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RESEARCH ARTICLE

GOCKEN TECHNOLOGY: ENHANCING HEALTH OF HAPLIC ACRISOLS AND MULTIPLICATION OF TARO IN NIGERIA

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ABSTRACT

The National Root Crops Research Institute (NRCRI), Umudike, Nigeria, developed Gocken Rapid Multiplication Technology (GRMT) as a solution to twin challenges of declining soil fertility and scarcity of taro (*Colocasia esculenta* (L) Schott) planting materials. This was demonstrated in a field experiment conducted on a Haplic Acrisol (FAO/UNESCO) correlated with dystric Typic Paleudult (USDA) at Umudike (5°24[1] to 5°30[1] N; 7°31[1]N to 7°37[1] E), southeast agro-ecological zone of Nigeria, in 2008 and 2009 cropping seasons. The experiment was a split plot design with three replications. Main plot treatments were taro varieties: cv NCe 001 and NCe 003 and mulch (rice [*Oritza sativa]* mill waste, and wilted *Panicum maximum* at 4 t/ha + NPK 15 15 15 at 400 kg/ha respectively, and a control). Results showed that total yield ranged from 17.0 – 25.0 t/ha and seed harvest multiplication ratio (SHMR) ranged from 33 - 75. Post cropping soil analysis showed an improvement in soil pH (H_20) by 16.7 – 18.9 %, organic matter by 66.7 – 84.1 %, total N by 66.7%, available P by 30.4 – 39.1 % and exchangeable K increased by 83.3 - 200 % on plots that received integrated plant nutrient relative to control plot. GRMT is therefore recommended as a new agronomic approach to enhance soil health and very rapid multiplication of taro.

INTRODUCTION

In Nigeria, cocoyam is a generic name for *Colocasia esculenta* (taro) and *Xanthosoma mafafa* (tannia). They are staple edible aroids popularly known as Nigeria's giant crop (Chukwu, 2011). Taro is grown primarily for its corms and cormels and secondarily for its flower and leaves. Taro is the fifth most harvested root crop in the world with production estimated at 9.0 million tonnes for 2011(FAO, 2012). Nigeria maintains the lead among cocoyam producing nations, with an annual production of 4.55 million metric tonnes in 2012, representing 61.2 and 43.1 % total production in West Africa and Africa, respectively (FAO, 2012). She also accounted for 34.3, 46.2 and 62.3 % of land area under cocoyam in the world, Africa and West Africa, respectively within the same period. In Nigeria, cocoyam ranks third after cassava and yam among staple roots and tubers crops, in terms of importance, total output and area under production. It has high economic potentials, not only as food (main meal, snacks and adjunct in thickening soup) but as an agro-industrial raw material for pharmaceutical, confectionery, and livestock industries (FAO, 1990, Kudu *et al*., 2012).

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In Nigeria, the bulk of cocoyam produced is consumed as food, either as a primary product (corm, cormel, leaves and the inflorescence) or as a secondary product (flour, cake, crisp, and chip) (Akomas *et al*., 1987). Cocoyam is nutritionally superior to cassava and yam, in terms of digestibility because of its smaller starch grain size (FAO1990). In phyto-medicine, Ilonzo (1995) reported that diabetic patients placed on a diet of roasted cocoyam (tannia) eaten with palm oil for three months would regain their health. Similarly, in clinical health management, Kundu *et al*., (2012) identified a novel potential therapeutic agent derived from taro that potently and specifically inhibits tumour metastasis. Sustainable production of taro in Nigeria is threatened by declining soil fertility, scarcity and high cost of planting materials (Chukwu, 2011). The NRCRI Umudike, Nigeria, which has national mandate for root and tuber crops research in Nigeria, launched Cocoyam Re-birth Initiative (CRI) in 2007 to increase awareness on nutritional, health and economic importance of cocoyam. The campaign was so great that Akoroda (2012) remarked that the "*fire*" of the re-birth programme glows on, as buttressed by a shift from cassava and yam production to cocoyam by many farmers, especially in Oshimili North Local Government Area, Delta State (Chukwu *et al*., 2010). Rapid multiplication techniques help to overcome the low multiplication ratio that is common in vegetative propagated crops like cassava, yam and cocoyam. Multiplication ratio is the increase in planting material over what was planted (Okoli, 1993). Attempts to solve the problem of scarcity of planting materials in cocoyam was initiated by Okonko (1983) who found that apical shoot of *C esculenta* could be used as planting material provided a small portion of it, about1 cm of the corm or cormel flesh was still attached. This led to the development of cocoyam minisett technology (Udealor, 1983; Udealor and Arene, 1986). The technology was standardised by using 25 g of planting material. Udealor, (1983) reported that yields under minisett technology could range from 15 – 20 t/ha which is higher than yields obtained 100 g sett or more used by farmers. Arene *et al*., (1987) reported that the minisett technology resulted in increased multiplication ratios of cocoyam from 1: ≤ 15 under farmers' farms to1: 18 - 23.

Sarkar *et al*. (989) reported that long - term application of fertilizers and manures in India increased crop yields and response to major nutrients was higher on plots that received organic manure along with mineral fertilizers. In a related long – term trial with 13 years of continuous cropping (Acharya, *et al*., 1988) found that treatments that received farmyard manure + 100 % of the recommended N, P and K fertilizers improved soil physical properties as well as organic carbon content, available N, P and K of the soils and resulted in significant higher crop yield than other treatments. Surprisingly, the effect of IPNS on crop and soils is similar to observation in fishery nutrition by Sarkar (1988) who reported that application of cow dung and poultry manure together or separately did not produce significant influence on fish yield but addition of single superphosphate and or urea along with poultry manure significantly increased fish yields. Similarly, Sharma *et al*., (1990) found a marked improvement in residual soil fertility due to organic matter application as estimated by organic carbon, and available N, P and K contents after harvest. The objective of this paper is to present Gocken Rapid Multiplication Technology (GRMT) as a panacea to declining soil fertility and low multiplication ratio of taro.

The Emergent of "Gocken" Technology

In the course of human development and increasing knowledge, neologisms (words or terms that have recently been coined, but generally do not appear in any dictionary, but may be used widely or within certain communities) are introduced. Apart from broadening human knowledge neologisms make research researcher-friendly. Specific examples abound. In 1840, William Whewell of Trinity College, Cambridge, introduced the term "scientist" into English language; in 1909 Wilhelm Johannsen coined the following terms: gene, genotype and phenotype; in 1919, Kark Ereky, a Hungarian scientist introduced the word biotechnology (Witt, 1990).

In pedological science, Professor Alex McBratney, in 1992, introduced "pedometrics" as a term that quantitatively considers soils in their natural setting (Bouma, 1997). Similarly, "Kriging" a geostatistical tool that accounts for spatial dimension of soil parameters at unsampled locations (Oliver, 1987) is an eponym derived from D.G. Krig who developed the theory of regionalized variables. Against this background, "gocken" is an eponym derived from Drs Godwin Ogbonnaya Chukwu and Ken Nwosu, two Nigerian scientists, who developed this technology that accounts for very rapid multiplication of cocoyam and soil health management.

MATERIALS AND METHODS

The study area

The study was conducted at NRCRI, Umudike (05^0 29^1 N; 07^0 33^1E), south-east agro-ecological zone of Nigeria, on a sandy loam Haplic Acrisol with udic and isohyperthermic soil moisture and temperature regimes in 2008 and 2009. The experimental site is typical of highly degraded Orlu Series in soils of Ikwuano Local Government Area with silt: clay ratio ranging from 0.19 to 0.33 in the epipedon (Chukwu, 2014). The experiment was a split plot design with three replications. Main plot treatments were taro varieties: cv NCe 001 and NCe 003 and mulch (rice [*Oritza sativa*] mill waste, and wilted guinea grass (*Panicum maximum*) and control without mulch). Sub plot (5 m x 4 m) treatments were planting materials comprising whole uncut micro cormels and cut setts (micro setts) were 7 g each (Plate 1). Such tiny cormels are commonly discarded in the field by farmers during harvesting or processing. This explains why cocoyam commonly constitute weed to subsequent crops grown after cocoyam in the next cropping season. Pre-cropping composite soil sample was collected at 0 – 20 cm depth. Poultry manure was applied to all the plots except the control, at the rate of 4 t/ha in May each year in shallow grooves made on the crests of the ridges (Plate 2).

Plate 1. Micro cormels and micro setts

Plate 2. Incorporation of poultry manure

This was followed immediately by planting at a spacing of 1 m x 0 .20 m to have a plant density of 50, 0000 plants/ha. The mulches were applied at the rate of 4 t/ha. Pre - emergent herbicide (premextra) was applied 48 hours after planting at the rate of 350 ml in 20 litres of water. At six (6) weeks after planting, 400 kg/ha of NPK 15 15 15 was applied as basal dressing on the mulched plots excluding the control. Earthening up was done using hoe or spade at two weeks after fertilizer application by hoeing from furrow to crest to heap up soil on the base of the plant, to re-build and fatten ridges reduced by soil erosion, to cover corms and cormels exposed by soil erosion and reduce direct heat effect on exposed corms and cormels to minimize rot at harvest. At 7 months after planting (December), the plants senescenced and matured for harvest. Harvesting was done using digging fork but care was taken to minimize bruises or cut on corms and cormels. Post cropping soil samples were collected from each plot to evaluate of the effect of treatments on soil health. Seed harvest multiplication ratio (SHMR) was calculated as a quotient of the quantity harvested over the quantity planted thus:

SHMR = QH/QP...1.

Where QH = quantity harvested; QP = Quantity planted.

Percentage available yield (AY) was calculated using the formula:

AY (%) = QH - 2QP/QP x 100 ...2

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

Laboratory Analysis

Soil sample preparation involved air-drying at room temperature and crushing the air – dried samples gently with a wooden roller before sieving with a 2-mm sieve. Particle size distribution was analyzed following the modified hydrometer method (Gee and Or, 2002), using sodium hexametaphosphate (calgon) as a dispersant. Total N was determined by the micro Kjedahl wet oxidation method (Bremner, 1996). Organic carbon was determined by the method of Nelson and Sommers (1982), and this was converted to organic matter by multiplying the percentage carbon by 1.724. Exchangeable bases were extracted with neutral 1N ammonium acetate (NH_4OA_C) solution. Subsequently, Ca and Mg were determined by EDTA titration while K and Na were determined using flame photometry. Exchangeable acidity was determined by KCl extraction, following the procedure of Mclean (1982). Effective cation exchange capacity (ECEC) was obtained by summation of total exchangeable bases (TEB) (Ca, Mg, K and Na) and exchangeable acidity. The base saturation was calculated by multiplying the quotient obtained after dividing TEB by ECEC by 100. Soil pH was determined in distilled water using Bechman's zeromatic pH meter, in a soil: liquid ratio of 1:2.5 (Thomas, 1996).

RESULTS AND DISCUSSION

Table 1 shows that the mulches applied contained appreciable amounts of the primary nutrients (N, P and K). The *Panicum maximum* is slightly richer than rice mill waste (RMW) in percentage N and P by 19.0 and 20.0 %, respectively but lower in percentage K by 17.2%.

Table 1. Primary nutrient contents of the mulches applied.

Type of mulch	Primary Nutrients		
	N (%)	P (%)	K (%)
Guinea grass *(Panicum maximum)*	0. 25	0. 30	0. 29
Rice (*Oritza sativa*) mill waste	0. 21	0. 25	0. 34

The implication is that mineralization of the mulches will increase the amount of these nutrients in the pool for absorption by plant roots to enhance crop nutrition, growth and crop yield, at one hand and recapitalization of depleted soil resources. Table 2 shows that the experimental sites in 2008 and 2009 are acidic with medium loamy texture and low in total N and exchangeable K but medium in available P and organic matter contents, based on critical levels for these nutrients for optimum crop production in soils of south-eastern Nigeria (Enwezor *et al*., 1989).

Table 2. Selected soil characteristics of the experimental sites

Parameters	2008	2009
Sand (%)	69.0	72.0
Silt (%)	8.00	5.00
Clay (%)	25.0	23.0
Textural class	Sandy clay loam	Sandy clay loam
pH(H_20)	5.00	5.20
Total N (%)	0.09	0.08
Available P (mg/kg)	20.0	25.4
Organic carbon (%)	1.25	1.40
Exchangeable Ca (cmol/kg)	0.69	0.78
Exchangeable Mg (cmol/kg)	1,34	1.36
Exchangeable K (cmol/kg)	0.09	0.08
Exchangeable Na (cmol/kg)	1.00	2.00
Moisture regime	Udic	Udic
Temperature regime	Isohyperthermic	Isohyperthemic

Effect of mulch on total yield (Tables 3 and 4) showed that plots that received rice mill waste (RMW) and *Panicum* significantly ($p \geq 0.05$) out – yielded the control in corm, primary cormel, secondary cormel, tertiary cormel, and total yields as well as SHMR and available yield. Total yield was higher in mulched plots by a range of 7.7 to 10.1 t/ha than the control, representing 220 to 168.3 % increase in total yield over the control. Corm yield ranged from 3.00 to 5.60, 2.93 to 5.38, and 1 .00 to 2.50 t/ha respectively for RMW, *Panicum* and control plots from 2008 to 2009.

Table 5 shows the effect of the treatments on sustainable soil health management.

Table 3. Treatment effects on corm and cormel yields, SHMR and available yield in 2008

Treatments		Corm(t/ha)	Types of Cormels (t/ha)			Total Yield (t/ha)	SHMR	AV (%)
			Primary	Secondary	Tertiary	Corm+ Cormel		
Mulch Type	RMW	3.00	3. 87	3. 52	0. 81	11. 2	27.0	92.0
	Panicum	2.93	5. 00	4. 00	0. 60	12. 6	29.0	92.0
	Control	1. 00	2. 00	0.50	0	3. 50	9.00	45.8
Cultivar	NCe 001	2.53	4.67	3.57	0.73	21. 4	33.0	92.1
	NCe 003	3.00	3.70	3.90	1.50	12. 3	35.0	92.0
Planting material	Mcormel	2. 86	5. 05	4. 57	1. 55	14. 0	33.0	93.5
	Msett	2. 37	3. 30	2. 90	0. 70	9. 39	30.0	90.0
	SE	0. 37	0.18	0.15	0.12	0.37	0.81	0.27
	CV (%)	13.1	15.6	17.3	49.6	13.1	12.1	1.22

Where: Mcormel = Micro cormel; Msett = Micro sett; AV = Available yield; SHMR = Seed harvest multiplication ratio; RMW = Rice mill waste.

Table 4. Treatment effects on corm and cormel yields, SHMR and available yield in 2009

Treatments		Corm (t/ha)	Types of Cormels (t/ha)			Total Yield (t/ha)	SHMR	AV (%)
			Primary	Secondary	Tertiary	Corm + Corm		
Mulch Type	RMW	5.60	5.50	4. 00	1. 00	16. 1	27.0	94.0
	Panicum	5.38	4.00	3. 00	1. 42	13. 8	26.0	94.0
	Control	2.50	2.50	0.50	0.50	6. 00	11.0	55.8
Cultivar	NCe 001	5.73	8.38	4.25	0.72	22.8	42.0	93.1
	NCe 003	7. 64	10.0	3.95	2.71	24.0	71.0	92.0
Planting material	Mcormel	4.50	5. 05	4. 57	1. 55	24.5	39.0	94.5
	Msett	3.50	3. 30	4. 90	1.00	18.3	35.0	92.0
	SE	0.16	0.18	0.15	0.12	0.37	0.81	0.28
	CV (%)	17.4	15.6	17.3	49.6	13.1	12.1	1.12

Table 5. Percentage Improvement in Soil Health by Soil Amendments over Control (Mean of Two Years)

Soil Amendment	Soil Fertility Parameters				
	pH (H_20)	Organic matter (%)	Total N (%)	Available P (mg/kg)	K^+ (cmol/kg)
Control	4.80 -	1.26 -	0.06 -	23.0 -	0.06 -
Panicum at 4 t/ha + NPK 15 15 15 at 400 kg/ha	5.60 (16.7)	2.10 (66.7)	0.10 (66.7)	30.0 (30.4)	0.11 (83.3)
Rice mill waste at 4 t/ha + NPK at 400 kg/ha	5.70 (18.9)	2.32 (84.1)	0.10 (66.7)	32.0 (39.1)	0.18 (200.0)

NB: Numbers in parenthesis represent percentage increase over the control.

Tertiary cormels yields ranged from 0.60 to 1.42 t/ha on mulched plots (RMW and *Panicum*), and 0 to 0.50 t/ha on the control plots suggesting that improvement. Cultivar effects (Tables 3 and 4) showed that mean total yield for 2008 and 2009 cropping seasons for NCe 001 (22. 1 t/ha) was slightly higher than that of NCe 003 (18. 2 t/ha). Total yield ranged from 21.4 to 22.8 t/ha for NCe 001 and 12.3 to 24.0 t/ha for NCe 003 from 2008 to 2009 cropping seasons, respectively.

Similarly, seed harvest multiplication ratio (SHMR) ranged from 33 to 42 and 35 to 71 for NCe 001 and NCe 003, respectively within the cropping seasons. However, available yield was high (90.0 to 94. 5) among the cultivars within the two years. This shows that the technology is productive because the farmer will have enough materials for sale or for consumption after removing twice what was planted to sustain and expand the scale of production (Okoli, 1978). Effect of planting material showed that micro cormels had no significant difference in corm yield with micro sett but it had significantly higher yields of primary, secondary and tertiary yields than micro setts. Similar trend was observed in total yield, SHMR and available yield (Tables 3 and 4). It is interesting to note that SHMR ranged from 30 for micro sett to 33 for micro cormel. Generally, treatment effects on mean SHMR was in the magnitude of planting materials > cultivar > mulch type.

Post cropping soil analysis showed an improvement in soil pH (H_20) by 16.7 – 18.9 %, organic matter by 66.7 – 84.1 %, total N by 66.7%, available P by 30.4 – 39.1 % and exchangeable K increased by 83.3 - 200 % on plots that received integrated plant nutrient (the GRMT) relative to control plot. The GRMT involves not just the use of micro cormels and micro setts weighing about 7 g as planting materials, but includes an integration of organo-mineral soil amendment. This is the only way it can solve the twin problems of scarcity of planting materials and improvement in health status of highly degraded soils. The boost in total yield which resulted in enhanced available yield and multiplication ratio over the control showed that GRMT improved the productivity of taro as reported for yam by Okoli (1993). Both available yield and multiplication ratio (indices of the ability of planting materials to multiply itself) are factors of productivity recommended for selecting breeding lines in yam (Okoli, 1993). The GRMT resulted in 83.3 – 226.0 % increase in multiplication ratio over what Udealor and Arene (1986) and Arene *et al*. (1987) obtained with cocoyam minisett technology. This is good news because it will make more planting materials available to potential cultivators and reduce high cost of planting materials. The GRMT has the following advantages over minisett technology.

- GRMT recycles cocoyam cormels weighing ≤ 7.0 g, usually discarded as wastes at harvest or processing.
- There is reduction in seed rate from 1 - 2 t/ha in minisett to 0.45 t/ha in GRMT, saving more materials to scale up production, for consumption or sale.
- Cost of planting materials is my implication, drastically reduced with GRMT.
- Total yield could be increased from 15 - 20 t/ha in minisett (Udealor, 1983) to 15 - 25 t/ha under GRMT.
- Seed harvest multiplication ratio could range from 33 – 75 in GRMT as against 18 – 23 reported for minisett technology.

Since GRMT is rooted on the basic concept underlying integrated plant nutrition system (FAO, 1989), the poultry manure applied at planting, probably, increased pool of available soil nutrients at early and crop developmental growth stages. This was most likely sustained by mineral fertilizer applied at six weeks after planting to satisfy plant requirement for nutrients at the mid season growth stage characterized by anthesis and bulking. All these explained the higher yield and multiplication ratio obtained in GRMT over what Udealor and Arene (1986) and Arene *et al*. (1987) obtained in minisett technology. It is evident that pH, organic matter, total N, available P and exchangeable K were appreciably higher in plots that received integrated plant nutrition (GRMT) relative to the control plot. The observation is in consonance with reports by Acharya, *et al*. (1988) and Sharma *et al*., (1990) in related studies. In natural resource accounting, native soil nutrients are capital which is depleted during cropping as observed in the present study. Consequently, improvement in soil fertility by GRMT is a recapitalization of the depleted soil resource and an enhancement of soil health, in line with Nigerian Soil Health Consortium (NSHC) Project reported by Chukwu *et al*., (2014)

Conclusion

The GRMT is therefore recommended as a novel approach to very rapid multiplication of taro and soil recapitalization to boost its production and improve soil health.

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