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Abstract
Low multiplication ratio of cocoyam {*Colocasia esculenta* (taro) and *Xanthosoma mafafa* (tannia)} and scarcity of planting materials are major constraints militating against sustainable cocoyam production. During harvesting and processing of cocoyam, very small cormels weighing about 7.0 g (micro cormels) and less are discarded as wastes. These 'wastes' usually sprout in the wet season to constitute environmental problem. The Gocken Multiplication Technology is a new technology developed at the National Root Crops Research Institute (NRCRI), Umudike, Nigeria, for very rapid multiplication of cocoyam by recycling 'wastes' of cocoyam (≤7.0 g cormels) in cocoyam production. The technology utilizes a seed rate of about 0.35 - 0.45 t/ha compared to 1.0-2.0 t/ha currently in use. Total corm + cormel yield ranged from 7.34-15.5t/ha. Similarly, seed harvest multiplication ratio (SHMR) ranged from 19.0-39.0, while available yield ranged from 89.5-94.7 %. Economic analysis showed that the benefit **c**ost ratio was 4.24:1.0, indicating that the technology is profitable by returning N4.24 to every N1.00 spent.

Key words: Gocken; very rapid multiplication; technology and cocoyam.

Introduction
Colocasia esculenta (taro) and *Xanthosoma mafafa* (tannia) are the food cocoyams of economic importance in Nigeria. Nigeria remains the largest producer of cocoyam in the world, with an estimated production of 5.49 million metric tonnes (FAO, 2007). It ranks third after cassava and yam, in terms of total production, land area under crop and importance (National Bureau of Statistics, 2006). A review by Chukwu and Nwosu (2008) and Okoye *et al.,* (2008a) revealed that cocoyam is nutritionally superior to cassava and yam, in terms of digestibility, and contents of crude protein and essential minerals, such as Ca, Mg and P.

To take advantage of the nutritional qualities of cocoyam for healthy living, the NRCRI, Umudike, Nigeria, on 4th June 2009, launched Cocoyam Consumption Awareness Campaign (COCAWAC). Unfortunately, cocoyam is scarce and not easily available and accessible to prospective consumers. This problem is linked with low total output, ascribed to lack of sufficient quantities of planting materials to boost production and the low multiplication ratio of cocoyam. Okoye *et al*. (2007a; 2007b 2008a; 2008b and 2008c) advocated for measures to increase planting materials as a way to enhance yield, technical and allocative efficiency in cocoyam production. During harvesting and crop processing of cocoyam, very small cormels weighing about 7 g (micro cormels) or less, are usually discarded as wastes (Chukwu *et al*., 2008). Incidentally, many of the 'wastes' sprout the following wet season, to become weed and an environmental problem to succeeding crops.

It was against this background that a technology that recycles these 'wastes' (cocoyam cormels weighing ≤ 7g) in cocoyam production was developed. The technology 'Gocken Multiplication Technology' was named after the two leading scientists Drs Godwin O. Chukwu and Kenneth I. Nwosu who developed the technology. The Gocken Multiplication Technology is a pragmatic, very rapid method of multiplying cocoyam. It is simple and a low-input technology. Gocken Multiplication Technology is environmentally friendly and economically viable. It is currently a panacea to the endemic problems of scarcity of cocoyam for food and processing, lack of planting materials, low multiplication ratio of cocoyam and environmental problem of cocoyam as weed to succeeding crop due to the regrowth of volunteer cocoyam where it was harvested the previous season. The paper presents the 'Gocken Multiplication Technology' as a recent advancement in cocoyam research at NRCRI, Umudike, Nigeria.

Materials and methods

The study was carried out at the National Root Crops Research Institute, Umudike, in South-East agro-ecological zone of Nigeria. The soils ranged from sandy to loamy- Haplic Acrisols (FAO/UNESCO) and Arenic Paleudults ;Typic Paleudults (USDA)(Chukwu, 2007).The area is warm and humid. Annual rainfall ranged from 1911-2184 mm with temperatures of 26- 30^{0}C and a relative humidity ranging from 53- 83 %.

Experimntal design used in the study was a split plot arrangement with three replications. Main plot treatments were variety (NCe 001 and NCe 003) and mulch (rice mill waste and wilted *Panicum maximum*). Sub plot treatment was type of planting material (micro cormels or micro setts that is cut setts) of 7.0 g each. Poultry manure was applied at the rate of 2.0 t/ha in shallow groves on the crest of ridges before planting, at a spacing of 1.00 m x 0.20 m, on 5.0 m x 4.0 m plots to give a plant density of 50,000 plants/ha. The mulch were applied at the rate of 4.0 t/ha. A mixture of primextra and paraquat was applied as pre-emergent herbicide. At six (6) weeks after planting, 400.0 kg/ha of NPK 15:15:15 was applied as basal dressing. Harvesting was done at 7 months (December) after planting. Seed harvest multiplication ratio (SHMR) was calculated thus:

QH/QP……………………………………………1

Where QH= quantity harvested; QP= quantity planted.

Available yield (AY) (%) was calculated using the formular:

QH-2QP/QP x 100……………………………...…2

Where QH and QP are as defined above. Data collected were statistically analysed using analysis of variance.

Results and Discussion

Results showed that total yield (corm + cormel), corm yield, primary, secondary and tertiary cormel yields ranged from 9.17-14.3, 2.47-3.10, 3.36-5.05, 2.96- 4.57, 0.66-1.55 t/ha respectively (Table 1). The multiplication ratio and available yield ranged from 23.0-33.0 and 90.8-93.5%. Generally, among the cormel types, yields decreased in the magnitude of primary cormels > secondary cormels > tertiary cormels. *Panicum* mulch out-yielded rice mill waste mulch in total yield by 11.5 %. Similarly, cultivar NCe 003gave 5.26 % higher significant ($p \leq 0.05$) total yield than NCe 001. A comparison of total yields between micro cormels and micro setts showed that micro cormels significantly ($p \leq 0.05$) out-yielded micro setts by over 50 %. Coefficient of variability was highest (49.6%) for tertiary cormel yields and least (13.1%) for total yields due to effects of mulch, cultivar and type of planting materials used. *Panicum* mulch resulted in 7.40 % higher SHMR than rice mill waste (RMW) mulch. Similarly, NCe 001 is superior to NCe 003 in multiplication ratio and micro cormel gave over 40.0% SHMR than microsett. The higher total yields from *Panicum* mulch, NCe 001, and micro cormels over RMW, NCe 003, and microsett, respectively, explained the observed differences in SHMR. However, available yield was over 90.0 % among the treatments, reflecting in very low (< 2.00 %) coefficient of variability. This is also a measure of profitability because a farmer who adopts the Gocken technology, after removing twice of what was planted should have over 90.0 % of materials left for consumption, sale or processing.

Table 1. Effects of Mulch, Variety and Planting Material on Total (corm+cormel) Yield, Yield of Cormel Types Seed Harvest Multiplication Ratio (SHMR) and Available Yield.

	Mulch type		**Cultivar**		**Planting material**			
Parameter	**RMW**	**Panicum**	**NCe 001**	**NCe 003**	**Mcormel**	**Ms**	**SE**	**CV(%)**
Total yield (t/ha)	11.3	12.6	11.4	12.2	14.0	9.39	0.37	13.1
Corm yield (t/ha)	3.10	2.93	2.53	3.00	2.86	2.37	0.10	15.6
Pimary cormel yield (t/ha)	3.87	5.0	4.67	3.7	5.05	3.3	0.18	17.3
Secondary cormel yield (t/ha)	3.52	4.0	3.57	3.9	4.57	2.9	.15	16.1
Tertiary cormel yield (t/ha)	0.81	0.6	0.73	1.5	1.55	0.7	0.12	49.6
SHMR	27.0	29.0	29.0	26.0	33.0		0.81	12.1
Available yield (%)	92.0	92.0	92.1	92.0	93.5	90.0	0.27	1.22

Where RMW= rice mill waste; Mcomel= micro cormel; Msett= microsetts; SHMR= seed harvest multiplication ratio.

Table 2 shows the effect of micro cormel and micro sett in relation to yields and yield components. Micro cormels of cultivar NCe 001 out-yielded the micro sett in all parameters assessed. For instance, the cormel total yield and SHMR were higher when micro cormels were used than micro setts by 111.8% and 105.3% respectively. The lower percentage establishment (32.0- 49.0 %) of micro setts of NCe 001 as against 70.0-84.0 % establishment of the cormels accounted for the differences in the yields obtained. Nevertheless, the yields compared favourably with yield figures commonly reported when 50.0- 100.0 g setts were planted (Obasi et al., 2005, 2008). Similarly, micro cormel of NCe 003 out-yielded its micro sett by 18.2 %. The results suggest that micro cormel of NCe 001 generally out yielded that of NCe 003 but the reverse were observed with their micro setts. The microsett of NCe 003 resulted in 49.0 % higher significant ($p \leq 0.05$) total yield than that of NCe 001. This is attributable to 32.0- 49.0 % establishment of microsetts of NCe 001 relative to 70.0-87.0 % establishment by microsetts of NCe 003. This is explained by differences in the number of buds 'eyes' from where sprouts could emerge as viewed through a hand lens. An average of 5.00 buds /cut sett of 7.00 g for NCe 001and 10.0 buds for NCe 003 was observed. In terms of primary cormel yield, and SHMR, cormels of NCe 001 was 75.7 % and 44.4 % significantly ($p \leq 0.05$) higher than that of NCe 003.This could be explained by bigger sizes of cormels from NCe 001with higher weights than cormels from NCe 003. The available yield is high, ranging from 89.0to 94.0 %.Economic analysis showed that the benefit **c**ost ratio was 4.24:1.0 indicating that the technology is profitable by returning N4.24 to every N1.00 spent.

Table 2. Yields and Yield Components as influenced by Micro Cormels and Micro Setts of Cultivars.

	NCe 001		**NCe 003**			
Parameter	**Micro cormel**	**Micro sett**	**Micro cormel**	**Micro sett**	**SE**	**CV (%)**
Total yield(t/ha)	15.5	7.34	13.0	11.0	0.86	29.4
Corm yield (t/ha)	3.15	1.79	3.01	2.98	2.00	29.1
Primary cormel yield(t/ha)	6.43	2.88	3.66	3.83	0.39	37.4
Secondary cormel yield (t/ha)	5.05	2.08	4.08	3.83	0.31	32.9
Tertiary cormel yield (t/ha)	0.87	0.59	2.23	0.81	0.19	66.1
SHMR	39.0	19.0	27.0	26.0	2.07	29.9
Available yield (%)	94.7	89.5	92.3	92.1	0.55	2.39

The implications of the results include: the widely held view that the yields of tuber crops are dependent on the size of material planted, may no longer hold (at least for cocoyam), since 7g cormels and 7 g setts out-yielded yields from 50- 100g setts planted (Obasi et al., 2005, 2008). More planting materials will be available for breeding, germplasm distribution and seed multiplication, consumption, and processing. Corms and cormels bigger than 7g could be consumed and processed, leaving the small-sized cormels for production.

Conclusion.

The Gocken multiplication technology is a novel approach for very rapid multiplication of cocoyam. It could save over 0.50 t/ha of planting material when compared with the popular minisett technology or over 1.60 t/ha of planting material when 100 g setts were used. It could also result in much higher yields and higher multiplication ratio than any currently practiced method of cocoyam production. The technology is profitable by returning N4.24 to every N1.00 spent.

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