feuilles des semis, influençant ainsi le rendement faible ou élevé. Des nutriments supplémentaires devront être appliqués aux plantules pour pouvoir se développer au stade de la pépinière.

Mots-clés: Colocasia esculenta, matériel végétal, multiplication rapide, multiplication du ratio.

Introduction

Taro *(Colocasia esculenta (L) Schott)* is primarily propagated vegetatively using daughter and volunteer suckers which sprout when a new farm is cleared and the corms, which are of economic importance. Availability of good planting material is essential to sustain high production of taro in Ghana. However, its multiplication is constrained by the vegetative nature characterised by its bulkiness and perishability coupled with the low multiplication ratio. These constraints make commercial production of the crop not attractive. The conventional methods of using the corm or suckers for propagation are cost intensive and require a longer period of time and land area to produce. In addition, although micro-propagation assures more rapid production or multiplication of healthy, vigorous and disease free planting materials (Swennen, 1990), it requires sophisticated techniques, skill and care to handle. Thus tissue culture as a method for regeneration is not a friendly system for resource poor small scale farmers who are the major producers in the taro value chain. Several scientists working on bananas and plantain have suggested the use of macro-propagation techniques for inducing increased sucker developments from vegetative propagated crops that have the tendency to regenerate naturally through suckering at farm level (Faturoti *et al.,* 2002; Buah and Tachie-Menson, 2015). They observed that repression of apical dominance will stimulate lateral bud development and increase suckering rate. It is suggested by Kwa (2003) and Tenkouano *et al.,* (2006) that pre-sprouting in growth / humidity chambers) will result in increased multiplication ratio for high planting material production. Demand for high quality planting materials would be heightened by the release of new taro varieties; therefore the conduct of such a study is very critical for sustained and increased taro production. It is expected that this study will develop a farmer friendly system to multiply quality and healthy planting materials for increased availability and accessibility. Hence the need to establish a protocol for low input rapid multiplication of taro planting material.

The main objective of this study was to

rapidly produce high quality disease free taro planting materials (seed) using the growth chamber technique. And specifically, identify the best medium and plant part with the potential to provide high multiplication ratio.

Methodology

A growth chamber with controlled humidity and temperature was constructed at the CSIR-Crops Research Institute, Fumesua. Local planting materials were sourced from communities that grow taro for the study. A total of 36 growth chambers (100 cm x 100 cm) were built with blocks and these were either filled with river sand or saw dust. The 2 factor (growth media and planting material type) pre-sprouting experiment was laid out as a completely randomised design replicated 3 times. Two different growth media (M) with distinct characteristics used were river sand and saw dust. The soil particle distribution in the river sand was 96% of sand and the remaining being silt and clay; while saw dust used had none of these soil particles but may contain organic matter, available P and other soil nutrients which are higher than that in river sand (Florence *et al.,* 2013).

Three different portions of the taro plant were used as planting materials/propagules(P) and prepared as following:

1. The apical dormancy of the corm was repressed or destroyed and then cut into 2 parts - the lower and upper portions. These were further cut into a standard size of about 100-150 grams.

2. The huli which is the apical 1-2 cm of the corm as base of 15-20 cm of the petioles attached were prepared in 2 batches one lot had its apical meristem repressed / destroyed and the other had its meristem intact and their weights ranged from 20 50 g.

   Young suckers that sprout from mother

3. plants were cleaned and also grouped into two one batch had their apical meristem removed / destroyed and the other not destroyed.

All the planting materials used were treated with fungicide and pre sprouted in either river sand or sawdust using 30 pieces per growth chamber which was covered with a clear polyethylene sheet in a specialised net mesh shaded growth chamber (Plates 1 & 2). The pre-sprouting experiment was initiated on the 26th June 2016 and at a regular weekly harvest periods, excised and transplanted

Plate.1: Sprouted corm from sawdust

Plate 2: Growth chamber

seedlings or plantlets at 2 leaf stage into polybags filled with soil. Watering was done as and when necessary. Daily temperature and humidity levels of the growth chamber were monitored using a data logger placed in the chambers. Sprout counts were done at regular intervals and the criterion for counting was visible protrusions in the growth media.

Response variables assessed were days to start of sprout, number of sprouts, and petiole length and leaf count and survival rate after transplant into soils in polybags. Growth rate of the seedlings in polyethylene bags as a measure of seedling vigour using petiole length and leaf count were also evaluated. All data was subjected to statistical analysis using the software GENSTAT V17.

Results and Discussions

Growth media used in propagating vegetative propagules and seeds have been found to influence rooting in the case of stem cuttings and sprouting when modified stems are used as propagules. According to Hartmann *et al.* (2007) seed germination is influenced by many factors such as the type of substrate used, environmental factors such as oxygen, water, and temperature and for some plant species, light. Generally, growth medium has been found to be the most critical factor determining seedling quality in the nursery (Baiyeri and Mbah, 2006), acting as a reservoir for nutrients and moisture (Grower, 1987). Its physical properties have been established to influence the supply of water and air to the young seedlings (Baiyeri, 2005). This experiment therefore evaluated the effect of two growth media (a river sand and sawdust) for sprouting taro three different sources of propagules were used the huli, suckers and corms whose apical dominance were either repressed to stimulate lateral bud development and increase seedling development or not repressed for normal growth development. Mean Days to sprout initiation in both media were 17 days after sowing (DAS), however the taro propagules in the river sand generally sprouted earlier (15 DAS) than the saw dust (19 DAS). Significant differences were observed among days to sprout initiation among type of propagules (P=0.001), growth media (P=0.001) and interaction between the propagules and growth media (P=0.01).

Average mean distributions of days to sprout initiation are presented in Table 1. Early sprouting were recorded on plots that were sown with suckers (12 DAS) and huli (11 DAS) with intact apical dominance. Sprouting was initiated at 20 days after sowing on all plots sown with propagules whose apical dominance have been repressed, except for the upper part of the corm which started to sprout at 19 days after sowing. River sand generally reduced the days to sprout initiation on all types of propagules used. Sprouting huli and suckers with their apical dominance destroyed in sawdust delayed days to initial sprouting to 25 and 23 days respectively when compared with propagules with intact apical meristems. Delays were shorter for the same materials pre-sprouted in river sand (3-6 days) as against 10 - 15 days with sawdust. This makes the river sand a superior medium when compared with sawdust.

The upper parts of the corm sprouted earlier than the lower parts whose sprout initiation was delayed by 5 days in river sand (Table 1). The study also revealed significant differences in the rate of sprout initiation expressed as number of sprouts at measured intervals or days after sowing. Table 2 presents number of sprouts that were initiated at critical periods in the growth media. The number of sprouts count were consistently higher on river sand than saw dust. Propagules from plant parts whose apical dominance were repressed significantly produced more sprouts and

Table 1: Average effect of treatments on days to sprout initiation

Treatment	River sand (M1)	Sawdust (M2)	Average effect of Type of Propagules (P)
Huli (AP intact)	12	10.33	**11.17**
Huli (AP destroyed)	15	24.67	**19.83**
Sucker (AP intact)	10.67	12.67	**11.67**
Sucker (AP destroyed)	17.33	23.33	**20.33**
Upper Corm (AP destroyed)	15.67	22.00	**18.83**
Lower Corm	20.0	21.33	**20.67**
Ave. Growth Media	**15.11**	**19.06**	**17.08(GM)+**
SED (M)***	0.795		
SED (P)***	1.377		
SED (M X P)**	1.948		
CV (%)	14		

** - Significant at P=0.01; *** - significant at P=0.001; GM+ - Grand mean of all treatment
AP apical meristem

subsequently higher number of seedlings. More seedlings were obtained from the upper part of the corms with destroyed apical dominance when compared with the lower part of the corm with destroyed apical dominance used in the study. This confirms findings from previous studies where apical dominance of plantain and bananas destroyed produced more suckers when pre-sprouted in similar growth chambers (Baiyeri *et al,* 1994; Buah and Tachie- Menson, 2015).

The total number of seedlings produced as influenced by the growth media used and type of propagule or planting material are presented in Table 2. Seedling counts gave an indication of the performance of the type of planting materials used. There was no difference between the huli and suckers performance, however destroying the apical dormancy decreased the number of sprouts from both the suckers and huli. Sprout counts from the river sand (391.2) were higher than from the sawdust (304.6). Total average seedlings obtained in the study ranged from 231 to 479 per plot sown with 30 propagules, giving a multiplication ratio of about 8 to 16 seedlings per propagule. Suckers and huli with their apical dominance repressed produced more seedlings than the upper cut of the corm with a repressed apical meristem (Table 2).

The highest seedlings of 479 were obtained from suckers with destroyed apical meristem and pre-sprouted in river sand media and the least number of seedlings were from suckers with intact apical dominance (231) and sprouted in sawdust. Differences in total seedlings obtained due to the main effect of the growth media used in sprouting and type of propagules were highly significant.

Seedlings at 2 leaf stage were transplanted into poly bags filled with top soils and assessed for seedling vigour as influenced by

Table 2: Average effect of growth media and type of propagules on sprout counts at critical periods after sowing

Treatments	Days After Sowing				Total Seedlings
	12	**33**	**60**	**88**	
M1 (River Sand	7.22	25.1	40.06	47.33	391.2
M2 (Sawdust)	4.61	17.61	32.72	42.39	304.6
Huli (AP destroyed)	19.71	26.5	39.67	48.83	408
Huli (AP Intact)	0	17.0	33.17	41.50	303.5
Sucker (AP destroyed)	16.33	28.17	44	52.5	441.2
Sucker (AP intact)	0	15.33	29.83	39.67	277.3
Upper Corm (AP destroyed)	0	23.50	39.17	46.33	360.8
Lower Corm (AP destroyed)	0	17.69	32.5	40.33	296.7
GM+	**5.92**	**21.36**	**36.39**	**44.86**	**347.9**
SED (M)	0.89**	1.99***	1.77	1.43**	17.8***
SED (P)	1.54***	3.44**	3.07***	2.47***	30.91***
SED (M X P)	2.18***	4.87	4.34	3.49	43.72
CV (%)	45.1	27.9	14.6	9.5	15.4

** - Significant at P=0.01; *** - significant at P=0.001; GM+ - Grand mean of all treatment

the type of propagule and the source of sprouting media. Seedling vigour was expressed as petiole length and number of leaves per seedling and this generally increased with time showing significant variation due to the source of propagules and growth media used. Seedling vigour expressed as petiole length, generally increased from 6.14 cm to 29.07 cm but were consistently higher on seedlings from river sand and those from propagules whose apical meristems were destroyed (Table 3). Petiole growth of seedlings from river sand were significantly higher than those from saw dust and consistently increased from 8 cm to 33 cm as against 3.9 cm to 2.51 cm (25.1 cm) (sawdust). Significant differences was also observed among type of propagules used in generation of seedlings. Huli and suckers with their apical meristem destroyed had higher seedling vigour than those with intact apical meristem. Petiole growth of seedlings obtained from the upper portion of corms with destroyed apical meristem were lower than huli and suckers with destroyed apical meristem; this ranged from 5.73 cm to 28.3 cm. The lower portion of the corm was not different from the huli and suckers with intact apical meristem.

Leaf growth, was significantly influenced by growth media used for sprouting and type of propagules used to generate the seedlings. Leaf count per seedling generally increased with time from 0.67 to 8.89 within 3 months of initiation of experiment. The highest number of leaves were obtained from seedlings sprouted in river sand and this increased from 0.82 to 9.6 (Table 3). The highest number of leaves was obtained from seedlings generated from suckers and huli whose apical meristem were repressed (10);

Table 3: Average Treatment Effect on Seedling Vigour after Sprouting at Critical Growth Period

Treatments	Petiole length(cm) Days after sprouting				Leaf count/seedling Days after sprouting			
	12	**33**	**60**	**88**	**12**	**33**	**60**	**88**
M1 (River Sand)	8.33	14.77	24.34	33.0	0.82	2.62	8.06	9.6
M2 (Sawdust)	3.94	9.32	18.36	25.14	0.51	1.54	6.80	8.19
Huli (AP destroyed)	115	15.87	24.37	31.63	1.97	2.77	9.07	10.27
Huli (AP intact)	3.5	9.3	17.93	26.38	0	1.47	5.97	7.8
Sucker (AP destroyed)	10.97	16.63	27.93	35.47	2.03	3.57	8.97	10.3
Sucker (AP intact)	2.0	9.58	19.10	26.63	0	1.17	6.60	7.9
Upper Corm (AP destroyed)	5.73	11.22	20.33	28.33	0	2.33	7.5	9.1
Lower Corm (APdestroyed)	3.13	9.65	18.43	25.98	0	1.27	6.47	8.03
GM+	**6.14**	**12.04**	**21.35**	**29.07**	**0.67**	**2.08**	**7.43**	**8.89**
SED (M)	0.88***	0.87***	1.13***	1.14***	0.14	0.36**	0.4**	0.43**
SED (P)	1.53***	1.51***	1.95***	1.97***	0.25***	0.62**	0.69***	0.75**
SED (M X P)	2.16**	2.12	2.76	2.79	0.36**	.088	0.97	1.06
CV (%)	43	21.8	15.8	11.8	65	51.5	16	14.6

** - Significant at P=0.01; *** - significant at P=0.001; GM+ - Grand mean of all treatment
AP - Apical meristem

followed by the upper portion of the corm (9.1); and the least were on lower portion of the corm (8.03), huli (7.8) and suckers (7.9) with intact apical meristem (Table 3).

Since planting material or propagule quality can affect many aspects of seedlings performance like the total number of sprouts, leaf and petiole growth (Tekrong and Egli, 1990), seedling vigour affects vegetative growth in the field and subsequently yields. It has been observed that sprouting behaviour of cuttings or vegetative propagated crops varies with age, genotype and physiological status of the mother plant (Pal, 1980). These may be the factors that significantly influenced the observations for the different parts of the crop used to generate the seedlings. Furthermore, the study confirmed the findings of Kwa (2003) and Tenkouano *et al.,* (2006) that planting in growth chambers where humidity can be adjusted results in a higher production of seedlings especially for planting materials that require some level of warm temperature to develop roots. Removing or destroying the apical meristem increases the number of sprouts as observed by several workers working with bud initiation techniques in plantains and bananas, which have the ability to increase suckering rate with the repression of the apical meristem (Kwa, 2003; Tenkouano *et al.,* 2006; Buah and Tachie - Menson, 2015). Rate of sprout initiation were consistently higher on propagules (huli and suckers) with destroyed apical meristem. And for the media, river sand as reported by Florence *et al.,* (2013) consistently gave higher number of sprouts and higher seedling vigour expressed as petiole length and number of leaves. The suitability of river sand may be explained by the good aeration and drainage characteristics coupled with appropriate temperature regulation due to the high percentage of sand particles present.

Conclusions and Recommendation

It is therefore recommended that the best sources of planting material for seedling production are suckers and huli with destroyed apical meristem and pre-sprouted in a river sand as the growth media. This has the potential of giving a multiplication of 14-16 sprouts per single propagule (20-50 g by weight) as against 9-10 sprouts recorded on the propagules that had their apical meristem destroyed. Corms weighing 100-150 g produced seedlings at a multiplication ratio of 10 to 12 with the upper section producing more seedlings than the lower section. There is a possibility of recording higher number of seedlings per propagule when large sett sizes are used and this requires further investigation. Managing the seedlings in the nursery is critical before transplanting into the field.

Acknowledgement

The Authors gratefully acknowledge the World Bank sponsored West Africa Agricultural Productivity Program (WAAPP), Ghana for providing funds for this study.

References

Baiyeri K. P. 2005. Response of Musa Species to Macro-Propagation. II: The effects of genotype, initiation and weaning media on sucker growth and quality in the nursery. Afr. J. Biotechnol. 4(3): 229234.

Baiyeri K. P and Mbah B N. 2006. Effects of soilless and soil based nursery media on seedling emergence, growth and response to water stress of African breadfruit (Treculia Africana Decne). African Journal of Biotechnology, 5: 1405-1410.

Baiyeri K. P and Aba SC. 2007. A review of protocols for macro propagation of Musa species. Fruit, Vegetables and Cereal Science and Biotechnology 1 (2), 110-115

Baiyeri K. P, Egbufor FC and Ndubizu T.O.C. 1994. Evaluation of sucker production technique infalse horn plantain. Nigerian Journal of Horticultural Science 2, 41-43

Buah JN and Tachie-Menson J.W. 2015. Suitability of bud manipulation tech niques as an alternative to tissue culture in the production of suckers for plantain and bananas. Biotechnology, 14: 41-46

Faturoti B, Tenkouano A, Lemchi J, and Nnaji N. 2002. Rapid multiplication of plantain and banana: Macro-propagation techniques. A pictorial guide, IITA, Ibadan, Nigeria, 12 pp

Florence. A., Gwali S., Ssegawa P., Okullo J.B.L., Tumwebaze S.B., Mbwambo J.R and Muchugi A. 2013. Vegetative propagation of Warburgia ugandensis Sprague: An important medicinal tree species in Eastern Africa. Journal of Medicinal Plants Research Vol. 5(30), Pp. 6615-6621.

Grower, S.T. 1987. Relations between mineral nutrient availability and fine root biomass in two Costa Rican tropical wet forests. Hypothesis Biotropica, 19: 171- 175.

Hartmann H., Kester, D.E. Davies, F.T., And Genve, R.I. 2007. Hartmann and Kester's plant propagation, principles and practices. Seventh edition. Prentice-Hall of India Private limited pp880.

Kwa M. 2003. Activation de bourgeous latents et utilization de fragments de tiqe du bananier pour la propagation en masse de plants en conditions horticoles *in vivo*. Fruits 58, 315-328.

Pal M. 1980. Vegetative propagation of teak by rooting stem cuttings IN Proceedings

Sec. for Conference 1980, 2, 145-148. Cited by M Kathiravan, AS Ponnuswamy and C Vanitha (2009). Determina-Tion of suitable cutting size for vegetative propagation and comparison of propagules to evaluate the seed quality attributes in Jatropha. Natural Product Radiance Vol.8 28), pp162-166.

Swennen R. 1999. Plantain cultivation under West African condition: A reference manual. IITA, Ibadan, Nigeria, 24 pp

Tenkouano A, Hauser S, Coyne D, Coulibaly O. 2006. Clean planting materials and management practices for sustained production of banana and plantain in Africa. Chronica Horticulturae 46, 14-18

Tekrong DM and Egli D.B. 1990. Relationship of seed vigour to crop Yield: A review. Crops Science Vol. 31 #3. P -822