ISSN:1511-3701

Pertanika Journal of

TROPICAL Agricultural Science

VOLUME 26 NO.1
MARCH 2003

A scientific journal published by Universiti Putra Malaysia Press

Pertanika Journal of Tropical Agricultural Science

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Published by Universiti Putra Malaysia Press
ISSN No.: 1511-3701

Pertanika Journal of Tropical Agricultural Science

Volume 26 Number 1 (March) 2003

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Pertanika J. Trop. Agric. Sci. 26(1): 1 - 5 (2003) ISSN: 1511-3701

Input Energy Requirements for Processing Convenient Chicken Products

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Keywords : Energy, chicken, poultry gizzard

ABSTRAK

Bagi menaksir pengeluaran ekonomi stok ayam yang dimasak dan stok hempedal burung yang dimasak, data ke atas hasil produk, keperluan tenaga input output dan perbezaan kualitatif produk-produk tersebut yang diproses secara manual pada skala eksperimen telah dikumpulkan. Sejumlah lapan ujian termasuk empat replikasi telah dilakukan untuk setiap produk. Penyediaan stok ayam yang dimasak menjadikan 46.24% dan 69.01% untuk daging ayam mentah dan dibuang kulit masing-masing. Sebaliknya pemprosesan stok hempedal burung yang dimasak menghasilkan 36.79% dan 60.05% produk untuk hempedal burung yang mentah dan dibuang lemak. Kajian perintis ke atas keperluan tenaga input mendedahkan keperluan untuk 0.765 MJ tenaga manusia (hE) dan 2.617 MJ input elektrik diperlukan untuk memproses satu kg hempedal burung yang mentah; manakala 1.138 MT adalah tenaga manusia dan 3.148 MJ input elektrik diperlukan untuk memproses satu kg hempedal burung yang mentah Sampel analisis fizik-kimia menunjukkan nilai tekanan ricih yang lebih baik untuk stok hempedal burung yang dimasak tetapi keseluruhannya penerimaan produk tidak secara signifikannya (P<0.05) berbeza. Walau bagaimanapun, lebih output kalori dikira daripada stok hempedal burung yang dimasak (333 Cal/100 g) daripada stok ayam yang dimasak (315 Cal/100 g). Berdasarkan kadar pasaran bahan digunakan yang sedia ada dan keperluan tenaga input, pemprosesan stok hempedal burung yang dimasak didapati berkos efektif (22 Cal/rupee) dibandingkan dengan stok ayam yang dimasak (17 Cal/rupee).

ABSTRACT

In order to assess the economic production of cooked chicken stock and cooked gizzard stock, data were collected on product yield, input output energy requirements and qualitative differences in these products processed manually at experimental scale. A total of eight trials, including four replicates, were done for each product. Preparation of cooked chicken stock rendered 46.24% and 69.01% yield for raw and de-skinned chicken meat respectively, whereas the processing of cooked gizzard stock yielded 36.79% and 60.05% product for raw and de-fatted gizzard respectively. Pilot studies on input energy requirements revealed the need for 0.765 MJ human energy (hE) and 2.617 MJ electrical inputs for processing a kilogram (kg) of dressed chicken; while 1.138 MJ human energy and 3.148 MJ electrical inputs were required to process a kg of raw gizzards. Physico-chemical analysis of samples showed greater shear press value for cooked gizzard stock but overall acceptability of products was insignificantly (P<0.05) different. However, more caloric outputs were calculated from cooked gizzard stock (333 Cal/100 g) than from cooked chicken stock (315 Cal/100 g). Based on the existing market rates of the ingredients used and input energy requirements, the processing of cooked gizzard stock was found to be cost effective (22 Cal/rupee) as compared to cooked chicken stock (17 Cal/rupee).

INTRODUCTION

To a great extent, the growth of fast food industry depends upon the cost of processing which is based on the cost of inputs, including the energy used. In this context many workers (Ostrander 1980; Singh and Dhingra 1987; Sachdevl *et al.* 1995) have published their findings on the application of energy in food processing. In order to facilitate the optimal use of energy through its proper audit during product development/commercial processing, the present study was aimed at standardization of input energy requirements as well as estimation of product yield for cooked gizzard stock and cooked chicken stock where such information collected for the first time may be expected to

pave the way for future developments in a food processing economy.

MATERIALS AND METHODS

A total of eight replicates including 4 trials for each product were undertaken for which 50 kg of dressed chicken and 45 kg of gizzard were collected from pilot poultry processing plants in the Division of Post Harvest Technology of Central Avian Research Institute, Izatnagar. Cooked chicken stock and cooked gizzard stock were prepared after de-skinning of dressed chicken/removal of adipose tissue from gizzard and utilizing recipe/formulation methodology of Sachdevl *et al.* (1996). The percent product yield was defined as –

Product yield (%) = (weight of product x 100)/ weight of dressed chicken or gizzard

Estimation of Input Energy

Quantification of human energy (hE) and electrical inputs (EI) utilized in preparation of cooked chicken stock as well as cooked gizzard stock was done through recording of time consumed at particular steps of processing such as cleaning and cutting of meat/gizzard, weighing, frying of condiments and pressure cooking, etc. Observations on electrical inputs were based on preparation of products with the help of a 1500 watt hot plate. Pressure-cooking was performed at 1.1 kg/sq. cm for 10 ± 2 min. Calculation of hE and EI was done as stated below:

Man hours/kg = Average time taken in the processing / Average quantity of organ used x 60

1 man hour/kg = 1.96 MJ (Panesa and Bhatnagar 1987)

E1 (kWh) = Watt x Time (min/(1000 x 60)

EI/kg chicken for gizzard = EI (kWh/Average quantity (kg) of chicken or gizzard processed

1 kWh/kg = 11.93 MJ (Panesar and Bhatnagar 1987)

Physico-chemical and Sensory Traits

Proximate characters including pH, percent – moisture, crude protein (CP) and ether extract (EE) were analyzed as per standard methods of AOAC (1990). Shear force value was determined in kg/sq. cm by using Warner Bratzler Shear Press (Model 13806). A minimum of three samples was taken for recording the observations of each trait. Sensory characteristics including colour, flavor, juiciness, tenderness, texture and overall acceptability of cooked chicken stock and cooked gizzard stock were estimated on a 10 point Hedonic Scale (1= extremely poor, 10=excellent) by a minimum of 7 panelists randomly taken from the professional staff of this institute.

Output Energy

The nutritional energy (Cal/100 g) of these products was determined using the formula of Shackleford *et al.* (1989).

Statistical techniques (Snedecor and Cochran 1967) aiming at determination of means, standard error and Duncan's multiple range test have been applied to check and confirm the validity of the findings and the obtained database has been presented in the tabular form.

RESULTS AND DISCUSSION

Yield and Product Quality

Means of percent product yield (Table 1) showed higher recoveries from dressed chicken as compared to that from gizzards. In fact, this effect is caused by the amount of inedible proportion of tissues present over the gizzard, which is generally formed by the superficial fat and other inedible materials. In spite of lower gains from raw gizzards, the economic aspects of processing were eminent due to its cheaper cost as being the less preferred organ in India. Percent product yield determines the commercial viability of the food products developed, hence these observations formed the basis for further efforts to improve upon the product yield.

Physico-chemical and sensory traits, generally, did not reveal significant differences ($P<0.05$) in the quality of experimental products (Table 1).

TABLE 1
Mean observations of product yield, physico-chemical and sensory characteristics

Parameters	Cooked stock	
	Chicken	Gizzard
Weight(kg) of raw organ/dressed meat percent	50.00	45.00
Product yield		
c) on raw organ weight	46.24±1.23[a]	36.79±0.98[b]
d) on cleaned organ weight	69.01±2.01[a]	60.05±1.67[b]
pH	5.86±0.87[a]	5.45±0.18[a]
Shear force value (1b/s. inch)	0.23±0.05[a]	0.30±0.04[b]
Moisture (%)	52.19±1.78[a]	54.51±3.07[a]
Crude protein(%)	31.83±1.96[a]	30.21±2.27[a]
Ether extract (%)	9.21±0.34[a]	11.84±0.93[b]
Colour	8.31±0.77[a]	7.93±0.48[a]
Flavor	7.57±0.29[a]	7.66±0.19[a]
Juiciness	7.56±0.45[a]	7.46±0.33[a]
Tenderness	7.52±0.31[a]	7.05±0.18[a]
Texture	7.96±0.66[a]	7.58±0.27[a]
Overall acceptability	8.20±0.73[a]	7.66±0.59[b]

N=8
Figures bearing identical superscripts did not differ significantly (P<0.05) between columns

TABLE 2
Energy consumption profile for processing cooked chicken stock

A. Human

Parameter	Time Taken		Man Hours/ kg dressed Chicken	Energy(MJ)/ kg dressed chicken
	Minutes	(%)		
1. De-skinning	130	32.50	0.127	0.248
2. Washing	15	3.75	0.015	0.029
3. Peeling garlic and ginger	35	8.75	0.034	0.066
4. Weighing condiments	30	7.50	0.029	0.057
5. Frying condiments	20	5.00	0.020	0.039
6. Grinding garlic and ginger	15	3.75	0.015	0.029
7. Pressure cooking of meat	45	11.25	0.044	0.086
8. Enrobing	10	2.50	0.009	0.019
9. Oven treatment	55	13.75	0.054	0.106
10. Packing	45	11.25	0.044	0.086
Total	400	100.00	0.291	0.765

B. Electrical inputs

Parameters	kWh	%kWh	kWh/kg	MJ/kg
Frying condiments	0.417	9.74	0.002	0.024
Grinding garlic, etc.	0.113	2.68	0.006	0.007
Pressure cooking	0.938	22.24	0.055	0.656
Oven treatment	2.750	65.19	0.162	1.932
Total	4.217	99.85	0.225	2.619

MJ=Mega joule

Input Energy

Table 2 revealed utilization of most of hE for de-skinning and oven treatment. Similarly, higher amounts of electrical inputs were also used for oven treatment and pressure-cooking. Since no other report is available on this product regarding such parameters, the finding could not be compared and are deemed to be the pioneer work in this direction. However, such findings are an indication of basic norms to be

foxed for cost effective production of convenient poultry products.

Observations on input energy requirements for cooked gizzard stock (Table 3) indicated the maximum use of hE in cleaning and cutting of gizzards followed by packaging. Greater utilization of electrical inputs was recorded for oven treatment and frying of condiments.

This information on quantification of input energy requirements for preparing cooked chicken stock and cooked gizzard stock paved way for optimization of such important components determining the cost of production. While studying input energy needs for processing gizzard pickle, similar trends on higher requirements of hE for cleaning and cutting of gizzards followed by pressure cooking have earlier been reported (Sachdevl *et al.* 1995).

Output Energy

Calculation revealed comparatively higher caloric yields from cooked gizzard stock (333 cal/100 g) than from cooked chicken stock (315 cal/100 g) obviously due to slightly higher fat content in this product.

Cost of Production

Based on the existing market rates of inputs including cost of energy, the cost of producing cooked chicken stock at laboratory scale was determined to be higher (Rs. 184/kg) as compared to that of cooked gizzard stock (Rs. 150/kg). Caloric yields per Indian rupee were found beneficial in the case of gizzard stock (22 cal/rupee) over cooked chicken stock (17 cal/rupee). These products have the convenience of reconstitution through boiling in ordinary drinking water for about 1 to 2 min to get instant curried chicken or curried gizzard which adds to their cost effectiveness.

CONCLUSION

Observations were recorded on input requirements for processing cooked chicken stock and cooked gizzard stock. Due to lesser requirements of hE for de-skinning of meat as compared to cleaning and cutting of gizzards, the processing of cooked chicken stock utilized lesser amounts of human energy. Similarly, the lesser time needed for frying of the necessary quantity of condiments rendered lower

TABLE 3
Energy consumption profile for processing cooked gizzard stock

A. Human

Parameter	Time Taken		Man Hours/ kg gizzard	Energy(MJ)/ kg gizzard
	Min	(%)		
1. Cleaning and cutting of gizzard	220	41.90	0.244	0.478
2. Weighing of gizzards	10	1.90	0.011	0.021
3. Peeling & slicing of ginger and garlic	50	9.52	0.055	0.108
4. Weighing condiments	30	5.72	0.033	0.065
5. Frying condiments	45	8.58	0.050	0.098
6. Grinding ginger and garlic	10	1.90	0.011	0.022
7. Pressure cooking of gizzard	40	7.62	0.044	0.086
8. Enrobing	10	1.90	0.011	0.022
9. Oven treatment	50	9.53	0.055	0.108
10. Packaging	60	11.43	0.066	0.129
Total	525	100.00	0.580	1.138

B. Electrical inputs

Parameters	kWh	%kWh	kWh/kg	MJ/kg
Frying condiments	0.938	21.58	0.063	0.752
Grinding garlic etc.	0.075	1.73	0.001	0.006
Pressure cooking	0.833	19.16	0.056	0.668
Oven treatment	2.500	57.53	0.167	1.992
Total	4.436	100.00	0.287	3.418

MJ=Mega joule

requirements for electrical inputs for processing cooked chicken stock. However, the lower initial cost of gizzard and insignificant differences between quality of these products determined the better cost effectiveness of producing cooked gizzard stock.

REFERENCES

AOAC. 1990. *Official Methods of Analysis.* 15th ed. Washington, D.C.: Association of Official Analytical Chemists.

OSTRANDER, C. E. 1980. Energy use in agriculture poultry. In *Handbook of Energy Utilization in Agriculture,* ed. D. Pimental. Boca Raton: CRC Press Inc.

PANESAR, B. S. and A. P. BHATNAGAR. 1987. Energy norms for inputs and outputs of agriculture sector. In *Proceedings of National Conference on Energy in Production Agriculture and Food Processing,* October 30-31, PAU Ludhiana, India.

SACHDEVL, A. K., R. GOPAL and S. S. VERMA. 1995. Input and output of energy in processing gizzard pickle. *Pertanika J. Trop. Agric. Sci (Malaysia)* **18(3)**: 209-214.

SACHDEVL, A. K., R. GOPAL and S. S. VERMA. 1996. Processing of cooked chicken stock and cooked gizzard stock. (Indian Patent No. 185748).

SHACKLEFORD, S. D., J. O. REAGEN, T. F. MANN, C. F. LYON and M. F. MILLER. 1989. Effects of blade tenderization, vacuum massage time and slat level on chemical, textural and sensory characteristics of precooked beef chuck roasts. *J. Food Sci.* **54**: 843-845.

SINGH, Y. and D.P. DHINGRA. 1987. Energy conservation studies in food processing. In *Proceedings of National Conference on Energy in Production, Agriculture and Food Processing.*

SNEDECOR, G. W. and W. G. COCHRAN. 1967. *Statistical Methods.* 6th edn. Calcutta: Oxford and IBH Publishing Co.

(Received: 16 June 1998)
(Accepted: 23 September 2002)

Pertanika J. Trop. Agric. Sci. 26(1): 7 - 13 (2003) ISSN: 1511-3701

The Effect of Feeding Sodium Sesquicarbonate Treated Soyabean on the Energy Utilization and Performance of Broiler Chickens

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Keywords: Effect, feeding, sodium sesquicarbonate, soyabean, energy utilization, broiler, performance

ABSTRAK

Pelbagai jenis benih kacang soya tempatan (Glycine max) *yang direndam dalam empat pekatan 'sodium sesquicarbonate' (0.0, 0.1, 0.5, dan 1.0%) selama 24 jam, dibuang airnya dan dikering udara telah digunakan dalam merumuskan diet isokalorik dan isonitrogenous untuk ayam daging. Semua diet menyokong pembesaran ayam daging. Tiada perbezaan signifikan (P>0.05) diperhatikan pada purata pengambilan makanan, berat badan dan pertambahan berat badan kumpulan ayam daging yang berlainan walaupun persamaan dalam pengambilan tenaga. Kecekapan tenaga secara signifikannya (P<0.05) sangat tidak memuaskan dalam memberi makan ayam daging dengan diet yang dikawal berbanding kacang soya yang dirawat dengan 1.0% 'sodium sesquicarbonate'. Penilaian Carcass menunjukkan bahawa bahagian kepala, paha dan lemak pada perut secara signifikannya (P<0.05) turut meningkat sama seperti pekatan 'sodium sesquicarbonate'. Pemprosesan kacang soya dengan 'sodium sesquicarbonate' mengurangkan kandungan protein kasar (CP) dan fiber kasar (CF) biji benih ion-ion Na^+, Ca^{2+} dan Mg^{2+} biji benih yang dirawat meningkat manakala ion-ion K^+ menurun.*

ABSTRACT

*A local variety of soyabean (*Glycine max*) seeds which were soaked in four different concentrations of sodium sesquicarbonate (0.0, 0.1, 0.5, and 1.0%) for 24 h, drained and air dried were used in formulating isocaloric and isonitrogenous diets for broilers. All the diets supported the growth of the broilers. No significant differences (P>0.05) were observed in the average feed intake, body weight and body weight gains of the different groups of broilers in spite of the similarities in energy intake. Energy efficiency was significantly (P<0.05) poorer in broilers fed the control diet than in 1.0% sodium sesquicarbonate treated soyabean. Carcass evaluation showed that the proportions of the head, drumsticks and abdominal fat significantly (P<0.05) increased as the concentration of sodium sesquicarbonate increased. Processing of soyabean with sodium sesquicarbonate reduced the crude protein (CP) and crude fibre (CF) contents of the seeds, Na^+, Ca^{2+} and Mg^{2+} ions of the treated seeds increased as K^+ ions decreased.*

INTRODUCTION

The potential value of soyabean as a relatively cheap source of protein in animal diet is on the increase. However, raw soyabean needs to be processed to remove the anti-nutrients including polyphenols and trypsin inhibitors. The common methods of processing, that is, soaking and boiling have their limitations. Soaking under tropical climates can lead to deterioration. Boiling uses fuel or firewood which are scarce and expensive (Omueti *et al.* 1992). Heat treatment of soyabean may not be of any advantage since when heat processing is applied below or above a required level, protein availability and solubility are adversely affected (Sadiku and Jauncy 1977).

Singh *et al.* (1988) had demonstrated that the addition of alkaline salts such as sodium bicarbonate has been shown to be effective in reducing soaking and cooking time for many legumes. However, processing of soyabean with a strong alkali like phosphate resulted in decreased protein quality, loss of amino acids and reduction in lysine availability (Friedman *et al.* 1984). The use of mildly alkaline salts had been demonstrated to improve the nutritive value

of products (Bourne *et al.* 1976). Sodium sesquicarbonate, a cheap alkaline salt is commonly used as a flavouring agent and as a tenderiser in cooking legumes and vegetables (Raeburn and Jones 1934; Buchanan and Pugh 1969). The enhancement of nutritional and organoleptic properties of cowpeas was demonstrated by Uzogara *et al.* (1988, 1991). It is however, feared that alkaline processing of soyabean can have undesirable nutritional and toxicological consequences (Friedman *et al.* 1984). This work was therefore carried out to investigate the effect of feeding soyabean treated with sodium sesquicarbonate on energy utilization and performance of broiler chickens.

MATERIALS AND METHODS

Preparation of Sodium Sesquicarbonate Solutions

Aqueous solutions of sodium sesquicarbonate ($Na_2CO_3NaHCO_3.2H_2O$) were prepared by adding 0.0 g, 1.0 g, 5.0 g and 10.0 g of powdered sodium sesquicarbonate to 1,000 millilitres of water at room temperature. The water was properly stirred with the powdered samples of sodium sesquicarbonate to obtain 0.0. 0.1, 0.5 and 1.0% solutions respectively. Raw local variety of soyabean seeds were then divided into four parts. Each part was then soaked in each of the prepared solutions for a period of 24 h after which the soyabean seeds were brought out of the solutions, drained and air-dried. Soaking was done in such a way that about 10.0 cm of the solution was above the soyabean levels in the containers. The soyabean, when properly dried was ground and used in preparing four isocaloric and isonitrogenous diets fed to the broiler chickens. The composition of the diets is shown in Table 1.

Feeding Trial

A total of one hundred and twenty Avian broiler chickens were randomly allocated to the four diets at thirty birds per diet in three replicates. Starter diets were fed for 35 days while finisher diets were fed from 36 to 63 days. Feed and water were supplied *ad-libitum*. All the birds were raised from day-old on a deep litter system. The litter materials were wood shavings. Open-sided poultry houses for birds raised under tropical climates as described by Oluyemi and Roberts (1979) were used for raising the birds. The broiler chickens used were of mixed sexes with equal numbers of male to female that is ratio 1:1. Data were collected weekly on average growth rate, feed consumption and body weight gain.

Carcass Evaluation

At the end of the feeding trial two birds (one male and one female) were randomly selected per replicate and fasted for twelve hours (overnight) to allow the gut to be cleared of feeds. The birds were weighed at 0600 h in the morning. The feathers were removed after scalding. A cut was made in the abdominal

TABLE 1
Composition of experimental diets(%)

Ingredients	Starter diets				Finisher diets			
	T_1	T_2	T_3	T_4	T_1	T_2	T_3	T_4
Maize	43.25	43.25	43.25	43.25	44.25	44.25	44.25	44.25
Soyabean	15.00	15.00	15.00	15.00	11.00	11.00	11.00	11.00
Maize Offal	10.00	10.00	10.00	10.00	16.50	16.50	16.50	16.50
Groundnut Cake	19.00	19.00	19.00	19.00	16.00	16.00	16.00	16.00
Fish Meal	3.50	3.50	3.50	3.50	3.00	3.00	3.00	3.00
Palm Oil	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Bone Meal	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Oyster Shell	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
*Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Lysine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10

* supplied per kg diet: Vitamin A 10,000 *Im*; vitamin D_3, 2000 *Im*; vitamin E, 5 *Im*; vitamin K, 2.24 *Im;* vitamin B 12, 0.01 mg; riboflavin, 5.5 mg; pantothemic acid, 10 mg; nicotimic acid, 25 mg; choline, 35 mg; folic acid, 4 mg; manganese, 56 mg; iodine, 1 mg; iron 20 mg; copper, 10 mg; zinc, 50 mg; cobalt, 1.25 mg.

region of each bird with a sharp knife. Each of the livers, kidneys, lungs, hearts and gizzards were removed, weighed and labelled. The different parts of the body (head, neck, thighs, drumsticks, shanks, backs and breasts) were manually cut and expressed as the percentage of the live weight.

Experimental Design and Statistical Analysis

The experimental design for the feeding trial was Randomized Complete Block (RCB) Design. The statistical analysis was done according to the methods of Gomez and Gomez (1984); Steel and Torrie (1981) and mean separation was by Duncan Multiple range test (Duncan 1955).

Analytical Procedure

The air-dried soyabean was milled and protein determination was carried out by the Kjeldahl method. Proximate analysis involving determination of ether extract, crude fibre, ash and dry matter contents were done according to procedures by A.O.A.C (1990).

Energy Efficiency Determination

Energy efficiency was calculated as:

$$\text{Energy efficiency} = \frac{\text{Energy intake}}{\text{Weight gain}}$$

where energy intake is

Feed intake (dry matter basis) x metabolisable energy of diets.

RESULTS AND DISCUSSION

The composition of the soyabean seed processed with different concentrations of sodium sesquicarbonate is shown in Table 2.

The chemical composition of the soyabean seeds processed with the different concentrations of the sodium sesquicarbonate is shown in Table 2. There was a significant difference in the crude protein content of the soyabean seeds treated with 1% Na sesquicarbonate compared to the ones soaked in 0.1, 0.5 concentrations and water.

The crude protein content of the seeds tends to decrease as the concentration of sodium sesquicarbonate increased. A similar decrease in protein content as the alkaline pH increased had been attributed to increased solubility of soyabean' proteins and enhanced hydration causing increased permeability of the seed coat leading to more efficient leaching of the proteins into the water (Ku *et al.* 1976).

The fat content of the soyabean increased while the crude fibre (CF) decreased as the concentrations of the alkaline solutions increased. This is attributed to the combined effects of losses of protein and carbohydrates as observed by Omueti *et al.* (1992). Since the fat content of the soyabean increased with the increasing concentrations of Na sesquicarbonate, it means that there would be a corresponding increase in energy supply to birds by the diets. The reduction observed in the CF level indicates that more fibre had been digested and used as energy.

The mineral composition of the processed soyabean is presented in Table 3. The highest value of ash content was found in soyabean with the greatest concentrations of sodium sesquicarbonate (Table 2). The implication is that the uptake of the minerals from solutions increased as the concentrations of the sodium sesquicarbonate increased. The effects were particularly noticeable on Na^{+}, Ca^{2+} and Mg^{2+}.

TABLE 2
Composition of soyabean seeds processed with different concentrations of sodium sesquicarbonate

Parameters (%)	Sodium sesquicarbonate concentrations(%)				
	0.0	0.1	0.5	1.0	SEM[c]
Crude protein	48.20[a]	48.10[a]	48.00[a]	46.20[b]	0.31
Ether extract	22.30	22.50	22.60	22.60	0.49
Crude fibre	2.47	2.45	2.40	2.39	2.00
Total ash	3.50	3.40	3.60	3.90	2.15
Gross energy(kcal/g)	3.55	3.69	5.80	6.00	0.08

a, b. means with different superscripts within the same row are significantly different ($P<0.05$).
c SEM is the standard error of the mean.

TABLE 3
Mineral composition of soyabean seeds processed with different concentrations of sodium sesquicarbonate

Minerals(%)	Concentrations (%)			
	0.0	0.1	0.5	1.0
Ca	0.30	0.31	0.33	0.32
Mg	0.20	0.20	0.19	0.16
Na	0.06	0.09	0.15	0.24
K	0.90	0.78	0.80	0.90
P	0.60	0.39	0.40	0.45

There was increased sodium content as potassium decreased and this could be attributed to leaching. Incidentally, Na^+, Ca^{2+} and Mg^{2+} are involved in the process of energy metabolism in chickens (Kleiber *et al.* 1941; Lloyd *et al.* 1978; Church and Pond 1982).

Figs. 1, 2 and *3* illustrate the pattern of growth, feed intake and weight gain of the birds respectively. Feed intake, body weight and weight gain increased with age. The different concentrations of sodium sesquicarbonate did not affect the pattern of growth, feed intake and weight gain as body weight increased progressively with age. This is also true of the pattern of feed consumption shown in *Fig. 2*. This indicates that the energy consumption will obviously follow this trend. The figures indicate that maximum body weight, feed consumption and weight gain were reached at the ninth week.

The chemical composition of the diets compounded from the sodium sesquicarbonate treated soyabean is shown in Table 4. The data show that the diets are isocaloric for either the starter diets or the finisher diets.

Table 5 shows the energy efficiency of the diets based on sodium sesquicarbonate processed soyabean. The energy efficiency of the diets improved as the concentration of the sodium sesquicarbonate increased. The deficiency of Na^+ ions in the control diet is a contributing factor to the poor utilization of energy of the diet. Additional limitation on the utilization of energy in the control diet is placed by the marginal deficiency of Ca^{2+} ions and Mg^{2+} ions. Sodium functions as the extra-cellular components through an energy dependent sodium 'pump' and Na^+ ions promote glucose absorption against a concentration gradient which requires adenosine triphosphate (ATP). The Na^+ ion gradient is considered the primary driving force in the active transport of sugar through the intestinal wall. Deficiency of Na^+ ion aggravated

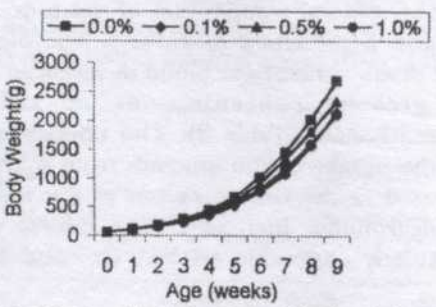

Fig. 1: Mean weekly body weight of broilers fed soyabean treated diets

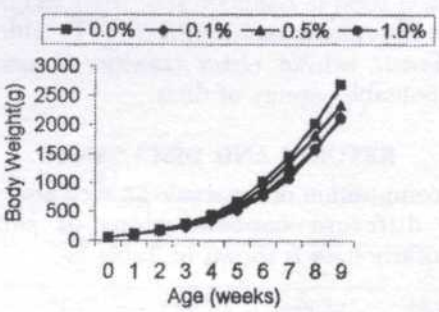

Fig. 2: Mean weekly body weight of broilers fed soyabean treated diets

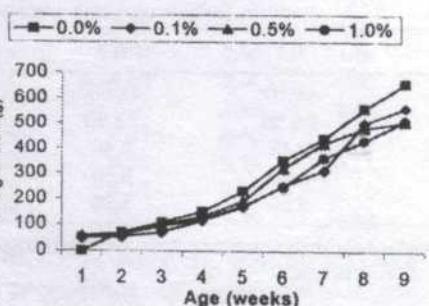

Fig. 3: Mean weekly weight gain of broilers fed soyabean treated diets

by marginal deficiency of Ca^{2+} and Mg^{2+} ions of the control diet could be the main factor for the poor energy efficiency of the diet. Kleiber *et al.* (1941) showed that Mg^{2+} deficiency decreased the efficiency of energy and protein utilization. Lloyd *et al.* (1978) stated that Mg^{2+} ions activate the enzymes (kinases, mutases and enolase) that are concerned with energy metabolism.

The data shown in Table 6 show that the broilers fed the control diet had the highest body weight (2.68 kg/bird) at 63 days of age. The control broilers also consumed higher feed along with 0.5% sodium sesquicarbonate treated soyabean. Similarly, feed to gain ratio tends to be better in the control birds than in any of the other groups. However, statistically, the values obtained were not significant (P>0.05). This agrees with the report in Table 5 that the deficiency of the Na^{+} in the control is a major contributory factor to the poor utilization of the energy of the diets since the diet cannot produce a significant difference in the performance of the birds in spite of high feed intake.

TABLE 4
Proximate composition of sodium sesquicarbonate processed soyabean diets (%)

Parameters(%)	Starter diets				Finisher diets			
	0.0	0.1	0.5	1.0	0.0	0.1	0.5	1.0
Dry matter	88.50	88.05	88.09	88.00	87.92	87.01	87.00	86.99
Crude protein	22.50	22.02	22.01	22.00	20.35	20.33	20.04	20.00
Crude fibre	4.88	4.63	4.63	4.59	6.79	6.58	6.52	6.79
Ether extract	14.00	14.12	14.20	14.34	14.80	14.82	14.88	14.85
Ash content	23.00	23.01	23.80	24.86	20.08	20.25	20.50	20.98
Nitrogen free extract	35.02	35.47	34.56	34.01	38.00	37.81	37.59	37.14
Metabolisable energy(kcal/g)	2.99	2.99	2.99	2.99	2.80	2.80	2.80	2.80

TABLE 5
Energy efficiency of broilers fed sodium sesquicarbonate treated soyabean

Starter Phase	Concentrations (%)				
(0 – 35 days)	0.0	0.1	0.5	1.0	SEM
Feed intake day^{-1}(g)	56.50	56.00	55.90	55.68	0.22
ME intake (day^{-1}) (kcal/kg)	168.00	164.59	163.85	164.74	2.34
Weight gain (day^{-1}) (g)	19.84	20.10	20.42	21.94	1.44
Energy efficiency (36 - 63 days)	8.46^{a}	8.19^{ab}	8.02^{ab}	7.74^{b}	0.17
Feed intake day^{-1}(g)	111.32	103.53	104.03	104.61	2.15
ME intake (day^{-1}) (kcal/kg)	323.65	300.25	301.70	303.38	2.18
Body weight gain (day^{-1}) (g)	24.54	23.33	23.06	26.02	1.07
Energy efficiency	13.18^{a}	13.02^{ab}	12.93^{ab}	11.63^{b}	0.12

Values denoted by different letters in the same row are significantly different (P<0.05).
SEM is the standard error of mean.

TABLE 6
Performance of broilers fed sodium sesquicarbonate processed soyabean

	Dietary Treatments (%)					
	0.0	0.1	0.5	1.0	SEM	
Initial live weight (g/bird)	55.62	55.60	55.61	55.60	-	
Final live weight (kg/bird)	2.68	2.14	2.33	2.32	2.03	NS
Total feed intake (kg/bird)	5.60	5.47	5.60	5.50	1.26	NS
Live weight gain (kg/bird)	2.62	2.08	2.27	2.26	2.11	NS
Feed gain ratio	2.14	2.63	2.47	2.43	1.05	NS

NS is no significant difference (P>0.05).

Pertanika J. Trop. Agric. Sci. 26(1): 15 - 18 (2003) ISSN: 1511-3701

Effect of Number and Timing of Pinching on Reproductive Growth of Potted Poinsettia (*Euphorbia pulcherrima* Willd.)

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Keywords: Floral induction, bract colour development, finish date, bract area, flower bud formation

ABSTRAK

Satu eksperimen untuk menilai kesan bilangan pengutilan (tanpa pengutilan, pengutilan tunggal dan pengutilan dua kali) dan masa pengutilan ke atas pertumbuhan reproduktif poinsettia telah dijalankan. Keputusan menunjukkan bahawa pengutilan lewat melambatkan pembentukan bunga, perkembangan warna pada brakta dan kematangan jika dibandingkan dengan pengutilan awal. Tetapi, masa pengutilan tidak memberikan kesan yang bererti terhadap bilangan brakta dan luas brakta. Pengutilan tunggal dan dua kali melambatkan pembentukan bunga, perkembangan warna dan kematangan pokok berbanding pokok yang tidak dikutil. Bilangan dan luas brakta juga bertambah selepas pengutilan tunggal dan berulang-ulang.

ABSTRACT

An experiment to evaluate effects of pinching number (unpinched, once-and twice-pinched) and timing (early- and late-pinched) on reproductive growth of poinsettia was conducted. The results showed that late-pinched plants were delayed in floral induction, bract colour development and finish date compared to early-pinched plants. However, the time of pinching did not significantly affect the number of bracts and bract area, once- and twice-pinched treatment delayed floral induction, bract colour development and finish dates compared to unpinched plants. The number of bracts and bract area were increased after the plants had been pinched once or twice.

INTRODUCTION

Poinsettia, *Euphorbia pulcherrima* is a very lovely plant due to its red and attractive bract colours. It is the most popular decorative plant for Christmas and New Year. Poinsettias have a good market potential as potted flowering plants. Poor plant quality may result from crowding, poor light, pest and disease problem, and poor scheduling. Scheduling poinsettia is complicated by the interaction of daylength, temperature and cultivar on lateral growth and floral development (Larson and Langhans 1963). The removal of shoot apexes to overcome apical dominance and to promote lateral shoot development is referred to as pinching (Larson 1985). In areas with good light, much more latitude may be allowed in time and type of pinching. Suggested pinch dates for Christmas crops vary somewhat with the area from which the information comes (Pertuit 1973; Tayama *et al.* 1975; Tayama 1978). Pinched potted plants are more floriferous and shorter than single-stem plants. Timing a pinch can also affect plant quality. Pinching too early can result in plants that are too tall, and pinching too late can result in plants too short. Therefore, pinching, as part of the poinsettia production cultural practices, is done to overcome the apical dominance in order to produce a better quality plant. The objective of this research was to study the influence of the numbers of pinching and their timing on flowering responses of poinsettia.

MATERIALS AND METHODS

Materials

The 10 cm terminal shoots of Ecke's Red cutting with 3-4 internodes, pre-treated with 1000 ppm of indole-butyric acid, were propagated in 27 cm x 38 cm x 10 cm plastic trays using coconut dust: sand (1:1 v/v) as rooting media. The cutting stroke roots in about 10 days. After the root stroke, the cuttings were potted in a 15 cm diameter pot using peat (PeatGro® : vermiculite (2:I v/v) media, amended with slow release fertilizer (Agloblend® 18:8:9 + 3 MgO) at the rate of 4 g cm^{-3}.

Treatment

The plants were pinched manually by removing the apical shoots, leaving about 3-4 nodes.

(i) Pinching Number

Pinching number treatment consists of unpinched (P0) as the control, once-pinched (P1) and twice-pinched (P2). For the P0 plants, flurprimidol at 50 mgL^{-1} were sprayed 2 weeks or 4 weeks after potting, and the short day (SD) treatment was given 1 week after the flurprimidol at 50 mgL^{-1} application. For the P1 plants, plants were pinched once, 2 weeks or 4 weeks after potting. Three weeks after pinching, plants were treated the same way as P0 plants at 2 weeks after potting. For the P2 plants, plants were pinched twice with the first pinch in the second week or fourth week after potting, and the second pinch in the fourth week after the first pinch. Three weeks after the second pinch, flurprimidol was sprayed to the plants and SD treatment was given 1 week after flurprimidol at 50 mgL^{-1} application.

(ii) Timing Frequency

Plants were pinched 2 weeks and 4 weeks after potting for early- and late-pinched, respectively.

The parameters observed were number of bracts, bract size, number of days from propagation to first flower bud formation, number of days from propagation to visible bract colour and number of days from propagation to finish date.

Experimental Design

A factorial experiment with 3 pinching occasions (P0, PI and P2) and 2 pinching times (early and late) were established in a Randomized Complete Block Design with 6 replications of one pot each. Analysis of variance was performed on all parameters. Differences between treatments' means were compared using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Bract Number

The bract number was significantly increased when Ecke's Red was pinched (Table 1). Single-pinched increased 42% and 38% more bracts number than control for both early- and late-pinched, respectively. Double-pinched increased 21% and 45% more bracts number than single-

TABLE 1

Effect of pinching frequency on bract number, bract area (cm^2), flower bud formation (day), appearance of visible bract colour (day) and finish date (day) of early- and late-pinched of Ecke's Red cultivar poinsettia

Pinching Frequency	Bract Number		Bract Area (cm^2)		Flower Bud Formation (Day)		Appearance of Visible Bract Colour (Day)		Finish Date (Day)	
	Early	Late	Early	Late	Early	Late	Early	Late	Early	Late
P0	19.17	18.17	328.30	337.00	82.33	92.17	99.17	103.83	105.00	125.17
P1	27.17	25.00	467.00	397.00	104.17	121.50	123.50	135.30	124.67	156.17
P2	32.83	36.33	538.20	631.00	129.33	131.67	143.50	144.00	135.17	162.33
Factorial Effect										
Pinching	**[z]		*		**		**		**	
Frequency (Fre)	NS		NS		**		*		**	
Pinching Time (Tim)										
Fre X Tim	NS		NS		**		*		NS	

[z]NS, *, ** Not significant and significant at P= 0.05 and 0.01, respectively.

pinched for both early- and late-pinched plants, respectively. Double- pinched plants for both early-and late-pinched treatments produced the most number of bracts compared to single-pinched and control plants.

Bract Area

Bract area increased significantly as the pinching number increased. Single-pinched plants produced 42% and 18% larger bract area than the control plant for early- and late-pinched plants, respectively. Double-pinched plants produced larger bract area than single-pinched plants that is 15% and 59% for early- and late-pinched, respectively. This finding was contrary to the study of O'Rourke and Carlos (1984) where the later pinched were associated with smaller bract to some extent for several poinsettia cultivars.

Number of Days to Flower Bud Formation

There was significant effect of pinching number, pinching timing and interaction between the two factors on flower formation. The flower bud formation was delayed with pinching treatment. The plants, which were unpinched (control), took 87.3 days for floral induction (Table 1). It was delayed to 112.8 days when pinched once, and 130.5 days when pinched twice (Table 1). For the early-pinched plants, single-pinched plants were delayed by 22 days and double-pinched plants were delayed by 47 days of flower bud formation days compared to control plants. The delaying trend in flower bud formation for late-pinched plants was also observed. The late-pinched plants induced flower buds later than early-pinched plants by 10 days (*Fig. 1*). However, with late pinching, there was not much difference between single or double pinch compared to early pinch for number of days to flower bud formation. Late-pinched plants delayed flower induction by 10 days, 18 days and 3 days as compared to early-pinched plants in control, single- and double-pinched plants, respectively. O'Rourke and Carlos (1984) obtained similar results in the study of selected pinching dates for poinsettia. Out of 11 cultivars studied, 7 cultivars showed a delay in floral induction.

Number of Days to Visible Colour

Pinching time had significant effect on number of days to visible bract colour. Late-pinched plants delayed the appearance of number to visible bract colour compared to early-pinched plants. Late-pinched plants required more days to reach visible bract colour compared to early-pinched plants. The number of days to visible bract colour was delayed significantly as pinching frequency increased. The control plants started bract colour development earlier than pinched plants. Control plants started bract colour development on the 102nd day, single-pinched plants on the 129th day and double-pinched plants on the 133rd day (*Fig. 2*). There was a

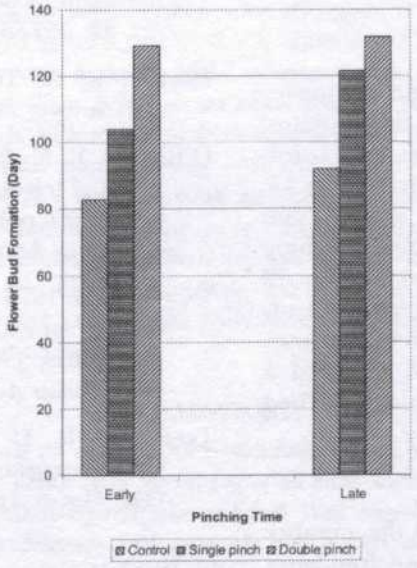

Fig. 1: Interaction effect of pinching time and number of pinching on number of days to flower bud formation of poinsettia

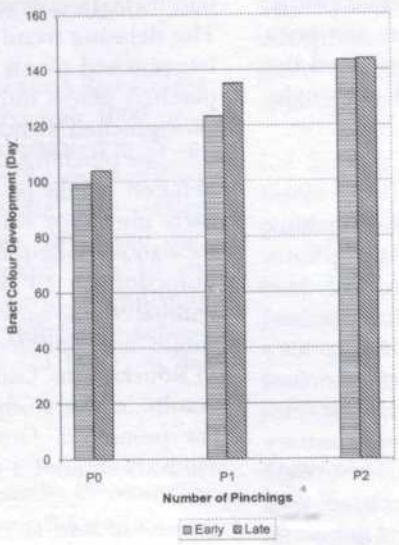

Fig. 2: Interaction effect of number of pinching and pinching time on number of days to visible bract colour of poinsettia

significant interaction between the pinching frequency and pinching time for number of days to visible bract colour development (Table 1). The days to visible bract colour development between twice pinched and pinching time showed less difference of days as compared to once pinched and controlled plants where the difference of days were at 14 days and 4 days respectively (*Fig. 2*). Therefore with late and double pinching of plants, the number of days to visible bract colour development will be greater.

Finish Dates

The effect of pinching timing and frequency were significantly different for finish dates. However, there was no significant interaction between the pinching timing and frequency for finish dates. Early-pinched plants reached full bloom stage at 141 days after the first pinching while late-pinched plants were delayed for 12 days. The finish date of single-pinched plants was delayed compared to unpinched plants. O'Rourke and Carlos (1984) also reported a delay of finish dates in poinsettia plant pinched 2 weeks later.

CONCLUSION

In conclusion, pinching increased the number of bracts and bract areas. Pinching frequency increased the bract number and produced a larger area of bracts than control plants. However, the increased number of pinches delayed the finish date and bract colour development of poinsettia compared to control plants. The late-pinched treatment increased the bract number and area of poinsettia but delayed the flower bud formation, bract colour development and finish date.

REFERENCES

LARSON, R. A. and R. W. LANGHANS. 1963. The influence of temperature on flower bud initiation in poinsettia. *Proc. Amer. Soc. Hort. Sci.* **82**: 552-556.

LARSON, R. A. 1985. Growth regulators in floriculture. *Hort Reviews.* **7**: 454-61.

O'ROURKE, E. N. JR. and A. S. CARLOS, JR. 1984. Effect of selected pinching dates and lighting regimes on poinsettia quality. Louisiana State University Agricultural Centre Bull. 758. Jan.

TAYAMA, H. K. 1978. Effect of position of pinching on the growth, flowering and quality of poinsettias, cv. 'Annette Hegg Top Star.' *Ohio Florists Assn. Bull.* **587**: 8.

TAYAMA, H. K., H. POOLE and R. K. LINDQUIST. 1975. Extension slants poinsettia production. *Ohio Florists Assn. Bull.* **549**: 8.

(Received: 5 October 1999)
(Accepted: 5 September 2002)

Pertanika J. Trop. Agric. Sci. **26(1)**: 19 - 25 (2003) ISSN: 1511-3701

Raising Oil Palm Seedlings in Urban Cities Using Sole and Amended Woodash and Sawdust Manurial Treatments

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Keywords: Oil palm seedlings, organic fertilizer, woodash, sawdust, manurial treatments

ABSTRAK

Biji benih yang sihat diperlukan sebagai prasyarat bagi kejayaan penanaman kelapa sawit. Tanah yang sesuai untuk penanaman ini amat terhad di kawasan bandar. Oleh itu, satu kajian telah dijalankan di hutan hujan Akure (Lat 7ºN, 5'10'E), Barat Daya Nigeria tentang keberkesanan penggunaan abu kayu dan habuk kayu yang biasa digunakan dengan campuran najis kambing, babi dan binatang ternakan sebagai baja tumbesaran, khasiat daun dan komposisi kimia tanah bagi penanaman kelapa sawit (Elaies guineesis L). *Lapan jenis baja rawatan telah dibandingkan dengan kawalan (tanpa baja, tanpa najis binatang) dan NPK 12:12:17 + baja Mg 2. Rawatan tersebut diaplikasikan ke atas 40 g dalam setiap polibeg yang diisi dengan 10 kg tanah (8t/hat), diterbalikkan sebanyak tiga kali dan disusun atur secara rawak. Baja organik dan tanah tersebut dianalisis secara kimia. Keputusan menunjukkan bahawa aplikasi organik tersebut meninggalkan sisa di dalam tanah dan meningkatkan (P<0.05) tanah dan daun N,P, K, Ca, Mg, nilai pH tanah dan O.M, ketinggian tumbuhan, lilitan batang dan jumlah daun pokok kelapa sawit tersebut berbanding rawatan kawalan. Abu kayu + najis binatang ternakan dan habuk kayu + najis binatang ternakan, mencatatkan nilai tanah, khasiat daun dan parameter tumbesaran yang lebih tinggi terhadap kelapa sawit tersebut berbanding NPK + baja Mg. Abu kayu + najis binatang ternakan telah meningkatkan nilai pH tanah, O.M, N, P, K, Ca, Mg dan Na dengan kadar masing-masing 14.8%, 328%, 75%, 51%, 8.4%, 2546%, 58% dan 1123%, berbanding NPK dan baja rawatan Mg. Abu kayu + najis binatang ternakan tersebut juga telah meningkatkan N, P, K, Ca dan kandungan khasiat Mg terhadap daun pokok kelapa sawit dengan kadar masing-masing 3%, 38%, 20%, 266% dan 200% mengatasi baja NPK dan juga telah meningkatkan kelebaran daun, lilitan batang, jumlah daun dan berat tunas dengan kadar masing-masing 14%, 22.75%, 17% dan 57% mengatasi NPK + baja Mg. Walau bagaimanapun, NPK + baja Mg telah memberikan nilai N, P dan K, ketinggian tumbuhan, kelebaran daun, jumlah daun dan berat tunas yang baik berbanding abu kayu dan habuk kayu yang diaplikasikan secara berasingan. Manakala aplikasi organik tersebut meninggalkan sisa di dalam tanah dan meningkatkan (P<0.05) tanah dan Ca dan Mg daun berbanding baja. Abu kayu dan habuk kayu yang diaplikasikan secara berasingan atau yang diubah pada 8t/ha telah memberikan kesan ke atas sumber khasiat baja bagi tumbesaran benih kelapa sawit.*

ABSTRACT

A healthy seedling is a pre-requisite for a successful establishment of oil palm planting in the field. There were very limited soils available in the urban cities for raising of oil palm seedlings. Therefore, a study was conducted in Akure (Lat 7ºN, 5'10'E) in the rainforest zone of South West Nigeria on the effectiveness of woodash and sawdust used ordinarily or in combination with goat, pig and poultry manure as fertilizers on the growth, leaf nutrients and soil chemical composition of oil palm (Elaies guineesis L) *seedlings in the nursery. Eight organic fertilizer treatments were compared to the control (no fertilizer; no manure) and NPK 12:12:17 + Mg 2 fertilizer.*

The treatments were applied at 40 g per polybag filled with 10 kg soil (8t/ha), replicated three times and arranged in a complete randomized block design. The organic fertilizers and soils were chemically analysed. The results showed that the application of organic residues to the soil significantly increased (P<0.05) the soil and leaf N, P, K, Ca, Mg, Soil pH and O. M, plant height, stem girth and number of leaves of oil palm seedlings compared to the control treatment. Woodash + poultry manure and sawdust + poultry manure gave higher values of soil, leaf nutrients and growth parameters of oil palm seedlings than NPK + Mg fertilizer. Woodash + poultry manure increased the soil pH, O. M, N, P, K, Ca, Mg and Na by 14.8%, 328%, 75%, 51%, 8.4%, 2546%, 58% and 1123% respectively when compared to NPK + Mg fertilizer treatment. The woodash + poultry treatment increased the oil palm seedling leaf N, P, K, Ca and Mg nutrient contents by 3%, 38%, 20%, 266% and 200% respectively more than NPK fertilizer while it also increased the leaf area, stem girth, number of leaf and shoot weight by 14%, 22.75%, 17% and 57% respectively more than the NPK + Mg fertilizer. However, NPK + Mg fertilizer gave better values of soil N, P, and K, plant height, leaf area, number of leaves and shoot weight than woodash and sawdust applied in sole forms while the organic residues significantly increased (P<0.05) soil and leaf Ca and Mg compared to the fertilizer. Woodash and sawdust applied solely or amended at 8t/ha has been effective as sources of fertilizer nutrients for raising oil palm seedlings.

INTRODUCTION

The oil palm (*Elaies guineensis*) belongs to the family palmea. It is the most important source of a palm oil and produces more oil per hectare than any of the oil producing crops. The palm oil is used for much domestic cooking, manufacture of soap, production of margarine and candles.

Folorunso and Akinyemi (1999) reported that there has been a phenomenal increase in production of oil palm, cashew and coffee seedlings in urban cities by individuals and horticultural farmers for income generation, self employment, and as supplement to the demand among farmers in the rural areas, whose palms are ageing on the field or by city dwellers who need few oil palm seedlings for planting to meet their families' cooking needs.

The production of oil palm seedlings covers a period of between ten and twelve months from the pre-germinated seeds to the maturity stage for transplanting and it is usually between October and July to be ready at the onset of rains. The inhabitants in cities use the available land spaces in the backyard of their homes, riversides and other unutilized spaces for raising the seedlings of oil palm. Both city and rural dwellers raise livestock (goat, pig and poultry) and their wastes constitute serious health hazards to the people because they are not utilized for crop production.

The vast potential of the oil palm crop is being threatened by continued decline in soil fertility and this is because the same piece of land is used for filling the polybags of oil palm seedlings. Efforts to increase the soil nutrient status through the use of inorganic fertilizers are accompanied by high cost, scarcity at farmers' level and probable degradation of soil by continuous use (Folorunso 1999).

A critical review of literature showed that there was a scarcity of research information on the use of woodash and sawdust residues applied alone or in combination with goat, pig and poultry manure to raise the crop at the seedling stage in the nursery and field.

Therefore, the objective of this paper was to investigate the effectiveness of these organic residues on the soil, leaf nutrient content and growth parameters of oil palm seedlings in the nursery at Akure, Nigeria.

MATERIALS AND METHODS

The experiments were carried out at Akure (7^0N', $5^0$10'E) in the rainforest zone of Nigeria in 1997 and 1999 on the same site. The soil is a sandy loam, skeletal, kaolinitic, 150 hyperthemic oxic paleustalf (Alfisol) or Ferric Luvisol (FAO) while the annual rainfall is 1300 mm and the temperature is 70^0C.

The samples of the surface (0-15 cm) soils used for the raising of oil palm seedlings were collected, airdried, sieved with a 2 mm sieve and utilized for routine soil analysis. The particle size was determined by the hydrometer method (Bouycous 1951). The soil pH (1:1 soil/water) and 1.2 soil/0.01M Cacl2 solutions were calculated using a glass/calomel electrode system (Crockford and Mourell 1956). The organic matter was determined by Walkley and Black (1934). The exchangeable bases (K, Ca, Mg and Na) were extracted with 1M NH_4 OAC pH7 and

the amounts of K, Ca and Na were determined on flame photometer using appropriate element filters while the Mg content in the extract was read on atomic absorption spectrophotometer (Jackson 1958).

The exchangeable acidity (H^+ and Al^{3+}) was measured from 0.01 M Kcl extracts by titrating with 0.1M HCL (Mclean 1965). Percentage N was determined using the microkjedahl method (Jackson 1964). Available P was extracted using Bray P1 extractant and the amount in the extract measured with Murphy-Riley blue method (Murphy and Riley 1962) on spectronic 20 at 882 Um. Ten kg of surface (0-15 cm) soil from the site of the experiment was weighed into each of 150 black polythene bags (1400 cm^3). Water was added and allowed to equilbrate at field capacity for 48 h. These polybags were arranged on the flat ground.

There were eight manurial treatments, viz-sawdust (sole), sawdust + poultry manure, woodash + goat dung and woodash (sole), woodash + pig dung, woodash + goat dung and woodash = poultry manure. Zero manure and NPK + Mg 12-12-17 + 2 fertilizer were applied as control and reference treatments respectively.

The manure treatments were applied at the rate of 40 g per bag (8t/ha) for the ordinary forms of woodash and sawdust while their amendment with goat, pig dung and poultry manure were applied at a ratio of 50:50% by weight (20 g each). The NPK + Mg fertilizer was applied at a single rate of 2 g per polybag (400 kg/ha) to each of the five bags as reference treatments and there were five blank treatments (zero fertilizer or manure) as control. The manure or fertilizer treatments were mixed thoroughly with the soils in polybags using hand fork ten days before planting sprouted oil palm seedlings. The experiment was laid out using a completely randomized design (CRD) with three replicates in which the manurial treatments were the only sources of variation.

The sprouted teneral hybrid oil palm seeds were planted per bag and a shade was built to prevent the seedlings from scorching by sun and they were watered daily. Weeding was carried out at 2, 6 and 10 weeks after planting and 20 mL a. i. of basudin in 5 L of water was also sprayed on the site every 3 weeks to control termite attack while 20 mL a. i. of dithane M-45 in 6 L of water was sprayed on the seedlings against fungus attack at 4 and 9 weeks after planting.

Measurement of the growth parameters of oil palm seedlings started seven weeks after planting. Plant height, leaf area and stem girth (cm) were measured using ruler, graph method and calipher respectively. The measurements were taken at one week intervals till 13 weeks after planting. The leaf population measurement started from the 15th week after planting and shoot weight was determined at the time of transplanting.

Before transplanting, the shade was slightly reduced to thicken the seedlings. Fresh leaf samples were taken at 18 WAP from the seedlings and put into labeled envelopes and oven-dried for 2 days at 70°C to obtain dry leaf samples. They were milled into powdered forms and 2 g of the sample weighed for dry ashing in muffle furnace at 500°C for 6 h. Five mL of water was added to the ash and %P was determined by phospho-vanade molybdate coloration on spectronic 20 at 442 Um. The N content was determined by microkjedahl distillation process and K, Ca, and Na contents were determined on flame Photometer while Mg was determined using atomic absorption spectrophotometer.

The chemical analysis of the manurial treatments earlier used for raising the oil palm seedlings was also determined. At harvest (35 WAP), soil samples were taken from each bag, air-dried, sieved and analysed for nutrient contents. The data obtained for the growth parameters, leaf and soil chemical composition of oil palm seedlings were analysed using ANOVA F-test and the overall treatment mean effects were compared using Duncan multiple range test at 5% level.

RESULTS

The physical and chemical properties of the soils used for raising the oil palm seedlings are presented in Table 1. The soils are low in organic matter if compared with the critical level of 3% O.M. (Agboola and Carey 1973). The total nitrogen is less than 0.16% considered as optimum for oil palm production (Omoti *et al.* 1990).

The available P is less than 10 mg/kg P considered as adequate for crops (Agboola and Carey 1973), while the exchangeable K, Ca, Mg and Na contents were lower than the 0.22, 0.20, 0.27 and 0.17 mg/kg critical levels considered as adequate for oil palm seedlings respectively (Agboola 1982c).

TABLE 1
Chemical analysis of the soil before the experiment

pH		Organic Matter	N	P	Exchangeable Cations			
H_2O	Caclz	%		mmol/kg	Na	K	Ca	Mg
					mmol/kg Soil			
6.10	5.50	0.65	0.096	7.89	0.17	0.112	0.192	0.15

The low values of soil K, Ca, Mg, Na, P total N, soil pH and O.M were indications of soils with poor fertility status and oil palm seedlings growth on the soil would respond favourably to the application of the organic fertilizer materials. The soils were sandy loam in texture, skeletal, kaolinitic, isohyperthermic, oxic paleustalf (Alfisol) or perric Luvisol (FAO) or Akure series.

Table 2 shows the chemical properties of the organic fertilizer materials used in the experiment. The goat and pig dung had lower contents of N, P, K, Ca and Mg compared to poultry manure while the nutrient composition of woodash was higher than sawdust. The C/N values of goat dung, pig dung and poultry manure were lower than that of woodash and sawdust respectively.

The soil N, P, K, Ca, Mg, Na, O.M and pH (Table 3), leaf N, P, K, Ca and Mg (Table 4) and leaf area, plant height, stem girth, shoot weight and leaf population (Table 5) of oil palm seedlings in the nursery of treated soils increased significantly ($P<0.05$) relative to the control treatment.

Among the plant residues, woodash gave better values of growth parameters of oil palm seedlings such as plant height (12.27 cm), leaf area (35.48 cm^2), stem girth (1.80 cm), leaf population (4.80) and shoot weight (1.60 kg) than the corresponding values of 11.38 cm, 35.21 cm^2, 1.58 cm, 4.35 and 1.10 kg in sawdust (sole) treatment. The woodash also gave higher leaf and soil N, P, K, Ca, Mg, Na, soil O.M and pH.

Relative to NPK + Mg fertilizer, the woodash and sawdust (sole) treatments had lower growth parameters such as plant height, leaf area, stem girth, shoot weight and leaf population (Table 5). It also had lower leaf and soil N, P and K contents than the NPK fertilizer (Tables 3 and 4).

However, the woodash and sawdust (sole and amended) gave higher values of soil O.M, pH, Ca, Mg and Na than NPK fertilizer. For instance, woodash + poultry manure treatment increased soil O.M (3%), pH (7.89), Ca (3.44 mmol/kg), Mg (1.31 mmol/kg) and Na (2.08 mmol/kg) when compared to the corresponding values of soil O.M (0.7%), pH (5.90), Ca (0.13 mmol/kg), Mg (0.83 mmol/kg) and Na (0.19 mmol/kg), respectively in NPK fertilized treatment.

The amended woodash and sawdust with goat, pig and poultry manure gave higher growth, soil and leaf nutrient contents than their sole forms. The amendment of woodash + poultry manure had highest soil P, K, Ca, Mg and Na compared to woodash amended with pig and goat manure respectively. The soil O.M and pH decreased under the NPK + Mg fertilizer and control treatments.

TABLE 2
Chemical analysis of the organic fertilizers used for the experiment

Organic Materials	C	N	Organic Matter	C/N ratio	Available P	Exchangeable cations			
						Na	K	Ca	Mg
			%		mg/P	mg/L			
Poultry manure	32.10	4.53	50.30	7.08	376.10	6.10	10.62	2.90	4.30
Goat dung	22.00	2.60	36.51	8.46	169.10	7.40	10.52	2.70	3.80
Sawdust	9.00	0.43	11.73	20.90	12.10	4.39	5.41	0.14	0.90
Woodash	20.20	1.54	32.53	12.98	80.30	9.60	25.12	12.14	9.30
Pig manure	25.00	3.72	33.10	6.72	312.00	5.22	14.45	3.10	4.80

TABLE 3
The values of soil properties at harvest produced by using different organic residues for oil palm seedlings in the nursery (1997 to 1999)

Treatments	pH	O.M	N	P	K	Ca	Mg	Na
Control (No fertilizer)	5.10a	0.55a	0.09a	6.10a	0.11a	0.15a	0.15a	0.17a
NPK12-12-17+Mg	5.90b	0.70b	0.20h	29.73e	6.17h	0.13a	0.83f	0.19b
Woodash (Sole)	8.351	2.57e	0.11c	25.78d	6.15h	2.60h	1.66h	1.16g
Woodash + goat dung	8.00g	2.37d	0.13d	42.54h	4.80f	2.58f	1.46g	1.98l
Woodash + pig dung	9.01h	2.73f	0.18f	4.19l	6.69l	3.51h	1.59l	1.63h
Woodash + poultry manure	7.89f	3.00j	0.35j	44.76j	6.69l	3.44g	1.31f	2.08j
Sawdust (Sole)	7.22d	1.67c	0.10b	7.90b	2.29b	0.33b	0.20b	0.37c
Sawdust + goat dung	7.24e	2.84i	0.16e	30.59f	3.02e	0.51c	0.3d	0.58e
Sawdust + pig dung	7.01c	2.75g	0.19g	25.55c	2.37c	0.33b	0.21c	0.51e
Sawdust + poultry manure	7.24e	2.81h	0.24l	41.06g	2.95d	0.58d	0.37e	0.61f

Treatment means within each column followed by the same letters are not significantly different from each other using Duncan Multiple Range Test at 5% level.

TABLE 4
The mean values for the leaf nutrient contents at harvest produced by the different organic residues for oil palm seedlings in the nursery

Treatments	N	P	K	Ca	Mg
			%		
Control (No fertilizer)	0.20a	0.016a	0.03a	0.04b	0.007ab
NPK 12-12-17 + Mg	1.61h	0.08c	0.53c	0.003a	0.006a
Woodash (Sole)	0.46c	0.09cd	1.06h	0.074g	0.018d
Woodash + goat dung	1.56g	0.08c	0.85f	0.069ef	0.19e
Woodash + pig dung	1.64hi	0.07bc	0.60e	0.082h	0.031h
Woodash + poultry manure	1.66l	0.11ef	0.73g	0.11i	0.018d
Sawdust (Sole)	0.21b	0.06b	0.36b	0.03c	0.013c
Sawdust + goat dung	0.60d	0.15g	0.56c	0.05d	0.026f
Sawdust + pig dung	0.73e	0.10e	0.42d	0.06e	0.03fg
Sawdust + poultry manure	0.78ef	0.10e	0.64ef	0.068e	0.035i

Treatment means within each column followed by the same letters are not significantly different from each other using Duncan Multiple Range Test at 5%

TABLE 5
The values of growth parameters of oil palm seedlings produced by using different organic residues

Treatments	Plant Height Cm	Leaf area cm^2	Stem girth Cm	Number of leaf +	Shoot weight ++ kg
Control (No fertilizer)	7.35a	27.26a	1.38a	4.10	0.50a
NPK 12-12-17 + Mg	16.60fg	42.27c	1.89cd	5.30e	1.80cd
Woodash (Sole)	12.27c	35.48b	1.80c	4.80c	1.60c
Woodash + goat dung	12.27c	42.10c	1.85cd	5.60b	2.00e
Woodash + pig dung	16.13f	45.31e	1.79d	5.67f	2.10ef
Woodash + poultry manure	16.21f	48.08g	2.01e	6.20f	2.83i
Sawdust (Sole)	11.38b	35.21b	1.58b	4.35b	1.10b
Sawdust + goat dung	14.29e	43.87d	1.81c	5.16d	2.40g
Sawdust + pig dung	13.32d	47.40f	2.08e	5.93g	2.50h
Sawdust + poultry manure	16.37fg	58.46h	2.52f	6.48l	3.56j

Note: + = At 21 – 25 WAP (Weeks after planting)
++ = At 35 WAP

Treatment means within each column followed by the same letters are not significantly different from each other using Duncan Multiple Range Test at 5% level.

DISCUSSION

The soils used for raising oil palm seedlings were generally low in pH, O.M, N, P, K, Ca and Mg, and these could be responsible for the poor growth of oil palm seedlings in the control treatment. The observation supported that of Agboola (1982c) who had reported poor growth of cocoa and, oil palm seedlings in soils not fertilized. Hence, it was expected that the application of woodash and sawdust in sole forms or amended with goat, pig and poultry manure to the soils would increase the growth responses, soil and leaf nutrient content of oil palm seedlings.

Adepetu and Anyaduba (1983) reported that the acidic soils were not conducive for good performance of oil palm seedlings. This was because nutrient uptake by oil palm is adversely affected by soil acidity; hence, the application of woodash and sawdust residues increased soil pH, thereby reducing soil acidity. The observation was further corroborated by Folorunso (1999) who reported that continuous use of NPK + Mg fertilizer would lead to increase in soil acidity, Ca and Na deficiency stymptoms.

The better leaf and soil Ca, Na, soil pH and O.M under residue and manure treatments compared to NPK fertilizer is consistent with the fact that the organic materials are sources of all plant residues (Swift and Anderson 1992) including Ca and Na not supplied by the NPK fertilizer.

The increases in growth parameters such as plant height, leaf area and stem girth of oil palm seedlings by NPK fertilizer could be associated with quick release of the nutrients for assimilation. However, the organic residues increased the leaf and soil qualities of oil palm seedlings.

The performance of amended woodash and sawdust treatments in growth parameters of oil palm seedlings compared to the sole treatments can be adduced to the high P, K, Ca, Mg contents and lower C:N ratio of the manures which would aid decomposition and release of nutrients.

Among the types of animal manure, the poultry manure was generally more effective in improving plant nutrients (N, P, K, Ca and Mg) status, plant height, leaf area, leaf population and stem girth of oil palm seedlings whereas the goat gave the least P, K, Ca and growth parameters. This was consistent with the fact that it had the highest N, P, K, Ca, Mg, Na and micronutrients. The woodash residue increased leaf K, Ca and Mg compared to sawdust and this could be adduced to its nutrient composition and lower C:N (Folorunso 1999). All these facts will aid quick establishment of oil palm seedlings in the nursery and field.

CONCLUSION

It is concluded that plant residues such as woodash and sawdust were effective as fertilizer and sources of nutrients for oil palm seedlings. Their application enhanced leaf, soil and growth of oil palm seedlings in the nursery.

Amendment of the residue with pig, goat and poultry manure improved their effects on the growth of leaf and soil content of oil palm seedlings.

The research also proved that improved utilization of these residues will increase prospects of farming activities in the cities for poverty alleviation.

It is, therefore, recommended that organic residues such as woodash, sawdust and their amendment with goat, pig and poultry manure applied at 40 g per 10 kg soil (8t/ha) are very useful as fertilizer materials for improving the nutrient availability and ensuring sustainable cultivation of oil palm seedlings on lowly fertile soil in humid tropics.

This recommendation corroborates with the fact that inorganic fertilizers are scarce and expensive for the resource poor farmers and some city dwellers who are the growers of oil palm seedlings in most developing countries.

REFERENCES

ADEPETU, J. A. and E. T. ANYADUBA. 1983. Predicting the phosphorus fertilization of tropical soil critical solution P requirement of cowpea P, sorption capacity and free iron content of soils. *J. Trop. Agric. Vet. Sci.* **21(1):** 21-70.

AGBOOLA, A. A. 1982c. Organic manuring and green manuring in tropical agricultural system. In *Proceedings of 12th International Congress of Soil Sciences*, p. 198-212, 8-16 February, New Delhi, India.

AGBOOLA, A. A. and R. B. CAREY. 1973. Soil testing NPK for maize in the soil derived from metamorphic and igneous rocks of Western State of Nigeria. *Journal of West African Science Association* **17(2):** 93-100.

BOUYCOUS, H. 1951. Mechanical analysis of soil using the hydrometer method. *Analytical Chem. Acta*: 32-34.

CROCKFORD, L. and R. MOURELL. 1986. *Laboratory Manual of Physical Chemistry*. p. 558-559. New York: John Wiley and Sons.

FOLORUNSO, O. O. 1999. Use of plant residues for improving soil fertility and the yield of Okra (*Abelmuschus esculentum* L) and Amaranthus (*Amaranthus viridis* L). Ph.D Thesis, Federal University of Technology, Akure.

FOLORUNSO, O. O. and F. T. AKINYEMI. 1999. Crop farming in urban cities for food security, Akure as a case study. A study report conducted for Federal College of Agriculture, Akure, p. 20-22.

JACKSON, M. L. 1958. *Soil Chemical Analysis*. p. 86-92. Englewood Cliffs, N. J.: Prentice Hall Inc.

JACKSON, M. L. 1964. *Soil Chemical Analysis*. p. 57-67. Englewood Cliffs, N. J.: Prentice Hall Inc.

MCLEAN, E. O. 1965. Aluminum. In *Methods of Soil Analysis*, ed. M.C.A. Black. p. 927-932. Part 2, Agronomy 9. U.S.A: Amer. Soc. Agron. Madison Wisconsin.

MURPHY, J. and J. P. RILEY. 1962. A modified single solution method for determination of phosphate in natural waters. *Analytic Glumi Acta* **27**: 31-36.

OMOTI, U., L. R. OBATOLU and J. A. FAGBEMRO. 1990. Complimentary use of organic and inorganic fertilizers for tree and forest crops production in Nigeria. In *3rd Annual Organic Fertilizer Conference*, p. 163-175. Durbar Hotel, Kaduna, Nigeria.

SWIFT, M. J. and J. M. ANDERSON. 1992. Biodiversity and ecosystem function in agricultural systems. In *Biodiversity and EcoSystem Function*, ed. Schultz, M., Woomer, P. and Ingram, J. S. L. p. 201-203. Berlin, Germany: Springer Verlag.

WALKLEY, A. and I. A. BLACK. 1934. An examination of Degtagjaroff method for determining soil organic acid filtration method. *Soil Science* **37**: 29-38.

(Received: 8 August 2000)
(Accepted: 31 October 2001)

Pertanika J. Trop. Agric. Sci. 26(1): 27 - 33 (2003) ISSN: 1511-3701

Performance and Yield Predictions in Double Cross Hybrids of Tropical Grain Maize

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Keywords: *Zea mays* L., maize, double cross, hybrids, yield predictions

ABSTRAK

Penggunaan hibrid kacukan dua ganda dalam jagung disarankan dalam keadaan terdapatnya masalah pengeluaran biji benih sekiranya kacukan tunggal digunakan, kesan dari kecergasan dan hasil rendah yang diberikan oleh induk-induk inbrednya. Hibrid kacukan dua ganda diketahui boleh menunjukkan prestasi yang agak baik dalam keadaan persekitaran yang pelbagai. Sebagai sebahagian daripada program pembiakbakaan jagung bijian yang sedang dijalankan di Universiti Putra Malaysia, titisan-titisan inbred yang berprestasi tinggi telah dipilih dan dikacukkan untuk menghasilkan kacukan-kacukan tunggal. Kacukan-kacukan tunggal ini seterusnya digunakan untuk membentuk beberapa hibrid kacukan dua ganda. Dalam kajian ini, prestasi sepuluh hibrid dua ganda terpilih telah dinilaikan pada dua persekitaran di kawasan penyelidikan Universiti Putra Malaysia. Prestasi ramalan hibrid kacukan dua ganda ini juga dibandingkan dengan prestasi sebenar menggunakan kaedah berdasarkan nilai-nilai yang ditunjukkan oleh kacukan tunggal bukan induknya. Hibrid kacukan dua ganda yang memberikan prestasi terbaik, DC-26 dan DC-34 didapati memperoleh hasil yang tinggi di tiap-tiap daripada dua persekitaran serta juga dalam analisis gabungan. DC-26 dan DC-34 masing-masing memberikan purata hasil bijian sebanyak 6125.0 dan 5917.8 kg/ha di Ladang 2, masing-masing 5648.9 dan 5676.2 kg/ha di Ladang Kongsi, dan masing-masing 5887.0 dan 5797.0 kg/ha di dalam analisis gabungan. Daripada keputusan analisis korelasi, kedua-dua prestasi sebenar dan prestasi ramalan untuk hibrid-hibrid dua ganda ini didapati selari antara satu dengan lain di tiap lokasi dan lokasi gabungan ($r = 0.38$, 0.46 and 0.27, masing-masing di Ladang 2, Ladang Kongsi dan gabungan kedua-dua lokasi), membuktikan bahawa kaedah yang digunakan untuk ramalan hasil dalam hibrid-hibrid tersebut adalah sesuai.

ABSTRACT

The use of double cross hybrids in maize was suggested to overcome the problem of seed production related to single cross resulting from low vigor and yield associated with the inbred parents. Double cross hybrids were known to perform quite well under a wide range of environmental conditions. As a part of an ongoing grain maize improvement program at Universiti Putra Malaysia, the best performing inbred lines were selected and crossed to produce single crosses. These single crosses were further used to produce some double cross hybrids. In this study, the performance of ten selected double cross hybrids was evaluated at two environments in the research areas of Universiti Putra Malaysia. The predicted performance of these double cross hybrids was also compared with the actual, using the method based on the mean values of non-parental single crosses. The best performing double cross hybrids, DC-26 and DC-34 were found to have high yields at both environments as well as in the combined analysis. DC-26 and DC-34 gave mean grain yields of 6125.0 and 5917.8 kg/ha respectively, at Field 2, 5648.9 and 5676.2 kg/ha respectively, at Share Farm, and 5887.0 and 5797.0 kg/ha respectively, in the combined analysis. From the correlation analysis, the actual and the predicted performances of the double cross hybrids were found to be in good agreement at each location and locations combined ($r = 0.38$, 0.46 and 0.27, respectively, at Field 2, Share Farm and at the two locations combined), implying that the method used for yield predictions in the crosses was appropriate.

INTRODUCTION

In Malaysia, local production of grain maize is encouraged to minimize the cost of importing animal feed from abroad. The seed production of single cross hybrids faces some constraints as a consequence of low vigor and yield of inbred parents after the successive selfing process at the early generations. To overcome this, Jones (1918, 1922) suggested the use of double cross hybrids in maize. A double cross hybrid results from the cross between two single crosses that are themselves the result of crosses between two selected inbred lines (Hallauer and Miranda 1982). For successful double cross hybrid development, heterotic effects have to be maximized, and the best results are expected when four unrelated or diverse inbred lines are used.

Although double cross hybrids show slightly higher variation in plant and ear characters as compared to single crosses, which might affect the grain yield, the cost of seed production could be reduced because they are produced on single cross hybrids as parents, which produce more seeds compared to inbred parents, as in the case of single cross hybrids (Jugenheimer 1976; Stoskopf *et al.* 1993).

Testing and selection of superior inbred lines for their combining ability for hybrid production demands a great amount of effort. When a high number of inbred lines are tested, the possible number of hybrid combinations to be evaluated is tremendously high. This poses a lot of practical difficulties in conducting extensive yield tests. Therefore, with the ability to accurately predict the performance of double cross hybrids from the performance of single crosses, only promising double crosses need to be developed and the yield performance confirmed in actual yield tests. This would effectively facilitate double cross hybrid development.

Several methods of making predictions of performance of double cross hybrids based on performance of single crosses were proposed. However, the most accurate prediction was found to be the mean value of the four non-parental single crosses (Allard 1970).

The main objectives of this study were to evaluate the performance of some double cross hybrids developed from previously selected highly potential single crosses, and to compare their performance with the predicted ones.

MATERIALS AND METHODS

Ten double cross hybrids developed from eleven inbred lines originating from five different source populations were used in this study. Experiments were conducted using the open-pollinated varieties, Suwan 1, Suwan 3 and Metro functioned as checks at two locations, Field 2 and Share Farm, Universiti Putra Malaysia.

The double crosses were formed on the basis of the performance of their respective single crosses revealed earlier (Sujiprihati 1997). Double crosses D-26, D-27 and D-28 were formed from two high single cross performers; D-29, D-30, D-31 and D-32 were formed between high and medium single cross performers, while D-33, D-34 and D-35 were the double crosses formed from two medium single cross performers.

The experiment was conducted using a Randomized Complete Block Design (RCBD) with three replications. The planting density used was 0.75 X 0.25 m. In each replication, plants were grown in 5-m long, 5-row plots, where the middle three rows (4 m in length) were used as harvested area. The experiments were conducted under standard cultural practices. Characters measured include:

a. Pre-harvest characters:
   1. Plant height at tasseling (cm)
   2. Days to tasseling (days)
   3. Days to maturity (days)

b. Post-harvest characters:
   1. Grain yield (kg/ha)
   2. Ear weight (g)
   3. Grain weight/ear (g)
   4. 100-grain weight (g)
   5. Shelling percentage.

The analysis of variance (ANOVA) was applied to the double cross performance data, where sample means in each plot were used for most of the characters studied except for grain yield, and flowering and maturity characters, where plot values were used. The analysis of variance was carried out using the Statistical Analysis System (SAS) computer package (SAS Institute Inc. 1991).

Predicted performance of the double cross hybrids was calculated on the basis of average performance of the non-parental single crosses from data obtained by Sujiprihati (1997), and

using the formula by Allard (1970) as follows: Predicted performance of double cross =

$$[(A \times C) + (A \times D) + (B \times C) + (B \times D)] / 4;$$

where A, B, C and D are inbred lines involved in a double cross (A X B) X (C X D).

For all characters studied, simple phenotypic correlations between actual and predicted performances of double cross hybrids were computed and their significance was determined using the t-test.

RESULTS

From results of the test of homogeneity of error variances (Table 1), error variances were found to be homogeneous for all characters except for ear weight, grain weight per ear and shelling percentage. Therefore, results from the combined analysis applied and are relevant.

Significant effects of locations were observed only for grain yield, grain weight/ear, 100-grain weight and plant height (Table 2), indicating that variations between the two locations only affected these traits. Significant effects of genotypes were shown for all characters studied at each location and locations combined, except for ear weight, grain weight/ear and shelling percentage at Field 2, and grain yield, ear weight and plant height at Share Farm.

The mean values for performance of the double cross hybrids for all characters were presented in Tables 3 to 5 for each of the two locations and locations combined. The best performing double cross hybrid at Field 2 was DC-26 which yielded (6125.0 kg/ha), followed by DC-34 and DC-29 with mean grain yields of 5917.8 and 5802.6 kg/ha, respectively. These values were higher than the two check varieties Suwan 3 and Metro, but not significantly different from Suwan 1 (Table 3). At Share Farm, the leading double cross hybrids were DC-26 and DC-34, with mean grain yields of 5648.9 and 5676.2 kg/ha, while for locations combined the two hybrids gave average grain yields of 5887.0 and 5797.0 kg/ha, respectively (Tables 4 and 5). These values were significantly higher than the three check varieties used. The two double cross hybrids, DC-26 and DC-34 were superior for all yield components, in particular at Field 2 and the locations combined.

From results shown in Table 6, the predicted grain yields of the double cross hybrids were found to be lower than the actual, but the relative trends were in good agreement, with significant correlation coefficients between the actual and predicted being 0.38, 0.46 and 0.27, respectively at Field 2, Share Farm and the locations combined. The correlation coefficients between the actual and the predicted performances were in general significant for other characters at both locations and locations combined. Exceptions were, however, shown by ear weight, grain weight/ear and shelling percentage at Field 2, and grain weight/ear and shelling percentage at Share Farm and the combined analysis, which showed non-significant correlations.

DISCUSSION

It was clearly seen from the results that the hybrids responded quite similarly at the two locations, and the variances were quite homogeneous. Average yield superiority of the

TABLE 1
Test of homogeneity of error variances from the ANOVA on performance of double cross maize hybrids between locations

Character	Error Mean Squares		F calculated
	At Field 2	At Share Farm	
Grain yield	196285.77	277256.10	1.41
Ear weight	269.53	110.79	2.43*
Grain weight /ear	207.05	97.33	2.12*
100-grain weight	3.65	3.41	1.07
Shelling percentage	8.77	3.28	2.68*
Plant height	228.57	275.92	1.21
Days to tasseling	1.14	1.40	1.23
Days to maturity	0.89	1.22	1.38

* Significant at $p \leq 0.05$

TABLE 2
Mean squares for characters measured on double cross maize hybrids at each of the two locations and locations combined

Source of variation	d.f.	Grain yield	Ear weight	Grain weight/ear	100-grain weight	Shelling percentage	Plant height	Days to tasseling	Days to maturity
At Field 2:									
Blocks	2	366193	1038*	652	8.77	6.30	135	0.03	4.39*
Genotypes	12	757405**	569	437	13.93**	14.35	786**	13.02**	8.17**
Error	24	196286	270	207	3.65	8.78	229	1.14	0.88
At Share Farm:									
Blocks	2	70970	25	40	19.02*	1.31	1916**	29.56**	0.31
Genotypes	12	464997	184	261*	12.26**	18.24**	507	10.26**	8.03**
Error	24	277256	111	97	3.41	3.28	276	1.40	1.22
At Locations Combined:									
Locations	1	900285*	662	663*	207.80**	21.29	438	7.39	1.85
Blocks/Location	4	218582	532*	346	13.90**	3.80	1025**	14.80**	2.35
Genotypes	12	1109479**	589**	559**	22.28**	23.46**	1120**	21.67**	14.51**
Pooled Error	60	212002	185	150	3.60	6.65	236	1.34	1.18

* Significant at $p \leq 0.05$
** Significant at $p \leq 0.01$

TABLE 3
Mean values for characters measured on double cross maize hybrids and check varieties, at Field 2

Double cross/ Check variety	Grain yield (kg/ha)	Ear weight (g)	Grain weight/ear (g)	100-grain weight (g)	Shelling percentage (%)	Plant height (cm)	Days to tasseling (days)	Days to maturity (days)
Double cross:								
DC-26	6125.0	175.3	152.8	30.3	87.8	187.7	51.7	93.3
DC-27	4504.9	130.0	114.0	26.4	88.2	179.4	58.0	94.7
DC-28	5135.2	155.5	134.2	25.9	86.2	180.1	54.0	95.3
DC-29	5802.6	156.0	134.4	27.1	86.2	172.1	51.3	91.7
DC-30	4449.0	129.6	111.8	23.6	86.4	153.8	53.7	95.3
DC-31'	5437.6	151.7	133.5	29.0	90.6	194.9	52.7	95.7
DC-32	5432.8	152.0	130.9	28.8	86.9	178.8	53.7	93.7
DC-33	5193.4	161.9	138.4	30.0	85.5	185.1	54.7	95.7
DC-34	5917.8	173.0	146.9	29.1	84.7	179.5	55.0	96.3
DC-35	5422.2	152.7	127.6	27.9	83.2	178.3	53.3	93.7
Check variety:								
Suwan 1	5341.5	139.1	115.3	30.3	83.3	193.1	55.0	95.3
Suwan 3	4884.5	148.4	128.4	31.6	86.6	180.5	52.3	96.0
Metro	4984.5	152.0	126.2	28.4	82.8	225.8	58.0	98.3
LSD (0.05)	746.6	27.7	24.3	3.2	5.0	25.5	1.8	1.6
c.v. (%)	8.4	10.8	11.0	6.8	3.4	8.2	2.0	1.0

TABLE 4
Mean values for characters measured on double cross maize hybrids and check varieties at Share Farm

Double cross/ Check variety	Grain yield (kg/ha)	Ear weight (g)	Grain weight/ear (g)	100-grain weight (g)	Shelling percentage (%)	Plant height (cm)	Days to tasseling (days)	Days to maturity (days)
Double cross:								
DC-26	5648.9	147.5	123.7	32.0	84.1	176.7	52.0	93.0
DC-27	4470.4	134.9	114.1	31.5	84.0	164.9	56.0	94.7
DC-28	5021.9	151.7	133.1	29.7	87.9	181.2	53.0	95.3
DC-29	4970.5	143.5	122.9	29.7	85.7	170.8	51.7	94.3
DC-30	4625.9	135.9	114.2	29.5	84.2	160.4	54.3	94.7
DC-31'	5455.4	153.5	135.0	29.9	88.0	189.6	51.3	96.0
DC-32	5410.4	150.0	128.4	32.3	85.6	184.1	51.3	94.0
DC-33	5107.9	149.7	127.6	31.3	85.2	177.4	53.0	94.3
DC-34	5676.2	160.8	141.1	31.8	87.7	191.1	53.0	95.7
DC-35	5134.4	146.5	129.8	29.3	86.9	157.4	53.7	94.7
Check variety:								
Suwan 1	4862.4	147.3	119.5	33.8	80.7	185.9	54.3	96.7
Suwan 3	4868.8	143.5	121.4	35.9	84.6	185.4	53.0	96.0
Metro	4585.0	134.0	107.9	33.7	80.3	202.7	57.7	99.7
LSD (0.05)	887.3	17.7	16.6	3.1	3.1	28.0	2.0	1.9
c.v. (%)	10.4	7.2	7.9	5.9	2.1	9.3	2.2	1.2

TABLE 5
Mean values for characters measured on double cross maize hybrids and check varieties, at the two locations combined

Double cross/ Check variety	Grain yield (kg/ha)	Ear weight (g)	Grain weight/ear (g)	100-grain weight (g)	Shelling percentage (%)	Plant height (cm)	Days to tasseling (days)	Days to maturity (days)
Double cross:								
DC-26	5887.0	161.4	138.2	31.0	86.0	182.2	51.8	93.2
DC-27	4487.6	132.5	114.1	29.0	86.1	172.1	57.0	94.7
DC-28	5078.5	153.6	133.6	27.8	87.1	180.6	53.5	95.3
DC-29	5386.6	149.8	128.7	28.4	85.9	171.5	51.5	93.0
DC-30	4537.5	132.8	113.0	26.5	85.3	157.1	54.0	95.0
DC-31'	5446.5	152.6	134.3	29.4	89.3	192.3	52.0	95.8
DC-32	5421.6	151.0	129.6	30.6	86.3	192.3	52.5	93.8
DC-33	5150.7	155.8	133.0	30.7	85.4	181.5	53.8	95.0
DC-34	5797.0	166.9	144.0	30.4	86.2	181.3	54.5	96.0
DC-35	5278.3	151.1	128.7	28.6	85.0	167.9	53.5	94.2
Check variety:								
Suwan 1	5102.0	143.2	117.4	32.1	82.0	189.5	54.7	96.0
Suwan 3	4876.7	146.0	124.9	33.8	85.6	182.9	52.7	96.0
Metro	4784.9	143.0	117.1	31.0	81.5	205.4	57.8	99.0
LSD (0.05)	564.9	16.0	14.3	2.2	2.9	18.4	1.3	1.2
c.v. (%)	9.4	9.2	9.7	6.3	2.9	8.8	2.1	1.1

TABLE 6
Predicted and actual performance of double cross hybrids and their correlations at each of the two locations, and locations combined

Performance	Grain yield (kg/ha)	Ear weight (g)	Grain weight/ear (g)	100-grain weight (g)	Shelling percentage (%)	Plant height (cm)	Days to tasseling (days)	Days to maturity (days)
At Field 2:								
Predicted	3402.0	129.3	99.1	27.4	82.0	160.8	51.9	92.3
Actual	5342.1	148.6	132.5	27.8	86.6	179.0	53.8	94.5
Correlations (r)	0.38*	0.23	0.01	0.36*	0.09	0.40*	0.56**	0.44*
At Share Farm:								
Predicted	4699.0	131.4	100.9	28.9	82.0	172.5	52.0	91.5
Actual	5152.2	147.7	127.7	30.7	85.9	175.4	53.0	94.7
Correlations (r)	0.46*	0.40*	0.26	0.37*	0.28	0.45*	0.62**	0.36*
At Locations Combined:								
Predicted	4217.0	130.4	100.0	28.2	82.0	166.7	56.5	91.9
Actual	5226.1	148.1	130.1	29.2	86.2	177.2	58.0	94.6
Correlations (r)	0.27*	0.25*	0.09	0.54**	0.16	0.33*	0.58**	0.39*

* Significant at $p \leq 0.05$
** Significant at $p \leq 0.01$

double cross hybrids over the check varieties was shown with particularly excellent performance of DC-26 and DC-34. With their high yielding capability (5 to 6 tons/ha) and early maturity, these double cross hybrids are promising with good potential use in commercial production. The average yields of these hybrids were higher than the average productivity of the presently available open-pollinated varieties, and as high as that of the local single cross hybrid variety, Putra J-58, which was found to give grain yield 6.2 tons/ha (Saleh 1998). Although only two locations were used in this study, double cross hybrids were proven capable of performing well in a wide range of environments as reported by Eberhart and Russell (1969) and Weatherspoon (1970).

The method used for yield prediction was satisfactory and was supported by results from previous research workers such as Eberhart and Hallauer (1968); Zuber *et al.* (1973) and Moll and Stuber (1974). There were strong correlations between the predicted and actual performances of the hybrids at both locations and in the combined analysis as indicated by the significant correlation coefficients for most of the characters.

The results of this study on yield prediction were strengthened and advocated by reports from Otsuka *et al.* (1972) and Stuber *et al.* (1973), showing that preliminary selections for double cross hybrids can be efficiently performed by utilizing predictions based on non-parental single cross means obtained from a number of environments. Furthermore, the final evaluation of a reduced number of selected hybrids require sufficient environments to verify hybrids' suitability for commercialization. The information obtained on performance of the non-parental single crosses in this study was, therefore, effective in predicting performance of the double cross hybrids from a selected group of inbred lines. However, it suggested that the appropriate single crosses should be evaluated in preliminary field trials at several locations.

CONCLUSION

Results of this study on actual yield, as well as yield predicted based on the average performance of the non-parental single crosses, had reflected the superiority of the two double cross hybrids DC-26 and DC-34 over the check varieties. Thus, they could be suggested for further testing in larger scale evaluation trials towards their use in commercial production in this country.

ACKNOWLEDGEMENT

The authors would like to express their appreciation to Universiti Putra Malaysia and the Ministry of Science, Technology and the Environment for the financial support through IRPA Research Grant Nos. 1-07-05-017 and 1-02-04-0041.

REFERENCES

ALLARD, R. W. 1970. *Principles of Plant Breeding.* New York: John Wiley & Sons.

EBERHART, S. A. and A. R. HALLAUER. 1968. Genetic effects in single, three-way and double-cross maize hybrids. *Crop Sci.* **8:** 377-379.

EBERHART, S. A. and W. A. RUSSELL. 1969. Yield and stability for 10-line diallel of single-cross and double cross maize hybrids. *Crop. Sci.* **9:** 357-361.

HALLAUER, A. R. and J. B. MIRANDA. 1982. *Quantitative Genetics in Maize Breeding.* Ames: Iowa State University Press.

JENKINS, M. T. 1934. Methods of estimating the performance of double crosses in corn. *J. Amer. Soc. Agron.* **26:** 199-204.

JONES, D. F. 1918. The effects of inbreeding and cross breeding upon development. *Connecticut Agric. Exp. Stat. Bull.* **207:** 1-100.

JONES, D. F. 1922. The productiveness of single and double first generation corn hybrids. *Agron. J.* **14:** 241-252.

JUGENHEIMER, R. W. 1976. *Corn Improvement, Seed Production and Uses.* New York: Wiley-Interscience Publication, John Wiley & Sons.

MOLL, R. H. and C. W. STUBER. 1974. Quantitative genetics – empirical results relevant to plant breeding. *Adv. Agron.* **26:** 277-313.

OTSUKA, Y., S. A. EBERHART and W. A. RUSSELL. 1972. Comparison for prediction for maize hybrids. *Crop. Sci.* **12:** 325-331.

SALEH, G.B. 1998. Putra J-58 - The hybrid grain maize variety. Bulletin for the launching of the grain maize variety, Putra J-58. 8 Oct., Faculty of Agriculture, Universiti Putra Malaysia, Serdang, Malaysia.

SAS INSTITUTE INC. 1991. SAS/STAT™ Guide for personal computers, Version 6.03 ed. SAS Inst., Cary, NC.

STOSKOPF, N. S., D. T. TOMES and B. R. CHRISTIE. 1993. *Plant Breeding. Theory and Practice.* San Francisco: Westview Press Inc.

STUBER, C. W., W. P. WILLIAMS and R. H. MOLL. 1973. Epistasis in maize (*Zea mays* L.). III. Significance in predictions of hybrid performances. *Crop. Sci.* **13:** 195-200.

SUJIPRIHATI, S. 1997. Heterosis, combining ability and yield prediction in hybrids from local maize inbred lines. Ph.D. Thesis, 256p. Universiti Pertanian Malaysia.

WEATHERSPOON, J. H. 1970. Comparative yields of single, three-way and double-crosses in maize. *Crop. Sci.* **10:** 157-159.

ZUBER, M. S., E. S. HILDER, P. J. LOESCH and A. J. KEASTER. 1973. Prediction of reactions to dwarf mosaic virus in double-cross hybrids based upon single cross reactions. *Crop. Sci.* **13:** 172-175.

(Received: 18 October 2000)
(Accepted: 24 September 2002)

Pertanika J. Trop. Agric. Sci. 26(1): 35 - 40 (2003) ISSN: 1511-3701

A Protocol for Efficient Plantlet Regeneration from Leaf Derived Callus of Lablab Bean (*Lablab purpureus* var. lignosus (L) prain)

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Keywords: ***Lablab purpureus*, multiple shoot induction, organogenesis, tissue culture**

ABSTRAK

*Satu perbezaan mata tunas pucuk dan gandaan aruhan pucuk daripada kalus daun kacang Lablab (*Lablab purpureus *var. lignosus) telah diperoleh. Aruhan kalus dan penggandaan pucuk pada pelbagai frekuensi diperhatikan menggunakan konsentrasi berbeza dan kombinasi auksin (IAA, 2, 4-D dan NAA) dan sitokinin (BAP). Frekuensi aruhan kalus yang paling tinggi diperhatikan pada medium kultur asas MS yang mengandungi 2, 4-D (3.0 mg/1) dan BAP (0.5 mg/1). Nodular kalus padat hijau berlaku pada NAA (3.0 mg/1) dan BAP (0.5 mg/1). Peratusan pembentukan mata tunas pucuk dan penggandaan yang tertinggi diperoleh daripada kombinasi BAP (2.0 mg/1) dan NAA (0.5 mg/1). Pucuk-pucuk yang dijana semula dipindahkan ke medium kultur asas MS yang mengandungi IBA (1.5 mg/1) untuk aruhan akar. Tumbuh-tumbuhan berakar dipindahkan ke mangkuk plastik dan seterusnya telah berjaya dipindahkan ke ladang.*

ABSTRACT

An efficient shoot bud differentiation and multiple shoot induction from leaf derived callus of Lablab bean (Lablab purpureus *var. lignosus*) *have been obtained. Callus induction and shoot multiplication at various frequencies were observed using different concentrations and combinations of auxins (IAA, 2, 4-D and NAA) and cytokinin (BAP). The highest frequency of callus induction was observed on MS medium containing 2, 4-D (3.0 mg/1) and BAP (0.5 mg/1). The green compact nodular calli occurred on NAA (3.0 mg/1) and BAP (0.5 mg/1). Highest percentage of shoot bud formation and multiplication was obtained from a combination of BAP (2.0 mg/1) and NAA (0.5 mg/1). The regenerated shoots were transferred to MS medium containing IBA (1.5 mg/1) for the induction of roots. Rooted plants were transferred to plastic cups and subsequently these were successfully transferred to fields.*

INTRODUCTION

Legumes are one of the most important groups of crop plants and efforts have been focused to improve the crops, particularly for desirable traits, including their response to in vitro culture manipulation. Since legumes are notoriously recalcitrant to regeneration from tissue culture much effort has been devoted to developing and optimizing efficient in vitro regeneration systems to facilitate a variety of technologies (Geetha *et al.* 1998). The ability to regenerate plants from cultured cells, tissues or organs constitutes the basis of producing transgenic crops. Successful regeneration of legumenous species has been greatly aided by species-specific determination of critical parameters, such as explant source, genotype and media constituents (Parrot *et al.* 1992). Lablab bean (*Lablab purpureus*) var.

Abbreviations

NAA: 1-napthalene acetic acid; IAA: Indole-3-acetic acid; IBA: Indole-3-butyric acid; 2,4-D: 2,4-dichlorophenoxy acetic acid; BAP: 6-benzyl amino purine.

lignosus (L.) prain is an important high protein grain legume. It belongs to the family of Fabaceae, and grows in tropical and subtropical countries. Recent advances in in vitro culture technologies brought about new techniques for crop improvement. Application of tissue culture techniques to genetic upgrading of economically important plants have been reported (Scowcraft 1977). Only limited success has been reported for in vitro organogenesis and regeneration from *Lablab purpureus* (Sounder *et al.* 1991; Thiruvengadam and Jayabalan 2000a). Shoot and plantlet regeneration from seedling and other explants have been reported in many leguminous pulses like Glycine wigghtii (Pandey and Bansal 1992), *Pisum sataivum* (Ozean *et al.* 1992), *Phaseolus vulgaris* (Zambre *et al.* 1998) and *Macrotyloma uniflorum* (Varisai Mohamed *et al.* 1999). Hence the present investigation was attempted to standardize a protocol for rapid shoot multiplication from leaf explants of Lablab bean.

MATERIALS AND METHODS

Seeds of Lablab bean (*Lablab purpureus* var. lignosus (L) prain) cultivar CO 1 were obtained from Tamil Nadu Agricultural University, Coimbatore, India. The seeds were washed with distilled water 5 times, followed by treatment of 5% sodium hypochloride for 15 min and disinfected with 0.1% $HgCl_2$ for 3 min. The disinfected seeds were rinsed thoroughly with sterile water 6 times and aseptically placed over sterile moist cotton for germination. The young leaves were excised from 7 day old in vitro raised seedlings and cultured in 25 x 150 mm tubes containing 15 mL semisolid MS (Murashige and Skoog 1962) medium with of 3% (w/v) sucrose, 0.8% (w/v) Bacto agar and various concentrations (0.0-5.0 mg/1) of hormones 2,4-D, IAA, IBA and NAA either alone or in combination with (0.5 mg/1) BAP. The pH of the medium was adjusted to 5.8 and autoclaved at 1.06 kg cm^2 for 15 min before inoculation. All cultures were maintained under cool white fluorescent light (80 μ $Em^{-2}s^{-1}$) at 25± 2^0C with a 16 h photoperiod. Shoots obtained in vitro were transferred to MS medium supplemented with different concentrations (0.0 – 2.0 mg/1) of auxins (NAA, IAA and IBA). Histological analysis was done to confirm shoot regeneration from the leaf callus. At least 20-24 explants were cultured in each treatment and all the experiments were repeated three times. The regenerated plants were transferred to plastic cups containing sterile soil, sand and compost in the ratio (1:1:1) in a greenhouse.

RESULTS AND DISCUSSION

Callus initiation was observed within 8 days of culturing the leaf explants of cultivars CO 1 on MS medium supplemented with different concentrations of IAA, 2,4-D and NAA (0.0 – 5.0 mg/1) alone or in combination with BAP (0.5 mg/1). Young leaf explants were more responsive in producing callus than other seedling explants. Similar results were reported in *V. unguiculata* (Kulothungan *et al.* 1995) and *Lablab purpureus* (Thiruvengadam and Jayabalan 2000b). The combination of 2,4-D (3.0 mg/1) and BAP (0.5 mg/1) showed maximum callus induction frequency (70.0 ± 7.00) (Table 1) producing yellowish friable callus. In the present study, leaf explants cultured on MS medium supplemented with (NAA 3.0 mg/1) and BAP (0.5 mg/1) produced greenish compact callus

TABLE 1
The effect of various concentrations of IAA, NAA and 2,4-D in combination with 0.5 mg/1 BAP on callus induction frequency in *L. purpureus*

Auxins (mg/L)	Cytokinins (mg/1)	Callus induction Frequency(% mean ± SD)
IAA	BAP	
0.0	0.0	0.0
1.0	0.5	33.3 ± 3.50^{i}
2.0	0.5	37.0 ± 2.00^{h}
3.0	0.5	48.0 ± 3.61^{e}
4.0	0.5	45.0 ± 5.00^{fg}
5.0	0.5	42.0 ± 4.33^{gh}
2,4-D		
0.0	0.0	0.0
1.0	0.5	49.0 ± 3.00^{de}
2.0	0.5	52.0 ± 2.64^{c}
3.0	0.5	70.0 ± 7.00^{a}
4.0	0.5	57.0 ± 4.58^{bc}
5.0	0.5	46.7 ± 6.11^{ef}
NAA		
0.0	0.0	0.0
1.0	0.5	44.3 ± 4.04^{g}
2.0	0.5	49.6 ± 2.52^{d}
3.0	0.5	63.0 ± 1.73^{b}
4.0	0.5	52.0 ± 2.65^{cd}
5.0	0.5	45.6 ± 351^{f}

Values with the same letter are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

(*Fig. 1*) with maximum induction frequency (63.0 ± 1.73). Similar results were reported in *Vitex negundo* (Thiruvengadam and Jayabalan 2001) and *Vigna radiata* (Patel *et al.* 1991). The callus was subcultured on MS medium containing NAA (0.5 mg/1) with different concentrations of BAP (0.5 – 2.5 mg/1) for shoot bud differentiation (Table 2). The highest percentage (81.2 ± 8.5) of shoot initiation from the compact calli occurred on BAP (2.0 mg/1) and NAA (0.5 mg/1). Similar results were reported in *Carrica papaya* (Hossain *et al.* 1993) where adventitious buds were obtained when 2.0 µM BAP and 0.1 µM NAA were used. The buds developed into multiple shoots on medium containing BAP (2.0 mg/1) and NAA (0.5 mg/1) after 5 weeks of culture (*Fig. 2*). Shoots developed (*Fig. 3*) up to approximately 5-10 cm in length and subsequently transferred to rooting media. The highest frequency of root formation (72.0 ± 2.0) (Table 3) was observed on MS medium containing IBA 1.5 mg/1 (*Fig. 4*). Rooted plantlets were successfully transferred to plastic cups. During the initial period of acclimatization, transferred plants were kept under culture room conditions and high relative humidity was maintained by covering the plants with polyethylene bags (creating a humid chamber

TABLE 2
Effect of NAA (0.5 mg/1) in combination with various BAP concentrations on shoot bud regeneration from leaf derived callus of *L. purpureus*

BAP (mg/L)	% of culture showing regeneration (Mean ± SD)	Average number of shoots/culture (Mean ± SE)	Average length (cm) of shoots (Mean ± SE)
0.5	42.5 ± 9.5^{d}	9.7 ±5.0^{cd}	3.6 ± 0.2^{d}
1.0	56.0 ± 6.6^{c}	10.6 ± 3.7^{c}	5.5 ± 2.3^{c}
1.5	65.0 ±12.9^{b}	14.0 ±1.8^{b}	6.4 ± 0.1^{b}
2.0	81.2 ± 8.5^{a}	21.2 ± 1.8^{a}	7.8 ± 0.5^{a}
2.5	40.0 ± 8.1^{de}	7.8 ± 0.5^{d}	3.4 ± 0.3^{de}

Values with the same letter are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

TABLE 3
Rooting of shoots of Lablab bean on MS medium supplemented with different concentrations of IAA, NAA, IBA

Growth regulators (mg/1)	shoots forming roots (%)	Average no of roots/ shoots	Root length/ explant
IAA			
0.5	18.3 ± 3.0^{f}	1.0 ± 0.0^{e}	1.0 ± 0.0^{f}
1.0	20.0 ± 2.0^{e}	1.3 ± 0.4^{de}	1.3 ± 0.4^{d}
1.5	38.0 ± 1.6^{cd}	1.6 ± 0.4^{d}	1.5 ± 0.3^{cd}
2.0	22.6 ± 0.9^{de}	0.0 ± 0.0^{ef}	1.1 ± 0.0^{ef}
IBA			
0.5	27.0 ± 1.0^{d}	2.3 ± 0.5^{c}	1.96 ± 0.1^{c}
1.0	48.6 ± 1.5^{c}	3.0 ± 1.0^{b}	2.70 ± 0.6^{bc}
1.5	72.0 ± 2.0^{a}	4.0 ± 0.0^{a}	4.43 ± 0.3^{a}
2.0	54.3 ± 4.0^{b}	3.0 ± 0.8^{bc}	3.00 ± 0.2^{b}
NAA			
0.5	15.3 ± 1.5^{fg}	1.0 ± 0.0^{e}	1.2 ± 0.4^{de}
1.0	20.0 ± 1.6^{ef}	1.0 ± 0.0^{ef}	1.1± 0.2^{e}
1.5	–	–	–
2.0	–	–	–

Values with the same letter are not significantly different according to Duncan's Multiple Range Test (DMRT) at 5% level.

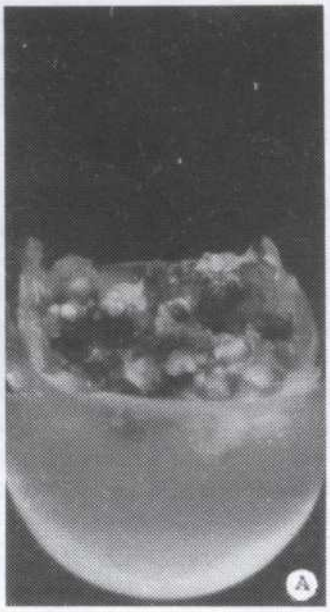

Fig. 1: A greenish compact nodular callus from leaf explant

Fig. 2: Adventitious shoots from leaf derived callus

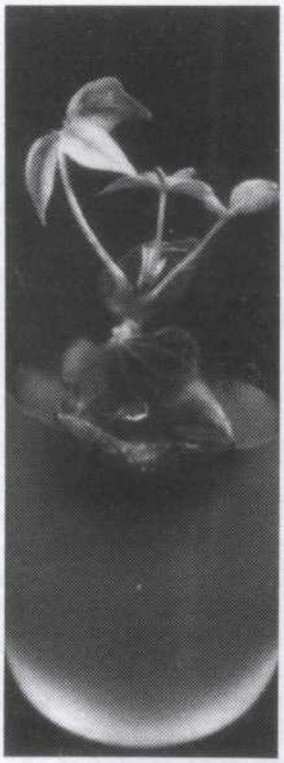

Fig. 3: A single isolated shoot

Fig. 4: Root induction of from regenated shoots

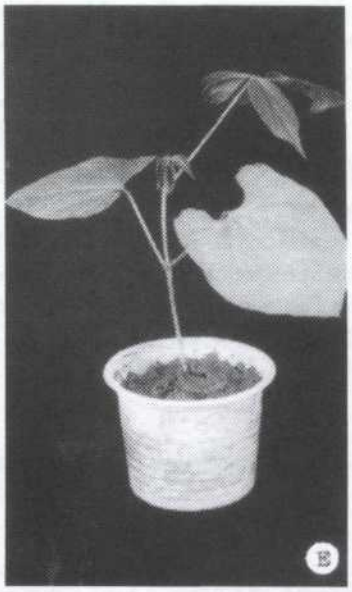

Fig. 5: A hardened plant (after 3 weeks of transfer to plastic cups)

Fig. 6: Histological section showing the development of shoot primordia from the leaf callus

effect). Finally, these plants were successfully transferred to the field (*Fig. 5*). The regeneration of shoot primordia from the leaf callus were histologically analysed confirming indirect regeneration (*Fig. 6*).

The study describes plant regeneration *via* callus culture with high frequency of plant recovery. This plant regeneration protocol may prove to be useful for genetic transformation studies in Lablab bean, for developing, disease-resistant, salt-resistant and herbicide-resistant plants.

REFERENCES

GEETHA, N., P. VENKATACHALAM, V. PRAKASH and G. LAKSHMI SITA. 1998. High frequency induction of multiple shoots and plant regeneration from seedling explants of Pigeon pea (*Cajanus cajan* L.) *Current Science* **75(10)**: 1036-1041.

HOSSAIN, M., S. M. RAHMAN, R. ISLAM and O. I. JOARDER. 1993. High frequency plant regeneration from petiole explants of *Carica papaya* L. through organogenesis. *Plant Cell Rep.* **13**: 99-102.

KULOTHUNGAN, S., A. GANAPATHI, A. SHAJAHAN and K. KATHIRAVAN. 1995. Somatic embryogenesis in cell suspension cultures of Cowpea (*Vigna unguiculata* (L) walp). *Israel J. Pl. Sci.* **43**: 385-390.

MURASHIGE, T. and F. SKOOG. 1962. A revised medium for rapid growth and bioassays with tobacco tissue cultures. *Physiol Plant* **15**: 476-497.

OZEAN, S., M. BARGHCHI, S. FIREK and J. DRAPER. 1992. High frequency adventitious shoot regeneration from immature cotyledons of Pea (*Pisum sataivum* L.) *Plant Cell Rep.* **11**: 44-47.

PANDEY, P. and Y. K. BANSAL. 1992. Plant regeneration from leaf and hypocotyl explants of *Glycine wightii* (W. and A.) VERDC var. longicauda. *Japan J. Breed.* **42**:1-5.

PARROT, W. A., M. A. BAILEY, R.E. DURHAM and H. V. MATHEWS. 1992. Tissue culture and regeneration of legumes. In *Biotechnology and Crop Improvement in Asia*, ed. J. P. Moss. p. 115-148. India: ICRISAT.

PATEL, M. B., R. BHARDWAJ and A. JOSHI. 1991. Organogenesis in *Vigna radiata* (L) Wilczek. *Indian J. Exp. Biol.* **29**: 619-622.

SCOWCRAFT, W. 1977. Somatic cell genetics and plant improvement. *Ann. Rev. Agron.* **29**: 39-81.

SOUNDER R., V., B. H. M. NIJALINGAPPA and D. H. TEJAVATHI. 1991. In vitro studies in Dolichos

lablab var. lignosus. *Indian J. Exp. Biol.* **29**: 221-225.

THIRUVENGADAM, M. and N. JAYABALAN. 2000a. Plant regeneration from cotyledonary nodes of Lablab bean (*Lablab purpureus* L). *J. Phytal. Res.* **13(1)**: 41-44.

THIRUVENGADAM, M. and N. JAYABALAN. 2000b. Effect of auxins and cytokinins on callus induction of Lablab bean (*Lablab purpureus*) var. lignosus (L.) prain. *Geobios.* **27**: 169-172.

THIRUVENGADAM, M. and N. JAYABALAN. 2001. In vitro regeneration of plantlets from internode derived callus of *Vitex negundo* L. *J. Medic. Arom. Plant Sci.* **22**.

VARISAI MOHAMED, S., M. JAWAHAR, M. THIRUVENGADAM, M. JAYAKUMAR and N. JAYABALAN. 1999. Effect of cytokinins on the proliferation of multiple shoots in Horse gram (*Macrotyloma uniflorum* (Lam.) Verdc). *J. Plant Biotech.* **1(2)**: 79-83.

ZAMBRE, M. A., J. DECLERCG, E. VRANOVA, M. V. MONTAGU, G. ANGENON and W. DILLEN. 1998. Plant regeneration from embryo-derived callus in *Phaseolus vulgaris* L. (Common bean) and *P. accutifolius* A. Gray (tepary bean). *Plant Cell Rep.* **17**: 626-630.

(Received: 19 February 2001)
(Accepted: 25 March 2003)

Pertanika J. Trop. Agric. Sci. **26(1)**: 41 - 47 (2003) ISSN: 1511-3701

Evaluation of Plant and Animal Tea Solution Fertilizers on the Soil Fertility and Growth of Locust Bean (*Parkia clappertonia*) Seedlings in the Nursery

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Keywords: ***Parkia clappertonia*, tea solutions, manurial tea fertilizers, growth parameters, control treatment**

ABSTRAK

*Satu eksperimen bagi menentukan keberkesanan 'liquid plant' dan 'animal tea solutions' sebagai baja ke atas tumbesaran dua benih kacang lokus (*Parkia clappertonia*), telah dijalankan di Akure, sebuah zon hutan hujan Nigeria. Lapan jenis campuran anak-anak pokok telah digunakan; kopi, koko,* Cajanus-cajan *(Pigeon pea), gajus, daun plantain, baja najis kambing, ayam belanda dan itik, di mana 100 mL/10 kg tanah yang diisi dalam polibeg digunakan dengan NPK 15-12-12 pada 1g, NPK/10 kg tanah dan kawalan (tanpa najis binatang, baja). Tanah tersebut diterbalikkan sebanyak tiga kali dan disusun secara rawak dalam bentuk yang berbeza. Campuran tanah dan baja tersebut dianalisis secara kimia sebelum benih kacang lokus tersebut ditanam. Keputusan menunjukkan anak-anak pokok yang ditanam dengan tanah tersebut meningkat secara signifikan ($P<0.05$) dari segi ketinggian tumbuhan, lilitan batang, jumlah dedaun, jumlah dahan, berat tunas dan kepanjangan akar, komposisi kimia pada dedaun dan status khasiat tanah kacang lokus tersebut. Bagi komposisi kimia tanah, campuran daun kopi meningkatkan nilai pH tanah, O.M, N, P,K Ca dan Mg masing-masing pada kadar 4.2%, 10%, 13.6%, 58.3%, 22%, 91.3% dan 84% apabila dibandingkan dengan campuran daun cajanus. Manakala, campuran daun gajus telah meningkatkan nilai pH tanah, O.M, N,P,K, Ca dan Mg masing-masing pada kadar 2.8%, 11%, 48%, 57%, 8.3%, 38.5% dan 33% jika dibandingkan dengan campuran daun koko. Campuran daun kopi meningkatkan nilai pH tanah, O.M, N, P, K Ca dan Mg masing-masing pada kadar 24%, 74%, 82%, 89%, 96%, 98% dan 97% jika dibandingkan dengan setiap rawatan kawalan. Anak pokok kopi meningkatkan nilai pH tanah, O.M, K, Ca dan Mg masing-masing pada kadar 25%, 69%, 39%, 98.7% dan 99% berbanding rawatan baja NPK. Baja najis ayam belanda juga meningkatkan nilai pH tanah, O.M, N, P dan Mg masing-masing pada kadar 2%, 19%, 37%, 42% dan 82% berbanding baja daripada najis itik. Pemerhatian yang dibuat ke atas parameter tumbesaran benih kacang lokus, anak pokok gajus telah meningkat dari segi ketinggian, jumlah daun, jumlah dahan, lilitan batang, kepanjangan akar dan berat tunas pada kadar 33%, 41%, 33.3%, 12.2%, 36.4% dan 16% berbanding rawatan baja NPK. Sama seperti di atas, ia juga meningkatkan parameter tumbesaran masing-masing pada kadar 61%, 71%, 78%, 62%, 77% dan 71% berbanding rawatan kawalan. Di dalam komposisi kimia daun kacang lokus, N, P, K, Ca dan Mg anak pokok gajus telah meningkat dengan 42%, 45%, 41.6%, 8.5% dan 83% berbanding baja NPK. Anak pokok gajus dan baja dari najis ayam belanda adalah yang paling menunjukkan tumbesaran yang pesat, tumbesaran daun dan tanah bagi benih kacang lokus.*

ABSTRACT

An experiment was carried out at Akure in the rainforest zone of Nigeria to determine the effectiveness of liquid plant and animal tea solutions as fertilizers on the growth of two crops of locust bean (Parkia clappertonia) tree seedlings in the nursery. Eight manurial tea solutions were used namely; coffee, cocoa, Cajanus-cajan *(Pigeon pea), Cashew, plantain leaf tea fertilizers, goat dung, turkey and duckmanure tea fertilizers, applied at 100 mL/ 10 kg soil filled polybag with NPK 15-15-15 at 1 g NPK/10 kg soil and control (no manure, no fertilizer). They*

were replicated three times and arranged in a completely randomized design. The soil and manurial tea fertilizers were chemically analysed before planting locust bean seeds. The results showed that the manurial tea solutions increased the plant height, stem girth, number of leaves and number of branches, shoot weight and root length at harvest, leaf chemical composition of locust bean seedlings and the soil nutrient status significantly ($P < 0.05$). For soil chemical composition, coffee leaf solution increased the soil pH, O.M, N,P,K, Ca and Mg by 4.2%, 10%, 13.6%, 58.3%, 22%, 91.3% and 84% respectively when compared with cajanus leaf solution while the cashew leaf solution increased the soil pH, O.M, N, P,K, Ca and Mg by 2.8%, 11%, 48%, 57%, 8.3%, 38.5% and 33% when compared with cocoa leaf solution respectively. Coffee leaf tea solution increased the soil pH, O.M, N, P, K, Ca and Mg by 24%, 74%, 82%, 89%, 96%, 98% and 97% compared with the control treatment respectively. Coffee tea solution increased the soil pH, O.M, K, Ca and Mg by 25%, 69%, 39%, 98.7% and 99% compared to NPK fertilizer treatment respectively. Turkey manure tea solution also increased the soil pH, O.M, N, P and Mg by 2%, 19%, 37%, 42% and 82% respectively compared to the duck manure tea. Concerning the growth parameters of locust bean seedlings, Cashew leaf tea solution increased the plant height, number of leaves, number of branches, stem girth, root length and shoot weight by 33%, 41%, 33.3%, 12.2%, 36.4% and 16% compared to the NPK fertilizer treatment respectively. It also increased the same growth parameters by 61%, 71%, 78%, 62%, 77% and 71% respectively when compared to the control treatment. In the locust bean leaf chemical composition, the cashew leaf tea solution increased the leaf N, P, K, Ca and Mg by 42%, 45%, 4.16%, 85% and 83% when compared with NPK fertilizer respectively. Cashew leaf solution and turkey manure tea solutions increased the growth, leaf and soils of locust bean seedlings most.

INTRODUCTION

African locust bean (*Parkia clappertonia*) is a traditional tea grown for its seeds which were used as condiment or spices for food preparation in most homes in the tropical countries. Despite the above importance, the crop is going into extinction (less of biodiversity) and this is because people are not growing the crop due to difficulty in raising the seedlings and the poor soil fertility which tend to prolong its maturity in the nursery and on the field. Now, there is a renewed interest in the crop as an organic condiment as demonstrated by some food industries such as Lever brothers PLC and Cadbury Nigeria PLC to replace the chemically manufactured maggi cubes and other food seasonings.

Efforts must be made to produce the locust bean seedlings for planting in commercial production and the use of inorganic fertilizers to sustain the soil fertility for the optimum growth of the crop is accompanied by high cost, scarcity at farmers' level and degradation of soil properties on continuous use.

Several researchers (Agboola 1974; Bredero 1977; Adu-Daaph *et al.* 1994; Ojeniyi 1998; Folorunso 1999) have established the importance of the following solid organic manures such as cocoahusk pod, woodash, spentgrain, poultry, goat, pig and rabbit manures in improving soil fertility, crop quality and yield of crops. They also established that these materials were locally available, cheap and sustainable. However, the adoption and utilization of these solid manures by farmers were still not encouraging because the farmers complained of the bulkiness, mess and difficulty in the transportation of the solid organic wastes (Agboola 1982).

The quest to find research answers to the above problems led to the development and use of organic tea solutions to raise locust bean seedlings in the nursery (Folorunso 1999 pers. comm.). An organic tea solution fertilizer is the one derived from plant leaves and animal dung through immersion in water. The objectives of the research were, therefore, to determine the effect of different organic tea fertilizers on the growth, nutrients in the leaf, and chemical composition of soil at a harvest of African locust bean (*Parkia clappertonia*) seedlings in the nursery.

MATERIALS AND METHODS

The experiment was carried out at Akure (70^0N^1, 5^010^1E) in the rainforest zone of Nigeria. The rainfall is between 1,500 mm per annum and temperature is 24°C all year round.

Soil Sampling and Analysis

The soil samples (30 core) were collected from the 0-15 cm depth on the site, mixed thoroughly, curdried and sieved to pass through a 2 mm sieve for routine analysis. The soil pH (1:1 soil/water) was read on the pH meter. Organic matter was determined by the wet oxidation method using chronic acid digestion procedure (Walkley

and Black 1934).

Soil P was extracted by Bray P1 extractant and P solution was determined with molybdate blue method (Murphy and Riley 1962).

The soil K, Ca, Mg and Ma were extracted with 1M NH_4Oac pH 7 and the content was determined by using atomic absorption spectrophotometer.

Total N was determined by microkjedahl (Jackson 1964).

Collection and Preparation of the Manurial Tea Solution Fertilizer

Cocoa, cashew and coffee leaves were collected from their plantations while cajanus cajan and plantain leaves were obtained from the nearby farms. The goat, turkey and duck manures were collected from their pens. The leaves were cleaned to remove the dust while the manures were airdried, and ready for the tea preparation.

The plant leaves (5 kg each) were weighed and the leaves were chopped, immersed in 50 litre (L) containers filled with the 40 L of water. The immersed leaves were stirred at every three-day interval with a wooden ladle until 14 days after setting up the experiment. Thereafter, the 40 L tea solution was diluted with 40 L of water and the diluted solution was applied to the soils on which locust bean seeds were grown.

The animal manure (10 kg each) was weighed into a polysac or salt bag, tied at the mouth with a rope into a crossbar stick of 10m length which had been suspended on two sticks with edges erected at a distance of 8 m from each other. The bag containing the weighed manure was gradually suspended into a 50 L container filled with 40 L water. Stirring of the solution took place at every three-day interval until 2 weeks after the initial setting of the experiment.

The tea solution (40 L of tea fertilizer) was diluted with 200 L of water for poultry manure (1:5) while goat, turkey and duck manure solutions were diluted with 120 L of water (1:3). The diluted solutions of the animal manure tea fertilizer were added to the soil to be used for raising locust seedlings.

Chemical Composition of the Manurial Tea Fertilizer

An aliquot of each tea fertilizer (5 mL) was taken for the chemical analysis. The total N was determined by microkjedahl method. The P content was analysed using vanado-molybdate method (Aduayi and Gatitu 1973).

The K, Ca, Na were determined using flame photometer and Mg on atomic absorption spectrophotometer (AOAC 1970).

Nursery Experiment

Seeds of locust bean were collected and pre-germinated in the pre-nursery boxes. One hundred and fifty (150) polybags were filled with 10 kg soil each and arranged in five sets for the ten treatments using a completely randomized design and replicated three times. Each replicate had 50 polybags.

Two germinated seeds of locust bean were planted into each polybag and one week after planting, 100 mL of each manurial tea fertilizer was applied per polybag while 1 g of NPK 15-15-15 fertilizer per 10 kg soil (400 kg/ha) was added to the five polybags (reference treatment) and the control treatment did not receive either manure or fertilizer.

The eight manurial tea fertilizers were made up of *Cajanus-cajan* (Pigeon leaves), coffee leaves, cocoa leaves, plantain leaves, cashew leaves, goat dung, turkey manure and duck dung solutions.

Hand weeding was carried out three times at 3, 6 and 9 WAP to control weed infestation. At 2 weeks after planting, the plant height, number of leaves, number of branches and stem girth were measured using ruler, visual counts and vernier calipher. The measurement of the growth parameters continued at a 7-day interval until 24 WAP.

At 9 WAP, leaf samples were taken from the middle part of the seedling, dried and used for nutrient analysis, N, P, K, Ca, Mg and Ma as described earlier.

Statistical Analysis

The mean data collected from the effect of different manurial tea fertilizer solutions on growth parameters, leaf and chemical composition of locust bean seedlings were subjected to analysis of variance (ANOVA) techniques and their means were separated and compared using the Duncan multiple range test at 5% level.

RESULTS

Initial Soil Fertility Status

The physical and chemical properties for soil used for the raising of locust bean seedlings in the nursery are presented in Table 1. Using the established critical levels for soils in Southwest Nigeria, the soils are acidic and low in organic matter, if compared with the critical level of 3% of organic matter (Agboola and Corey 1973) as optimum for crops (Sobulo and Osiname 1981). The available P is less than 10 mg/kg soil considered as adequate for crop production (Agboola 1982). The exchangeable K values are very low and crop grown on the soils is expected to respond to K application using 0.2 mmol/Kg as the critical level. The available Ca, Mg and Na are also low indicating soils with poor fertility status. The soils are very sandy and low in % clay. The soil bulk density is high (1.60 g/cm3) and would adversely affect crop growth. The soil belongs to Akure series and is an Alfisol (USDA 7th approximation).

Analysis of the Manurial Tea Fertilizers

Among the manurial plant tea solution fertilizers used, the cashew and coffee solutions had the highest N, P, K, Ca and Mg content followed by Plantain leaf solution, Cocoa leaf solution and *Cajanus cajan* leaf solution respectively. The animal dung tea solutions, especially turkey manure tea fertilizers, had better N, P, K, Ca and Mg contents than the goat and duck manure solutions (Table 2).

The leaf analysis of the locust bean seedlings under different manual tea solutions is presented in Table 3. There were significant increases ($P<0.05$) in the leaf N, P, K, Ca, Mg and Na contents. Locust bean seedlings treated with cashew leaf tea solution had the highest N, P, K, Ca and Mg contents. Coffee and cashew leaf tea solution had the higher leaf N content than NPK and unfertilized soil (control). *Cajanus cajan* (Pigeon pea) tea solutions contained the least P content.

All the manurial tea solutions gave better nutrients values of K, Ca, Mg and Na than NPK fertilizer. The Ca content was better in turkey and cashew leaf tea solution than that of NPK fertilizer. All the manurial tea solutions had better locust bean leaf nutrient contents than the control.

Effect of Manurial Tea Fertilizer on the Growth Parameters of Locust Bean Seedlings

The plant height, number of leaves, stem girth, root length and shoot weight of locust bean seedlings under different manurial tea solutions

TABLE 1
Physical and chemical composition of soil before planting locust bean seedlings

Bulk density	Texture Sand	Silt	Clay	Soil pH 1.20.01M $Cacl_2$	Organic matter	N	P	Exchangeable Cations K	Ca	Mg	Na	Exch acidity H^t	Al^{3t}	ECEC
g/cm³	-	%	-	-	%	-	mg/kg	-	-	-	mm01/kg	-	-	-
1.60	81.00	15.00	4.00	5.30	0.51	0.03	4.60	0.08	0.15	1.03	0.12	3.85	0.08	5.10

TABLE 2
Manurial tea solution chemical composition

Manurial types	N	P	K	Ca	Mg
			%		
Coffee leaf tea solution	0.16	0.22	0.49	0.72	0.34
Cocoa leaf tea	0.08	0.019	0.51	0.26	0.36
Cajanus cajan leaf tea (Pigeon pea)	0.06	0.01	0.57	0.42	0.18
Cashew leaf tea	0.19	0.12	1.88	0.70	0.48
Plantain leaf tea	0.10	0.11	1.56	0.64	0.25
Goat dung tea solution	0.12	0.04	0.77	0.32	0.16
Turkey manure tea	0.15	0.10	1.57	0.45	0.29
Duck manure tea	0.14	0.02	0.88	0.39	0.15
N P K fertilizer	5.33	4.33	3.2	0.00	0.00

TABLE 3
Nutrient content of the leaf of local bean seedlings at 9 WAP

Manurial tea solutions treatment	N	P	K	Ca	Mg
			%		
Coffee leaf tea	4.60f	0.349f	0.90d	0.14d	0.04c
Cocoa leaf tea	3.61de	0.294bc	0.69c	0.17e	0.05d
Cajanus-cajan leaf (Pigeon pea) tea	2.85b	0.208a	0.49b	0.10b	0.03b
Cashew leaf tea	4.75f	0.380g	1.44gh	0.20g	0.06e
Plantain leaf tea	2.99bc	0.286b	0.89e	0.11bc	0.03b
Goat dung tea	2.94c	0.309c	0.76cd	0.18ef	0.047c
Turkey manure tea	3.27d	0.345e	1.27f	0.21gh	0.048c
Duck manure tea	3.23d	0.312d	1.00e	0.12c	0.03b
NPK 15-15-15	2.75b	0.21a	1.38g	0.03a	0.01a
Control (no fertilizer)	0.08a	0.21a	0.03a	0.025a	0.01a

* Treatment means within each column followed by the same letters are not significantly different from each other using Duncan Multiple Range Test at 5%.

are presented in Table 4. The manurial tea fertilizers increased significantly ($P<0.05$) the growth parameters of locust bean seedlings relative to the control.

Among the plant tea fertilizers, the cashew leaf tea solution increased the plant height of locust bean seedlings by 39% compared to pigeon pea (*Cajanus cajan*).

The coffee leaf tea solution gave the highest number of leaves of locust bean compared to others while the goat dung had the least. The cashew, coffee, plantain and cocoa leaves and turkey manure tea solutions increased the number of leaves compared to NPK fertilizer (Table 4). The number of locust bean leaves produced by cashew leaf tea solution increased by 30% over that produced by goat dung.

The NPK fertilizer gave the best value of stem girth (cm) compared to other manurial tea solutions. The NPK fertilizer increased the stem girth of locust bean seedlings by 73% over goat dung solution tea.

The plantain leaf tea solution had the best value of stem girth of locust bean among the organic tea solutions.

The cashew leaf tea solution produced the longest value of root length of locust bean seedlings compared to other tea fertilizers while the NPK fertilizers produced the least root length, for-instance, the cashew leaf tea solution increased the root length compared to NPK fertilizer. The number of branches of locust bean seedlings was highest in cashew leaf tea solution. There was an increase in the number of branches of locust bean seedlings by all tea solutions compared with that of NPK fertilizer.

The cashew leaf tea solution gave the highest compared to other tea solutions. The cashew

TABLE 4
Growth parameters of locust bean seedlings using the different manurial tea solution fertilizers

Manurial tea solution treatment	Plant height (cm)	Number of leaves	Number of branches	Stem girth	Root length	Shoot weight
Coffee leaf tea	40.10g	15.00e	14.00d	2.72d	37.00g	67.00f
Cocoa leaf tea	38.40f	11.00d	14.00d	2.22c	33.00e	60.00d
Cajanus-cajan (Pigeon pea)	32.90b	11.00d	13.00c	2.02b	29.60c	58.00c
Cashew leaf tea	56.00h	17.00	18.00e	3.12g	44.00h	110.00j
Plantain leaf tea	39.40f	10.00c	13.00c	2.46d	30.20c	53.00b
Goat dung tea	34.50c	8.80b	12.00b	1.80b	30.00c	61.00de
Turkey manure tea	38.50f	11.00d	14.00d	2.86f	35.00f	71.00h
Duck manure tea	35.64d	10.10c	12.00b	2.08c	32.00d	68.00fg
Control (no fertilizer)	15.60a	5.00a	4.00a	1.20a	10.00a	32.00a
NPK 15-15-15	37.70d	10.00c	12.00b	2.74de	28.00b	93.00i

* Treatment means within each column followed by the same letters are not significantly different from each other using Duncan Multiple Range Test at 5% level.

leaf tea solution increased the shoot weight of locust bean seedlings by 47.27% compared to that produced by *Cajanus cajan* (Pigeon pea) leaf tea solution.

The manurial tea solutions and NPK fertilizer increased the soil N, P, K, pH, O.M, Ca, Mg and Na of locust bean seedlings significantly ($P<0.05$) relative to the control treatment (Table 5).

The cashew and coffee leaf tea solutions and turkey dung solutions gave the best values of soil pH, O.M, N, P, K, Ca, Mg and Na compared to other manurial tea solutions. The manurial tea fertilizers increased the soil pH, O.M, Ca, Mg and Na significantly compared to NPK fertilizer; however, the NPK fertilizer gave better soil N and P values than the manurial tea fertilizers.

DISCUSSION

The poor growth of locust bean seedlings in the nursery under the control treatment is consistent with the low nutrients in soil especially K, Ca, Mg and Na and low in) M and pH. This view is corroborated by Agboola (1982) who had identified poor soil fertility as the main factor retarding yield of crops, if not fertilized. The increase in the soil pH by the use of the manurial tea fertilizers could be responsible for the better growth of locust bean seedlings because it would favour nutrient release and this view was supported by Raymond (1990) who had reported the importance of neutral soil pH in effective release of nutrients for crops.

The increase in plant height, number of leaves, root length and plant shoot weight of locust bean seedlings by cashew leaf tea solution could be due to its high N, P, K and Ca contents. Calcium has been reported to encourage root growth while K is essential in the formation and transfer of carbohydrates during photosynthesis and N is responsible for vegetative growth and protein synthesis (Tisdale and Nelson 1966). The roots growth could encourage better uptake of nutrients and water from the soil for a fast vegetative growth.

Generally, the high nutrient status of the liquid tea fertilizer, especially the leaves tea solution might have been responsible for the possible influence on the growth parameters of locust bean seedlings. The increase in soil and leaf N, P, K, Ca, Mg and Na nutrient contents of locust bean seedlings was consistent with the nutrient composition of the manurial tea solution (Table 3). The higher soil and leaf K, Ca, Mg and Na nutrient contents of locust bean seedlings under the manurial tea fertilizers more than NPK fertilizer was consistent with the view of Swift and Anderson (1992) who had reported that organic manure supplied nutrients which NPK fertilizer could not supply to the crops. This showed the potential of the manurial tea fertilizers in increasing the yield of crops.

The availability of nutrients in solution form in the tea fertilizers could be responsible for the fast rate of growth parameters in locust bean seedlings.

TABLE 5
The soil chemical composition after planting under different manurial tea fertilizer treatments

Manurial tea Solution treatment	pH 0.01M $CaCl_2$	Organic matter	N	P	K	Ca	Mg
		%		mg/kg		mmol/Kg	
Coffee leaf tea	7.00g	1.58f	0.22	36.00g	1.80f	2.30h	1.00e
Cocoa leaf tea	6.90f	1.50e	0.15b	18.00c	2.20h	1.60fg	0.80d
Cajanus cajan leaf (Pigeon pea) tea	6.70d	1.42d	0.19d	15.00b	1.40e	0.20b	0.16b
Cashew leaf tea	7.10g	1.68g	0.29g	2.00i	2.40i	2.60i	1.20f
Plantain leaf tea	6.60c	1.35c	0.18c	26.00f	1.30d	0.80e	0.30c
Goat dung tea	6.70d	1.44d	0.16bc	22.00d	0.90b	0.50d	0.26c
Turkey manure tea	6.90f	1.56ef	0.26ef	38.00h	1.90g	0.50d	1.10f
Duck manure tea	6.80e	1.26b	0.20d	24.00e	1.10e	0.40g	0.20c
Control (no fertilizer)	5.30ab	0.41a	0.04a	4.00a	0.08a	0.05a	0.03a
NPK 15-15-15	5.25a	0.49a	0.32h	44.00j	1.10c	0.03a	0.01a

* Treatment means within each column followed by the same letters are not significantly different from each other using Duncan Multiple Range Test at 5% level.

CONCLUSION AND RECOMMENDATION

The use of plant and animal manure tea solution fertilizers such as coffee, plantain, cashew, cocoa and plantain leaf solutions turkey, duck and turkey tea fertilizers increased the growth parameters, leaf and soil chemical composition of locust bean seedlings.

However, the coffee and cashew leaf solution fertilizers appeared to be most effective especially when applied at 100 mL per locust bean seedling while the turkey manure was the best among the animal manurial tea fertilizer.

The recommendation germanes with the fact that chemical fertilizers are very expensive, scarce and destroy soil properties and the need to revive the production of economic tree crops such as locust bean seedlings for income generation, industrial growth and export oriented economy in developing countries.

REFERENCES

ADUAYI, E. A. and G. M. GATITU. 1973. Routine soil and leaf analysis advisory service for coffee growers at coffee research station. *Kenya Coffee* **38**: 278-281.

ADU-DAAPH, H. K., J. COBBINA and E. O. ASARE. 1994. Effect of cocoa pod ash on the growth of maize. *Journal of Agric. Science* Cambridge **132**: 31-33.

AGBOOLA, A. A. 1974. Organic materials as fertilizers, p. 147-152. F. A. O. Bull 27, Rome, Italy.

AGBOOLA A. A. 1982. Soil testing, soil fertility and fertilizer use in Nigeria. A paper presented at the *1st National Seminar in Agricultural Land Resources,* p. 6-8, September 15-18, Kaduna.

AGBOOLA, A. A. and R. B. COREY. 1973. Soil testing NPK for maize in the soil derived from metamorphic and igneous rocks of the Western State of Nigeria. *Journal of West African Science Association* **17(2):** 93-100.

A.O.A.C. 1970. *Official Method of Analysis.* 12th edition. Washington D.C, U.S.A: Association of Official Analytical Chemist.

BREDERO, B. W. 1977. Phosphorus requirement of crops using farm yard manure (Poultry manure) under intensive cultivation. *Expl. Agric.* **5**: 230-242.

JACKSON, M. L. 1964. *Soil Chemical Analysis.* p. 86-92. Englewood Cliffs, N. J: Prentice Hall Inc.

MURPHY, J. and J. P. RILEY. 1962. A modified single solution method for determination of phosphate in natural waters. *Analytical Chem. Acta* **27**: 31-36.

OJENIYI, S. O. 1998. Use of ash for soil fertility and crop yield improvement. A paper presented at *the 24th Annual Conference of Soil Science Society.* p. 12-16, Dec 7-11, ABTU.

RAYMOND, W. M. 1990. *An Introduction to Soils and Plant Growth.* p. 83-85. Englewood Cliff, N.J., U.S.A: Prentice Hall, Inc.

SOBULO, R. A. and O. A. OSINAME. 1981. Soils and fertilizer use in Western Nigeria. p. 20-26. Resource Bulletin No 11 I. A. R. & T, University of Ife, ile-Ife.

SWIFT, M. J and J. M. ANDERSON. 1992. Biodiversity and ecosystem function in agricultural systems. In *Biodiversity and Ecosystem Function,* ed. Schultz et al. p. 201-203. Berlin, Germany: Springer Verlag.

TISDALE, S. L. and W. L. NELSON. 1966. *Soil Fertility and Fertilizer.* p. 22-26. New York: Macmillian Publisher Ltd.

WALKLEY, A. and I. A. BLACK. 1934. An examination of Degtagjaroff method for determining soil organic acid filtration method. *Soil Sci.* **37**: 29-38.

(Received: 3 July 2001)
(Accepted: 25 March 2002)

Pertanika J. Trop. Agric. Sci. **26(1)**: 49 - 58 (2003) ISSN: 1511-3701

Incorporation of Agro-Industrial Biomass and Their Effects on Growth and Nutrient Content of Four Successive Crops of Amaranthus

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Keywords: Agro-industrial biomass, nutrient content

ABSTRAK

Satu kajian telah dijalankan di Akure, barat daya Nigeria ke atas kesan habuk kayu, sisa kulit koko, sisa bijian, habuk gergaji dan dedak padi, sama ada mentah atau ditambah dengan baja najis haiwan pada pertumbuhan, kandungan nutrien daun dan hasil empat tanaman Amaranthus viridis *(L). Dua puluh kombinasi biojisim industri pertanian telah digunakan ke atas tanah bersama satu rawatan dengan baja NPK dan satu petak yang tidak dirawat. Biojisim industri pertanian telah digunakan pada t/ha atau bergabung dengan baja najis kambing, khinzir dan ayam itik pada kadar 3tha-1 (nisbah 1:1). Dua puluh dua (22) rawatan yang direplikasi empat kali ke atas setiap empat tanaman secara berturutan menggunakan satu reka bentuk blok lengkap terawak. Keputusan menunjukkan bahawa penggunaan biojisim industri pertanian ke atas tanah meningkatkan N, P, K, Ca daun, abu Mg, protein kasar, ketinggian tumbuhan, kawasan daun, lilitan batang dan penghasilan daun amaranthus secara signifikannya ($P<0.05$) berbanding rawatan kawalan. Penggunaan sisa bijian, kulit koko dan habuk kayu lebih efektif dalam meningkatkan pertumbuhan, N, P, K daun, abu dan protein kasar, dan penghasilan daun amaranthus dibandingkan dengan dedak padi dan habuk gergaji. Rawatan sisa bijian meningkatkan N, P, K, Ca, Mg daun, abu dan protein kasar amaranthus kepada masing-masing 32.4%, 22%, 30%, 21%, 15.3%, 32% dan 6% berbanding penggunaan dedak padi sahaja. Penggabungan baja najis haiwan dan biojisim industri pertanian meningkatkan penghasilan daun. Habuk kayu + rawatan baja najis ayam itik meningkatkan penghasilan daun amaranthus kepada 67%, 50%, 35% dan 34% masing-masing pada tanaman 1, 2, 3 dan 4 berbanding penggunaan sisa bijian sahaja. Rawatan dengan biojisim industri pertanian memberikan lebih tinggi kandungan K, Ca, dan Mg pada daun berbanding baja NPK kecuali penghasilan daun. Tambahan pula, penambahan sisa bijian dengan baja najis ayam itik juga meningkatkan N, P, K, Ca, Mg daun, protein kasar dan abu atau amaranthus kepada masing-masing 12%, 34%, 17.40%, 96.30%, 93% 48% dan 26% berbanding rawatan NPK. Penambahan habuk kayu, sisa kulit koko, dedak padi, sisa bijian dan habuk gergaji dengan baja najis ayam itik meningkatkan kepanjangan akar amaranthus kepada masing-masing 47%, 42%, 41.58%, 53% dan 27% berbanding rawatan baja NPK. Penambahan biojisim industri pertanian sama ada tanpa atau digabungkan dengan baja najis ayam itik meningkatkan kandungan nutrien pada daun dan penghasilan amaranthus secara progresifnya melebihi empat musim tanaman. Hubungan nlai-nilai R^2 di antara penghasilan daun amaranthus dan N, P, K, Ca, Mg daun, protein kasar dan abu adalah 0.90, 0.92, 0.94 dan 0.98 dalam tanaman 1, 2, 3 dan 4. Implikasinya ialah nutrien daun menjelaskan variasi 90%, 92%, 94% dan 98% dalam penghasilan daun amaranthus.*

ABSTRACT

A study was conducted in Akure, South West Nigeria on the effect of wood ash, ground cocoa husk, spent grain, saw dust and rice bran, either raw or amended with animal manure on the growth, leaf nutrient contents and yield of four crops of Amaranthus viridis *(L). Twenty combinations of agro-industrial biomass were applied to the soil together with one treatment with NPK fertilizer and a control which received no treatments. The agro-industrial biomass was applied at t/ha or individually combined with goat, pig and poultry manures at the rate of 3tha-1 (1:1 ratio). The twenty two (22) treatments were replicated four times on each of the four consecutive*

crops using a randomized complete block design. Results showed that the application of agro-industrial biomass to the soil increased the leaf N,P,K,Ca, Mg ash, Crude protein, plant height, leaf area, stem girth and leaf yield of amaranthus significantly ($p<0.05$) compared to the control treatment. Application of spent grain, cocoa husk and wood ash was more effective in increasing growth, leaf N, P, K, ash and crude protein, and leaf yield of amaranthus than the rice bran and sawdust. The spent grain treatment increased the leaf N, P, K, Ca, Mg, ash and crude protein of amaranthus by 32.4%, 22%, 30%, 21%, 15.3%, 32% and 6% respectively compared to the rice bran (sole) application. Incorporation of animal manure with agro-industrial biomass further increased the leaf yield. Wood ash + poultry manure treatment increased the amaranthus leaf yield by 67%, 50%, 35% and 34% respectively in crops 1, 2, 3 and 4 compared to the sole application of spent grain. Treatments with agro-industrial biomass gave higher leaf K, Ca, and Mg contents compared to NPK fertilizer except the leaf yield. In addition, amendment of spent grain with poultry manure also increased the leaf N, P, K, Ca, Mg, crude protein and ash or amaranthus by 12%, 34%, 17.40%, 96.30%, 93%, 48% and 26% respectively compared to the NPK treatment. The amended wood ash, cocoa husk, rice bran, spent grain and sawdust with poultry manure increased the root length of amaranthus by 47%, 42%, 41.58%, 53% and 27% respectively compared to NPK fertilizer treatment. Addition of agro-industrial biomass either alone or incorporated with animal manure increased the nutrient content in the leaf and yield of Amaranthus progressively over the four cropping seasons. The R^2 values of the relationship between amaranthus leaf yield and leaf N,P, K, Ca, Mg, Na, crude protein and ash were 0.90, 0.92, 0.94 and 0.98 in crops 1, 2, 3 and 4 respectively. The implication is that leaf nutrients accounted for 90%, 92%, 94% and 98% variations in leaf yield of amaranthus.

INTRODUCTION

Vegetable farmers in humid tropical countries use the same piece of land continuously and after some years, the crops suffer from nutrient deficiency and low yield (Aweto and Ayuba 1993). In areas where NPK fertilizer is commonly used, the crops suffer from nutrient deficiency such as Ca and Mg. Due to the problems of scarcity and high cost of chemical fertilizer, there is a need to investigate into locally available and cheap sources of organic fertilizers for vegetable production.

Unlike the animal manures, use of agro-industrial biomass organic fertilizers in vegetable production has not received research attention. Decomposing plant residues release important and appreciable amount of nutrients into the soil (Ayanlaja and Sanwo 1991).

Amaranthus viridis L is a common vegetable in the humid tropics grown for its edible leaves. In this study, plant residues such as wood ash, ground cocoa husk, rice-bran, spent grain and sawdust, applied sole or amended with animal manure were tried as fertilizers on four crops of amaranthus. Their effects on growth parameters, nutrient composition and leaf yield of amaranthus were investigated.

MATERIALS AND METHODS

Source and Preparation of Organic Materials

Cocoa pod husk, wood ash, poultry, goat and pig dropping were obtained from the cocoa farm plots, cassava processing unit and livestock section of the Federal College of Agriculture, Akure.

Rice bran was obtained from the 05-6 varieties of rice processed at College rice-mill. Sorghum based spent grain was collected from the International Breweries Nigeria and the sawdust from a nearby sawmill industry at Akure township.

The organic materials were processed to allow decomposition. The dried cocoa pod husks were ground into powdery form using hammer mill while the wood ash was sieved mechanically with 2 mm sieve to remove foreign materials such as charcoal and wood remnants. The rice bran, spent grain and sawdust were each thoroughly wetted with water and composted separately to reduce the high C/N ratio. The poultry, pig and goat manures were heaped separately to allow for quick mineralisation and were placed under shade.

The processed individual agro-waste was added separately to the soil at $6tha^{-1}$ while the amended forms of the agro-wastes, involves mixing the agro-wastes together with each animal manure (pig, goat and poultry manures) and allowed to compost before adding to the amaranthus plants. The amended forms (agro wastes + manures) were added at $3tha^{-1}$ each (1:1). The animal manures were not applied to the soils individually but mixed with agro-wastes.

Chemical Analysis of the Organic Materials Used

Two grammes each of the processed forms of the organic materials used, were analysed.

The nitrogen content was determined by kjedahl method (Jackson 1964) while the determination of other nutrients such as P, K, Ca, Mg, Na, Fe, Zn, Cu and Mn was done using the wet digestion method based on 25-5-5 ml of HNO_3-H_2SO_4-$HC10_4$ acids respectively (A.O.A.C., 1970). The K, Ca and Na elements were read on flame photometer while Mg, Fe, Zn, Cu and Mn were read on atomic absorption spectrophotometer. The P content was developed into colouration with vanado-molybdate solution and read on spectronic 20 at 442 Um.

The organic carbon (%) was determined by wet oxidation method through chromic acid digestion (Walkley and Black 1934).

Field Experiment

The experiments were carried out at Akure in the rain forest zone of South West Nigeria on a sandy loam soil, skeletal, kaolinitic, isohyperthermic oxic paleustalf (Alfisol) or Ferric Luvisol (FAO). The surface soil (0-15 cm) had pH (water) of 5.1, organic matter 0.56%, 0.02% nitrogen, 4.3 mg/kg extractable P, 0.11 mmol/kg exchangeable Mg and 0.08 mmol/kg exchangeable K (Folorunso 1999).

The soil had been cropped for 10 years. The four field experiments were conducted between April 1998 and July 1999. Twenty agro-industrial biomass treatments, sole and amended, were applied to the amaranthus. Additional treatments included NPK fertilizer at 400 kg/ha and the control (no manure, no fertilizer). The five agro-industrial biomass were wood ash, ground cocoa pod husk, rice bran, brewery spent grain and sawdust.

The materials were applied sole at $6tha^{-1}$ and each agro-industrial biomass was combined with goat, pig and poultry manure at the rate of $3tha^{-1}$.

The twenty two (22) treatments were replicated four times on each of the four consecutive amaranthus crops at the same time using randomized complete block design. The size of each of the 88 plots was 16 m^2 (4 m x 4 m) and the soils were ploughed and harrowed to maintain good tilth for the amaranthus crops. The sole and amended residues and NPK fertilizer were incorporated into the soil seven days before planting.

Seeds of amaranthus (NHAC – 35) were hand drilled in rows that were 30 cm apart (13 rows per plot) at the rate of 7.5 kg/ha. Seeds were mixed with equal volumes of sand for even spreading. Ten days after planting, seedlings were thinned to a population of 535, 332 plants per hectare (i. e. 212 plants per plot).

The plant height (cm), leaf area (cm^2) and stem girth (cm) were measured at the second, third and fourth week after planting. Vetox 85 at in the rate of 28 g a.i. in 9 L of water was sprayed in the second and fourth weeks after planting. Thirty-five days after planting, the plants were harvested and weighed. The root length (cm) was measured for each crop of amaranthus.

Analysis of the Amaranthus Leaves for Chemical Composition

Sub samples of the plant were dried at 70°C for three days. The % N was determined by microjedahl method (Jackson 1964). P was determined by using vanado-molybdate solution and it was read on spectronic 20 at 442 Um. The % K, Ca and Na were read on the flame photometer using appropriate filters. The Mg was determined on atomic absorption spectrophotometry.

The crude protein content was determined by multiplying % N X 6.25 and the % total ash was also determined as reported by the Association of Analytical Chemists (AOAC 1970).

Statistical Analysis

The mean data for amaranthus growth parameters; plant height, leaf area, stem girth and root length, leaves % N, P, K, Ca, Mg, ash and crude protein and leaves' yields for each of the four crops were presented. They were subjected to ANOVA F-test and their levels of significance were determined for the sole and manure amended treatments using Duncan Multiple Range Test (DMRT) at a level of 5%.

RESULTS

Analysis of the Organic Material Used

Table 1 presents the chemical composition of the organic material used for the cultivation of amaranthus. Among the agro-industrial biomass, the wood ash had the highest nutrient status with regards to C, N, Ca, K, Mg, Fe, Mn, Cu and Zn. Wood ash and cocoa husk were relatively

TABLE 1
Analysis of the organic fertilizers used for the field experiments

Organic fertilizer	C	N	C/N ratio	Available P(mgkg)	Na	Ca	K	Mg	Fe	Mn	Cu	Zn
	%				mg/kg					mg/kg		
Poultry manure	30.00	4.33	6.93	385.00	5.65	3.20	9.72	4.10	37.85	1.66	0.15	1.26
Pig manure	25.00	3.72	6.72	312.00	5.22	3.10	14.45	4.80	34.00	1.62	0.17	1.34
Goat dung	20.00	2.52	7.93	167.50	6.30	2.90	9.97	4.50	34.50	1.60	0.16	1.30
Cocoapod husk	16.00	1.44	11.11	100.00	4.41	9.34	15.59	7.10	50.40	8.64	0.65	1.69
Wood ash	18.00	1.53	11.76	86.00	8.26	9.40	23.02	8.52	65.51	11.92	0.66	1.83
Spent grain (Brewery waste)	1.00	0.78	12.82	76.00	4.57	0.13	7.86	3.10	3.39	0.99	10.10	0.70
Rice bran	14.00	0.60	23.33	56.00	4.43	1.12	7.93	1.80	6.25	1.78	0.18	0.49
Sawdust	9.00	0.12	75.00	10.00	4.39	0.10	5.12	1.30	4.01	1.69	0.16	0.40

high in K, Ca, and Mg. The spent grain is also high in available P, K, and Mg generally; the sawdust and rice bran had the least nutrient status. The rice bran had C/N ratio of 1:23 while the sawdust C/N ratio was usually very high 1:75.

Among the types of animal manure used for amending the agro-industrial wastes, poultry manure had the highest values of % N, P, Ca, Fe and Mn compared to pig and goat manure. The manure had lower C/N ratio ranging from 6.72 to 7.93 and higher P status compared with the agro-industrial wastes.

It is therefore expected that mixing the animal manure with the agro-industrial wastes will enhance the effectiveness of improving nutrient availability.

Effect of Agro-Industrial Biomass on Amaranthus Leaf Chemical Composition

The sole and amended agro-industrial biomass increased the leaf N, P, K, Ca, Mg crude protein and ash content of amaranthus significantly ($p<0.05$) compared to the control treatment (Table 2).

Wood ash, spent grain, rice bran and sawdust incorporated with animal manure further increased the leaf N, P, K, Ca, Mg crude protein and ash. The sole and amended plant residues produced higher values of leaf Ca, Mg, P and K than the NPK fertilizer.

The spent grain treatment increased the values of amaranthus leaf Ca, Mg, P by 26%, 30% and 47% respectively compared to the wood ash treatment. Spent grain + poultry manure treatment increased the amaranthus leaf N, P, Ca, Mg, crude protein and ash by 56%, 33%, 14%, 26% and 18% respectively compared to the rice bran + poultry manure treatment.

Spent grain + poultry manure increased the leaf N, P, K, Ca, Mg, crude protein and ash of amaranthus by 12%, 34%, 17.40%, 96.3% 93%, 48% and 26% respectively compared to the NPK fertilizer treatment. It also increased the same parameters (N,P, K, Ca, Mg, crude protein and ash) by 98.9%, 94.4%, 98.0%, 93%, 93.10%, 98.7% and 92.4% respectively compared to the control treatment.

Generally, the rice bran and sawdust had the least values of leaf N, P, K, Ca, Mg, crude protein, and ash compared to the spent grain, wood ash and cocoa husk treatments.

The values of leaf P, Ca and Mg increased progressively throughout the four crops. There were high ratios of leaf K/Ca, K/Mg, P/Mg, in the amaranthus leaves: 1:35, 1:35 and 1:29 respectively under the NPK fertilizer treatment signifying nutrient interaction which could affect the amaranthus leaf quality in terms of nutrient utilization as noted by Bear (1950).

Effect of Agro-Industrial Biomass on the Growth and Yield Parameters of Amaranthus

The sole and amended agro-industrial biomass increased the plant height, leaf area, stem girth and root length (Table 3) and leaf yield of amaranthus (Table 4) significantly ($P<0.05$) compared to the control treatment.

The amendment of wood ash, cocoa husk, spent grain, rice bran and sawdust with animal manure increased the leaf area, plant height, stem girth, root length and leaf yield of amaranthus. However, agro-industrial wastes amended with pig and poultry manure increased the growth and yield parameters more than the amendment with goat manure. For example, the

TABLE 2
Effect of agro-industrial wastes plus manure on the leaf nutrient contents under the four crops of amaranthus

Treatment	N	P	K	Ca	Mg	Crude Protein	Ash content	Na
	%	%		%		%		%
Control (no fetilizer)	0.0286a	0.012a	0.019a	0.010b	0.005a	0.180a	1.143a	0.01a
NPK 15-15-15	2.3401	0.143d	0.8182e	0.005a	0.005a	8.652gk	16.275d	0.02b
Wood ash (sole)	1.379jk	0.145ef	1.7978q	0.864de	0.397de	8.620jk	18.16hi	0.06f
Wood ash + goat dung	2.423m	0.144de	1.1258p	0.0951fg	0.0357cd	15.140m	19.6731	0.04e
Wood ash + Pig dung	2.81no	0.1439de	0.7058b	0.11991m	0.604ij	15.51no	22.586t	0.04e
Wood ash + Poultry manure	2.529p	0.1951mn	0.8502h	0.0847d	0.033c	15.810p	20.43p	0.38d
Cocoa husk (sole)	1.184i	0.180l	0.9264i	0.0642c	0.0272b	7.400l	19.733m	0.06f
Cocoa husk + goat dung	2.474n	0.1584gh	0.8332fg	0.1064q	0.065kl	15.460n	21.01o	0.33c
Cocoa husk + pig dung	2.928tu	0.212p	1.3519u	0.1234m	0.063j	18.300tu	21.701r	0.09i
Cocoa husk + poultry manure	2.912t	0.214o	0.9536j	0.997gh	0.0652kl	18.200t	20.647n	0.06f
Rice bran (sole)	0.707c	0.122c	0.8315f	0.0929f	0.048f	4.420c	15.952c	0.04e
Rice bran + goat dung	0.967d	0.1682jk	0.9632j	0.1039i	0.60ij	6.040d	17.790f	0.06f
Rice bran + pig dung	1.011e	0.1661i	0.995m	0.1078ij	0.055gh	6.32e	17.966fg	0.07g
Rice bran + Poultry manure	1.173h	0.1449d	1.1018r	0.118k	0.054g	7.330h	18.114h	0.08h
Spent grain (sole)	1.046ef	0.1565g	1.1818t	0.11731	0.0567i	6.540ef	16.844e	0.06f
Spent grain + goat dung	2.587qr	0.1922m	1.2645t	0.1376o	0.082o	16.17qr	18.506j	0.08h
Spent grain + pig dung	2.56q	0.2343r	0.7877d	0.125mn	0.064jk	16.170qr	23.644u	0.04e
Spent grain + poultry manure	2.665s	0.2159p	0.99071o	0.1371o	0.0727m	16.660s	22.038s	0.07g
Sawdust (sole)	0.682b	0.1071b	0.990t	0.10451	0.0544g	4.260b	14.457b	0.07g
Sawdust + goat dung	1.007e	0.2235q	1.099n	0.1171	0.273p	6.290e	16.250d	0.08h
Sawdust + pig dung	1.089fg	0.1675ij	0.99m	0.139op	0.080n	6.810fg	18.873k	0.04e
Sawdust + poultry manure	1.332j	0.1781	1.1952o	0.1390p	0.072m	8.330j	21.236q	0.06f

Treatment means within each group or column followed by the same letters are not significantly different from each other using DMRT at 5% level

cocoa husk + poultry manure treatment increased the plant height, leaf area, stem girth and root length by 35%, 19.40%, 29% and 7% respectively compared to the cocoa husk + goat dung treatment.

The NPK fertilizer increased the plant height and stem girth of amaranthus by 58.5% and 40% respectively compared to the wood ash (sole) treatment. However, spent grain + poultry manure treatment increased the leaf area and root length of amaranthus by 72% and 53% respectively compared to the NPK fertilizer. The leaves of amaranthus in the third and fourth crops of amaranthus under NPK fertilizer were showing signs of marginal burn.

The amended wood ash, cocoa husk, rice bran, spent grain and sawdust with poultry manure increased the root length of amaranthus by 47%, 42%, 41.58%, 53% and 27% respectively compared to NPK fertilizer treatment.

The spent grain (sole) treatment increased the amaranthus leaf yield by 39%, 79%, 64.2% and 59% in crops 1, 2, 3 and 4 respectively compared to rice bran treatment. Wood ash + poultry manure increased the leaf yield by 67%, 50%, 35% and 34% respectively in crops 1, 2 3 and 4 amaranthus compared to the sole application of spent grain.

Spent grain + poultry manure treatment increased the leaf yield of amaranthus in crops 1, 2, 3 and 4 by 3%, 13%, 2.2% and 2% compared to NPK fertilizer treatment. The spent grain + poultry manure increased the leaf yield of amaranthus by 98% and 99% in crops 1, 2, 3 and 4 respectively compared to the control treatment.

Generally, the spent grain, wood ash and cocoa husk treatments increased the leaf yield of amaranthus two times higher than that of rice bran and sawdust treatments.

The multiple regression analysis showing the relationship between amaranthus fresh leaf yield and nutrient contents of N, Mg, Na, P, K ash, crude protein and Ca for the four crops of

TABLE 3
The effect of agro-industrial wastes plus manure on the growth parameters of amaranthus four cropping

Treatments	Plant Height (cm)	Leaf Area (cm2)	Stem Girth (cm)	Root Length (cm)
Control (no fertilizer)	4.49a	2.51a	0.15a	3.47a
NPK 15-15-15	44.54v	21.20i	1.741p	13.47d
Wood ash (sole)	18.48f	18.6g	1.043f	16.81e
Wood ash + Goat dung	27.71o	25.131	1.063fg	18.63f
Wood ash + pig dung	26.80n	28.64p	1.40f	19.41h
Wood ash + poultry manure	33.80q	30.84r	1.326l	25.25pq
Cocoa husk (sole)	22.19hi	17.24f	1.173h	20.36i
Cocoa husk + goat dung	25.22l	26.41n	1.253jk	21.58kl
Cocoa husk + pig dung	30.36p	30.29q	1.425no	23.45no
Cocoa husk + poultry manure	38.68st	32.78s	1.758pq	23.12n
Rice bran (sole)	13.55c	9.76b	0.785b	12.88b
Rice bran + goat dung	22.03h	15.70d	0.822c	20.45i
Rice bran + pig dung	23.31j	22.34j	1.383m	22.25m
Rice bran + poultry manure	24.78k	25.611m	1.038ef	23.02n
Spent grain (sole)	25.471m	27.95o	0.945d	24.35p
Spent grain + goat dung	35.05r	50.77t	1.063fg	25.92r
Spent grain + pig dung	38.02s	58.19u	1.028ef	28.20s
Spent grain + poultry manure	41.41u	74.72v	1.014e	28.90t
Sawdust (sole)	12.77b	11.40c	1.035ef	13.01c
Sawdust + goat dung	14.35d	16.03de	1.235l	18.82fg
Sawdust + pig dung	16.93e	19.21h	1.241ij	20.63ij
Sawdust + Poultry manure	18.97fg	22.78jk	1.415n	21.29k

Treatment means within each group or column followed by the same letters are not significantly different from each other using DMRT at 5% level.

TABLE 4
The effect of agro-industrial wastes plus manure on the fresh leaf yield (t/ha) under four cropping of amaranthus

Treatments	Crop 1	Crop 2	Crop 3	Crop 4	Mean
Control (no fertilizer)	0.15a	0.12a	0.123a	0.131	0.131a
NPK 15-15-15	7.50q	10.10u	11.63u	12.40u	10.40t
Wood ash (sole)	2.50ef	4.50j	6.40jk	6.98kl	5.095ij
Wood ash + goat dung	4.95l	6.53m	8.28m	8.90m	7.115m
Wood ash + pig dung	6.95p	8.10p	9.88op	10.30p	8.808op
Wood ash + poultry manure	7.60s	8.98q	9.83o	10.53r	9.235pqr
Cocoa husk + (sole)	3.15k	4.70k	6.15i	6.43i	5.108ijk
Cocoa husk + goat dung	5.45n	6.70n	9.03n	9.45n	7.658mn
Cocoa husk + pig dung	6.55o	9.18r	9.93pq	10.48q	9.035pq
Cocoa husk + poultry manure	6.95p	9.28s	10.58s	11.25s	9.515qrs
Rice bran (sole)	1.40c	2.05c	2.38b	2.83b	2.165b
Rice bran + goat dung	2.50ef	3.13e	4.15e	4.55e	3.583de
Rice bran + pig dung	2.05d	2.80d	3.98d	4.33d	3.29d
Rice bran + poultry manure	2.95j	3.40f	4.90g	5.35g	4.145g
Spent grain (sole)	2.85h	3.68gh	6.651	6.93k	5.028i
Spent grain + goat dung	5.35m	7.45o	10.00r	9.85o	8.1639
Spent grain + pig dung	9.35t	9.85t	11.38t	12.23t	10.68tu
Spent grain + poultry manure	7.53qr	11.63v	11.90v	12.60v	10.915tuv
Sawdust (sole)	0.63B	1.38B	3.23C	3.45C	2.173BC
Sawdust + goat dung	2.88hi	4.23i	5.33h	5.60h	4.51gh
Sawdust + pig dung	2.45e	3.63g	4.53f	4.57f	3.84ef
Sawdust + poultry manure	2.78g	5.331	6.53j	6.55j	5.253ijkl

Treatment means within ecah group or column followed by the same letters are not significantly different from each other using DMRT at 5% level.

TABLE 5
Multiple regression equation showing relationship between amaranthus fresh leaf yield, the nutrient composition of % N, Mg, Na, P, K, ash, crude protein and Ca under four crops of amaranthus

Amount of residues	Regression equation	R2 Regression Coefficient
Crop 1	Y = 0.081 + 1.475x1 – 6.8442 + 6.782x3 + 0.266x4 + 0.252x5 + 0.041x6 + 1.638x7 + 3.41x8	0.90
Crop 2	Y = 0.44 + 1.09x1 + 7.084x2 + 0.573x3 + 2.180x4 + 1.78x5 + 1.07x6 + 0.669x7 + 4.41x8	0.92
Crop 3	Y = 0.53 + 1.84x1 + 0.07x2 + 0.08x3 + 0.12x4 + 1.29x5 + 2.06x6 + 1.06x7 + 4.38x8	0.94
Crop 4	Y = 0.184 +0.839x1 + 2.037x2 + 3.78x3 + 0.30x4 + 0.22x5 + 0.05x6 + 2.152x7 + 3.56x8	

Note : X_1 = %N, X_2 = %Mg, X_3 = Na, X_4 = p, X_5 = %k, X_6 = %ash, X_7 = %Ca and X_8 = Crude protein

amaranthus is presented in Table 5. The R2 values for crops 1, 2, 3 and 4 were 0.90, 0.92, 0.94 and 0.98 respectively. The implication is that leaf nutrient contents accounted for 90, 92, 94 and 98% in the yield variations of amaranthus respectively.

The bar graphs showing the effect of the sole agro-industrial biomass on leaf Mg, N, leaf area and leaf yield of amaranthus under the four crops were presented in *Figs. 1, 2, 3,* and *4* respectively. The graphs also revealed that there was a progressive increase in these parameters from crop 1 to crop 4 of amaranthus respectively.

DISCUSSION

The agro-industrial biomass such as wood ash, rice bran, cocoa husk, spent grain and sawdust were lower in plant nutrients such as N, P, K, Ca, Mg, Na, Fe, Zn, Cu and Mn compared to the animal manure such as poultry, pig and goat dung. Hence, they have a high C:N ratio and were expected to decompose more slowly. Thus, the combination of the animal manure with low C:N was also expected to improve the effectiveness of the agro-industrial wastes as a source of plant nutrients.

Rice bran and sawdust have relatively high C:N ratios compared to cocoa husk, spent grain and wood ash and this could be responsible for their greater resistance to decomposition and being less efficient in returning plant nutrients for the use of crops.

The agro-industrial biomass such as cocoa husk, wood ash and spent grain had relatively high N, P, K, Ca and Mg contents; hence, they were more effective in improving the leaf nutrients growth and yield of amaranthus. The generally low leaf status of N, P, K, Ca and Mg ash content and crude protein and poor growth parameters such as plant height, stem girth, leaf area and root length recorded for the control (no fertilizer; no manure) treatment might be traced to the initial poor soil fertility and continuous cultivation which had affected the leaf and application of agro-industrial wastes to enhancement of crop productivity in the tropics (Agboola 1982c).

Spent grain, wood ash and cocoa husk gave the best yield of amaranthus, this was consistent with the fact that spent grain had the best Ca and Mg contents of amaranthus leaf. Wood ash had relatively low C:N (11.76) and the highest Ca, K, Mg, Fe, Mn, Cu, Zn contents compared with other agro-wastes and it was also reflected in the best values of leaf N, K, crude protein and ash of amaranthus.

Cocoa husk had the least C:N (11.11) which implies that it decomposes faster and makes its nutrients more easily available compared with spent grain, rice bran and saw dust. Cocoa husk had the best leaf P and fairly high leaf N, K, Ca, Mg crude protein and ash contents. Cocoa husk has been found to be a good source of K for maize (Adu-Daaph *et al.* 1994).

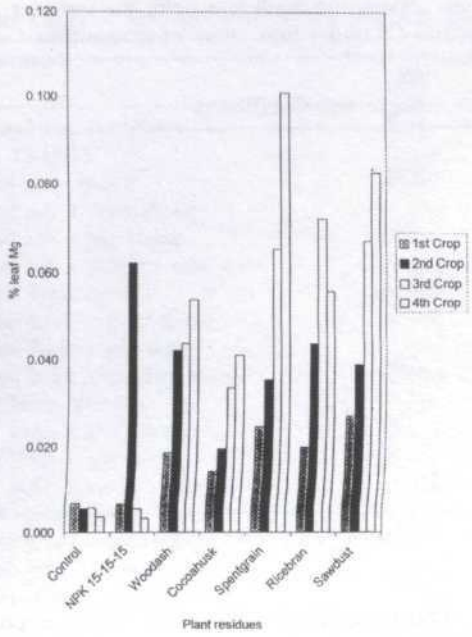

Fig. 1: The effect of plant residues on % leaf Mg under four crops of amaranthus

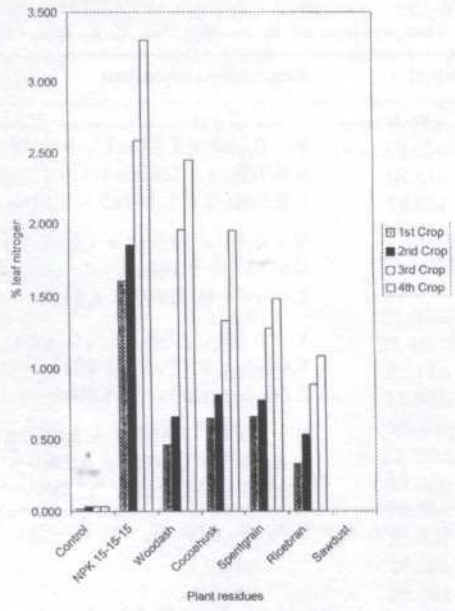

Fig. 2: The effect of plant residues on % leaf nitrogen of amaranthus under four crops

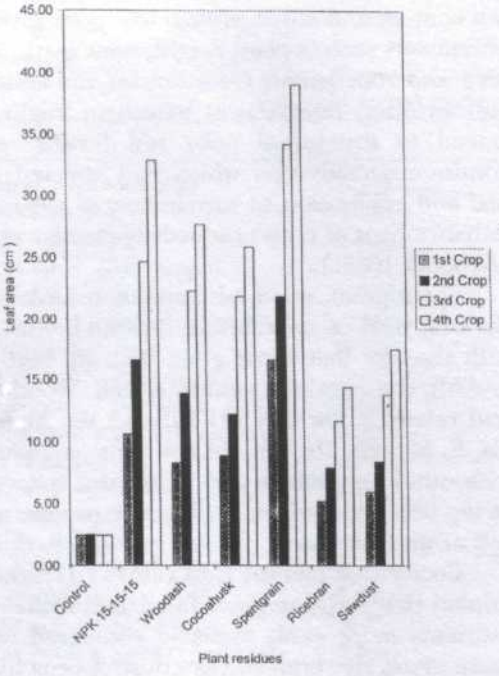

Fig. 3: The effect of plant residues on leaf area (cm^2) of amaranthus under four crops

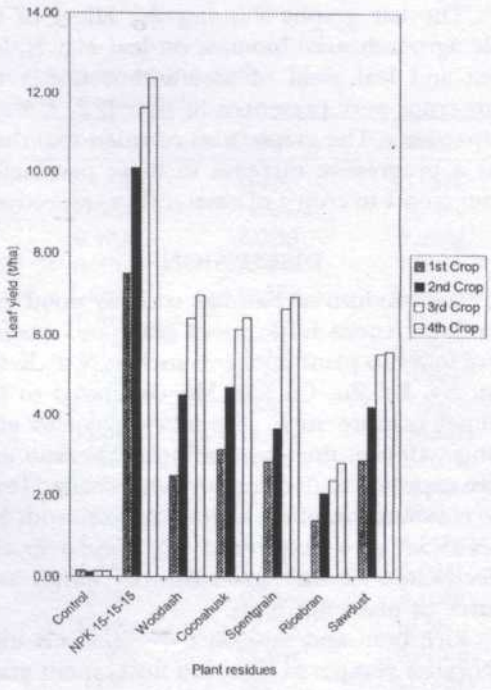

Fig. 4: The effect of plant residues on amaranthus leaf yield (t/ha) gross plot under four crops

amaranthus

crop. Accordingly, the amaranthus crop grown with sawdust and rice bran had the least yield, N, K, Ca, ash P, Mg contents and growth parameters. The poor performance attributed to sawdust and rice bran agreed with the fact that these residues had the least nutrient contents compared with wood ash, cocoa husk and spent grain. Sawdust had the least values of N, P, K, Ca, Mg and Zn while rice bran had relatively low N, Ca, Mg and Zn contents. Both sawdust and rice bran had C/N ratios of 75 and 23 respectively which would have reduced their rate of decomposition and nutrient release to crops.

The finding that the amendment of spent grain with pig and poultry manure gave the better values of amaranthus leaf yield in the four crops than NPK fertilizer, amended forms of wood ash, cocoa husk, rice bran and saw dust, could be attributed to the enhancement of its nutrient nutrients contents. This was also reflected in having the best leaf P, K, Ca, Mg and ash contents and these observations agreed with the work of Folorunso (1999) which reported that spent grain amended with pig and poultry manure gave the best yield of kora and amaranthus. He attributed this performance to the fact that spent grain reduced most soil bulk density which would have enhanced root growth, nutrient and water uptake. Besides, the high nutrient supplying power of spent grain + poultry manure to the crop was also mentioned as a contributory factor. The fact that amendment of spent grain, wood ash, cocoa husk, rice bran and sawdust with animal manure improved the plant height, leaf area, stem girth, root length, leaf nutrient status and leaf yield of amaranthus better than their sole forms agreed with the work of Titilayo (1982) which reported the nutrients' superiority of organically amended fertilizers over their sole forms.

Furthermore, Olayinka (1980) reported that amendment of sawdust with poultry manure increased maize plant height, dry matter yield, soil organic matter and uptake of N, P, K, Ca and Mg. Olayinka and Adebayo (1984) had also found that amendment of sawdust with dairy manure enhanced its decomposition.

The performance of NPK fertilizer in the improvement of growth parameters of amaranthus plant is consistent with the fairly high contents of leaf N, P and K.

The N, P, and K in the fertilizer are expected to be more readily available than those supplied by organic sources. Nitrogen is known to be mainly responsible for plant growth and protein synthesis (Ojeniyi 1984). Shortage of P is associated with reduction in plant growth and K is essential for carbon hydrate formation, synthesis of protein and promotion of mersitematic tissue (Tisdale and Nelson 1966).

However, as a result of continuous use of NPK fertilizer, the leaves of amaranthus were marginally burnt especially in the third and fourth crops and this could be adduced to an increased high ratio of K/Ca, K/Mg and P/Mg that resulted in nutrient interaction. It also agreed with the observation of Ojeniyi (1984) and Folorunso *et al.* (1995) who indicated that the continuous use of inorganic fertilizers might lead to nutrient imbalance, hidden hunger in crops and poor nutrient uptake.

The high R^2 values showing the relationship between the amaranthus leaf yield and leaf nutrient contents justified the fact that the use of agro industrial biomass encouraged increased harvest of leaf yield and this is of great importance to the amaranthus producers who will realise more income from the produce.

CONCLUSION

Application of wood ash, ground cocoa husk, rice bran, spent grain and sawdust increased availability of nutrients to amaranthus, thereby increasing its leaf yield. Wood ash, spent grain and cocoa husk were more effective while the amendment of the residues with animal manure increased their effectiveness as sources of plant nutrients.

REFERENCES

ADU-DAAPH, H.K., J. K. COBBINA and E. O. ASARE. 1994. Effect of cocoa pod ash on the growth of maize. *Journal of Agric. Science* Cambridge **132:** 31-33.

AGBOOLA, A. A. 1982c. Organic maturing and green maturing in tropical agricultural system. In *Proceedings of 12th International Congress of Soil Science*, p. 198-212, 8-16 Feb, New Delhi, India.

A.O.A.C. 1970. *Official Method of Analysis.* 11th ed. Washington D.C: Association of Analytical Chemists.

AWETO, A. O. and H. K. AYUBA. 1993. Effect of continuous cultivation with animal manuring on a sub-sahelian soil near Maiduguri North Eastern, Nigeria. *Biological Agriculture and Horticulture* **9**: 343-352.

AYANLAJA, S. A and J. O. SANWO. 1991. Management of soil organic matter in the farming systems of the low and humid tropics of West Africa, A. Review. *Soil Technology* **4:** 176-178.

FOLORUNSO, O. O., A. A. AGBOOLA and G.O. ADEOYE. 1995. Use of fractional recovery in Southwestern Nigeria. *Journal of Technical Education NBTE* **1** & **2**: p. 57-67.

FOLORUNSO, O. O. 1999. Use of plant residues for improving soil fertility and yield of okra (*Abelmoschus esculentum Moench* L) and Amaranthus (*Amaranthus viridis* L.) Ph.D Thesis, Federal University of Technology, Akure.

JACKSON, M. L. 1964. *Soil Chemical Analysis.* p. 86-92. Englewood Cliffs N.J.: Prentice Hall, Inc.

OJENIYI, S. O. 1984. Compound chemical fertilizer and food crop production. Effects of NPK 15-15-15 fertilizer on pepper, cowpea and maize. *Nigeria Journal of Applied Science* **2:** 91-95.

OLAYINKA, A. and A. ADEBAYO. 1984. The effect of methods of application of sawdust on plant growth, nutrient uptake and soil chemical properties. *Ife Journal of Agric.:* 36-44.

TISDALE, S. L. and W. L. NELSON. 1966. *Soil Fertility and Fertilizers.* p. 20-26. New York: Macmillan Publishing Ltd.

TITILAYO, E. O. 1982. The evaluation of various types of organic wastes as sources of nutrients for growth and yield of maize. Ph.D Thesis, University of Ibadan. p. 70-80.

WALKLEY, A. and I. A. BLACK. 1934. An examination of Degtajaroff method for determining soil organic acid filtration method. *Soil Science* **37:** 29-38.

(Received: 16 July 2001)
(Accepted: 30 November 2002)

Pertanika J. Trop. Agric. Sci. **26(1)**: 59 - 64 (2003) ISSN: 1511-3701

Potential of Paclobutrazol for Controlling Excessive Growth of *Acacia mangium* and Storing Recalcitrant Dipterocarp Seedlings for Forest Rehabilitation

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Keywords: Paclobutrazol, gibberellins, *Acacia mangium*, dipterocarp seedlings, growth control, recovery

ABSTRAK

Anak benih Acacia mangium *akan membesar berlebihan apabila jadual penanaman di ladang tidak dapat diselaraskan dengan jadual pengeluaran anak benih. Biji benih dipterokarp sebaliknya tidak dapat hidup lama dan perlu disemai segera untuk menghasilkan anak benih. Oleh kerana kaedah biasa untuk menyimpan biji benih didapati belum lagi berkesan untuk mengekalkan kebolehidupannya, kaedah menyimpan anak benih dalam keadaan terbantut dengan menggunakan paklobutrazol dan kemudiannya disembur dengan asid gibberellik untuk menggalakkan semula tumbesaran apabila perlu bagi penanaman di ladang adalah satu pilihan yang menarik. Kertas kerja ini melaporkan keputusan beberapa kajian berkenaan penggunaan paklobutrazol dan asid gibberellik kepada anak benih* A. mangium, Shorea leprosula *dan* S. parvifolia. *Keputusan-keputusan dibincangkan dengan mengambil kira implikasi-implikasi untuk kegunaan praktikal.*

ABSTRACT

Acacia mangium *seedlings often overgrow in size when the timing between plant production and field planting cannot be synchronized. Dipterocarp seeds, on the other hand, are short-lived and when available need to be sown immediately for the production of planting stocks. Since conventional storage methods have not been proven to be successful in maintaining the viability of these seeds, storing their seedlings at a slow growth phase with paclobutrazol and applying gibberellic acid to induce growth recovery when needed for field planting is an attractive option. This paper reports the results of various experiments on the use of paclobutrazol and gibberellic acid for* A. mangium, Shorea leprosula *and* S. parvifolia *seedlings. The results are discussed with implications for practical application.*

INTRODUCTION

Forest rehabilitation can take the form of the restoration of vegetative cover which may be purely an ecological exercise or reforesting an area with timber trees of commercial value. In the former, the sites are often very denuded and *Acacia mangium* is the principal species used in Malaysia. On the other hand, the better sites as in logged over forests are often rehabilitated by enrichment planting with commercial dipterocarp species.

Acacia mangium is selected to rehabilitate tailing sites, ex-shifting cultivated areas and other denuded sites because of the species' ability to survive and grow remarkably fast even in very poor soils. In the nursery, however, excessive growth of *A. mangium* is a liability if transplanting in the field is delayed. Overgrown seedlings are difficult to transport and plant and have poor survival rates because of root coiling and unfavourable root to shoot ratio resulting in desiccation post-transplanting (Abod and Abun 1989).

Adequate and continuous supply of dipterocarp seedlings are unpredictable because of the gregarious flowering pattern of the mother trees and the recalcitrant nature of the seeds. Dipterocarp seeds are short-lived and when available need to be sown immediately for the production of planting stocks. Storage of these

seedlings at a slow growth phase is one option to provide planting material on a continuous basis for various planting programmes. Factors that are of main concern for storage of seedlings are the quality of such seedlings during storage and the potential of the stored seedlings to resume rapid growth on return to normal growth condition (Tsan *et al.* 1997).

Paclobutrazol, a gibberellin biosynthesis inhibitor, has been reported to be effective in controlling the growth of a wide range of angiosperms (Williams 1982; Quinlan and Richardson 1984; Abod and Webster 1991). This paper reports the results of some preliminary studies on the potential of paclobutrazol for controlling excessive growth of *A. mangium* and for storing recalcitrant dipterocarp seedlings for forest rehabilitation.

MATERIALS AND METHODS

This paper reviews materials and methods from a number of experiments. In all cases potted, uniform size seedlings, well supplied with water and nutrients were used in experiments in a green house at Universiti Putra Malaysia, Serdang, Selangor. The air temperature ranged from 22°C at night to 38°C in the day and the relative humidity from 60 to 90 % while light intensity was above 50% of full sun.

Paclobutrazol (PP333) was supplied by Imperial Chemical Industries (ICI) in aqueous suspension at a concentration of 250 g/l with an active ingredient content of 22.0% w/w. Its trade name is Cultar and chemical formula (2RS, 3RS) – 1-(4 chlorohenyl) –4, 4 dimethyl 1-2 (1H-1, 2, 4, triazol-1-yl) pentan –3-ol). The chemical was diluted in distilled water to give a range of concentrations. A surfactant (Du Pont Agricultural surfactant) also supplied by ICI was added at a concentration of 2.0 mL/l. The aerial parts of plants were sprayed to runoff using a hand-held pressure sprayer.

Effects of Methods of Application

Experiment 1 tested the effects of five concentrations from 0 (control) to 12 g/l paclobutrazol and four methods of application on 10 week-old *A.mangium* seedlings as follows:

S : Soil drenching at week 0 (i.e. at the start of the treatment)

F1 : Foliar spray at week 0 (potting soil protected from chemical)

F2 : Foliar spray at weeks 0 and 6 (potting soil protected from chemical)

S+F : Foliar spray at week 0 (potting soil exposed to chemical)

The surfaces of the pots in the F1 and F2 treatments were covered with plastic sheets to shield the soil from the foliar sprays.

Effects of Concentration and Frequency of Application

Experiment 2 tested the effects of foliar spraying (i.e. potting soil exposed to chemical deposits) paclobutrazol at 8 concentrations and 2 frequencies of spray on 10 week-old *A. mangium* seedlings.

Effects of Paclobutrazol and Gibberellic Acid on Shorea leprosula *and* S.parvifolia *Seedlings*

Two experiments labelled as experiments 3 and 4 were conducted on the dipterocarp species. Experiment 3 tested the effects of foliar spraying 2 sizes i.e. 20 and 45 cm tall *S.leprosula* and *S.parvifolia* seedlings to a wide range of paclobutrazol concentrations from 0 to 12.0 g/l. When the results (Table 2) showed that growth control was more effective on smaller seedlings and that low concentrations were adequate, Experiment 4 was set up.

Experiment 4 tested the effects of spraying 10 cm tall *S.leprosula* and *S.parvifolia* seedlings to a range of low concentrations from 0 to 1000 mg/l paclobutrazol. The effects of foliar spray with different concentrations of gibberellic acid (GA3) were also tested to determine the effects on the recovery in height growth of paclobutrazol-treated plants.

RESULTS AND DISCUSSION

Effects of Methods Application

Soil drenching (S) or soil and foliar spray (S+F) gave similar and statistically significant reductions ($P<0.05$) in height increment compared to the foliar spray alone at either one (F1) or two (2) frequencies (Table 1, *Fig. 1a*). It appeared that the chemical can be absorbed by both the shoots and roots. Richardson and Quinlan (1986) reported paclobutrazol to be translocated almost exclusively in the xylem acropetally to the metistematic regions. The binding nature of the chemical with the soil colloidal particles might

account for the greater persistence of its effects observed in this study. Conversely, paclobutrazol when sprayed onto the foliage alone (F1 and F2), merely accumulated in leaves and was not translocated into other shoot tissues; the quantity of chemical reaching the sites of action was often reduced. Foliar spraying of the shoot which inevitably would also result in deposition of the chemical to the soil (if unprotected) appeared to be the most effective and pragmatic method of application.

Effects of Concentration and Frequency of Application

The results revealed the main effects of concentration (Table 1, *Fig. 2*) and frequency of application (Table1, *Fig.1a*) to be significant in reducing height increment. This concurs with the works of Tsan (2000) on recalcitrant dipterocarp seedlings at the Forest Research Institute of Malaysia.

The results in both experiments 1 and 2 revealed that paclobutrazol-treated plants had significantly lower height increments than the control. The growth reduction increased with increasing chemical concentration and time after application (Table 1, *Figs. 1b* and *2*)

Two frequencies of spray in both experiments 1 (*Fig. 1a*) and 2 (Table 1) gave statistically greater reduction in height growth. Abod and Leong (1993) suggested that the uptake and translocation of the chemical at the second spray additively act together with the remaining triazole compounds from the previous application.

Minimal height increments were recorded for treated plants from the onset of spray to 8 weeks for both species (*Figs. 3a, 3b*). On the other hand, control plants grew markedly in height recording up to 400 percent more increment at week 8.

At week 8, all paclobutrazol-treated plants were sprayed with gibberellic acid (GA3) at 100, 300 and 500 mg/l to induce a recovery in height growth. The results in *Fig. 3a* and *3b* revealed that the recovery in height growth was instant in all treatments. Generally, the recovery was more pronounced in plants initially treated with a low concentration of paclobutrazol and subsequently given a higher dosage of gibberellic acid. At week 16, eight weeks after the GA3 treatment, most of the paclobutrazol-treated plants recorded significantly greater increment than the control for both species.

TABLE 1
Main effects of paclobutrazol on the growth of *A. mangium* seedlings 12 weeks after treatment

Experiment 1			Experiment 2		
Factor		Height increment (cm)	Factor		Height increment (cm)
Method of application	Soil	4.5	Concentration	0_	10.7
	Foliar F1	7.2		0.25	7.4
	Foliar F2	6.1		0.5	5.1
	Soil & Foliar	4.4		1.0	2.5
				2.0	2.5
				8.0	2.3
				12.0	1.2
F-test		**	F-test		**
Sed		0.11	Sed		0.50
Concentration (g/l)	0	13.3	Frequency of spray	1	5.1
	0.5	5.0		2	3.3
	1.0	4.3			
	4.0	2.7			
	12.0	2.5			
F-test		**	F-test		**
Sed		0.12	Sed		0.25

**, $p<0.01$; Sed in standard error difference

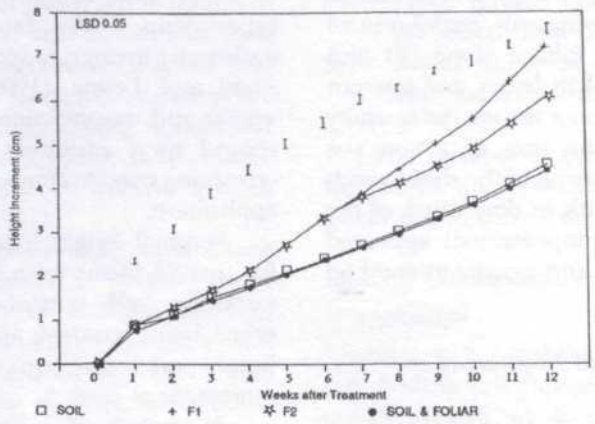

Fig. 1a: Effect of method of applying paclobutrazol on the height increment of Acacia mangium seedlings

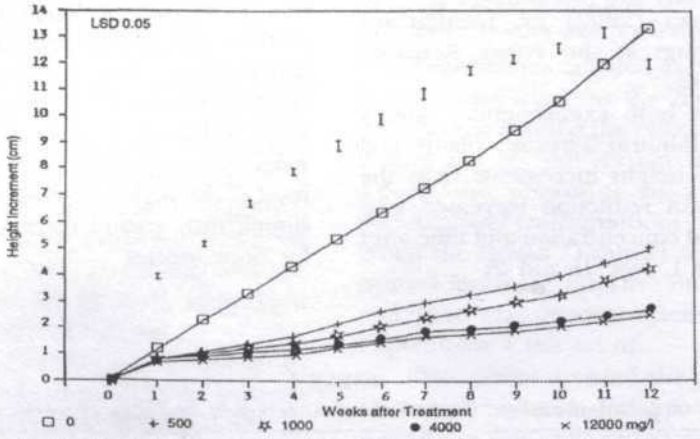

Fig. 1b: Effect of concentration of paclobutrazol on the height increment of Acacia mangium seedlings

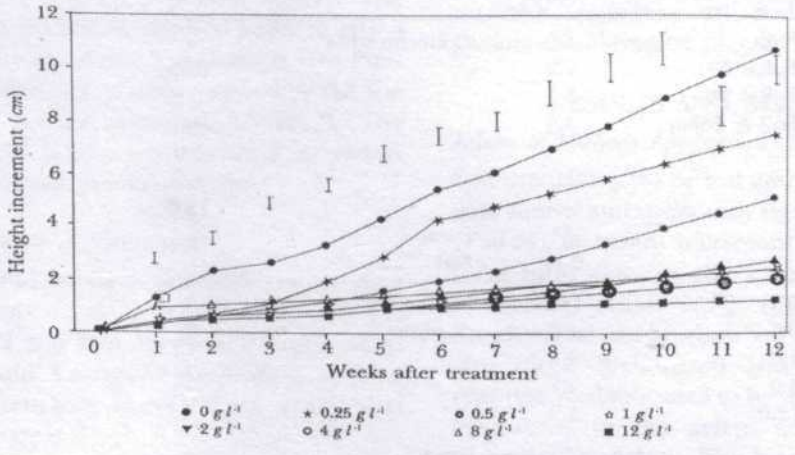

Fig. 2: Main effect of concentration of paclobutrazol on the weekly height increment of Acacia mangium seedlings

TABLE 2
Main effect of paclobutrazol on the growth of *Shorea leprosula* and *S. pavifolia* seedlings 12 weeks after treatment for factor 1 (species), factor 2 (size) and factor 3 (concentration)

Factor	Height increment (cm)
Species	
S. leprosula	4.9
S. parvifolia	4.3
Df=1 Sed	0.02
F-test	**
Size	
Big (45 cm)	6.5
Small (20 cm)	2.8
Df=1 Sed	0.02
F-test	**
Concentration (g/l)	
0	11.6
0.1	8.2
0.25	7.5
0.5	5.8
1.0	4.0
2.0	2.7
4.0	1.2
8.0	0.7
12.0	0.7
Df=8 Sed	0.58
F-test	**

** p<0.01; Sed is standard error difference

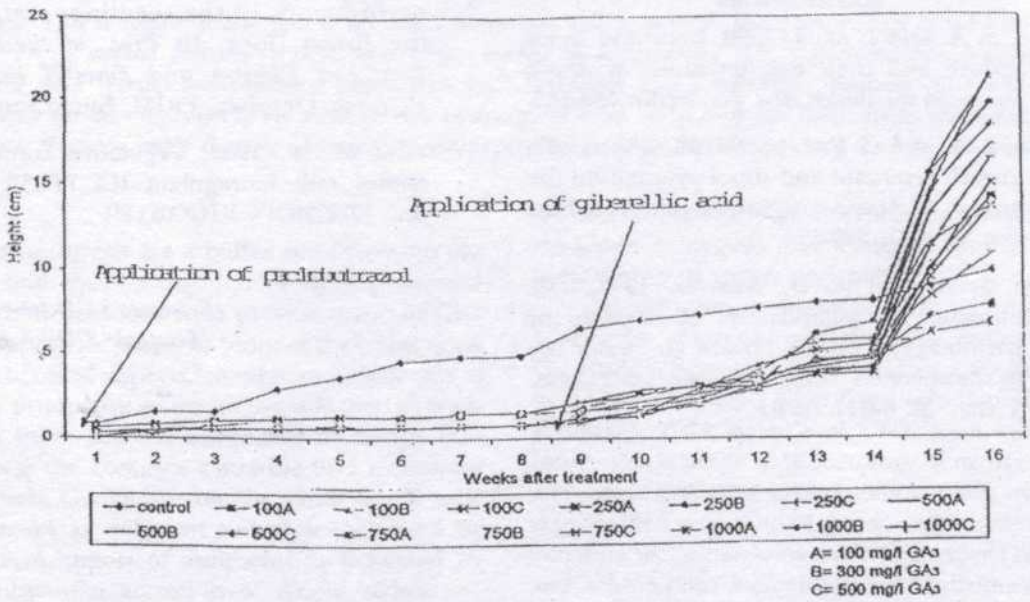

Fig. 3a: Effect of paclobutrazol and gibberellic acid on the height increment of Shorea pavifolia

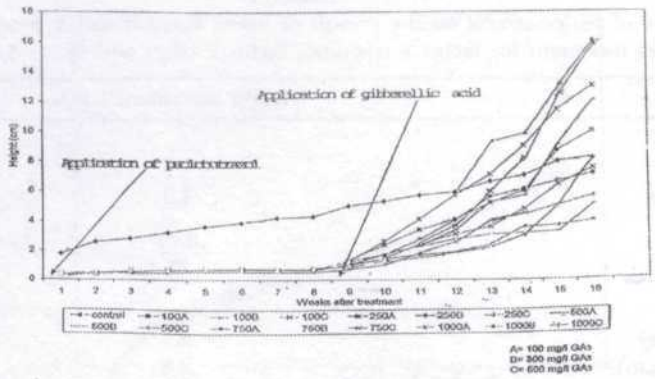

Fig. 3b: Effect of paclobutrazol and gibberellic acid on the height increment of Shorea laprosula

CONCLUSION

Paclobutrazol is a cheap, effective and practical method for controlling the growth of *A. mangium*, *S.leprosula* and *S. parvifolia* seedlings.

Storage of the dipterocarp seedlings at a slow growth phase inhibited by paclobutrazol may be the solution to a regular supply of planting stocks. The ability of such seedlings to recover and gain rapid growth when treated with gibberellic acid gives further credence to this method of storage.

Further research is necessary to develop blueprints for practical application.

REFERENCES

ABOD, S. A. and J. ABUN. 1989. Root and shoot growth and their manipulations of *Acacia mangium* seedlings. *Mal. For.* **52(3)**: 136-145.

ABOD, S. A. and C. K. LEONG. 1993. Effects of a growth retardant and shoot pruning on the growth of *Acacia mangium* seedlings. *J. Trop. For. Sc.* **6(3)**: 239-48.

ABOD, S. A. and A. D. WEBSTER. 1991. The influence of foliar sprays of *tetcyclasis* or paclobutrazol on the growth and water use by transplanted *Malus, Tilia* and *Betula* stocks. *J. Hort. Sc.* **66(1)**: 85-94.

QUINLAN, J. D. and P. J. RICHARDSON. 1984. Effects of paclobutrazol on apple shoot growth. *Acta Horticulturae* **146**: 105-111.

RICHARDSON, P. J. and J. D. QUINLAN. 1986. Uptake and translocation of paclobutrazol by shoots of M.26 apple rootstocks. *Plant Growth Regulator* **4**: 347-56.

TSAN, F. Y. 2000. Storage of seedlings of three recalcitrant dipterocarp species by slow growth techniques. Ph.D. dissertation. Universiti Putra Malaysia. 358p.

TSAN, F. Y., J. BASHARUDDIN, K. AWANG and B. KRISHNAPILLAY. 1997. The growth performance of the seedlings stored on the forest floor. In *Proc. of the Fourth Conf. on Forestry and Forestry Products Research*, October, FRIM, Kuala Lumpur.

WILLIAMS, M. W. 1982. Vegetative control of apples with bioregulant ICI PP333. *Hort. Sci.:* 17-577.

(Received: 11 October 2001)
(Accepted: 8 October 2002)

Pertanika J. Trop. Agric. Sci. **26(1)**: 65 - 71 (2003)

ISSN: 1511-3701

The Determination of Accretion Rate in Setiu Mangrove, Malaysia: Thorium-230 Versus Artificial Horizontal Marker Method

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Keywords: $^{230}Th_{excess}$, artificial horizon marker, mangroves

ABSTRAK

Dalam kajian ini, penentuan kadar sedimentasi telah dibuat dengan menggunakan kaedah $^{230}Th_{excess}$ dan penanda tiruan mendatar. Dengan menggunakan kaedah $^{230}Th_{excess}$, purata sedimentasi sebanyak 0.62 cm thn^{-1} adalah diperolehi. Kadar sedimentasi ini adalah setanding dengan kaedah penanda tiruan mendatar yang memperolehi sebanyak 0.61 cm thn^{-1}. Kaedah $^{230}Th_{excess}$ adalah didapati lebih baik dan tepat bagi penentuan kadar sedimentasi. Penyediaan sampel adalah juga ringkas, malah prosedur penyediaannya adalah cepat dan mudah bagi penentuan kadar sedimentasi di hutan paya bakau. Sekiranya kadar sedimentasi melalui sampel teras diambil kira, kadar sedimentasi pada kedalaman 100 cm adalah dianggarkan termendap pada 163 tahun dahulu.

ABSTRACT

In this study, determination of sediment accretion rate using the ^{230}Th and the artificial horizon marker method in Setiu mangrove were done. Applying the $^{230}Th_{excess}$ method, an average accretion rate of 0.62 cm yr^{-1} was obtained. This is comparable to that of an artificial horizon marker method giving an average of 0.61 cm yr^{-1}. The $^{230}Th_{excess}$ method provides a rapid and simple method of evaluating $^{230}Th_{excess}$ accumulation histories in sediment cores. Sample preparation is also significantly simplified, thus providing a relatively quick and easy method for the determination of the accretion rate in mangrove areas. Assuming that the accretion rate values are accurate, this may imply that the sediments in the upper 100 cm were deposited during the last 163 years.

INTRODUCTION

Mangrove forests are a buffer zone between the coast and the ocean. One of their presumed important functions is to provide a mechanism for trapping sediment. In terms of their biological and chemical aspects, mangrove forests are a highly productive source of organic matter, from which there is a net outwelling of energy that supports the complex estuarine and nearshore food web. Geologists, on the other hand, view mangroves as sediment sinks, characterized by long-term import of sediments as indicated by the substantial accretion of recent sediments, which underlie mangrove forests and adjacent coastal plains (Wolanski *et al.* 1992). Physically, by virtue of being in the intertidal areas, they can act as recorders of environmental changes via sedimentological characteristics and in the preservation of spores and pollens.

Despite the acceptance that mangrove ecosystems are important sinks for sediments, few studies have addressed sediment accretion in this environment. Several authors (Goldberg and Koide 1962; Koide *et al.* 1972) have studied some aspects of the sedimentology of mangroves and quote different sedimentation rates, which is probably a reflection of the non-representative sampling techniques employed. Spenceley (1982) and Shahbuddin *et al.* (1998) have introduced a simple method for measuring accretion by simulating pneumatophores using rods and stakes and an artificial horizon marker method,

respectively. Although long-term accretion rates using radionuclides have been well-documented (Sharma *et al.* 1987; Lynch *et al.* 1989; Anderson 1982) publications on the use of this approach have been few (Kamaruzzaman *et al.* 2000; Shahbuddin *et al.* 1998) and limited in the mangrove ecosystems. In the present study, we use thorium (^{230}Th) and an artificial horizon marker method to establish sediment accretion rates.

The measurement of ^{230}Th concentrations in sediments provides one method of developing accretion histories. ^{230}Th is formed at a constant rate in the water column from the decay of ^{238}U and is rapidly scavenged and incorporated into the underlying sediments. ^{230}Th is a valuable tracer of the processes whereby reactive elements are scavenged from seawater and produced at a constant rate throughout the oceans. Following its production in seawater, ^{230}Th is rapidly hydrolyzed and subsequently removed to sediments on a time scale of a few decades in the deep ocean and weeks to months in surface water. Their excess ^{230}Th (i.e., the amount in excess of that expected from secular equilibrium with ^{238}U present in mineral latices) has been widely used to date sediment horizons and estimate average accretion rates (Goldberg and Koide 1962; Ku 1976; Scholten *et al.* 1990). For the artificial horizon marker method, sediment accretion was based on the vertical basis only. Vertical sediment accretion refers to the vertical thickness of sediment gained in a certain area for a certain period and can either be positive, denoting accretion and growth, or negative, denoting erosion.

MATERIALS AND METHODS

Sampling

The Setiu mangrove of the study area is located on the South China Sea coast of Peninsular Malaysia and about 60 km northwest of Kuala Terengganu, the capital state of Terengganu (*Fig. 1*). The Setiu mangrove is a unique area as it covers many ecosystems such as estuaries, intertidal areas and lagoons. The lagoon's ecosystem is semi-enclosed with limited and poor tidal flushings and has a total water surface area of about 880 ha. This study area is of primary oceanographic interest since it is one of the largest estuaries of the Terengganu coast into which two river systems flow, i.e., the Setiu and Chalok rivers. These areas are areas of diverse ecosystems, with utilizable natural resources, a vast array of biological diversity and coastal and riverine fishing activities. The Setiu area lies in the wet tropics where high rainfall (averaging 400 mm) is recorded during the monsoon season. In this study, four transect lines (TR1, TR2, TR3 and TR4) were set up inside the mangrove (*Fig.* 1), where the total of 54 sampling stations were fixed along the transects. Two 150 cm sediment cores were also collected with a D-section core sampler from the mangrove forests. The cores were cut into segments of approximately 5 cm interval, labelled and stored frozen until analysis in the laboratory.

Determination of Sediment Accretion Using Artificial Horizon Marker Method

For the determination of the sediment accretion, the methodology applied in this work is based on measuring the thickness of a vertical sediment section divided by the time span necessary for its deposition. For the purpose of this study, a slab of perspex (9 cm x 9 cm x 1.5 mm) was planted at each sampling point and acts as a marker level. As a stabilization measure, the disturbed sediment above the markers were left for a month before initial readings of marker level depths were recorded. As another measure to aid stabilization of sediments above the marker levels, 5 holes were drilled in each perspex slab to enable water to pass through from the surface to the bottom. The thickness of sediments above the markers was then measured on a monthly basis for a 12 month period. The thickness of sediment at every sampling point was determined by taking the average of six readings per marker. Accuracy of reading is approximately ± 2 mm. The average thickness of the sediment for the month in study is then subtracted by the thickness of sediment obtained from the previous month. A positive value indicates accretion while a negative value indicates erosion.

Analytical Method for ^{232}Th and ^{230}Th

The sediment samples were digested and the analyses for total Th (^{232}Th) following the published methodologies with some modifications (Noriki *et al.* 1980; Sen Gupta and Bertrand 1995; Kamaruzzaman 1999). An inductively-coupled plasma mass spectrometer (ICP-MS) was used for the quick and precise determination of Th in the digested sediment. In brief, the digestion method involved heating of 50 mg of

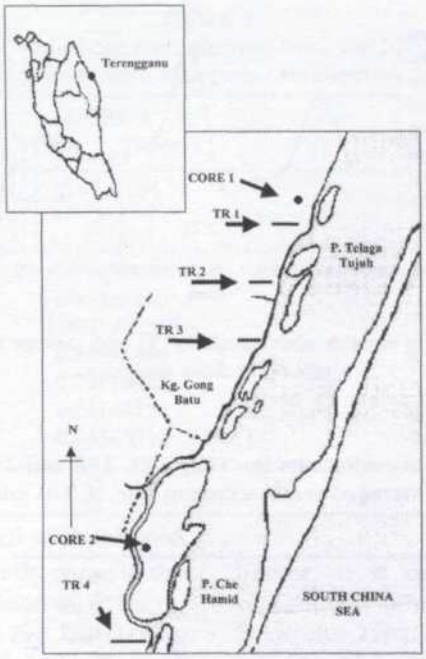

Fig. 1: Location of transects (TR1, TR2, TR3 and TR4) and cores (•) in the mangrove forests of Setiu mangrove, Terengganu, Malaysia

a finely powdered sample in a sealed teflon vessel in a mixture with a mixed acid solution (1.5 mL) of concentrated HF, HNO_3 and HCl. The Teflon vessel was kept at 150 °C for 3 – 5 h. After cooling, a mixed solution of boric acid and EDTA (3 mL) was added, and the vessel was again heated at 150 °C for at least 5 h. After cooling to room temperature, the content of the vessel was transferred into a 10 mL polypropylene test tube and was diluted to 10 mL with deionized water. A clear solution with no residue should be obtained at this stage. A laboratory standard material of mangrove sediment was also subjected to the same procedure. The relative 1 σ value of replicate determinations of a sample was less than 3% and the results obtained for HA, coincided with certified values within a difference of ± 3%.

The analytical method of ^{230}Th for the determination of sedimentation rate in the sample was carried out according to the published method (Tsunogai and Yamada 1979; Harada and Tsunogai 1985; Kamaruzzaman 1999) with some modifications. The method involved heating 1 - 2 g of dried sediment and digesting it with a mixture of solution of concentrated HF, HNO_3 and HCl. The solution containing Th was heated to make the solution clear before being treated with anion and cation exchange resins for the separation and purification. The effluent containing Th was then heated to dryness and finally dissolved in 5% HNO_3. The concentration of ^{230}Th was then measured with a fast and sensitive ICP-MS. The precision assessed by the replicate analyses was less than 3%. The accuracy was also examined by analyzing in duplicate a Canadian Certified Reference Materials Project standard (DL-1a) and the results coincided with the certified values within a difference of ± 3%.

RESULTS AND DISCUSSION

Accretion Rates

This study spanned 11 times from January 2001 to January 2002 and a thickness at all sampling points along each transet was recorded during low tides. Sampling dates and times were predetermined based on the yearly predicted tidal data table produced by the Hydrographic Department of the Royal Malaysian Navy. *Fig. 2* shows that the summary of the average accretion rate obtained was 0.61 cm yr^{-1}. The highest average accretion rates are found in the period from March to July corresponding to the non-monsoon season (*Fig. 2*). There is a positive accretion rate for all months (Table 1). The

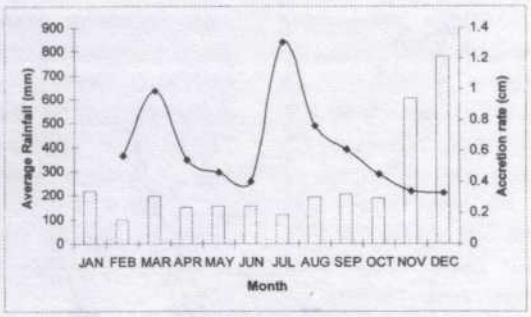

Fig. 2: Average of monthly mean rainfall (□) with average monthly accretion rate (▪) at Setiu mangrove

TABLE 1
Monthly accretion rate for TR1, TR2, TR3 and TR4 giving an averaged yearly accretion rate of 0.61 cm/yr

Month	Accretion Rate (cm)
February	0.62
March	0.99
April	0.57
May	0.46
June	0.40
July	1.31
August	0.89
September	0.65
October	0.55
November	0.45
December	0.36
Average cm/yr	0.61

highest accretion rate was observed in the month of July (1.31 cm month^{-1}) and lowest in December (0.36 cm month^{-1}). The much lower accretion rate during monsoon seasons (Nov – Jan) may be due to the higher energy of water movement from the upper stream, which may carry the fine sediment to the seas.

For the second method using thorium, $^{230}Th_{excess}$ was used to determine the accretion rates of the study areas (Scholten *et al.* 1994; Suman and Bacon 1989; Mangini and Stoffers 1990). The amounts of $^{230}Th_{excess}$ are calculated using the following equation:

$$^{230}Th_{excess} = {}^{230}Th_{total} - (0.8 \times {}^{232}Th_{total}) - {}^{234}U(1-\exp\{-l^{230}t\}) \quad (1)$$

where $^{230}Th_{total}$ and $^{232}Th_{total}$ are the measured concentrations of ^{230}Th and ^{232}Th, respectively, and ^{234}U and l^{230} are the concentrations of ^{234}U (of which radioactivity is assumed to be 1.1 times the ^{238}U concentration) and the decay constant of ^{230}Th (9.24×10^{-6} yr), respectively. The second term on the right hand side of the equation ($^{232}Th_{total}$) is necessary in order to subtract the lithogenic fraction and the assumed coefficient, 0.8, which is a mean activity ratio of $^{230}Th/^{232}Th$ for the lithogenic fraction as reported by Anderson (1982). The third term ($^{234}U(1 - \exp\{-\lambda^{230}t\})$ is for the correction of ^{230}Th produced from ^{234}U in the sediments, which is necessary because ^{230}Th is produced from authigenic U contained in the sediment.

The determination of average sedimentation rate is based on the assumption that the $^{230}Th_{excess}$ is incorporated into the sediments with a constant rate (Ku and Broecker 1966; Osmond 1979). The values of $^{230}Th_{excess}$ derived from Equation 1, are as in Table 2. If this assumption is correct, the radioactivity of $^{230}Th_{excess}$ in sediment core which decreases exponentially with depth, and the sedimentation rates can be calculated from the following equation:

$$S=-\lambda^{230}/b \quad (2)$$

TABLE 2
The values $^{230}Th_{excess}$ from both cores derived from the ICP-MS determination for samples from Setiu mangrove, Terengganu, Malaysia

Depth (cm)	CORE 1 $^{230}Th_{excess}$ (dpm)	CORE 2 $^{230}Th_{excess}$ (dpm)
5	0.9212354	0.0999891
15	n.d	n.d
25	n.d	0.175643256
35	0.81126842	0.17549332
45	0.80461206	n.d
55	1.0091255316	0.05433326
65	0.84016584	0.154021403
75	0.79115462	n.d
85	0.81121136	0.097565956
95	0.64565212	0.087338325

(n.d: not detectable)

where b is a gradient of the 'best-fit' curve in the plot of logarithmic concentrations of $^{230}Th_{excess}$ against depth (cm). As shown in *Fig. 3*, accretion rates for both cores were calculated to be 0.61 cm yr^{-1} and 0.62 cm yr^{-1}, respectively.

Our results for both methods, i.e. ^{230}Th and the artificial horizon marker method, are quite consistent giving an average accretion rate of about 0.61 cm yr^{-1}. However, the $^{230}Th_{excess}$ method provides a rapid and simple method of evaluating $^{230}Th_{excess}$ accumulation histories in sediment cores. Sample preparation is also significantly simplified, thus providing a relatively quick and easy method for the determination of the aceretion rate in mangrove areas. Even though our values for both the methods are somewhat higher, it is comparable to accretion rates reported at other intertidal areas (Bird 1971; Spenceley 1982; Shahbuddin *et al.* 1998).

Our higher values can be explained by the geographical position of our study area, where their location is located inside the estuary, close to the mouth, providing it with 2 sediment sources, fluvial and tidal. Greater water discharge from the river also brings much more suspended sediment to be trapped by the mangrove roots. Assuming that the sedimentation rate values are accurate, this may imply that the sediments in the upper 100 cm were deposited during the last 163 years. The high average accretion rates in the Setiu mangroves indicate that this mangrove is still prograding and in an immature stage.

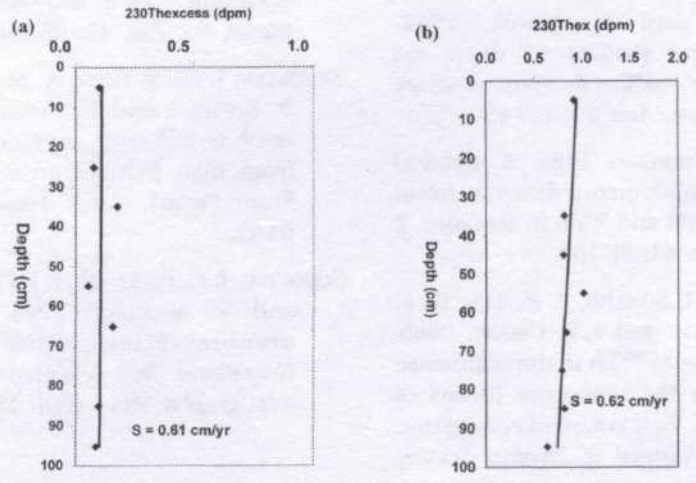

Fig. 3: (a) $^{230}TH_{excess}$ versus depth for core 1 and (b) $^{230}THexcess$ versus depth for core 2 with sedimentation rate, S = 0.61 cm/yr and 0.62 cm/yr, respectively

This finding suggests that the mangrove forests are not just passive colonizers of mud banks, but actively capture mud to create their own environments. Mangroves are thus an important sink for the fine sediment from rivers and coastal waters. Sediment supplied to the mangrove area might undergo the common process where they are suspended and carried back and forth, deposited and eroded before they finally settle either permanently or for a certain time period. The opportunity for sediment to settle or be deposited is greatly influenced by the frequency and duration of flooding (Cahoon and Reed 1995).

ACKNOWLEDGEMENTS

This research was conducted with joint funding from the Malaysian Ministry of Science, Technology and Environment, under the Intensified Research for Priority Areas (IRPA) project numbers 51513 and 51447 and a grant from the Malaysian Toray Foundation (MTSF) project number 63905. The authors wish to express their gratitude to the MARU research teams for their invaluable assistance and hospitality throughout the sampling period.

REFERENCES

ANDERSON, R. F. 1982. Concentration, vertical flux and remineralization of particulate uranium in seawater. *Geochim. Cosmochim. Acta* **46**:1293-1299.

BIRD, E. C. F. 1971. Mangroves as land-builders. *Victorian Naturalist* **88**:189-197.

GOLDBERG, E. D. and M. KOIDE. 1962. Geochronological studies of deep sea sediments by the ionium-thorium method. *Geochim. Cosmochim. Acta* **26**: 417-450.

HARADA, K. and S. TSUNOGAI. 1985. A practical method for the simultaneous determinations of ^{234}Th, ^{226}Ra, ^{210}Pb and ^{210}Po in seawater. *J. Oceanogr. Soc. Jpn.* **41**: 98-104.

KAMARUZZAMAN, K. Y, H. SUHAIMI, E. K. TEH, H. F. LEONG, K. H. SOON and K.Y. CHONG. 2000. The determination of ^{230}Th in the sediments: Sedimentation in the mangrove forests of Pulau Sekeping, Kemaman, Terengganu. *Journal of Ultra Scientist of Physical Sciences* **13(2)**: 239 – 245.

KAMARUZZAMAN, B. Y. 1999. Geochemistry of the marine sediments: its paleoceanographic significance. Ph.D Dissertation. Hokkaido University, Japan. 143 p.

KOIDE, M., A. SOUTAR and E. D. GOLDBERG. 1972. Marine geochronology with ^{210}Pb. *Earth Planet. Sci. Lett.* **14**: 442-446.

KU, T. L. 1976. The uranium-series methods of age determination. *Ann. Rev. Earth Planet. Sci. Lett.* **4**: 347-379.

KU, T. L. and W. S. BROECKER 1966. Atlantic deep-sea stratigraphy, extension of absolute chronology to 320,000 years. *Science* **151**: 448 - 450.

LYNCH, J. C., J. R. MERIWETHER, B. A. MCKEE, F. VERA-HERRERA and R. R. TWINLLEY. 1989. Recent accretion in mangrove ecosystems based on ^{137}Cs and ^{210}Pb. *Estuaries* **4**: 284-299.

MANGINI, A. and P. STOFFERS. 1990. A high resolution ^{230}Th depth profile in a piston core from the Southern Lau Basin. *Geol. Jahrb. Reihe D.* **92**: 255 -261.

NORIKI, S., K. T. NAKANISHI, M. FUKAWA, M. UEMATSU, T. UCHIDA and S. TSUNOGAI. 1980. Use of a teflon vessel for the decomposition followed by the determination of chemical contituents of various marine samples. *Bull. Fac. Fish, Hokkaido Univ.* **31**: 354-465.

OSMOND, J. K. 1979. Accumulation models of ^{230}Th and ^{231}Pa in deep-sea sediments. *Earth Planet. Sci. Lett.* **15**: 95-150.

SCHOLTEN, J. C., R. BOTZ, A. MANGINI, H. PAETSCH, P. STOFFERS and E. VOGELSANG. 1990. High resolution $^{230}Th_{excess}$ stratigraphy of sediments from high latitude areas (Norwegian Sea, Fram Strait). *Earth Planet. Sci. Lett.* **101**: 54-62.

SCHOLTEN, J. C. R., H. BOTZ, J. PAETSCH, P. STOFFERS and M. WEINELT. 1994. High-resolution uranium-series dating of Norwegian Greenland Sea sediments: ^{230}Th vs. δ^{18}O stratigraphy. *Mar. Geol.* **121**:77-85.

SEN GUPTA, J. G. and N. B. BERTRAND. 1995. Direct ICP-MS determination of trace and ultratrace elements in geological materials after decomposition in a microwave oven, quantitation of Y, Th, U and the lanthanides. *Talanta* **42**: 1595-1607.

SHAHBUDDIN, S., H. MOHD LOKMAN, Y. ROSNAN and T. ASANO. 1998. Sediment accretion and variability of sedimentological characteristics of a tropical estuarine mangrove: Kemaman, Terengganu, Malaysia. *Mangroves and Salt Marshes* **55**: 1–8.

SHARMA, R., L. R. GARDNER, W. S. MOORE and M. S. BOLLINGER. 1987. Sedimentation and bioturbation in a salt marsh as revealed by ^{210}Pb, ^{137}Cs and ^{7}Be studies. *Limnology and Oceanography* **32**: 313-326.

SPENCELEY, A. P. 1982. Sedimentation patterns in a mangal on Magnetic Island near Townville, North Queensland, Australia. *Singapore Journal of Tropical Geography* **3**: 100-107.

SUMAN, D. O. and M. P. BACON. 1989. Variations in Holocene sedimentation in the North American Basin determined from ^{230Th} measurements. *Deep Sea Res.* **36**: 869-873.

TSUNOGAI, S. and M. YAMADA 1979. ^{226}Ra in Bering Sea sediment and its application as a geochronometer. *Geochemical Journal* **13**:231-238.

WOLANSKI, E., Y. MAZDA and P. RIDD. 1992. Mangrove hydrodynamics. In *Tropical Mangrove Ecosystems*, ed. Robertson, A. I. and Alongi, D. M. p. 436-462. Washington D. C: American Geophysical Union.

(Received: 4 July 2002)
(Accepted: 19 December 2002)

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Pertanika Journal of Tropical Agricultural Science

Volume 26 Number 1 (March) 2003

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ISSN 1511-3701

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