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Effect of Different Chemical Treatments on the Settleability of Palm Oil Mill Effluent

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Keywords: palm oil mill effluent, alum, zeolite, coagulants

ABSTRAK

Kesan alum dan ferik klorida terhadap pemendakan pepejal terampai di dalam bahan buangan kelapa sawit (POME) mentah telah dibandingkan dengan zeolit semula jadi dan kalsium karbonat. Kajian ini merupakan sebahagian daripada kajian teknologi penyingkiran minimum di dalam pengurusan keseluruhan POME. Keputusan kajian menunjukkan kesemua agen pemendakan dapat mengurangkan lebih 80% pepejal terampai manakala COD hanya 40-50% pengurangan. Isi padu termendak selepas 3-7 jam secara umumnya adalah di antara 35-50% daripada jumlah isi padu asal. Pemendakan terbaik mengikut susunan menaik adalah 3 g/L ferik klorida, 11 g/L alum, 10 g/L zeolite dan 20 g/L kalsium karbonat. Kadar pemendakan paling cepat ditunjukkan oleh 20 g/L kalsium karbonat di mana pemendakan hampir selesai dalam tempoh 2 jam berbanding POME mentah (tanpa rawatan) yang mengambil masa sehingga 20 jam. Dos zeolite yang digunakan adalah setara dengan agen pemendakan tradisional. Bagi kalsium karbonat walaupun dos lebih tinggi diperlukan, hasil buangan atau penggunaan pepejal enapcemar bebas-logam adalah memenuhi sistem penyingkiran minimum untuk POME.

ABSTRACT

The effect of alum and ferric chloride on the settleability of suspended solids in raw palm oil mill effluent (POME) was compared with that of natural zeolite and calcium carbonate. This work forms part of our overall research on minimal discharge technology in the overall management of POME. The results showed that all the flocculants could effectively reduce more than 80% of the suspended solids but only 40-50% of the COD. The settled volume after 3-7 hours was generally within 35-50% of the original mixture. The best settleability in increasing order were at 3 g/L ferric chloride, 11 g/L alum, 10 g/L zeolite and 20 g/L calcium carbonate. The fastest settling rate was obtained with 20 g/L calcium carbonate, where settling was almost completed within 2 hours as compared to more than 20 hours for raw POME. The dosage of zeolite was comparable to the traditional coagulants. As for calcium carbonate, although the dosage was higher, subsequent disposal or utilisation of the metal-free sludge solids fits well with our minimal discharge system for POME.

INTRODUCTION

Palm oil mill effluent (POME) is one of the most highly polluting organic wastewater in Malaysia. It is a combined effluent made up mainly of the steriliser condensate, centrifuge sludge and the discharge from the hydrocyclone. The essential characteristics of this effluent can be summarised as being of high organic strength (25000-30000 mg/L BOD and 40000-50000 mg/L COD), hot during discharge (60-70oC), acidic (pH 3.5-4.5) and highly turbid (20000-30000 mg/L suspended solids with 45000-60000 mg/L total solids). The solids which contribute to the BOD comprise mainly fine lignocellulosic materials and a small amount of residual oil. There are currently about 300 palm oil mills operating in Malaysia. A typical mill processes about 60

tons of fresh fruit bunch per day (Ma *et al.* 1993), producing more than twice the amount of POME. The POME is normally collected in a pit where part of the residual oil which floats upon cooling is recovered. The effluent is then pumped into either large digester tanks or more commonly to a series of anaerobic and aerobic lagoons for a combined treatment prior to discharge. Typical residence times in these lagoons exceeds 30 days (Ma *et al.* 1993). Mixed microbial action on the organic matter resulted in the formation of biogas which is rarely utilised and normally released to the atmosphere. The final treated effluent must meet the BOD and COD discharge standards of 100 mg/L, set by the Department of Environment for the palm oil industry, before discharge to watercourses. This represents a 300-fold reduction of the organic strength. This fact, coupled with the large daily volumetric throughput involved, means that the treatment system has to cope with a very high organic loading rate, putting a severe strain on the treatment facility.

Traditional wastewater treatment from food and agro-based industries employs primary treatment systems consisting basically of sedimentation tanks or primary clarifiers aimed at removing settleable solids prior to the secondary treatment which is essentially biological in nature. With this strategy, usually about one-third of the initial BOD present will be removed with the solids, hence reducing the load on the subsequent secondary treatment. Thus, with POME, it would seem logical to remove the bulk of the suspended solids prior to biological treatment. Unfortunately, most of the suspended solids in POME are very fine and are difficult to remove by gravity settling (Ho and Tan 1989). Flocculants and coagulants such as alum (aluminium sulphate) and ferric chloride have been used to remove suspended particulate matter from water and wastewater worldwide (Sawyer *et al.* 1994; Rossini *et al.* 1999). There have been several reports on the use of such agents on POME (Abdul Karim and Lau 1987; Ng *et al.* 1987). Although the effluent solids could be removed by these methods, the use of heavy metals such as aluminium and iron and their presence in the settled sludge means that the disposal of such sludges would be problematic.

Our research group has been concerned with the utilisation of POME incorporating a minimal discharge strategy towards a zero-discharge system in the management of POME (Hassan *et al.* 1997; Nor Aini *et al.* 1999). Thus we propose the use of other flocculants such that the eventual sludge could be more easily disposed or put to beneficial use. The use of natural zeolite and calcium carbonate would produce a concentrated biological solid from POME which could be used for the production of value-added products such as biodegradable plastics (Hassan *et al.* 1997). The objective of this work is to evaluate the effect of appropriate chemical precipitants such as zeolite and calcium carbonate on the settleability of POME in comparison to the use of conventional agents such as alum and ferric chloride. In consonant with our overall strategy, the characteristics of the residual clarified effluent will also be assessed in order to determine subsequent treatment methods.

MATERIALS AND METHODS

Materials

Raw POME, obtained fresh from Bukit Raja Palm Oil Mill (Sime Darby Group), Klang was kept in the cold room at 4°C prior to use. The characteristics of raw POME is shown in Table 1. Laboratory grade alum (aluminium sulphate, $Al_2(SO_4)_3.18H_2O$) was obtained from BDH, ferric chloride ($FeCl_3$) from Merck and calcium carbonate ($CaCO_3$) from Fluka. Natural zeolite-mordenite was obtained from Harta Semarak Sdn. Bhd., Batu Pahat, Johor, Malaysia in a rock-like form. The zeolite was dried, pulverised, sieved, washed several times with distilled water and dried prior to use.

Experimental Procedure

The settleability experiments were performed using several 100 milliliters measuring cylinders onto which 10 mm x 100 mm strips cut from standard graph paper were attached. POME which was thoroughly mixed with different dosages of the chemical flocculants in separate beakers was then poured into the measuring cylinders, and left to sediment. Raw untreated POME was used as control for each treatment. All the treatments were carried out at 30°C. The settling velocity was determined by measuring the change in height of the sludge zone with time (Ng *et al.* 1987). From the plot of this data, the constant maximum settling velocity was obtained.

Analyses

BOD, COD, total solids and suspended solids were determined as in the Standard Methods (APHA 1985).

RESULTS

Effect of Alum

Fig. 1 shows the rate of sedimentation of POME with 0-20 g/L alum. The settling rate is measured by the drop in the level of the clarified liquid interface with time. It is evident that most of the settling occurred within the first 5-7 hours. In the first 3-4 hours, settling was fastest and the rates were constant. The best settling was at 11 g/L of alum, whereby the lowest solids volume of 30% of the original volume was obtained. Table 1 gives the constant settling velocity as well as the residual suspended solids and COD of the supernatant. The settling rate at 11 g/L alum was nearly 3 times faster than raw POME, with the lowest suspended solids and COD in the clarified liquor. It is evident that alum could effectively reduce the suspended solids in POME but not its COD or BOD (Table 1).

Effect of Ferric Chloride

Fig. 2 showed that the same pattern was obtained with ferric chloride as with alum. The concentrations of Ferric chloride required were lower, and the final solids volume was quite similar. From Table 1, the best settleability was with 3 g/L ferric chloride. Increasing the flocculant level resulted in slower settling, as was also observed by Ng *et al.* (1989), probably due to restabilisation instead of flocculation. The reduction in suspended solids and BOD (Table 1) were significant, but not the COD.

Effect of Zeolite

From Fig. 3, zeolite treatment on POME resulted in good settling of the solids, with 50% settled volume achieved with only 10g/L zeolite after only 3 hours. As shown in Table 1, the settling rates were even better than alum and

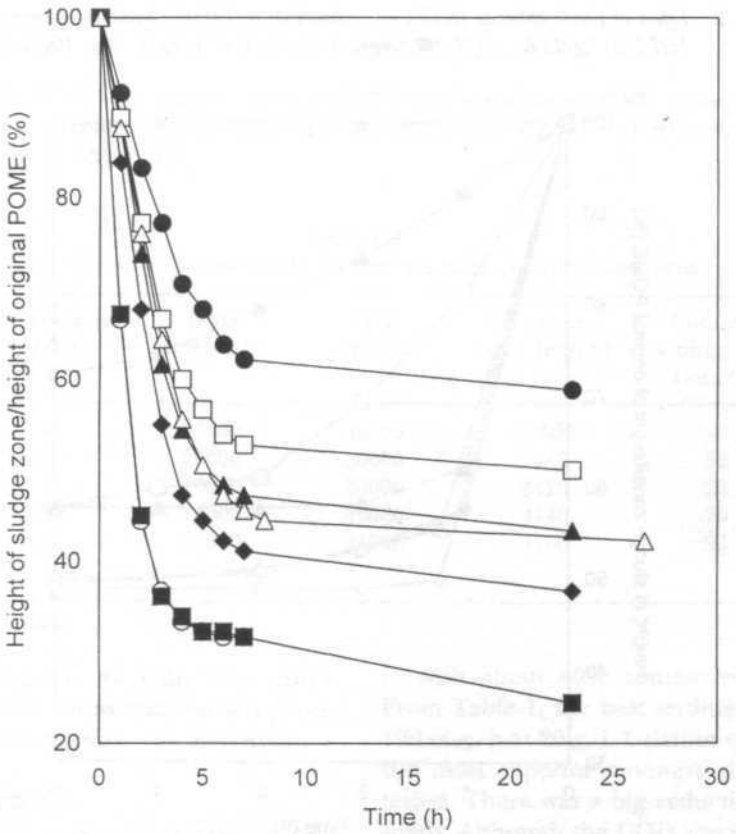

Fig. 1. Effect of alum on settleability of POME. Symbols represent; control (●); Ig/L(□); 5g/L(▲); 9g/L (◆); 11g/L (O); 13g/L (■); 20g/L (△)

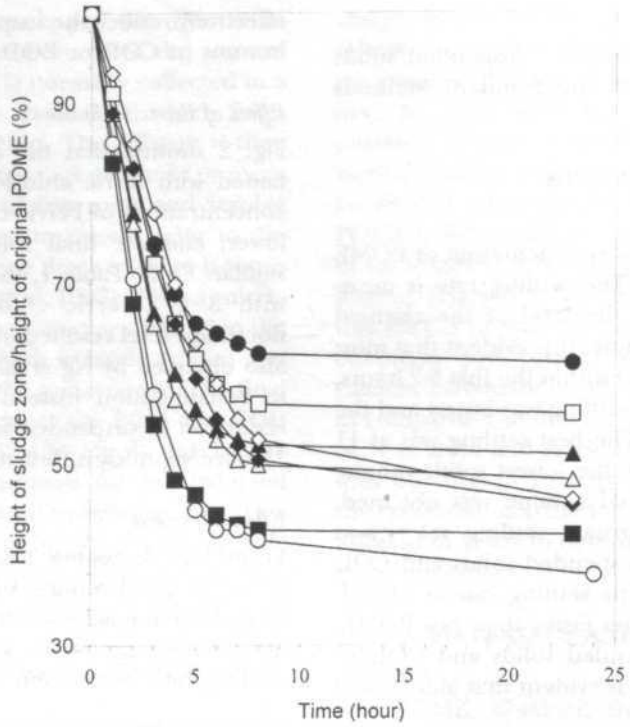

Fig. 2. Effect of Ferric chloride ($FeCl_3$) on settleability of POME. Symbols represent; control (●); Ig/L(□); 2g/L(▲); 3g/L (■); 4g/L (△); 5g/L (◇); 6g/L (◆); 10g/L (O).

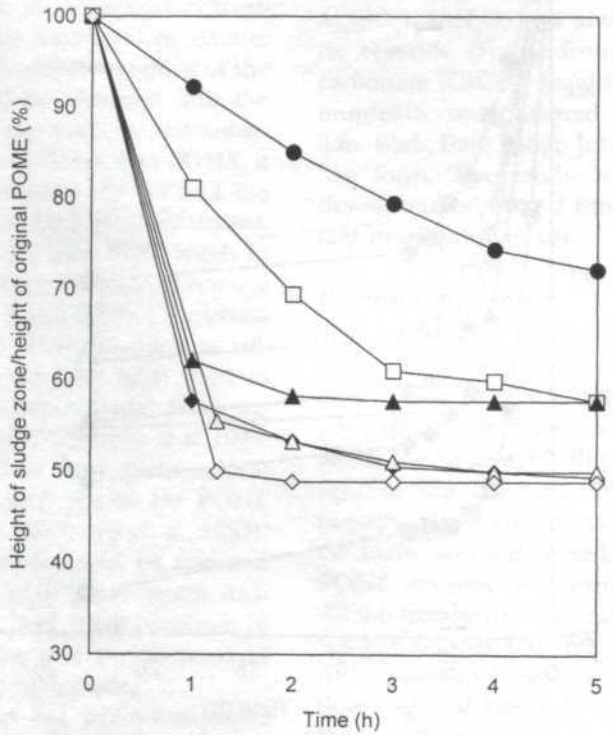

Fig. 3. Effect of Zeolite on settleability of POME. Symbols represent; control (●); 5g/L(□); 10g/L(◇); 30g/L (△); 60g/L (▲); 100g/L (◇)

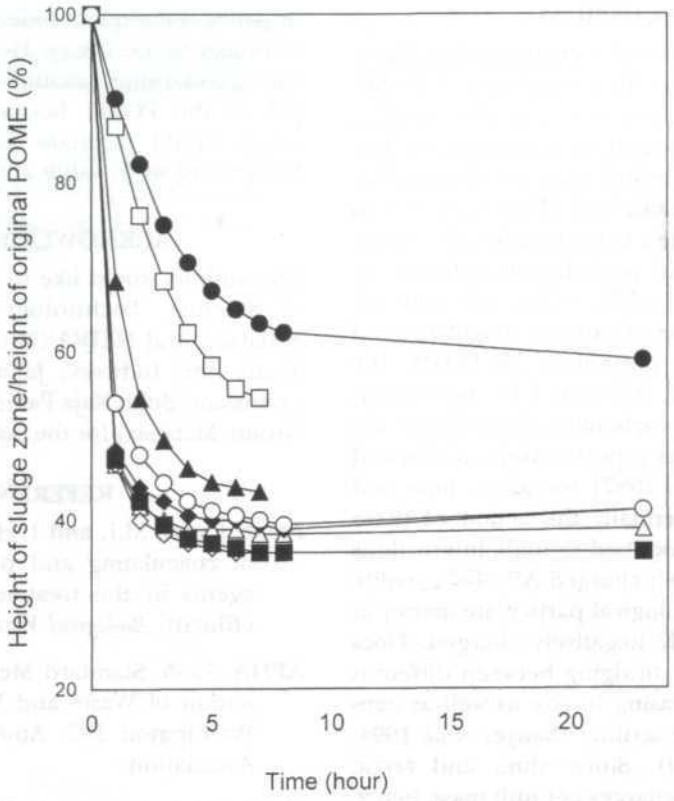

Fig. 4. Effect of Calcium carbonate (CaCO3) on settleability of POME. Symbols represent; control (●); 5g/L(□); 10g/L(▲); 20g/L (△); 40g/L (◇); 60g/L (◆); 80g/L(); 100g/L (O)

TABLE 1
Characteristics of raw POME before and after chemical treatment

Flocculant	Concentration (g/L)	BOD (mg/L)	COD (mg/L)	Suspended solid (mg/L)	Constant settling rate (mm/h)	pH
(Raw POME)	–	23200	45000	17500	–	4.20
Alum	11	23000	20000	1940	52	3.35
Ferric chloride	3	16000	30000	3420	28	3.44
Zeolite	10	15000	40000	4140	76	4.30
Calcium carbonate	20	21000	31000	4100	96	5.20

ferric chloride. Again, as with the other flocculants, suspended solids removal was good. However, the COD reduction was increased.

Effect of Calcium Carbonate

The effect of Calcium carbonate is given in Fig. 4. Settling was quite fast and almost completed within 2-3 hours at concentrations above 10 g/L, with about 40% compacted solids volume. From Table 1, the best settling rate approaches 100 mm/h at 20 g/L Calcium carbonate – by far the most superior amongst all the flocculants tested. There was a big reduction in suspended solids. Although the COD was reduced by about 30%, however the BOD was essentially unchanged.

DISCUSSION

Generally, the effect of the chemical flocculants used in this study on the settleability of POME was quite similar, resulting in higher settling rates with higher clarified volume obtained. The suspended solids removal were also better, but the reductions in COD and BOD were not as good. Overall, the best concentrations for alum, ferric chloride, zeolite and calcium carbonate in weight/volume are 1.1%, 0.3%, 1% and 2% respectively. In terms of ratio of coagulant used to suspended solids present in raw POME, the values are 0.63, 0.17, 0.57 and 1.15 respectively. Apart from calcium carbonate, these figures are comparable to earlier reports (Abdul Karim and Lau 1987; Ng *et al.* 1987) for alum, lime and ferric chloride. Essentially the action of these flocculants can be ascribed to ionic interactions between the positively-charged Al^{3+}, Fe^{3+}, zeolite and Ca^{2+} and the biological particulate matter in POME being mainly negatively charged. Flocs could be formed by bridging between different particles, thus increasing in size as well as density which aided the settling (Sawyer *et al.* 1994; Ho and Tan 1989). Since alum and ferric chloride have more charges per unit mass, hence it is expected that the quantities of these flocculants required were less than Calcium carbonate. With zeolite however, there is an additional mechanism – binding within the pores (Ouki *et al.* 1994), thus the quantity required is comparable to alum. Although the highest concentration required was for Calcium carbonate, the settling was the fastest. This would be beneficial in sizing-up for the sedimentation tanks, since a smaller retention time would be sufficient. The effect of chemical addition on pH as shown in Table 1 varies by only within 1 pH unit. Based on our observation, within pH 2-10 (adjusted by NaOH), there is no effect on the settleability of raw POME. Thus the settling behaviour of POME in this study was not due to pH. In relation to our objectives, it is seen that zeolite and calcium carbonate would be equally suitable in comparison to the traditional flocculants (alum and ferric chloride), if not better. Settled solids associated with zeolite or Calcium carbonate would be more amenable to subsequent utilisation or disposal. In industrial application, the Calcium carbonate could be replaced with lime. We will look into that in our future work. As for the high residual BOD in the clarified effluent – probably due to dissolved organics –subsequent biological treatment would obviously be necessary. However, the added advantage of using calcium carbonate is that the pH of the POME became higher (Table 1) which would facilitate its utilization such as bioconversion to value added products.

ACKNOWLEDGEMENT

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REFERENCES

ABDUL KARIM, M.I. and L.H. LAU. 1987. The use of coagulating and polymeric flocculating agents in the treatment of palm oil mill effluent. *Biological Wastes* **21**: 209-217.

APHA. 1985. Standard Methods for the Examination of Waste and Wastewater, 16th edn. Washington DC: American Public Health Association.

HASSAN, M.A., Y. SHIRAI, N. KUSUBAYASHI, M.I. ABDUL KARIM, K. NAKANISHI and K. HASHIMOTO. 1997. The production of polyhydroxybutyrate from anaerobically treated palm oil mill effluent by *Rhodobacter sphaeroides. J. Fermentation and Bioengineering* **83(5)**: 485-488.

HO, C.C. and Y.K. TAN. 1989. Comparison of chemical flocculation and dissolved air flotation of anaerobically treated palm oil mill effluent. *Water Research* **23:** 395-400.

MA, A.N., S.C. CHEAH and M.C. CHOW. 1993. Current status of palm oil processing waste management in Malaysia. In *Current Status and Prospects for Bioremediation* eds Yeoh, B.G. *et al.*, p. 111-136. Ministry of Science, Technology and Environment.

NOR AINI, A.R., M.A. HASSAN, Y. SHIRAI, A.B. ARIFF and M.I. ABDUL KARIM. 1999. Organic acids production from palm oil mill effluent during continuous anaerobic treatment. *Asia Pacific J. Molecular Biology and Biotechnology* **7(2)**: 179-184.

NG. W.J., C.A. GOH and J.H. TAY. 1987. Palm oil mill effluent treatment – an assessment of coagulants used to aid liquid-solid separation. *Biological Wastes* **21**: 237-248.

OUKI, S.K., C.R. CHEESEMAN and R. PERRY. 1994. Natural zeolite utilisation in pollution control. *J. Chemical Technology and Biotechnology* **59**: 121-126.

ROSSINI, M., J.G. GARRIDO and M. GALLUZZO. 1999. Optimization of the coagulation-flocculation treatment. *Water Research* **33**: 1817-1826.

SAWYER, C.N., P.L. MCCARTY and G.F. PARKIN. 1994. *Chemistry for Environmental Engineering.* New York: McGraw Hill Inc.

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Prevalence and Effect of Parasitic Infections on Cycling in Traditionally Managed Cattle Herds in Bauchi, Nigeria

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ABSTRAK

Kejadian jangkitan dan infestasi oleh parasit (seperti helmint, ektoparasit dan hemoparasit) dan hubungan antara parasit tersebut dengan kitaran pada lembu telah dikaji pada sekumpulan 16 ekor lembu yang diurus secara tradisional di Bauchi, Nigeria. Jangkitan parasitik dan infestasi berlaku secara bermusim dengan kebanyakan jangkitan dan infestasi berlaku dalam musim hujan. Kajian ini juga menunjukkan sesetengan hubungan antara jangkitan parasitik dan infestasi dengan kitaran pada sekawan lembu yang tidak diuruskan dengan baik. Terbukti bahawa amalan pengurusan yang baik sangat penting dalam pengawalan dan pencegahan penyakit.

ABSTRACT

The incidence of infection and infestation by parasites (i.e. helminth, ectoparasites and haemoparasites) and the relationship between them and cycling in cattle was investigated in 16 traditionally managed herds in Bauchi, Nigeria. Parasitic infection and infestation show seasonality with most infections and infestations occurring in the rainy season. This study also shows some relationship between parasitic infection and infestation with cycling in some poorly managed herds. Good management practices were also shown to be important in disease control and prevention.

INTRODUCTION

In many countries of the world, parasitic infection is of major importance in the animal production sector (Blood 1979). In addition to the purely physical injury caused by the parasites, some serve as vectors of many viral, rickettsial, bacterial and protozoan diseases (Fabiyi 1984). They have a marked effect on the production of meat and milk in Africa (Jawara 1990).

Given an appropriate environment, parasitic infection may cause substantial losses in production or even acute clinical symptoms and death (Morley and Donald 1980). The disease causes a rather gradual deterioration of animal performance and does not show dramatic clinical symptoms especially in mature animals (Okaeme and Ogwu 1984).

Most losses in productivity of grazing animals are now associated with clinically in-apparent disease. Therefore the prevention and treatment of parasitic infection involve measures applied to the whole herd. The tropical climate is extremely conducive to the growth and propagation of pathogens and consequently, the environment is rife with disease agents and their vectors (Jawara 1990). Helminthiasis is significant in this case and is a cause of high mortality and decrease production in most farms in Africa (De Haans and Bekure 1991).

Helminthic diseases have been and are still known to be major causes of economic losses in livestock in the tropical world and Nigeria in particular (Maina 1986; Nuru and Dennis 1976; Ogunsusi 1985; Pullan 1979). Most of the losses are due to decreased milk production, poor

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wool quality, inferior carcass grade, sterility, long calving anoestrus and loss of weight (Georgi and Georgi 1990; Istifanus *et al.* 1990; Mohammed *et al.* 1989; Morley and Donald 1980; Ngategize and Kaneene 1985; Ogunsusi 1979).

It is with the above in mind that this study was undertaken to look at the prevalence of parasitic infections and their effect on cycling in a herd health program involving traditionally managed cattle in northern Nigeria.

MATERIALS AND METHODS

Livestock Production System

The selected livestock farms in the study area practice agropastoralism, which is regarded in this part of the country as the traditional managed herds. This involves a management practice whereby the farmers grow cash and food crops in addition to raising livestock. The agropastoralists practice limited transhumance at the end of the crop-growing season to graze predominantly maize and sorghum residues during early December to the end of May. Animal feeds on offer during the rainy season and harvest time decreases so fast that a more critical nutritional stress period occurs during the pre-rainy season (Mid May to Mid June). Watering is done in streams or ponds. There were no deliberate management systems or strategy aimed at controlling the breeding season. Bulls run with the breeding females all the time thus allowing cows to conceive throughout the year, thereby spreading the farmers income from sale of milk.

Selection of Herds

Herds were selected in Bauchi area because Bauchi State has the largest population of livestock in Nigeria and is considered the livestock hub of the country (Ajayi 1995). Only traditionally managed farms were selected. At the beginning of the study, 25 herds were randomly selected but as the study progressed, some herds dropped out. This was because of suspicion that the study was a head count for tax purposes.

Fieldwork/Observation

The fieldwork covered January 1993 to December 1995. Planned periodic monthly visits were made to each herd. At the start of the study through the end, every animal in each herd was examined individually. On each visit to each herd, blood and faecal samples were taken and examined for haemoparasites and helminths (strongyles) using the thin smear method and floatation method respectively. Tick infestation was also noted especially when seen around the legs, mammary gland, dew lap and in-between legs areas. Rectal examination was carried out on each visit to check for pregnancy and /or ovarian activity. Palpation for pregnancy diagnosis was done as described by Eduvie and Dawuda (1986) and Voh JR *et al.* (1994).

Statistical Analysis

Simple percentages, chi square and cow-months methods were used to analyse the data (Remington and Schork 1972). Cow months was used to account for additions and subtractions to and from the herds. The seasonal index (average of the 3 years cow months value) was calculated for each herd by combining the cow month data for the 3 years and plotting it to give a calculated seasonal index.

RESULTS

During the study, 5 herds dropped out after the first year of study and 2 dropping out during the second year of study. This was taken care of statistically using the cow month method of analysis.

The yearly distribution of parasites in the selected herds showed that the prevalence decreased in almost all the herds. The prevalence of haemoparasites infection decreased in all herds for at least the first two years of study except for Kobi, Bula and Tahir herds (Tables 1 and 2). These herds had high prevalence in the third year. Furthermore infection were found to be due to anaplasmosis (Table 1) than babesiosis (Table 2) and both infections showed seasonality in their prevalence (Fig 1). Even though most herds have the prevalence of anaplasmosis reduced with years, Kobi, Bula and Tahir herds have a higher incidence in the third year. For babesiosis, only the Bula herd had higher prevalence in the third year. A similar trend was observed for helminthiasis except that Fawu and Kobi herds have higher incidence in the third year (Tables 3 and 4) (Fig 1). Species of ticks identified were Amblyoma and Hyaloma species. The general picture in this study is that diseases

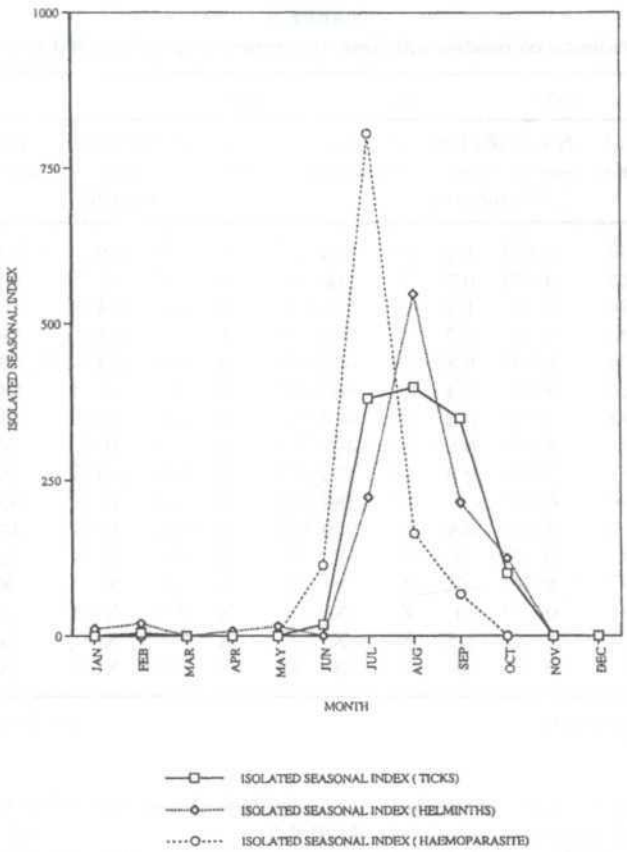

Fig. 1: Seasonal distribution of parasites in 16 herds in Bauchi (1993-1995)

TABLE 1
Yearly incidence of anapalma infection (expressed per hundred cow months)

FARM	1993			1994			1995		
	Cow month	No +ve	%/100 cow months	Cow month	No +ve	%/100 cow months	Cow month	No +ve	%/100 cow months
UNIVERSITY	368	25	6.8	519	25	4.8	501	0	0
FAWU	593	23	3.9	566	17	3.0	634	12	1.9
KOBI	785	45	5.7	715	20	2.8	584	25	4.3
OSKA	772	27	3.5	704	10	1.4	588	0	0
JUMBA	728	42	5.8	678	17	2.5	802	9	1.1
BULA	514	15	2.9	580	4	0.7	530	23	4.3
STATE POLY.	366	13	3.6	419	3	0.7	447	0	0
BUBA	393	40	10.2	407	12	2.9	X	X	X
LIBC	541	42	7.8	436	11	2.5	X	X	X
GIWO	515	10	1.9	480	3	0.6	502	2	0.4
TAHIR	409	26	6.4	279	0	0	458	2	0.4
BARAMI	225	0	0	X	X	X	X	X	X
GALAMBI	206	3	1.5	X	X	X	X	X	X
BISHI	493	7	1.6	X	X	X	X	X	X
MIRI	493	7	1.6	X	X	X	X	X	X
MAIKANO	318	0	0	X	X	X	X	X	X

X - Not done (farms dropped out)

TABLE 2
Yearly incidence of babesia infection (expressed as per hundred cow months)

FARM	1993			1994			1995		
	Cow month	No +ve	%/100 cow months	Cow month	No +ve	%/100 cow months	Cow month	No +ve	%/100 cow months
UNIVERSITY	368	5	1.4	519	1	0.2	501	0	0
FAWU	593	4	0.7	566	0	0	634	0	0
KOBI	785	9	1.2	715	3	0.4	584	2	0.3
OSKA	772	5	0.7	704	1	0.1	588	0	0
JUMBA	728	6	0.8	678	3	0.4	802	0	0
BULA	514	2	0.4	580	0	0	530	2	0.4
STATE POLY.	366	1	0.3	419	0	0	447	0	0
BUBA	393	3	0.8	407	0	0	X	X	X
LIBC	541	5	0.9	436	2	0.5	X	X	X
GIWO	515	0	0	480	0	0	502	0	0
TAHIR	409	2	0.5	279	0	0	458	0	0
BARAMI	225	0	0	X	X	X	X	X	X
GALAMBI	206	0	0	X	X	X	X	X	X
BISHI	493	0	0	X	X	X	X	X	X
MIRI	493	1	1.2	X	X	X	X	X	X
MAIKANO	318	0	0	X	X	X	X	X	X

X - Not done (farms dropped out)

TABLE 3
Yearly incidence of helminths (expressed as per hundred cow months)

FARM	1993			1994			1995		
	Cow month	No +ve	%/100 cow months	Cow month	No +ve	%/100 cow months	Cow month	No +ve	%/100 cow months
UNIVERSITY	368	62	16.8	519	33	6.4	501	32	6.4
FAWU	593	75	12.6	566	30	5.3	634	51	8.0
KOBI	785	132	16.8	715	54	7.6	584	63	10.8
OSKA	772	64	8.3	704	24	3.4	588	17	2.9
JUMBA	728	100	13.7	678	52	7.7	802	28	3.5
BULA	514	37	7.2	580	13	2.2	530	22	4.2
STATE POLY.	366	41	11.2	419	24	5.7	447	26	5.8
BUBA	393	61	15.5	407	45	11.1	X	X	X
LIBC	541	91	16.8	436	69	15.8	X	X	X
GIWO	515	46	8.9	480	34	7.1	502	24	4.8
TAHIR	409	66	16.1	279	19	6.8	458	27	5.9
BARAMI	225	16	7.1	X	X	X	X	X	X
GALAMBI	206	15	7.3	X	X	X	X	X	X
BISHI	493	54	12.8	X	X	X	X	X	X
MIRI	493	46	9.3	X	X	X	X	X	X
MAIKANO	318	32	10.1	X	X	X	X	X	X

X - Not done (farms dropped out)

TABLE 4
Yearly incidence of ectoparasite (expressed as per hundred cow months)

FARM	1993			1994			1995		
	Cow month	No +ve	%/100 cow months	Cow month	No +ve	%/100 cow months	Cow month	No +ve	%/100 cow months
UNIVERSITY	368	149	40.5	519	86	16.6	501	52	10.4
FAWU	593	82	13.8	566	77	13.6	634	53	8.4
KOBI	785	126	16.1	715	73	10.	584	73	12.5
OSKA	772	129	16.7	704	57	8.1	588	22	3.7
JUMBA	728	111	15.2	678	122	18.0	802	26	3.2
BULA	514	32	6.2	580	19	3.3	530	59	11.1
STATE POLY.	366	38	10.4	419	35	8.4	447	29	6.5
BUBA	393	64	16.3	407	61	15.0	X	X	X
LIBC	541	76	14.0	436	83	19.0	X	X	X
GIWO	515	34	6.6	480	50	10.4	502	30	6.0
TAHIR	409	69	16.9	279	23	8.2	458	25	5.5
BARAMI	225	10	4.4	X	X	X	X	X	X
GALAMBI	206	11	5.3	X	X	X	X	X	X
BISHI	493	20	4.8	X	X	X	X	X	X
MIRI	493	0	0	X	X	X	X	X	X
MAIKANO	318	13	4.1	X	X	X	X	X	X

X - Not done (farms dropped out)

cause by these parasites occurred mainly during the rainy season (Fig. 1).

The relationship between parasitic infection and cycling, shown in Tables 5 and 6, showed that only in the University and Buba herds that ectoparasitism was found to affect cycling in the first and second year of study ($P<0.1$), while endoparasites affected cycling ($P<0.l$) in Jumba and Tahir herds in the third year only.

DISCUSSION

The livestock industry in Nigeria, is faced with many problems and one of such problems is parasitic diseases (Jawara 1990). Parasitic infection is known to cause great economic loses in livestock production in Africa in general (Ajayi 1995). In this study, babesiosis and anaplasmosis were the only haemoparasites encountered in all herds and most infections were due to anaplasmosis. High incidences were recorded for the herds in the first year of study, which was seen to reduce greatly in the second and third year of study respectively. This was due to the control measures instituted on a herd basis against tick infestation followed by prophylactic treatment. However, the incidence became high in Kobi, Bula and Tahir herds because of new additions to the herds during the third year.

Infestation due to helminths was found to be mainly by strongyles. The higher incidence in the first year was reduced in the second and third year in all the herds except Fawu and Kobi herds where new animals were added during the third year. Seasonality of infestation was noticed for both haemoparasites and helminths. This agrees with the work of Fabiyi (1984) and Istifanus *et al.* (1990) where outbreaks of helminthiasis occurred in farms, during the rainy season. It also demonstrated negligible peak of infective larvae or eggs during the dry season with a carry over of infective materials in the host from one wet season to the next. The season distribution was used during the course of the study to device control measures by planned deworming of herds during the rainy season. This resulted in the improvements seen in the herds at the second and third year of study. The main problem encountered in most herds was that instead of treating their herds on a herd basis, the farmers treat individual cases. However, this study has demonstrated that treatment on a herd basis takes care of not only clinical cases but subclinical ones too. Subclinical cases are known to be responsible for most decrease in productivity of herds (Blood and Radostits 1995).

A similar trend of distribution as that of haemoparasites and helminthiasis was observed for tick infestation in this study. Infection and infestation for the 3 classes of parasites encountered in our study showed seasonality in distribution. Most of the infection and infestation occurred during the rainy season. This could be because the climate was conducive for their multiplication and development (Ajayi 1995; Jawara 1990).

Statistically, only in a few herds, where management was very poor, that a relationship between parasitic infection/infestation and cycling was found (P<0.0 1). From our study, it was shown that there was seasonality of infection/infestation in herds in Bauchi and this information could be used to plan a control program in herds in these areas. It also showed that good management is essential for disease control and prevention and in increasing productivity by increasing the rate of cycling and hence pregnancy.

REFERENCES

AJAYI, S.T. 1995. An overview of livestock productivity in Nigeria. Paper presented at *A National Workshop on Nutrition and Health as constraints to increased Livestock Productivity in Nigeria*, Bauchi, 14th-16th November.

BLOOD, D.C. 1979. The veterinarian in planned animal health and production. *Can. Vet. J.* **20**: 341-347.

BLOOD, D.C. and O.M. RADOSTITS. 1995. *Herd Health: A Textbook of Health and Production Management of Agricultural Animals.* New York, *U.S.A:* W.B. Saunders Company.

DE HAANS, C. and S. BEKURE. 1991. Animal health services in sub-Saharan Africa. Initial experiences with alternative Approaches. *World Bank Technical Paper* 134: 1-34.

EDUVIE, L.O. and P.M. DAWUDA. 1986. Effect of suckling on reproductive activities of Bunaji cows during the postpartum period. *J. Agric. Sci.* (Cambridge) **107**: 235-238.

FABIYI, J.P. 1984. Coping with clinical tick-borne disease in cattle in Nigeria. *Nigerian Livestock Farmer* **4(3)**: 7-11.

GEORGI, J.R. and M.E. GEORGI. 1990. *Parasitology for Veterinarians.* 5th Edition. London: W.N. Saunders Company.

ISTIFANUS, W.A., D.M. MOHAMMED and A.C. KUDI. 1990. An investigation into the prevalence of bovine gastrointestinal helminth parasites in Bauchi area of Nigeria. *Nigerian J. of Tech. Res.* **2(2)**: 145-146.

JAWARA, D.K. 1990. Animal disease as a factor limiting economic development in Africa. *Cornell Veterinarian* **80**: 17-25.

MAINA, J.A. 1986. Animal health in subhumid Nigeria. In *Livestock System Research in Nigeria's Sub-Humid Zone*, eds. Von Kaufmann, R., Charter, S. and Blench, R. Pp 167-188. Ethiopia, Addis Ababa, ILCA.

MOHAMMED A., W.A. ISTIFANUS and N.H. ANYAWU. 1989. Parasitological survey of bovine anaplasmosis in Bauchi area of Nigeria. *Nig. J. Tech. Res.* **1**: 97-80.

MORLEY, F.H.W. and A.D. DONALD. 1980. Farm management and systems of helminth control. *Veterinary Parasitology* **6**: 105-134.

NGATEGIZE, P.K. and J.B. KANEENE. 1985. Evaluation of the economic impact of animal diseases on production: a review. *Vet. Bull.* **55**: 153-162.

NURU, S. and S.N. DENNIS. 1976. Abortion and reproductive performance of cattle in northern Nigeria. A questionnaire survey. *Trop. Ani. Health and Prod.* **8**: 213-219.

OGUNSUSI, R.A. 1985. Parasitic problems and control in small ruminants production. In *Small Ruminants Production in Nigeria*, eds. Adu, I.F., Osinowo, A.O., Taiwo, B.A.B. and Alhassan, W.S. In *Proceedings of the Conference on Small Ruminants Production in Nigeria*, p. 231-238. Zaria, Nigeria, 6th-l0th October, NAPRI, Shika.

OGUNSUSI, R.A. 1979. Pasture infectivity with trichstrongylid larvae in northern guinea Savannah of Nigeria. *Res. In Vet. Sci.* **26**: 320-323.

OKAEME, A.N. and D. OGWU. 1984. Helminth profile of migrant cattle in the Kainji lake basin of Nigeria. *Nig. J. Agri. Extension* **2(1)**: 30-35.

PULLAN, N.V. 1979. Productivity of white fulani cattle on Jos plateau, Nigeria. 171. Nutritional factors. *Trop. Ani. Health and Prod.* **12**: 17-24.

REMINGTON, T. and K. SCHORK. 1970. *Statistics with Application to Biological and Health Sciences*, p.340. Englewood Cliffs, New Jersey: Prentice-Hall Inc.

VOH, JR.A A., D. OGWU and E.O. OYEDIPE. 1994. Incidence of late embryonic mortality and repeat breeder syndrome in artificially inseminated Bunaji cows following oestrus synchronization. Paper presented at National Animal Production Research Institute (NAPRI) Seminar, Ahmadu Bello University, Zaria, Nigeria, 12th April.

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Identification of Aroma, Earthy Flavour and Aftertaste in Tilapia Using Sensory Evaluation Technique

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ABSTRAK

Panel terlatih digunakan untuk mengenal pasti profil rasa yang merangkumi aroma, rasa dan rasa selepas ditelan bagi ikan tilapia hitam (Oreochromia mossambica). *Untuk tujuan perbandingan, 2 jenis ikan laut iaitu ikan kembung* (Rastrellinger kanagurta) *dan ikan aya* (Euthynnus affinis) *dan ikan* (Clarias batracus), *sejenis ikan air tawar, juga dinilai. Sepuluh, dan lapan ciri aroma, rasa dan rasa selepas ditelan telah dikenal pasti. Walau bagaimanapun, kehadiran ciri lumpur yang kuat hingga sederhana menguasai sifat aroma, rasa dan rasa selepas ditelan ikan tilapia yang juga sentiasa mendapat skor yang lebih tinggi daripada ikan keli kecuali bagi rasa selepas ditelan. Kehadiran geosmin di dalam otot ikan tilapia mungkin di dalam julat 1.0 hingga 10.0 μgml^{-1}. Aroma lumpur mungkin boleh dikurangkan dengan memasak.*

ABSTRACT

Trained panelists were used to identify the flavour profile which consists of aroma, flavour and aftertaste of wild black tilapia (Oreochromis mossambica). *For the purpose of comparison, 2 marine fish namely Indian mackerel* (Rastrelinger kanagurta) *and bonito* (Euthynnus affins) *and catfish* (Clarias batrachus), *a freshwater fish, were also evaluated. Ten and eight aroma, flavour and aftertaste attributes respectively were recognized in tilapia. However, the presence of kerosine-like attribute could be due to petrochemical contaminants. The presence of strong to moderate earthy attribute is dominantly recognized in its aroma and flavour which are consistently scored higher than that in catfish except for the aftertaste. The presence of geosmin in the tilapia muscle could most probably be in the range of 1.0 to 10.0 μmg^{-1}. The earthy aroma may be reduced upon cooking.*

INTRODUCTION

Acceptance of fishery products is dependent on safety, nutrition, flavour, texture, colour, appearance and the suitability of the raw material for processing and preservation. However, flavour seems to be the most important factor for acceptance (Haard 1992). Even though fish exhibits a similar recognizable flavour characteristic, each species has its unique attributes which are dependent on the non-nitrogenous constituents such as aldehydes, alcohols, volatile sulfur and ketones (Josephson 1991; Jones 1967). The consumer acceptance of muddy-flavoured catfish is very low (Mills *et al.* 1993). Black tilapia is abundant and easily cultured in Malaysia, but its marketability is mainly constrained by the unpopular presence of the muddy odour and flavour.

The detection and the quantification of this unique and complex flavour notes could be carried out instrumentally such as by gas chromatography, but this cannot be done with ease. It is also a common practice in quality control laboratories to assess the presence of any particular odour and flavour through sensory evaluation by trained panelists. Johnsen and Dupree (1991) reported using trained panelist to investigate the role of feed ingredients on the flavour quality of farmed

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catfish. The use of trained panelists to assess the lipid oxidation in frozen stored catfish was reported by Brannan and Erickson (1996). The use of trained panelist to monitor quality changes in strawberry industry has also been reported (Shamaila *et al.* 1992). Trained panelists are frequently used for sensory-instrumental correlation. They are consistent, superior in describing odour notes, are articulate and highly motivated (Foss 1981). General methods for the sensory evaluation of food products have been outlined by several researchers such as Amerine *et al.* (1965), Larkin (1969), Larmond (1971) and Spencer (1971). Specific training of panelists to the earthy odour of pure extracts of known important compounds that contribute to the characteristic of muddy odour such as geosmin and 2-methylisoborneol (MIB) has been reported by Persson (1980). It is crucial that the identification and quantification of these flavour notes recognised by the trained sensory panelists since the ultimate marketability of the fish and its products are dependent on its acceptability by the consumers particularly the sensory perception of the buyers. To date, the flavour note of black tilapia has not been reported. Hence, this study was carried out to identify and quantify the flavour note of black tilapia as well as to identify the concentration of geosmin in the fish muscle detectable by panelists.

MATERIALS AND METHODS

Materials

Wild black tilapia (150-300 g each) were caught by netting from a lake near the university. The marine fish (Indian mackerel and bonito) and catfish used for comparison purposes were bought from the local wet market. The geosmin standard (1% solution in propylene glycol) was kindly donated by Mr. Romke Hengst of Bush Boarke Allen, Singapore.

Sample Preparation

For the identification and quantification of the flavour profile, 2 pieces (5 g each) of Indian mackerel, bonito and tilapia muscle were placed in randomly labeled and sealed laminated aluminium pouches (7 x 6 cm) and cooked to an internal temperature of over 71°C (Sawyer *et al.* 1988). The internal temperature of the pouch was monitored by a thermocouple inserted in the centre of the pouch.

The samples for the quantification of the earthy characteristics were prepared as above. However, for raw sample evaluation, the sample was prepared by finely grinding 10 g of the muscle, placed in randomly labeled glass containers, and immediately evaluated.

Preparation of the Standard Geosmin Solution

The geosmin solutions were prepared at 0.0 (control), 0.1, 1.0, 10.0 and 100.0 μgm–1 concentrations. The series of standard solutions were arrived at after an initial trial to identify the threshold of the compound.

Sensory Evaluation

Seven panelists, consisting of 3 females and 4 males, aged between 23 and 40 years old who had been selected and trained were used in this experiment. The identification and quantification of the flavour profile and the earthy characteristics (aroma, flavour and aftertaste) were carried out both individually and through group discussion. The design of the group discussion was a modification of the procedure described by Winger and Pope (1981), Persson (1980) and Zook and Wessman (1977). The evaluation was repeated 5 times before the list of descriptions of the flavour profile was generally agreed to.

For the flavour profile description, each panelist was asked to list the sensory profile as much as possible and the evaluation was assisted by the list of fish attribute descriptions which were developed by Prell and Sawyer (1988) and Chambers and Robel (1993). These identified characteristics were then quantified by scoring them on a 7-point scale (1 = slight, 4 = moderate and 7 = strong) (Prell and Sawyer 1988).

In the quantification of the earthy attributes, each panelist was presented with four warm samples and was requested to evaluate the aroma, flavour and the aftertaste characteristics of the samples. These attributes of the muscle were to be scored against the standard geosmin solutions after dipping a paper strip (3 x 50 mm) and snipping it. Those attributes were scored on a 100 mm unstructured line anchored 0.5 mm from both ends by pairs of terms modified from the method outlined by Stone *et al.* (1974). The results were measured as the distance from the left end of the line.

The aroma was evaluated right after the pouch was snipped opened. For flavour, the panelists were asked to chew the sample for 60 sec before

giving their evaluation and the aftertaste was recorded 60 sec after swallowing the samples (Chambers and Robel 1993). Only aroma was evaluated in raw samples.

Statistical Analysis

Statistical Analysis System (SAS) was used to analyse all the date for one way analysis of variance (ANOVA) and the difference between samples were analysed by Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

The description of the flavour profile which consists of aroma, flavour and aftertaste attributes of the muscle of Indian mackerel, bonito, catfish and tilapia are as in Tables 1, 2 and 3 respectively. Basically, the identified individual flavour profile of the fish used are not the same and thus support the earlier findings that each fish has its unique flavour characteristics which is mainly attributed to the presence of specific component, recognition of the threshold value and their concentration (Josephson 1991).

Six aroma characteristics were recognized in Indian mackerel, 8 for bonito, 9 for catfish and 8 for tilapia (Table 1). Fish oil aroma was identified as the strongest characteristic in Indian mackerel, bonito and catfish. However, sweet and sour aromas scored the highest in the black tilapia. 'Sour' aroma also scored the highest in bonito. The same characteristic was also recognised in the other three fish. The 'sweet', 'fish oil' and 'fresh fish' attributes which were scored high to moderate in all the four fish evaluated is most probably due to the presence of eight-carbon volatile ketones which were derived through lipoxygenase-mediated conversion of the polyunsaturated fatty acids which are abundant in seafoods (Josephson 1991). Earthy character scored highest in tilapia, although it is also recognizable in bonito and catfish. The concentration of this earthy compound, namely geosmin and MIB produced by blue-green algae accumulate in the muscle (Yukowski and Tabacher 1980; Kuusi and Shuiko 1983).

The earthy flavour characteristic was recognized in both the freshwater but not in the marine fish (Table 2). It was the dominant character detected in tilapia. Earthy aftertaste was not at all recognized in both marine fish studied. It is among the three characteristics that scored highest in tilapia. An equivalent score was also given to the earthy attribute in catfish.

The two additional attributes identified by the panelists were kerosene and blood which were not in the original listing as described by Prell and Sawyer (1988) and Chambers and Robel (1993). The kerosene-like character detected by panelists in black tilapia might be due to the contamination of the lake water by the petrochemical compounds discharged into it. The detection of the kerosene taint in mullet taken from the Moreton Bay and Brisbane River in Queensland, Australia was also reported by Vale *et al.* (1970) and Shipton *et al.* (1970) respectively. The detected blood

TABLE 1
The description and scores for aroma in cooked muscle of Indian mackerel, bonito, catfish and tilapia

	Sencory scores*			
Description	Indian Mackerel	bonito	catfish	tilapia
1. Briny	4	4	3	3
2. Blood	2	4	NR**	NR**
3. Earthy	NR**	2	3	8
4. Fish oil	6	7	6	5
5. Fresh fish	5	4	5	5
6. Musty	NR**	NR**	3	3
7. Scorched	NR**	6	3	NR**
8. Smoke	NR**	NR**	3	3
9. Sour	5	7	5	6
10. Sweet	5	4	5	6

- *scores of 1 = light; 4 - moderate and 7 - strong
- **NR- not recognized
- Scores are average of 5 evaluations

LARKIN, A.L. 1969. The organoleptic assessment of food flavour. In *Food Technology Australia.* p. 126-127.

LARMOND, E. 1971. Food Quality Evaluation: A review of sensory methods. In *Fish Inspection and Quality Control*, ed. R. Kreuser. p. 172-174. England: Fishing News (Books) Limited Ludgate House.

KUUSI, T. and M. SHUIKO. 1983. Occurrence of various off-flavours in fish in Finland from 1969-1981. *Water Sci. and Tech.* **15**: 47-58.

LYMAN, B. 1989. *A Psychology of Food - More than a Matter of Taste.* p. 69-84. New York: Van Nostrand Reinhold Company.

MARNIAK, J.A. and A. MACKEY-SIM. 1984. The senses of smell. In *Sensory Analysis of Foods*, ed. J.R. Piggott. p. 23. London: Elsevier Applied Science Publisher.

MILLS, O.E., S.Y. CHUNG and P.B. JOHNSEN. 1993. Dehydration products of 2-methylisoborneol are not responsible for off-flavour in the chanel catfish. *J. Agri. Food Chem.* **42**: 1690-1693.

PERSSON, P.E. 1980. Sensory properties and analysis of two muddy odour compounds, geosmin and 2-methylisoborneol in water and fish. *Water Res.* **14**: 1113-1118.

PRELL, P.A. and F.M. SAWYER. 1988. Flavour profiles on 17 species of North Atlantic fish. *J. Food Sci.* **53(4)**: 1036-1042.

SAWYER, F.M., A.V. CARDELLO and P.A. PRELL. 1988. Consumer evaluation of the sensory properties of fish. *J. Food Sci.* **53(1)**: 12-18.

SHAMAILA, M., W.D. POWRIE and B.J. SKURA. 1992. Sensory evaluation of strawberry fruit stored under modified atmosphere packaging (MAP) by quantitative descriptive analysis. *J. Food Science* **57(5)**: 1168-1172.

SHIPTON, J., J.H. LAST, K.E. MURRY and G.L. VALE. 1970. Studies on kerosene-like taint in mullet. II. Chemical nature of the volatile. *J. Sci. Food and Agric.* 21: 433.

SPENCER, H.W. 1971. Techniques in the sensory analysis of flavours. *Flavours Industry.* p. 293-302.

STONE, H., J. SIDEL, S. OLIVER, A. WOOSLEY and R.C. SINGLETON. 1974. Sensory evaluation by quantitative descriptive analysis. *Food Tech.* **28**: 24-32.

VALE, G. L., G.S. SIDHU, W.A. MONTOGOMERY and A.R. JOHNSON. 1970. Studies on a kerosene-like taint in mullet (Mugil cephalus). I. General nature of the taint. *J. Sci. of Food and Agric.* **21**: 429-432.

WINGER, R.J. and C.G. POPE. 1981. Selection and training of panelists for sensory evaluation of meat flavours. *J. Food Tech.* **16**: 661-669.

YUKOWSKI, M. and J.L. TABACHER. 1974. Identification, analysis and removal of geosmin from muddy flavoured trout. *J. Fisheries Res. Board Can.* **31**: 1951-1958.

ZOOK, K. and C. WESSMAN. 1977. The selection and the use of judges for descriptive panels. *Food Tech.* : 56-61.

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Preliminary Distribution of Ephemeroptera, Plecoptera and Trichoptera (EPT) in Kerian River Basin, Perak, Malaysia

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Keywords: Ephemeroptera, Plecoptera, Trichoptera, EPT, distribution, abundance, Kerian River Basin

ABSTRAK

Kajian permulaan terhadap tiga order serangga akuatik, Ephemeroptera (lalat Mei), Plecoptera (lalat batu) dan Trichoptera (lalat kandul) (EPT) telah dijalankan di Lembangan Sungai Kerian (LSK) di sempadan negeri Kedah-Perak di Semenanjung Malaysia. Ephemeroptera yang terdiri daripada enam famili, 10 genus dan 460 individu adalah order yang paling dominan di situ. Sungguhpun Plecoptera dan Trichoptera diwakili oleh bilangan famili yang sama, lalat batu didapati lebih limpah di lembangan sungai tersebut. Mengikut turutan kelimpahan lalat batu Tetropina, *lalat Mei* Caenis, *dan* Centroptilum, *dan lalat kandul* Macrostemum *adalah paling dominan. Kepelbagaian fauna EPT berjulat 1.41 - 2.65 (H') dengan taburan yang berbeza (ANOVA, $F_{15,340} = 1.68$) pada P= 0.05 dan kesamaan taburan yang tak sekata (Indeks Kesamaan berjulat 0.15-0.95). Indeks kekayaan EPT adalah rendah di semua sungai dan nilai indeks FBI mengkategorikan kualiti air sungai sebagai sederhana tercemar sehingga kualiti yang sangat baik.*

ABSTRACT

A preliminary study on three aquatic insect orders, Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) (EPT) was carried out in Kerian River Basin (KRB), at the border of Kedah-Perak states, in Peninsular Malaysia. Ephemeroptera comprising six families of 10 genera and 460 individuals was the most dominant order. Although both Plecoptera and Trichoptera was represented by similar number of families, stoneflies were found to be more abundant in the river basin. In order of abundance, stonefly Tetropina, mayflies Caenis, *and* centroptilum, *and caddisfly* Macrostemum *were the most common geneva. The diversity of the EPT fauna ranged 1.41 - 2.65 with significantly different distribution (ANOVA, $F_{15,340} = 1.68$) at P= 0.05 and fairly unevenly distributed (Evennes Index Ranged 0.15-0.95). The EPT Richness indices were in low ranges in all river and the FBI scores categorised the water quality of river in this river basin as moderately polluted to excellent.*

INTRODUCTION

Among the macroinvertebrates, insects are the most successful inhabitants of fresh water environment. This is demonstrated by their compositions and abundance, broad distribution and their ability to exploit most types of aquatic habitats (Wallace Anderson 1996). The Ephemeroptera, Plecoptera and Trichoptera (EPT) are insect orders that recently have been proposed for biological monitoring of water quality especially in pristine areas (Lenat 1988). The mayflies are categorised as a primitive winged insect while stoneflies are primarily associated with clean and cool running water. Caddisflies is one of the largest group of aquatic insects (Morse *et al.* 1994) inhabiting aquatic ecosystem from moderately poor to good water quality.

Composition and distribution of EPT is determined by their physical-chemical tolerance to an array of environmental factors (Dudgeon 1984; Hyness 1976). Their distribution varies due to availability and types of microhabitats. As aquatic insects tend to remain in their original habitats, they are affected by local changes in water quality. By assessing the diversity and composition of indicator species such as EPT, it is possible to determine the status of water quality of an aquatic system.

Aquatic insects are not widely studied especially in the northern region of Peninsular Malaysia. This research provided a preliminary record of the EPT of the KRB. Their composition and distribution in several river basins would indicate their specificity towards available habitats or microhabitats in the area thus reflecting their affinity towards certain parameters of the environment. The implication of the distribution was compared to water quality categorization using other biological indices.

MATERIALS AND METHODS

Study Area

The Kerian River basin (5° 09'N - 5° 21'N and 100° 36.5'E - 100° 46.8'E) consists of two main rivers; Kerian and Selama (Fig. 1). The Selama River meets Kerian River approximately at the middle of the basin and continues westward to the Straits of Malacca. Kerian River, the main rivers that border the states of Kedah and Perak, starts from the hilly headwaters in Mahang, Kedah while the Selama River originates from hilly areas in Selama, Perak. Several tributaries contribute to the flow of these two rivers. Sixteen of them, Chelong, Incong, Air Puteh, Salleh, Air Itam, Damak, Siputeh, Nor, Selama, Relau, Mengkuang, Charok Merah, Taka, Kangar, Mahang and Serdang rivers were selected as sampling sites. Except for Serdang which is categorized as second order, all other rivers are first order rivers. They flow through forested areas, rubber and oil palm plantations, orchards, several newly constructed settlement areas and villages down to the Kerian Valley in Parit Buntar, Perak before entering the sea. Some of the rivers receive inflows of rice field drainage canals. Dominant riparian vegetation in the basins are oil palm, *Athocarpus* sp., *Ipomea* sp., tapioca, banana, wild rambutan (*Nephelium lappacaeum*) and rubber. *Hydrilla* is a dominant aquatic growth in several sampling stations.

Sampling of Insects

The mayflies (Ephemeroptera), stoneflies (Plecoptera) and caddisflies (Trichoptera) were collected along a 100 m stretch of each station by kick sampling techniques from September 1998 until May, 1999. Two stations were selected in each river and 10 samples were collected in each station. The sample size represented approximately 75% of the total insect taxa from each habitat which was below 40% standard error acceptable for benthic sampling (Elliot 1973; Furse *et al.* 1984). The kick net (500 mm mesh) was placed against water current and about a meter square area immediately in front of the net was disturbed for approximately 3 minutes (Davis and Simon 1995). The insects collected in the net were sorted in the laboratary and transferred into universal bottles containing 80% ETOH. They were identified to genera using keys of Merrit and Cummins (1996); Morse *et al.* (1994); McCafferty (1981); Edmondson (1683); and Usinger (1956). Differences in distribution of the EPT among rivers were analysed using a one way ANOVA. Selected biological indices were calculated to examine the structure of EPT community (Ludwig and Reynolds 1988) and scores of Family Biotic Index (FBI) (Hilsenhoff 1988) and EPT taxa richness (Morse *et al.* 1994) were used to categorize the quality of water of the rivers.

Measurement of Water Parameters

Several water parameters were measured to investigate the properties of aquatic habitat that possibly influenced the distribution of EPT in this river basin. They were also used to justify the reliabilities of scores of biological indices on data collected. Dissolved oxygen and water temperatures were measured using an oxygen meter (YSI-55). Water conductivity was recorded by a TDS meter (YSI-44600). A Toledo pH meter was used to measure the pH of the water and penetration of light on water surface was measured using a lux meter. A measuring tape was used to record the width and depth of the river and water flow was recorded using a hydoprop flow meter (MK-11-90 cm).

RESULTS

Ephemeroptera was the most abundant among the three orders in this river basin comprising more than half of the total number of all individuals collected (Table 1). Six genera representing six families of mayflies were recorded (Appendix 1). Plecoptera was relatively abundant, making up approximately 30% of total collection. Trichoptera contributed 18% of total EPT in the area. Dominant mayfly genera were identified (Table 2) and the most dominant among the three, *Caenis* had more than twice the number of the other two genera combined. However, although Plecoptera was fewer in number than the Ephemeroptera, *Tetropina* out-

numbered all other dominant genera of EPT. Caddisfly *Macrostemum* was relatively numerous in the Kerian River Basin. Appendix 1 shows detail distribution of EPT in all sixteen rivers sampled. *Caenis* was widely distributed in all but Mahang River. *Tetropina* was not collected from six rivers but was found in abundance in Mengkuang River. *Macrostemum* preferred Nor River and was hardly found in other rivers. A one way ANOVA indicated that the distribution of EPT was significantly different among rivers ($F_{15,340} = 1.68$) at P=0.05.

The EPT in this river basin were moderately diverse (H' range 1.41-2.65, D' range 0.45-0.16) with a relatively uneven distribution. The EPT richness Index was slightly low indicating the areas were slightly to seriously impacted (EPT Richness Index of 5-10, Davis and Simon 1995). Based on FBI scores, the water quality in these tributaries however was still in a relatively good condition with six rivers having excellent water quality (Category I), two rivers with slightly contaminated with organic matter (Category II) and the rest of the rivers moderately polluted with organic matter (Category III) (Table 3).

In general dissolved oxygen in the water was in good range in all rivers. The temperature difference was within 6°C which possibly related to the time of temperature recording. Water conductivities were in low ranges reflecting little contamination. The water however was slightly acidic in Mengkuang, Kangar, and Charok Merah rivers to acidic such as in Chelong and Salleh rivers. Current velocities were relatively slow in many rivers that might implicate sampling stations were in depositional zones. Most of the

TABLE 1
Composition and abundance of Ephemeroptera, Plecoptera and Trichoptera in Kerian River Basin

ORDER/Family	Abundance (Numbers)		
	Family	Genus	Individual
EPHEMEROPTERA	**6**	**6**	**460 (52.04%)**
Lepthophlebiidae	1	-	65
Pothamanthidae	1	-	12
Heptageniidae	1	1	21
Baetidae	1	4	180
Caenidae	1	1	181
Siphlonuridae	1	-	1
PLECOPTERA	3	1	263 (29.57%)
Perlidae	1	1	247
Perlodidae	1	-	9
Peltoperlidae	1	-	1
Unidentified	-	-	9
TRICHOPTERA	4	4	161 (18.21%)
Polycentropodidae	1	1	32
Hydropsychidae	1	3	113
Limnephilidae	1	-	16
TOTAL	**13**	**11**	**884 (100%)**

TABLE 2
Dominant genera of the EPT in Kerian River Basin

ORDER	Family	Genus	Individual	Total
EPHEMEROPTERA	Baetidae	*Baetis*	62	
		Centropilum	93	
	Caenidae	*Caenis*	**181**	336
PLECOPTERA	Perlidae	*Tetropina*	**247**	247
TRICHOPTERA	Polycentropodidae	*Polycentropus*	32	
	Hydropsyhidae	*Hydropsyche*	21	
		Macrostemum	**91**	144

TABLE 3
Scores of biological indices on EPT of Kerian River Basin

River	Shannon's Index (H')	Simpson's Index (D')	Evenness Index (E)	EPT Richness Index	Family Biotic Index (category)
Chelong	2.56	0.23	0.79	7	3.70 (I)
Inchong	2.14	0.18	0.52	5	5.72 (III)
Serdang	2.46	0.26	0.61	7	5.37 (III)
Air Puteh	2.48	0.16	0.25	5	5.00(III)
Salleh	2.65	0.30	0.40	6	4.26 (III)
Air Itam	2.52	0.24	0.61	6	5.11(III)
Damak	2.10	0.42	0.90	10	1.93 (I)
Siputeh	2.38	0.36	0.52	9	3.37 (I)
Nor 1.91	0.25	0.91	7	4.47 (III)	
Selama	1.41	0.42	0.38	8	4.24 (II)
Kangar	2.57	0.18	0.35	7	3.39 (I)
Mahang	2.16	0.20	0.17	7	3.13 (I)
Relau	2.46	0.23	0.15	5	4.46 (III)
Mengkuang	2.37	0.38	0.95	6	1.78 (I)
Charok Merah	2.59	0.45	0.48	10	3.93 (I)
Taka	2.65	0.22	0.48	5	5.48 (III)

TABLE 4
Water parameters and morphologies of the rivers in Kerian River Basin

River	Dissolved oxygen (mg/1)	Temperature (°C)	pH	Light Penetration (lux)	Conductivity (µs)	Width (m)	Depth (m)	Velocity (m/s)
Chelong	6.20-7.50	27.0-28.0	4.40-4.45	6.13-619	23-28	2.35	2.75	0.004
Inchong	6.70-7.45	29.0-30.0	5.40-5.50	1156-1558	50	8.00	1.40	0.02
Air Puteh	6.50-7.50	27.0-29.0	4.43-4.52	310-424	27-28	12.00	2.50	0.02
Serdang	6.10-7.60	26.0-30.0	5.24-5.38	259-760	35-37	11.50	4.60	0.029
Salleh	4.40-4.70	26.0-27.0	4.10-4.13	177-263	50	11.50	1.40	0.013
Air Itam	6.50-6.80	28.0-29.0	5.05-5.07	458-508	40	6.50	1.00	0.026
Relau	6.84-6.86	38.1-28.5	5.47-5.49	848-856	40-50	7.50	0.60	***
Mengkuang	7.78-7.85	26.2-26.6	6.63-6.67	653-852	12-20	11.00	5.00	0.004
Nor	6.50-6.80	26.0	5.40-5.54	1112-1240	10-12	3.70	0.80	0.171
Siputeh	7.50-7.70	27.0-28.0	5.18-5.37	235-270	18-20	18.50	4.00	0.019
Damak	7.10-7.30	27.0	5.36-5.54	115-193	20-40	6.40	4.00	0.017
Selama	8.10-8.15	26.0-27.0	5.58-5.65	394-407	20-30	25.00	2.50	0.155
C. Merah	7.41-7.47	26.8-27.0	5.89-5.86	418-428	60	6.30	0.60	0.005
Taka	6.17-6.23	28.7-29.4	5.65-5.71	540	35-40	4.80	0.85	0.036
Kangar	8.36-8.44	24.0	6.10-6.25	290-292	18-20	16.00	1.20	0.064
Mahang	8.56-8.57	24.3-24.5	4.82-4.88	250-252	18-20	10.50	2.00	0.045

*** no measurement made

sampling stations were partially shaded. Analysis of Pearson Correlation indicated that there was no correlation of water parameters with the distribution of EPT between rivers at P=0.05. Except for low water pHs, many of the rivers would make suitable habitats for the EPT.

DISCUSSION

A relatively abundant EPT fauna in KRB was quite diverse. Epheroptera was the most dominant orders of EPT in the area. Although they were differently distributed among rivers, a number of mayfly genera such as *Caenis*, *Centroptilum* and *Baetis* were collected in most of the river studied. In general mayfly are nearly cosmopolitan. The larvae of various species in-

habit an extensive range of standing and running fresh waters. Some of them burrow in substrates while others sprawl amongst fine sediment and detritus. Most mayfly larvae are collectors or scrapers and feed on a variety of detritus, some macrophyte and animal material (Dudgeon 1984; Merrit and Cummins 1996; Hong 1994). A few species are true carnivores. *Baetis* for example, occurs in permanent, flowing water and its species are most common in the clear water of cold streams. Some *Baetis* species together with *Centroptilum* and *Caenis* however live in erosional and depositional regions of rivers. They feed mostly by scraping algae and collecting diatoms and fine particulate detritus from solid surfaces. Many rivers in the KRB are slow flowing which would represent the depositional habitats that were suitable for these geneva.

Ephemeropterans are preys for carnivorous aquatic insects such as stoneflies (Stewart and Stark 1993). Selective pressures due to predation have resulted in behavioral responses by prey species. Some mayflies react to predators by drifting or by displaying scorpion - like threat postures (Peckarsky 1980; Peckarsky and Dodson 1980). Mayflies can apparently detect predators by non-contact chemical cues. They may be able to distinguish between predaceous and detritivorous stoneflies that have a similar body form. Suitable habitats in the KRB, behavioral adaption and sensitivity towards chemical cues may have contributed to the abundance of ephemeropterans in this river basin.

The distribution of stoneflies is rather restricted due to their preference for clean, lower temperature flowing water. Several species however, have adapted to living in warm and organically enriched environment (Harper 1994). They tend to prefer specific substract type and stream size or stream reach. Microhabitats preference include boulder surfaces, cobble and gravel interstices, debris accumulations and leaf packs as well as the hyporheal. Perlidae was the most abundant Plecopterans found in selected few rivers in the river basin such as Mengkuang, Damak, Kangar and Siputeh. Obviously they have adapted to living in fine sand and muddy substrates that represent habitats in those rivers. Most members of this family are engulfers that are herbivores-detritivors or carnivores throughout nymphal development. Stonefly carnivores subsist primarily on chironomid and mayfly larvae (Stewart and Stark 1993) that thrive in habitats found in many rivers in the KRB. As a group, stoneflies have diversified their food habits such that the different species fill about every conceivable major food niche in streams. Many species shift from herbivory-detritivory in later periods. However, some species such as *Pteronarcella badia* was herbivory-detritivory through their development and other species such as *Claassenia sbulosa* and *Hesperoperla pacifica* were carnivores throughout development (Fuller and Stewart 1977; 1979).

A member of the third order, the Trichoptera (caddisfly) occurs in most types of freshwater habitats such as streams and seepage areas, river, lakes, marshes and temporary pools. Many of them have exploited freshwater habitats that are larger, warmer and more lentic. Some larvae are mainly predaceous. Generally larval Trichoptera show little selectivity of food they are highly and diversely specialized for food acquisition (Morse *et al.* 1994). In the KRB, *Macrostemum* was abundant in Nor River that had a lot of decaying leaves and tree branches, submerged tree stumps and macrophytes along river margins. A net spinner that usually lives in fixed retreats is a collector-filterer of fine particulate organic matter that usually clings to its substrate. It is widely distributed in lotic water erosional zone such as that found in Nor River. *Hydropsyhe* was the next common genus of this caddisfly in this area. This genus is probably quite tolerant and widespread in distribution. In Langat River in the state of Selangor, *H. annulata* and *H. doctersi* were very commonly found (Rahim 1992).

Categorization of a river's water quality using the EPT richness index in this study was not conclusive mainly due to inability to identify specimens to species. For example, 247 individuals of *Tetropina* and *Caenis* could represent more than species. The number of taxa (species) is important since a richer community would reflect a healthier environment of unimpacted water. The FBI however, classified the water in sixteen rivers into three categories I, II and III implicating the water was without, slightly and moderately polluted with organic matter respectively. The classification of water using the FBI too needs to be interpreted with caution because the tolerance values used to calculate the index was based on those assigned for Wisconsin's insect (Hilsenhoff 1988). It has been proven that ecoregions influenced the scores of such

indices (Lenat 1988; 1993; 1994). Nevertheless these values could be used as guidelines until more appropriate values are available for Malaysian insects.

Within range of water parameters in this study, no significant correlation between distribution of EPT taxa and water parameters was detected, and no trend of any water parameter that might influence categorization of water quality was observed. Except for slightly lower river basin is relatively in good condition.

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REFERENCES

BISHOP, J.E. 1973. *Limnology of Small Malayan River, Sungai Gombak.* Dr. W. Junk B.V. Publ., The Hague.

DAVIS, W. S. and T. P. SIMON. 1995. *Biological Assessment and Criteria.* Lewis Publ. CRC Press Inc.

DUDGEON, D. 1984. Longitudinal and temporal changes in functional organization of the macroinvertebrate communities in the Tsuen River, Hong Kong. *Hydrobiologia* **111** : 207–317.

EATON, L. E. and D. R. LENAT. 1991. Comparison of rapid bioassessment method with North Carolina's qualitative macroinvertebrate collection methods. *J. North Am. Benthol. Soc.* **10 (30)**: 335-338.

EDMONDSON, W. T. 1963. *Freshwater Biology.* 2nd Edition. New Delhi, India: International Books Periodicals Supply Service.

ELLIOT, J. M. 1973. Some methods for statiscal analysis samples of benthic invertebrates, Freshwater Associated Society Publications. 25.

FULLER, R. L. and K. W. STEWART. 1977. The food habits of stoneflies (Plecoptera) in the upper Gunnison River, Colorado. *Environ. Entomol.* **6**: 193-302.

FULLER, R. L. and K. W. STEWART. 1979. Stonefly (Plecoptera) food habits and prey preference in the Colores river, Colorado. *Am. Midt. Nat.* **101**: 170-181.

FURSE, M. T., D. MORSE, J. F. WRIGHT and P. D. ARMITAGE. 1984. The influence of seasonal and taxonomic factors of the prediction to their macro-invertebrate communities. *Freshwat. Biol.* **14**: 257-280.

HARPER, P.P. 1994. Plecoptera. In *Aquatic Insects of China Useful for Monitoring Water Quality.* eds. Morse, J.C., Y. Lianfang and T. Lixin. Nanjing, China: Hohai Univ. Press.

HILSENHOFF, W.L. 1988. Rapid field assessment of organic pollution with family level biotic index. *J. North Am. Benthol. Soc.* **791**: 65-68.

HONG. G. 1994. Ephemeroptera. In *Aquatic Insects of China Useful for Monitoring Water Quality.* eds. Morse, J.C., Y. Lianfang and T. Lixin. Nanjing, China: Hohai Univ. Press.

HYNESS, H.B.N. 1976. Biology of Plecoptera. *Ann. Rev. Ent.* **21**: 135-153.

LENAT, D.R. 1988. Water quality assessment of streams using a qualitative collection method for benthic macroinvertebrates. *J. N. Am. Benthol. Soc.* **7(3)**: 222-233.

LENAT, D.R. 1993. A biotic index for southern United States: Derivation and list of tolerance with criteria for assigning water quality ratings. *J. North Benthol. Soc.* **12**: 279-290.

LENAT, D.R. 1994. Using insect to monitor water quality. In *Aquatic Insects of China Useful for Monitoring Water Quality.* eds. Morse, J.C., Y. Lianfang and T. Lixin. Nanjing, China: Hohai Univ. Press.

LUDWIG, J.A and J.F. REYNOLDS. 1988. *Statistical Ecology. A Primer on Method and Computing.* John Wiley and Sons Inc.

MCCAFFERTY, W.P. 1981. Aquatic Entomology. *The Fisherman's and Ecologist Illustrated Guide to Insect and their Relatives.* Boston, Massachusetts: Science Books Intern.

MERRIT, R.W. and K.W. CUMMINS. 1996. *An Introduction to Aquatic Insects of North America.* 3rd ed. Dubuque, IA, Kendall/Hunt Pub.

MORSE, J.C., Y. LIANFANG and T. LIXIN. 1994. *Aquatic Insect of China Useful for Monitoring Water Quality.* Nanjing, China: Hohai Univ. Press.

PECKARSKY, B.L. 1980. Predatory interactions between stoneflies and mayflies: behavioral observations. *Ecology* **61**: 932-943.

PECKARSKY, B.L and S.I. DODSON. 1980. Do stonefly predators influence benthic distributions in streams? *Ecology* **61**: 1275-1282.

RAHIM, A.B.I. 1992. Taxonomic and biological studies on caddisflies (Trichoptera: Insecta) from Peninsular Malaysia. Ph. D. dissertation, University of Wales, College of Cardiff, U.K.

STEWART K.W. and B.P. STARK. 1993. Nymphs of North American stonefly genera (Plecoptera). Denton, Texas, USA: University of North Texas Press.

USINGER, R.L. 1956. *Aquatic Insects of California*, Berkeley, Univ. Calif. Press.

WALLACE, J.B. and N.H. ANDERSON. 1996. Habitat, life history and behavioral adaptions of aquatic insects. In *An Introduction to Aquatic Insects of North America*, eds. Merrit, R.W. and K.W. Cummins (3rd Ed). Dubuque, IA, Kendall/Hunt Pub.

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Status of Rat Infestation and Recent Control Strategies in Oil Palm Plantations in Peninsular Malaysia

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ABSTRAK

Satu soal selidik telah dijalankan untuk menentukan status serangan tikus dan kaedah kawalan tikus semasa di ladang-ladang kelapa sawit di Semenanjung Malaysia. Rattus tiomanicus (Miller), *merupakan spesies tikus yang utama (68%) diikuti oleh* Rattus argentiventer (Robinson and Kloss), *(46%) dan* Rattus rattus diardii (L.), *(28%). Walaupun 75% dari ladang tidak menganggap tikus sebagai masalah yang serius, kerugian yang diperolehi adalah dalam anggaran 0.01 hingga 0.1 t/ha. Burung pungguk jelapang* Tyto alba (Scopoli) *kini merupakan komponen kawalan tikus yang penting dalam ladang kelapa sawit iaitu sebanyak 82% daripada ladang yang mengambil bahagian. Ada ladang (21.4%) bergantung sepenuhnya kepada* T. *alba, tanpa menggunakan racun tikus. Sebahagian besar ladang (60.7%) menggabungkan mengumpan dan kawalan menggunakan* T. alba *yang dapat menjimatkan kos mengumpan di antara RM2.64 sehingga RM30/ ha/tahun.*

ABSTRACT

A survey was carried out to establish the status of rat infestation and recent rat control practices in oil palm plantations in Peninsular Malaysia. Rattus tiomanicus (Miller) *constitutes a major rat species (68%), followed by* Rattus argentiventer (Robinson and Kloss), *(46%) and* Rattus rattus diardii (L.), *(28%). Although 75% of estates did not consider rats as a serious problem, the damage estimated ranges from 0.01 to 0.1 t/ha. The barn owl* Tyto alba (Scopoli) *is now an important rat control component in oil palm i.e. 82% of estates that participated in the survey. In some estates (21.4%) control is achieved entirely with* T. alba, *without baiting. In most estates (60.7%) baiting was done in combination with* T. alba, *whereby the latter reduced baiting cost from RM2.64 to RM30/ha/year.*

INTRODUCTION

Rat species that can be found in oil palm plantation in Peninsular Malaysia are *Rattus tiomanicus* (Miller), *Rattus argentiventer* (Robinson and Kloss), and *Rattus rattus diardii* (L.) (Wood 1976). *R. tiomanicus* is the dominant species especially in matured palms (Wood 1968), whereas the rice field rat *R. argentiventer* is normally found in nurseries and young oil palms (Wood 1982). It is also a common species in oil palm formerly planted with rubber (Wood 1976). *R. rattus diardii* is normally associated with human dwellings, but has also become common in oil palm (Mohd 1985) especially in areas where *R. tiomanicus* has been controlled by baiting (Soh *et al.* 1982).

Apart from attacking matured palms, rat also causes damage to young plantings. At the nursery stage, rat feeds on the apical tissue causing death or affecting normal development of the young shoots. On young oil palms, the most favourite part is the petiole that forms the fronds. Damage to this suppresses the formation of fronds. In matured palm, attack is concentrated on the inflorescence and the fruit bunch. Damage to inflorescence affects flowering while damage to fruits can reduce yield (Wood 1982).

Baiting, with anticoagulant rodenticides is the mainstay of rat control practices in oil palm estates in Malaysia. However, beginning mid-eighties, the barn owl *Tyto alba* (Scopoli) has been identified as an effective predator of rats and had since been relied upon to control rats with encouraging results. Following successful trials in estates in Selangor and Negeri Sembilan (Smal 1988), the biological control programme using barn owl has been implemented in many estates throughout the country, by providing nest boxes to wild populations of barn owl. As a result there has been a boost in the barn owl population in oil palm. The purpose of this study is to determine the current status of rat control by the barn owl in oil palm estates vis-‡-vis baiting in Peninsular Malaysia.

METHOD

A survey was carried out on 68 oil palm estates, all greater than 1000 ha, selected at random from nine states in Peninsular Malaysia; the breakdown were as follows; Kedah (6), Kelantan (6), Malacca (6), Negeri Sembilan (9), Pahang (9), Perak (8), Selangor (8), Terengganu (8), and Johore (8). The survey questions were designed to meet three major objectives. Firstly, to establish the common rat species recently found in both mature and young oil palms in Peninsular Malaysia. Secondly, to gauge the severity of rat damage, subjectively assessed in terms of yield loss, and finally, the method of control currently employed with particular reference to baiting and natural predation by barn owl.

RESULTS AND DISCUSSION

A total of 28 estates (41%) returned the survey forms. Twenty of these or 71% came from five states namely Negeri Sembilan, Pahang, Selangor, Malacca and Kedah.

Rat Species Composition in Oil Palm

Seven estates (25%) reported the presence of *Rattus tiomanicus* only, three estates (11%) reported *R. argentiventer* only and two estates reported *R. rattus diardii* only while seven estates (25%) reported the presence of both *R. tiomanicus* and *R. argentiventer,* three estates (11%) reported *R. tiomanicus* and *R. rattus diardii* and only one estate reported *R. argentiventer* and *R. rattus diardii.* Only one estate reported the presence of all three species. Three remaining estates were not sure of the identity of the rat species. The species composition is summarized in Fig. 1. Based on individual species, *R. tiomanicus* was reported in 68% of the estates, followed by *R. argentiventer* 46% and *R. rattus diardii* 28%.

The survey results show that *R. tiomanicus* is still the dominant species in oil palm, as initially reported by Wood (1971), then Wood and Liau (1978) and the latest by Basri and Halim (1985). *R. tiomanicus* is well adapted to live in oil palm due to its agility and arboreal habits as compared to *R. argentiventer* and *R. rattus diardii,* which live on the ground. *R. argentiventer* is more common in young palms (Wood 1982). Survey results indicate that 13 out of 33 (39%) rat damage reported by the estates occurred in young plantings. Seven out of the 13 (54%) damage on young plantings was attributed to *R. argentiventer.* The survey also confirms the status of *R. rattus diardii* reported by Basri and Halim (1985) as becoming more common in oil palm. There are several factors to explain the higher occurrence of *R. rattus diardii* in oil palm. Firstly, successful control on *R. tiomanicus* has opened the way for infestation by *R. rattus diardii* (Soh *et al.* 1982). Secondly, bait formulation and baiting techniques has been designed primarily for *R. tiomanicus,* leading to *R. rattus diardii* developing resistance due to insufficient (sub-lethal dose) bait consumption (Lam *et al.* 1982). Finally, the propagation of the pollinating weevil *Elaeidobius kamerunicus* in oil palm has become an attractive source of food (protein) to *R. rattus diardii.* Rat is more difficult to control after the introduction of the pollinating weevil (Mohd 1985). The inclusion of the pollinating weevil in the rat diet has lead to juveniles growing faster and heavier adults (Liau 1985).

The particularly high percentage of estates using barn owl points to a greater reliance on biological means to control rats in oil palm. Besides proven efficient and generally tolerant to baits, the high cost of rodenticides and the operational cost of baiting have lead many estates to start their own barn owl programme. The result of the survey indicates a departure from the control strategies normally employed in oil palm in the 80's whereby control is primarily achieved through baiting alone (Wood 1982; Basri and Halim 1985).

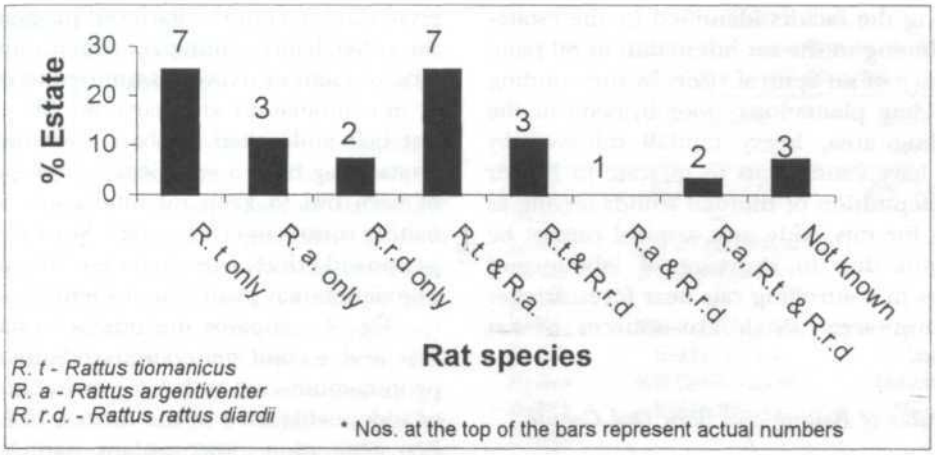

Fig. 1. Composition of rat species present in the estates surveyed

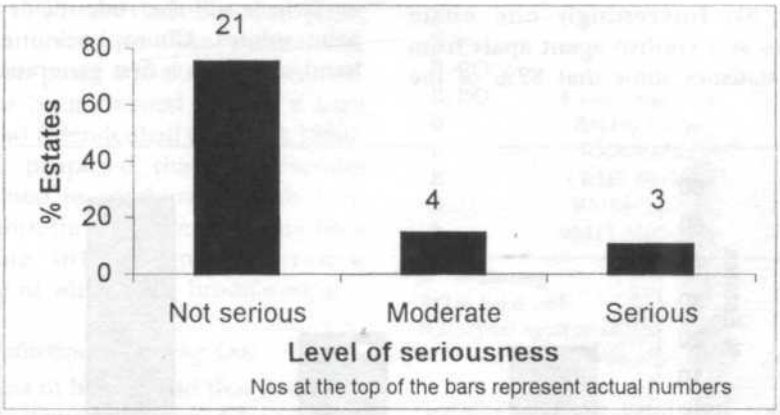

Fig. 2. Percentage of estates based on level of seriousness of rat damage

Rate of Losses due to Rat Damage

Estates were asked to subjectively assess the level of rat damage as not serious, moderate or serious. Fig. 2 shows the percentage breakdown of estates based on these categories. Results of the survey show that 75% of estates assigned their rat damage as not serious. Only 14.3% assigned rat damage as moderate and 10.1% as serious. Table 1 shows the estimated damage and loss incurred by some of the estates. The estimated damage in yield varies from 0.01 t/ha to 3 t/ha/yr. This translates into losses ranging from RM 4/ha to RM1200/ha/yr. These figures were either estimated on a per hectare or per hectare on a yearly basis. Therefore it may not be comparable. However it can be deduced that damage to oil palm lies in the range of 0.01 t/ha to 0.1 t/ha. When infestation is serious, the annual loss can exceed RM 1000 /ha. In terms of crude palm oil, Wood *et al.* (1973) estimated a loss of between 134 to 240 Kg/ha i.e. approximately 5% of total oil production.

TABLE 1
Estimated damage and loss due to rat damage on oil palm

Estates	Estimated damage	Estimated loss
1	0.4 t/ha	RM 180 /ha
2	0.7 t/ha	RM 200-300 /ha
3	0.32 – 0.93t/ha	RM 496 /ha
4	3t/ha/yr	RM 1000 /ha/yr
5	0.01t/ha	RM 4 /ha
6	1 – 2 t/ha	RM 400 /ha
7	5 – 10Kg/ha	RM 5 – 10 /ha
8	0.25t/ha	RM 115 /ha
9	3t/ha/yr	RM 1200 /ha/yr
10	2.2t/ha/yr	RM 594 /ha
11	0.02 t/ha	RM 8/ha
12	0.1 t/ha	RM 43 /ha

Among the factors identified by the estates as contributing to the rat infestation in oil palm are; absence of rat control effort by surrounding small holding plantations, poor hygiene in the surrounding area, heavy rainfall followed by flooding have caused rats to migrate to higher ground, deposition of thinned fronds serving as nest sites for rats, wide area control cannot be carried out due to shortage of labour and difficulties in controlling rats near forest fringes and swamp area which are sources of rat infestation.

Present Status of Baiting and Barn Owl Control Program

Of the estates surveyed 17.9% relied on baiting only, 21.4% relied on barn owls only and 60.7% on both (Fig. 3). Interestingly one estate employed snakes as a control agent apart from baiting. These statistics show that 82% of the estates implement the barn owl programme. On the other hand, baiting remained important as 79% of estates surveyed continued to bait, singly or in combination with barn owl. Six estates did not bait and relied on barn owls only. These estates may have a sufficiently large population of barn owl to keep rat infestation down that baiting is no longer necessary. Smal *et al.* (1990) proposed that the increase in barn owl population may justify the suspension of baiting.

Fig. 4 compares the number estates using first and second generation rodenticide singly or in combination with barn owls. On the types of rodenticide used by the estates, 76% used the first generation anticoagulant, namely warfarin (68%) and chlorophacinone (8%). This suggests that as in the 80's (Basri and Halim 1985), warfarin is still the rodenticide of choice in oil palm estates. Chorophacinone, on the other hand, although a first generation anticoagulant

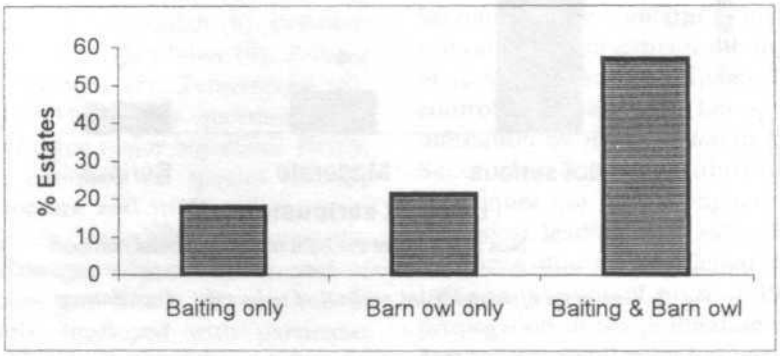

Fig. 3. Percentage of estates surveyed using baits and barn owl in controlling rats in oil palm

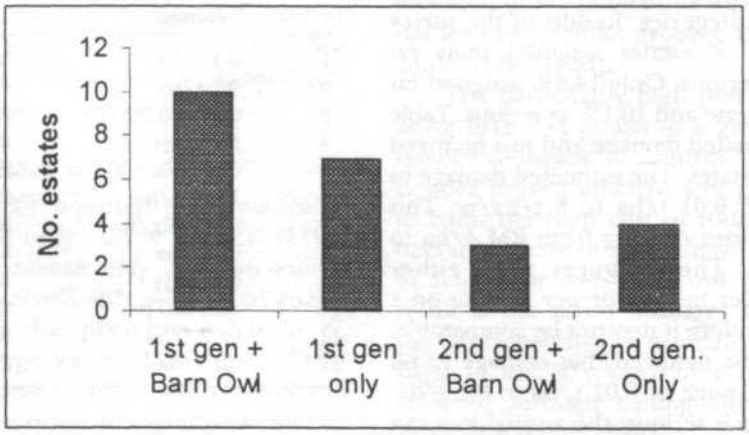

Fig. 4. Number of estates using first and second generation rodenticide singly and in combination with barn owls

having similar effects like warfarin (Wood and Liau 1978), is not widely used, as revealed by the survey. This is probably due to the latter being cheaper.

Warfarin is also a relatively safe rodenticide when used in combination with barn owl, as there have been no known cases of secondary poisoning to the latter (Duckett 1984). This is also reflected from the survey whereby 10 estates out of 16 (62.5%) that combines baiting and barn owl used warfarin in their baits. However with reports of rats developing resistance to first generation anticoagulant, as also revealed by the survey, some estates started to switch to second generation rodenticide. The results from the survey show that 24% of the estates indeed used second generation anticoagulant, namely bromadiolone (16%) and brodifacoum (8%). However, unlike first generation rodenticide, second generation poses a hazard to barn owls. Brodifacoum has been claimed to have a high toxicity to barn owl (Mendenhall and Pank 1980). Duckett (1984) proposed that brodifacoum should not be used in combination with barn owl. In spite of this, three estates combine barn owl and baiting with second generation rodenticide; one of which with brodifacoum.

Barn Owl and Reduction in Baiting Cost

The estimated cost of baiting and that to sustain the barn owl program, as indicated by some of the estates, are shown in Table 2. Not all estates have provided the information needed and no standard response was given. However, based on the survey returns it can be deduced that baiting cost can be substantially reduced by implementing the barn owl programmes. The cost of baiting varies from RM10/ha/yr to RM64/ha/yr with average cost of RM24.11/ha/yr. The average baiting cost was recorded by Basri and Halim (1985) as between RM10 – RM30/ha/yr. Duckett and Karuppiah (1989) indicated that in severe cases the cost may reach RM60/ha/yr. From the survey, the reduction in baiting cost from using barn owl ranges from RM2.64/ha/yr to RM20 – RM30/ha/yr. This also generally falls within the range quoted by Duckett and Karuppiah (1989) i.e. RM4.80 to RM20/ha/yr. Other estates gave less objective response which include 50% reduction in baiting requirements, reduction in baiting campaigns from twice to once a year, baiting campaigns continue at twice a year but with a reduced intensity up to 50%/ha or baiting rounds for each campaign reduced to 2 – 5 rounds from 7 – 10 rounds. There is one claim however, that barn owl did not lead to any reduction in cost.

TABLE 2
Cost of baiting and reduction in baiting cost from barn owl program

	Baiting Cost	Reduction in Baiting Cost
B+BO	RM 13/ha/yr	RM 3.20/ha/yr
B+BO	–	Yes
B+BO	RM 17.82/ha/yr	Yes
B+BO	RM40.82/ha/yr	Yes
B+BO	–	Yes
B+BO	RM40.60/ha/yr	RM20/ha/yr
B+BO	RM11.80/ha	< 10 ñ 20%
B+BO	RM12.60/ha/yr	RM2.64/ha/yr
B+BO	RM18.92/ha	Not much
B+BO	–	50%
B+BO	–	Yes
B+BO	–	RM20-30/ha/yr
B+BO	–	No of baiting rounds reduced
B+BO	–	Not sure
B+BO	–	RM26/ha/yr
B+BO	4 campaigns/yr	No reduction in cost
B	RM10/ha/yr	NA
B	RM8.40/ha	NA
B	RM5.80/ha	NA
B	RM64/ha/yr	NA
B	RM11.50/ha/yr	NA

B – Baiting
BO – Barn owl
NA – Not applicable

CONCLUSION

The results of the survey show that R. tiomanicus remained the dominant species in oil palm followed by *R. argentiventer.* The survey also indicates that *R. rattus diardii* is becoming important in oil palm probably as a result of baiting strategy and methods of oil palm propagation. Damage caused by rats is generally considered not serious but can be substantial and control can be difficult, often hindered by circumstances beyond the jurisdiction of the estates concerned.

The survey also shows that barn owl has become an important component in the rat control practices in oil palm estates in Peninsular Malaysia. First generation rodenticide namely warfarin remained widely used and by virtue of its low toxicity to barn owl would ensure the

survival of the latter. Earlier claims that barn owl programme can considerably reduce baiting cost has been substantiated by this study.

ACKNOWLEDGEMENT

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REFERENCES

BASRI, MOHD. W. and H.A. HALIM. 1985. The effects of *Elaeidobius kamerunicus* Faust on rat control programmes of oil palm estates in Malaysia. Occasional Paper **14**: 50 p.

DUCKETT, J. E. 1984. Barn *owls (Tyto alba)* and the 'second generation' rat baits utilised in oil palm plantations in Peninsular Malaysia. *Planter* **60**: 3-11.

DUCKETT, J E. and S. KARUPPIAH S. 1990. In *Proc. Intl. Palm Oil Dev. Conf.* eds. J. Sukaimi, Z. Zawawi, K. Paranjothy, A. Darus, N. Rajanaidu, S. C. Cheah, M. B. Wahid and I. E. Henson. p. 357-372. September 5 – 9, 1989. Kuala Lumpur.

LAM, Y. M., A.K. LEE, Y.P. TAN and E. MOHAN. 1982. A case of warfarin resistance in *Rattus rattus diardii* (Jentink). *MARDI Res. Bull.* **10(3)**: 378-383.

LIAU, S.S. 1985. Predators of the pollinating weevil, *Elaeidobius kamerunicus* Faust (Curculionidae) in Malaysian oil palm estates. In *Proc. Of the Symposium on impact of the pollinating weevil on the Malaysian oil palm industry,* 21 – 22 February, 1984. P 41-49. Palm Oil Research Inst. Malaysia, Kuala Lumpur, 376 pp.

MENDENHALL, V.M. and L.F. PANK. 1980. Secondary poisoning of owls by anticoagulant rodenticides. *Wildl. Soc. Bull.* **8(4)**: 311-315.

MOHD. MAT MIN. 1985. Current experiences on rat control in Peninsular Malaysian oil palm plantations. *Planter* **61(715)**: 477-488.

SMAL, C.M. 1988. In *Symp. Biological Control of Pests In Tropical Agricultural Ecosystems,* eds. Sosromarsono S., Gabriel B.P., Umaly R.C., Titrojosomo S.S., Titrojosomo S. and Thohari M. SEAMEO-BIOTROP, Special Publ. No. 36. p 255-276.

SMAL, C.M., A.H. HALIM and M.D. AMIRUDDIN. 1990. PORIM occasional paper – Predictive Modeling of Rat Population in relation to use of Rodenticide or Predator for Rat Control.

SOH, K.G., K.J., HAN, M. MUSTAFFA and L.R. GUSE. 1982. Evaluation of Bromethalin for the control of rats in oil palm. In *Proceedings of International Conference on Plant Protection in the Tropics.* (Abstract).

WOOD, B.J. 1968. Pests of oil palms in Malaysia and their control. *Inc. Soc. of Planters.* p. 1 – 204. Kuala Lumpur.

WOOD, B.J. 1971. Sources of reinfestation of oil palms by the wood rat *(Rattus tiomanicus).* In *Crop Protection in Malaysia,* eds. R.L. Wastie & B.J. Wood. *Inc. Soc. of Planters.* Pp. 146 – 165. Kuala Lumpur.

WOOD, B.J. 1976. Vertebrate pests. In *Oil Palm Research* eds. R.H.V. Corley, J.J. Handan & B.J. Wood, p. 395 – 418. Amsterdam, Elsevier.

WOOD, B. J. 1982. Progress in the control of Tropical field rats. In *Proc. Intl. Conf. Pl. Prot. in Tropics,* eds. K.L. Heong, B.S. Lee, T.M. Lim, C.H. Teoh, Ibrahim, M.Y. p 423 – 448.

WOOD, B.J., R.H.V. CORLEY and K.H. GOH. 1973. Studies on the effect of pest damage on oil palm yield. In *Advances in Oil Palm Cultivation* eds. R.L. Wastie & D.A. Earp, p. 360 – 379 *Inc. Soc. of Planters,* p 1 – 469. Kuala Lumpur.

WOOD, B.J. and S.S. LIAU. 1978. Rats as agricultural pests in Malaysia and the tropics. *Planter* **54**: 580 – 599. Kuala Lumpur.

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Some Observations in Pineapple Production under Different Fertilizer Programmes and Different Pineapple Residue Management Practices

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ABSTRAK

Kajian ini dijalankan untuk mengubah suai program pembajaan yang sedia ada, mengenal pasti program pembajaan bersama amalan pengurusan sisa nanas yang berkesan dari segi ekonomi. Program pembajaan yang digunakan ialah (i) pembajaan N (176, 176, 176 dan 176 kg ha^{-1}), P (11,11,7 dan 7 kg ha^{-1}), K(89,89,188, dan188 kg ha^{-1}) pada hari 65, 135, 191 dan 233 masing-masing selepas penanaman (amalan biasa) (FP1); (ii) pembajaan N (176, 176, dan 176 kg ha^{-1}), P (11,11, dan 7 kg ha^{-1}), K(89,89, dan 188 kg ha^{-1}) pada hari 65, 135 dan 191 hari masing-masing selepas penanaman (FP2) dan, pembajaan N (176, 264, dan 264 kg ha^{-1}), P (11,14, dan 11 kg ha^{-1}), K(89,183, dan 285 kg ha^{-1}) pada hari 65, 135, dan 191 masing-masing selepas penanaman (FP3). Pengurusan sisa yang digunakan ialah (i) pereputan sisa nanas secara in situ tanpa gangguan (RM1); (ii) penimbunan sisa nanas (daun, jambul, dan "peduncles") yang dipotong dan dikaruk dari baris 0.6 m x 10 m ke 0.9 m x 10 m (teknik "zero burning" -RM2), dan pembakaran daun, jambul, dan "peduncles" nanas secara in situ iaitu amalan biasa (RM3). Kombinasi rawatan program pembajaan serta pengurusan sisa nanas adalah seperti berikut: RM1FP1, RM1FP2, RM1FP3, RM2FP1, RM2FP2, RM2FP3, RM3FP1, RM3FP2 dan RM3FP3. Analisa statistik menunjukkan tiada perbezaan di antara ketiga-tiga program pembajaan (FP1, FP2, FP3) mahupun pengurusan sisa nenas (RM1, RM2, RM3) yang dapat meningkatkan hasil buah nanas secara bererti. Dari segi kos, FP2 merupakan program pembajaan yang paling murah, diikuti oleh FP3 dan FP1. RM1 pula merupakan amalan pengurusan sisa nenas yang paling murah, diikuti oleh RM2, dan RM3. Secara keseluruhan, kombinasi rawatan RM1FP2 merupakan program pembajaan dan pengurusan sisa nanas yang paling ekonomi. RM1 merupakan amalan yang paling ekonomi untuk nanas yang ditanam atas peat tropika walaupun ketiga-tiga teknik "zero burning" (RM2), pereputan sisa nanas secara in situ tanpa gangguan (RM1) dan pembakaran sisa nanas secara in situ tidak meningkatkan hasil nanas secara bererti. Pembajaan N, P, dan K pada hari 65, 135, dan 191 hari selepas penanaman (FP2) merupakan amalan pengurusan baja yang paling ekonomi, program ini dapat menjimatkan USD 110.17 ha^{-1}. Oleh itu, FP2 merupakan program pembajaan yang paling ekonomi bersama-sama pengurusan sisa nanas di bawah RM1.

ABSTRACT

The study evaluates the existing and potential fertilizer programmes and pineapple residue management practices in order to come out with a fertilization programme which is economically viable. The fertilizer programmes adopted were: (i) application of N (176, 176, 176, and 176 kg ha^{-1}), P (11, 11, 7, and 7 kg ha^{-1}), and K (89, 89, 188, and 188 kg ha^{-1}) fertilizers at 65, 135, 191, and 233 days after planting (FP1), respectively (the usual practice); (ii) application of N (176, 176, and 176 kg ha^{-1}) P (11, 11, and 7 kg ha^{-1}) and K (89, 89, and 188 kg ha^{-1}) fertilizers at 65, 135, and 191 days after planting (FP2), respectively; and (iii) application of N (176, 264, and 264 kg ha^{-1}) P (11, 14, and 11 kg ha^{-1}) and K (89, 183, and 285 kg ha^{-1}) fertilizers at 65, 135, and 191 days after planting (FP3), respectively. Pineapple residue management practices used were: (i) in situ decomposition of pineapple residue without any interference (RM1); (ii) stacking of pineapple residue (leaves,

crowns, and peduncles) slashed, and raked from 0.6 m x 10 m beds into 0.9 m x 10 m beds (RM2-zero burn technique); and (iii) in situ burning of pineapple leaves, crowns, and peduncles (the usual practice) (RM3). Combinations of the residue management practices and fertilizer programmes gave the following treatments: RM1FP1, RM1FP2, RM1FP3, RM2FP1, RM2FP2, RM2FP3, RM3FP1, RM3FP2, and RM3FP3. Neither of the fertilization programmes (FP1, FP2, and FP3) nor residue management practices (RM1, RM2, and RM3) significantly improved fruit yield. FP2 emerged as the least expensive programme followed by FP3, and then FP1. The cheapest residue management practice was RM1, followed by RM2, and RM3. RM1FP2 emerged the most economic treatment combination. Zero-burn technique (RM2), in situ decomposition of pineapple residues without any interference (RM1), in situ burning of pineapple residues did not significantly improve fruit yield, but practicing RM1 in pineapple cultivation on tropical peat is economical. Application of N, P, and K fertilizers at 65, 135, and 191 days after planting (FP2) was cost effective as it was possible to save as much as USD 110.17 ha^{-1}, and this programme was most economically viable under pineapple residue management practice RM1.

INTRODUCTION

Malaysia is perhaps the only country in the world that largely grows pineapple *(Ananas comosus)* on peat. This practice is characterized by recycling pineapple residues before replanting through in situ burning. Presently, 17,000 hectares of peat is under pineapple cultivation (AGRIQUEST 1999/2000). Pineapples produced from this area serve both the canary and fresh market. After realizing the need to apply balanced fertilizers for a better pineapple growth and production on peat (Dunsmore 1957), several of fertilizer recommendations (Tay 1972; Tay 1973; Selamat and Ramlah 1993) have intermittently been recommended. In nutrient budget studies, Ahmed *et al.* (2000) observed that the existing fertilizer programme for pineapple cultivation on tropical peat was inappropriate. The reason being inefficient synchrony between nutrient released from applied fertilizers and optimum nutrient uptake particularly during the last stage of fertilization (263 days after planting). They estimated that 46.79 % (leaching plus accumulation) of P and 73.52 % (leaching plus accumulation) of K were unutilized. Ahmed *et al.* (1999) estimated P and K fertilizer use efficiencies of 53.21% and 29.91 %, respectively.

Although Malaysia does not locally produce sufficient fertilizers, but based on unit land area, it is reported that Malaysia is one of the heaviest users of fertilizers in the world. For 1995/96, Malaysia used 223.4 kilogram per hectare fertilizer nutrients, compared to a world average use of only 83.4 kilogram per hectare (AGRIQUEST 1999/2000). From January to September in 1998, the Malaysian fertilizer import bills for nitrogeneous, phosphatic, and potassic fertilizers reached USD 107, USD 40, and USD 116 million, respectively.

Now that in situ burning of pineapple residues before replanting has been banned (Environmental Quality Act 1974 amended in 1998), time demands that pineapple fertilizer recommendations take into account interaction between fertilizer regime and crop residue management practices like zero burn or in situ mulching; an aspect that has received less consideration, even though as much as 15 Mg ha-1 of pineapple residue is recycled. This study evaluates the existing and potential fertilizer programmes and pineapple residue management practices in order to come out with a fertilization programme which is economically viable.

MATERIALS AND METHODS

The study was conducted at Simpang Rengam Pineapple Estate, Simpang Rengam, Johore, Malaysia on a Hemist peat. Nitrogen (N) P and K were applied in the forms of urea (46.00 % N), China phosphate rock (CPR = 14.00 % P), and muriate of potash (MOP = 49.80 % K), respectively (most commonly used fertilizers in pineapple cultivation in Malaysia). The fertilizer programmes adopted were: (i) application of N (176, 176, 176, and 176 kg/ha), P (11, 11, 7, and 7 kg ha^{-1}), and K (89, 89, 188, and 188 kg/ha) fertilizers at 65, 135, 191, and 233 days after planting (FP1), respectively (the usual practice); (ii) application of N (176, 176, and 176 kg/ha), P (11, 11, and 7 kg/ha) and K (89, 89, and 188 kg ha^{-1}) fertilizers at 65, 135, and 191 days after planting (FP2), respectively; and (iii) application of N (176, 264, and 264 kg ha^{-1}), P (11, 14, and 11 kg ha-1) and K (89, 183, and 285 kg ha^{-1}) fertilizers at 65, 135, and 191 days after

planting (FP3), respectively. Pineapple residue management practices used were; (i) in situ decomposition of pineapple residue without any interference (RM1), (ii) stacking of pineapple residue (leaves, crowns, and peduncles) slashed and raked from 0.6 m x 10 m beds into 0.9 m x 10 m beds (RM2-zero burn technique), and (iii) in situ burning of residues (the usual practice) (RM3). In order to estimate the amount of ash added through in situ burning of residues (R3), these parts were slashed from old pineapple stumps, raked, and collected from four representative plots of RM3 before the start of the experiment. The residues were air-dried to constant weight, burnt and the weight of ash recorded. A direct proportional relationship was assumed for estimating amount of ash added through in situ burning on a per hectare basis. The same procedure was used to estimate the amount of residue (leaves, crowns, and peduncles) added under RM1 and RM2 except that the residues were not burnt. Combinations of residue management practices and fertilizer programmes evaluated were: RM1FP1, RM1FP2, RM1FP3, RM2FP1, RM2FP2, RM2FP3, RM3FP1, RM3FP2, and RM3FP3. It must be emphasized that a treatment without residue was excluded in this study because of the following reasons: (I) Removal of pineapple residues is not practical and in Malaysia the issue of how to handle or use of pineapple residues is still open to discussion. Until value added products are developed from pineapple residues estates are unwilling to adopt this kind of residue management practice. (II) Results of Ahmed *et al.* (1999) showed no significant difference between residue removal and burning on P and K uptake or fruit yield.

The study was a 3 x 3 factorial experiment in a randomized complete block design with 4 replications. The experimental plots were 8 m x 10 m, and altogether, 480 cv Gandul (most popularly grown) suckers were planted in each of the plots. A day before the start of the experiment, peat samples were taken to a depth of 25 cm using peat augur in each of the designated experimental plots. At maturity (540 days after planting), fruits were harvested from all plots (excluding guard rows) and weighed fresh.

Soil extractable K and P were extracted using the double acid method (0.05 M HCL:0.025 M H2SO4) with soil to solution ratio of 1:10 for 1 hour (Modified from Van Lierop *et al.* 1980). Single dry ashing method was used to determine total P and K in ash and residue. Phosphorus was determined using the molybdate blue method (Murphy and Riley 1962) at a wavelength of 882 nm. Potassium was determined using atomic absorption spectrophotometer. Total N in peat samples and residue were determined using micro-Kjeldahl method (Bremner 1960). The method described by Ahmed *et al.* (1999) was used to quantify the amount (kg ha^{-1}) of P and K in ash and N, P, and K in residue recycled in a cropping season.

The estimation of cost of labour associated with the following activities: slashing, raking, and stacking pineapple residues, burning pineapple residues, fertilizer application, and weeding were based on the wage system of the pineapple plantations. Farm gate market prices were used for fertilizers and other farm materials. Other costs associated with the following: preparation of suckers, suckers (cost), planting suckers, pesticides and pesticides application, hormone and hormoning, harvesting, land (rent), and maintenance were the same, and as such were excluded in the cost analysis. Interest rate of 12% on capital was used. Interest factor was calculated using the formula: $(1 + i)^{w-1}$ where, i represents interest rate and w represents the number of years in attaining crop maturity (Davis and Johnson 1987).

RESULTS AND DISCUSSION

The status of N, P, and K before the introduction of treatments in the experimental plots were statistically similar (Table 1). In situ burning of leaves, crowns, and peduncles (RM3) recycled 1.31 Mg ha^{-1} containing 18.69 and 240.43 kg ha^{-1} P and K, respectively. In situ decomposition (RM1 and RM2) of leaves, crowns, and peduncles recycled 5.5 Mg ha^{-1} of residue containing 70.00, 6.10 and 13.81 kg ha^{-1} N, P, and K, respectively. At harvest, fruit yields were not statistically different for all three the residue management practices (Table 2). This observation is consistent with that of Ahmed *et al.* (1999). In their study leaf removal or burning did not show significant difference in fruit yield. Burning pineapple residue leads to addition of ash containing soluble nutrients (Ahmed *et al.* 1999). This practice is however characterized by recycling or addition of nutrients at an early stage where nutrient uptake has been observed to be generally slow (Py *et al.* 1987). In addition, high rainfall usually leads to some nutrient loss

TABLE 1
Total N and extractable P and K before experimentation

Treatment	N %	*S.E.M.	P mg kg^{-1}	*S.E.M.	K mg kg^{-1}	*S.E.M.
RM1FP1	1.73	0.09	30.78	2.13	402	36.69
RM1FP2	1.45	0.06	26.17	1.48	477	25.74
RM1FP3	1.37	0.05	27.71	1.53	575	62.86
RM2FP1	1.55	0.007	24.71	2.46	445	50.4
RM2FP2	1.58	0.13	33.34	2.93	450.50	41.68
RM2FP3	1.42	0.28	28.95	4.53	575.50	20.92
RM3FP1	1.31	0.16	40.01	3.87	564	40.82
RM3FP2	1.58	0.11	28.95	6.11	590	78.12
RM3FP3	1.56	0.04	34.44	7.75	534	72.03

*S.E.M: Standard Error of Mean
Note: There was no significant difference in experimental plots before experimentation (ANOVA at $P \leq 0.05$).

TABLE 2
Effect of residue management practices on fruit yield

Residue Management	Yield kg m^{-2}	*S.E.M.
RM1	5.18	0.10
RM2	5.09	0.05
RM3	5.25	0.11

*S.E.M : Standard Error of Mean
Note : No significant difference was observed between residue management practices (single degree of freedom contrast at $P \leq 0.05$).

in tropical peat through leaching and surface runoff (Funakawa *et al.* 1996; Ahmed 1999; Ahmed *et al.* 2000). These observations partly explain the non-significant effect on fruit yield for RM3 (in situ burning of pineapple residue). The practice of covering soil surface with crop residues does not only reduce nutrient losses through leaching and runoff, but also enrichment through the processes of decomposition and mineralization. The practice also ensures relatively slow nutrient release. Considering the quantity (5.50 Mg ha^{-1}) of pineapple residues recycled per cropping season (Ahmed *et al.* 2000) under RM1 and RM2, observed results were contrary to the expected response in fruit yield was expected but the contrary was the case. In fact in the course of the study, it was observed it took not less than 13 months for pineapple residues to start decomposing. Hence it is not surprising for the possibility of RM1 and RM2 not contributing sufficient amounts of N, P, and K at the right time for a meaningful improvement in the uptake of these nutrients and fruit yield.

The estimated labour cost associated with RM1, RM2, and RM3 were USD 7.49 ha^{-1}, USD 37.37 ha^{-1}, and USD 11.23 ha^{-1}, respectively with RM1 being the least expensive residue management practice followed by RM3 and RM2 (Table 3). This observation was obviously due to the differences involved in handling the residues before replanting and weed control. While no cost was involved in managing the residues except weed control (USD 7.49 ha^{-1}) under RM1, under RM3 it cost USD 3.74 ha^{-1} to burn pineapple leaves, crowns, and peduncles, and USD 7.49 ha^{-1} for weed control. In the case of RM2, slashing of leaves cost USD 22.46 ha^{-1}. Raking and stacking leaves, crowns, and peducles

TABLE 3
Costs associated with pineapple residue management practices

	RM1	RM2 USD ha^{-1}	RM3
Slashing of leaves	0	22.46	0
Raking and packing of leaves	0	11.1	7 0
Burning of leaves	0	0	3.74
Weeding	7.49	3.74	7.49
Pollution through burning of pineapple leaves[1]	0	0	638.20
Total	7.49	37.37	649.43

[1]Husni et al. 1999

under RM2 cost USD 11.23 ha^{-1}, and USD 3.74 ha^{-1} for weed control.

Comparing the cost of labour associated with RM2 (US$ 37.37 ha^{-1}) to that of the usual pineapple residue management practice RM3 (USD 11.23 ha^{-1}), it can be realized that an additional cost of USD 26.14 ha^{-1} will be required to consider RM2 as an alternative choice to RM3. But the reverse would be the case if the cost of pollution (open burning of pineapple residues) estimated at USD 626.97 ha^{-1} (Husni *et al.* 1999) associated with RM3 is taken into account. In the case of RM1 (USD 7.49 ha^{-1}) versus RM3 (USD 11.23 ha^{-1}), the difference was only USD 3.74 ha^{-1}. Although this difference is relatively small, the accompanied cost of pollution in practicing RM3 renders RM1 an economic residue management practice. Comparing RM2 (USD 37.37 ha^{-1}) and RM1 (USD 7.49 ha^{-1}), as much as USD 29.88 ha^{-1} could be saved if RM1 is adopted. In other words, the same amount will be forgone for adopting RM2. Table 4 shows the effect of fertilizer programmes FP1, FP2, FP3 under RM1, RM2, and RM3 on fruit yield. The effect of FP1, FP2 and FP3 on fruit yield was not significant. Razzaque *et al.* (1999b) recorded significant increase in fruit yield only when N rate ranged between 800 and 1000 kg ha^{-1}. This ranged however did not significantly increase N uptake (Razzaque *et al.* 1999a). Studies have shown that cultivar Gandul P requirement on peat is generally low (Tay 1972, 1973; Selamat and Ramlah 1993; Razzaque 1999) and hence, rarely respond to P application, but the presence of P enhances or increases the absorption of K in peat (Dunsmore 1957). At lower rates (203, 305 kg K ha^{-1}), Selamat and Ramlah (1993) observed a significant linear response for fruit weight but at higher rates (442, 662, 883, and 1104 kg K ha^{-1}), such relationship was not obtained but rather, K uptake and fruit yield depressed at higher doses particular at 883 and 1104 kg K ha^{-1} (Razzaque 1999).

TABLE 4
Effect of fertilizer regimes under different pineapple residue management practices on fruit yield

Treatment	Yield (kg m^{-2})	*S.E.M
RM1FP1	5.30	0.28
RM1FP2	5.16	0.06
RM1FP3	5.09	0.16
RM2FP1	5.21	0.08
RM2FP2	5.03	0.02
RM2FP3	5.03	0.11
RM3FP1	5.18	0.08
RM3FP2	5.24	0.14
RM3FP3	5.34	0.30

*S.E.M : Standard Error of Mean
Note : No significant difference was observed between treatments (single degree of freedom contrast at $P \leq 0.05$).

The respective costs associated with fertilizer programmes FP1, FP2, and FP3 were estimated at USD 395.18 ha^{-1}, USD 285.01 ha^{-1}, and USD 387.02 ha^{-1} (Table 5). Comparing FP2 to the usual fertilizer programme FP1, as much as USD 110.17 ha^{-1} was saved under FP2. This difference was obviously due to the difference in the amount of fertilizers used and their cost of application. Under FP1 the total costs of using 704 N, 36 P, and 554 K kg ha^{-1} and their cost of application were estimated at USD 362.55 and USD 32.63, respectively, while that of FP2 amounted to USD 260.54 and USD 24.47, respectively. The comparison of FP3 and FP1 revealed a difference of only USD 8.16 ha^{-1}. The difference was from N, P, and K application (Table 5) as the quantities applied under these programmes (FP3 and FP1) were the same ex-

TABLE 5
Costs associated with pineapple fertilization programmes

Fertilizer Programme	Urea	MOP	CPR USDha^{-1}	Fertilizer application	Total
FP1	242.82	102.44	17.29	32.63	395.18
FP2	182.12	67.52	10.90	24.47	285.01
FP3	242.82	102.44	17.29	24.47	387.02

TABLE 6
Overall costs associated with pineapple fertilizer programmes under different pineapple residue management practices

Treatment	Total cost (USD ha^{-1})
RM1FP1	402.67
RM1FP2	292.50
RM1FP3	394.51
RM2FP1	432.55
RM2FP2	322.38
RM2FP3	424.39
RM3FP1	1,033.38
RM3FP2	923.21
RM3FP3	1,025.22

cept that the frequency of application for FP3 and FP1 were 3 and 4, respectively.

Table 6 shows the total cost associated with each of the 9 treatment combinations. The combination RM1FP2 was the least expensive (USD 292.50 ha^{-1}) while RM3FP1 was the most expensive (USD 1,033.38 ha^{-1}). The respective costs associated with the treatment combinations; RM1FP2, RM2FP2, and RM3FP2 were generally lower than the rest of the treatments (Table 6).

CONCLUSION

Zero burn technique (RM2), in situ decomposition of pineapple residues without any interference (RM1) or in-situ burning of pineapple residues (RM3) did not significantly improve fruit yield but practicing RM1 in pineapple cultivation on tropical peat is economical. Application of N, P and K fertilizers at 65, 135 and 191 days after planting (FP2) is economically viable as it is possible to save as much as USD 110.17 ha^{-1}, and this programme is economically viable under pineapple residue management practice RM1.

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REFERENCES

AGRIQUEST SDN. BHD. 1999/2000. Malaysia Agricultural Directory and Index. Kuala Lumpur: AGRIQUEST Sdn. Bhd.

AHMED, O. H., M. H. A. HUSNI, R.S. SYED OMAR and M.M. HANAFI. 2000. Macronutrients distribution and cycling of pineapple planted on tropical peat. *Pertanika J. Trop. Agric. Sci.* **23(2)**: 84-95.

AHMED, O. H. 1999. Nutrients uptake and cycling of pineapple planted on tropical peat. Masters Thesis, Universiti Putra Malaysia. P 95.

AHMED, O. H., M.H.A. HUSNI, R.S. SYED OMAR, M.M. HANAFI and S.K. KOH. 1999. The effects of residue management practices on phosphorus and potassium uptake in pineapple. *Mal. J. Soil Sci.* **3**: 329-37.

BREMNER, J. M. 1960. Determination of nitrogen in soil by the Kjeldahl method. *J. Agric. Sci.* **55**: 11-31.

DAVIS, L.S. and K.N. JOHNSON. 1987. *Forest Management.* New York: McGraw-Hill Inc.

DUNSMORE, J.R. 1957. Pineapple fertilizer in Malaysia. *Mal. Agric. J.* **40**: 159-187.

ENVIRONMENTAL QUALITY ACT. 1974. *Act 127 and Subsidiary Legislations.* Kuala Lumpur: International Law Book Services.

FUNAKAWA, S., K. YONEBAYASSHI, J. F. SHOON and E.C. OI KHUN. 1996. Nutritional environment of tropical peat soils in Sarawak, Malaysia based on soil solution composition. *Soil Sci. Pl. Nutr.* **42(4)**: 833-843.

HUSNI, M. H. A., O. H. AHMED and AWANG NOOR. 1999. Pineapple residue burning and the amendments of the Malaysian Environmental Quality Regulations. In *Proceedings of the Malaysian Society of Soil Science* 1999: 306-311.

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

PY, C., J. J. LACOEUILHE and C. TEISSEN. 1987. *The Pineapple Cultivation and Uses.* Translated by Daphe and J. Goodfellow. Paris *(ve)*. 15 rue Victor-Cousin.

RAZZAQUE, A.H.M. 1999. Improvement of pineapple production on tropical peat through fertilizer use. Ph.D. Thesis, Universiti Putra Malaysia, Serdang, Malaysia. p 362.

RAZZAQUE, A. H. M., M. M. HANAFI, A. R. ANUAR and M.H.A. HUSNI. 1999a. Pineapple response to nitrogen application on tropical peat: I. Effect of N on plant growth, N uptake and recovery. *Fruits* **55**: 135-140.

RAZZAQUE, A. H. M., M. M. HANAFI, A. R. ANUAR, and M.H.A. HUSNI. 1999b. Pineapple response to nitrogen application on tropical peat: II. Effect on fruit yield and quality. *Fruits* **55**: 207-212.

SELAMAT, M.M. and M. RAMLAH. 1993. The response of pineapple cv. Gandul to nitrogen, phosphorus, and potassium on peat soils in Malaysia. *ACTA Horticulturae* **334**: 247-254.

TAY, T. H. 1972. Comparative study of different types of fertilizers as sources of nitrogen, phosphorous and potassium in pineapple cultivation. *Trop. Agric.* (Trinidad) **49**: 51-59.

TAY, T. H. 1973. Response of an improved Singapore Spanish pineapple to nitrogen, phosphorous, and potassium fertilization. *Planter* **49**: 414-420.

VAN LIEROP, W., Y. A. MARTEL and M. P. CESCAS. 1980. Optimal soil, pH, and sufficiency concentrations of N, P, and K alfalfa and onion yields on acid organic soils. *Can. J. Soil Sci.:* 107-117.

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Pineapple Residue Management Practices and Fertilizer Regimes: Effects on P and K Uptake, Yield and Some Economic Implications

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Keywords: pineapple residues management, fertilizer regime, potassium uptake, phosphorus uptake, yield, cost effectiveness, tropical peat

ABSTRAK

Kajian ini telah dijalankan untuk menentukan kesan yang paling efektif, efisien serta menguntungkan bagi kombinasi baja serta pengurusan sisa nanas untuk penanaman nenas di gambut tropika. Tiga jenis pengurusan sisa digunakan iaitu (i) pereputan sisa nanas secara in situ tanpa sebarang gangguan (R1), (ii) penimbunan sisa nanas yang dipotong dan dikaruk dari baris 0.6 m x 10 m kepada 0.9 m x 10 m (R2), dan pembakaran sisa nenas secara in situ digunakan dengan tiga rejim baja iaitu; (i) pembajaan P dan K pada hari yang ke 65, 135, 191 dan 233 selepas penanaman (F1), pembajaan P dan K pada hari yang ke 65, 135, 191 selepas penanaman (F2), dan pembajaan P dan K pada hari yang ke 65, 135, dan 191 selepas penanaman dengan baja hari yang ke 233 dibahagi dan dibaja pada hari ke 135 dan 191 (F3). Kesan pengurusan sisa bagi ketiga-tiga cara pada kandungan P dan K serta hasil didapati tidak memberikan sebarang perbezaan yang bererti. Dari segi kos pula, R1 merupakan pengurusan sisa yang paling murah manakala R3 merupakan yang paling mahal. F2 merupakan rejim pembajaan paling murah manakala F1 rejim yang paling mahal. Kombinasi rawatan yang paling kos efektif adalah R1F2. Pembakaran, penimbunan sisa nanas secara berbaris atau membiarkan sisa nanas mereput secara in situ tidak meningkatkan pengambilan P dan K serta hasil. Pembajaan K (188 gk/ha) dan P (7 kg/ha) pada hari yang ke 233 selepas penanaman adalah tidak perlu. Ini dapat menjimatkan kos baja sebanyak RM 187.98/ha. Pembajaan 'muriate of potash' dan batuan fosfat China pada hari ke 65, 135, and 191 (F2) dengan pereputan sisa nanas secara in situ (R1) menampakan sedikit kebaikan dari segi kos efektif.

ABSTRACT

The study was carried out to determine the most effective, efficient, and profitable combination of fertilizer regime and pineapple residue management practice for pineapple grown on tropical peat. Three residue management practices, namely; (i) In situ decomposition of pineapple residue without any disturbance (R1), (ii) Stacking of pineapple residue slashed and raked from 0.6 m x 10 m beds into 0.9 x 10 m beds (R2), and (iii) In situ burning of pineapple residue (R3) were used in combination with three fertilizer regimes; (i) application of P and K at the 65th, 135th, 191st, and 233rd days after planting (F1), (ii) application of P and K at the 65th, 135th, and 191st days after planting (F2), and (iii) application of P and K at the 65th, 135th, and 191st days after planting but sharing fertilizer amount of the 233rd day between the 135th and 191st days (F3). The effect of the three residue management practices on P and K uptake as well as fruit yield was not significant. Similar observation was made for the three fertilizer regimes. In terms of cost, R1 was the cheapest residue management practice with R3 being the most expensive practice. F2 emerged the cheapest fertilizer regime while F1 was the most expensive regime. The most cost effective treatment combination was R1F2. Burning, stacking of pineapple residue in rows or leaving pineapple residue to decompose in situ did not improve K and P uptake as well as fruit yield. The application of K (188 kg/ha) and P (7 kg/ha) fertilizers at 233rd day after planting is not necessary and by omitting it the practice could save as much as RM 187.98/ha. The application of muriate of potash and China phosphate rock at the 65th, 135th, and 191st days (F2) under in situ decomposition of pineapple residue (R1) looks promising in terms of the cost effectiveness.

INTRODUCTION

Pineapple (Ananas comosus); a tropical crop (Sampson 1980) is commonly grown on mineral soils (Py *et al.* 1987) but in Malaysia, the crop is largely and uniquely cultivated on peat (AGRIQUEST 1999/2000). This practice has been in existence for nearly a century (Selamat and Ramlah 1993). The present large scale cultivation started on a small scale basis without fertilization but after the extensive and comprehensive survey of pineapple cultivation on peat in Malaysia (Dunsmore 1957), the need to apply balanced fertilizers for a better growth and production of pineapple was found necessary. Afterwards, various fertilizer recommendations (Tay 1972; Tay 1973) were put forward. When it became obvious that the existing recommendations were unsustainable, new fertilizer recommendations were released (Selamat and Ramlah 1993; Razzaque 1999). Despite the fact that pineapple residue management practices such as burning, incorporation, mulching, and zero burn; each of which in one way or the other forms an integral part of pineapple cultivation, none of the preceding studies took due cognizance of the interactive effects of fertilizer regimes under any of the aforementioned residue management practices.

A recent study on the P, K, Ca and Mg budget in pineapple cultivation has revealed that the existing fertilizer regime is inadequate (Ahmed *et al.* 2000) as there is lack of efficient synchrony between the time frame at which nutrients are released from applied fertilizers and the optimum period of nutrient uptake. It was estimated that 46.79 % (leaching plus accumulation) of P and 73.52 % (leaching plus accumulation) of K are unutilized. In fact, this estimation is consistent with the findings of Ahmed *et al.* (1999) on P and K fertilizers use efficiencies which were found to be 53.21% and 29.91%, respectively.

In spite of the growing concern about the polluting effects of excess fertilizer application on the environment, it is on record that Malaysia is one of the heaviest users of fertilizers in the world (per unit land area basis) even though most of the fertilizers used in the country are imported. For 1995/96, Malaysia used 223.4 kilogram per hectare fertilizer nutrients, compared with a worldwide use of only 83.4 kilogram per hectare (AGRIQUEST 1999/2000). It is even thought that Malaysia is the only country in the world with a potash requirement higher than nitrogen requirement. In 1998 (January to September), the fertilizer import bills for nitrogeneous, phosphatic, and potassic fertilizers stood at RM 406.020, RM 150.870, and RM 442.662 million, respectively. In order that the Malaysian pineapple industry contributes its quota to the reduction of these alarming bills, there is the need to judiciously modify the present fertilizer regime. The modification however needs to be in tandem with a superior mode of handling pineapple residues like the modified version of zero burn technique where with the exception of leaves that needs to be removed for value addition instead of burning, roots, stems, crowns and peduncles can be left to decompose *in situ*. This approach will not only ensure that fertilizer recommendations are based on the interactive effect of fertilizers and crop residues management practices but it is also expected to be environmental friendly.

The objective of the study was to determine the most effective, efficient, and profitable combination of fertilizer regime and pineapple residue management practice for pineapple grown tropical peat.

MATERIALS AND METHODS

The study was carried out on a Hemist peat at the Simpang Rengam Pineapple Estate, Simpang Rengam, Johore, with the following residue management practices; (I) In situ decomposition of pineapple residue without any disturbance (R1); (II) Stacking of pineapple residue (leaves, crowns, and peduncles) slashed and raked from 0.6 m x 10 m beds into 0.9 m x 10 m beds (R2); and (III) *In situ* burning of pineapple leaves, crowns, and peduncles (the usual practice) (R3). In order to estimate the amount of ash added through in situ burning of pineapple leaves, crowns, and peduncles (R3), these parts that were slashed from old pineapple stumps, raked, and collected from four representative plots of R3 before the start of the experiment. The residues were air-dried and after obtaining constant weight, they were burnt and the weight of the ash recorded. A direct proportional relationship was assumed for estimating the amount of ash added through *in situ* burning on a per hectare basis. The same procedure was used to estimate the amount residue (leaves, crowns, and peduncles) added under R1 and R2 except that the residues were not burnt.

Potassium, P, and N were applied in the forms of muriate of potash (MOP, 49.80 % K), China phosphate rock (CPR, 14.00% P), and urea (46.00% N) at the total rates of 554 K, 36 P, and 704 kg/ha N, respectively. The fertilizer regimes adopted were: (I) application of N (176, 176, 176, and 176 kg/ha), P (11, 11, 7, and 7 kg/ha), and K (89, 89, 188, and 188 kg/ha) fertilizers at the 65th, 135th, 191st, and 233rd days after planting (F1), respectively (the usual practice); (II) application of N (176, 176, and 176 kg/ha) P (11, 11, and 7 kg/ha) and K (89, 89, and 188 kg/ha) fertilizers at the 65th, 135th, and 191st days after planting (F2), respectively, and (III) application of N (176, 264, and 264 kg/ha) P (11, 14, and 11 kg/ha) and K (89, 183, and 285 kg/ha) fertilizers at the 65th, 135th, and 191st days after planting (F3), respectively. Combinations of the residue management practices and fertilizer regimes gave the following treatments; RIF1, RIF2, RIF3, R2FI, R2F2, R2F3, R3F1, R3F2, and R3F3. It must be pointed out that a treatment without residue was excluded in this study because of the following reasons: (I) To the pineapple estates, removal of pineapple residues in pineapple cultivation on peat is not practical because the issue of how to handle or what to do with the pineapple residue after removal is still open to discussion in Malaysia. Not until value is added to or products are developed from pineapple residues that are of commercial value, the estates are unwilling to adopt this kind of residue management practice. (II) In their study to ascertain the effects of pineapple residue management practices on P and K uptake and fruit yield using the treatments, leaf residue removed and fertilization, and leaf residue burnt and fertilization, the Ahmed *et al.* (1999) found no significant difference between the effect of the practices on P and K uptake as well as fruit yield.

The study entailed 3 x 3 factorial experiment in a randomized complete block design with 4 replications. The experimental plot was 8 m x 10 m, and 480 cultivar Gandul suckers (most popularly grown cultivar) were planted in each of the plots. Planting distance of 0.3 m between plants and 0.6 m between rows was used. A day before the start of the experiment, soil samples were taken at a depth of 0-25 cm using peat auger in the already designated experimental plots. A second batch of soil samples was taken 466 days after planting (harvest time). At maturity, two plant samples were uprooted within 1m square area but prior to that, D-leaf (longest and easily identifiable leaf that provides a reliable and sensitive indication of pineapple nutritional status (Py *et al.* 1987) was taken from the two samples to be uprooted. The plants (tops without roots) were then oven dried at 60°C and their dry weights determined after ensuring that constant weights have been attained. Fruits were harvested from the various plots (excluding guard rows) and weighed. The roots of the uprooted plants were removed.

Soil extractable K and P were determined using the double acid method (0.05 M HCL:0.025 M H_2SO_4) with soil to solution ratio of 1:10 for 1 hour (Modified version (1:3) of Van Lierop *et al.* 1980). The reasons behind the modification of the extraction method were: (I) A dilute soil extractant helps in eliminating the possibility of the neutralization of the extracting solution through reaction with the soil and possibly reaction of Ca and Mg coming from the burnt crop residue plus artifacts in the soil, and (II) Prolonged extraction time plus wider extraction ratio helps in minimizing the effects of rewetting time variability of dry peat (Van Lierop *et al.* 1980). Single dry ashing method was used to determine total K and P in D-leaf, ash, and residue (leaves, crowns, and peduncles). Phosphorus was determined using the molybdate blue method (Murphy and Riley 1962) at a wavelength of 882 nm. Potassium was determined using atomic absorption spectrophotometer. Potassium and P concentrations in D-leaf multiplied by the plant weight gave the uptake of these nutrients. The respective amounts of ash and residue per hectare multiplied by the P and K concentrations represented the amounts P and K recycled through burning of leaves, crowns, and peduncles and that recycled through in situ decomposing of these parts.

The cost effectiveness of the nine treatments were estimated based on the cost involved in the amounts of fertilizers used under each fertilizer regime, residue management practices (burning, slashing and stacking), fertilizer application, weeding, and air pollution (for burning pineapple residue). These estimations were based on those used by the pineapple estate. Other costs like planting, preparation of suckers, pesticides and pesticide application, hormone and hormone application, land (rent), and maintenance have been reported to be the same (Husni *et al.* 1999), and as such were not included.

Interest rate of 12% on capital was used. Interest factor was calculated using the formula (Davis and Johnson 1987); $(1 + i)^{w-1}$ where; i represents interest rate; w is the number of years for attainment of crop maturity (harvest period).

RESULTS AND DISCUSSION

The initial status of the soil extractable K and P before the start of the experiment ranged between 24.71 to 40.01 mg/kg and 402.00 to 575.00 mg/kg, respectively (Table 1). These concentrations were relatively high (Ahmed *et al.* 2000). This was attributed to the period of cultivation as the land has been under pineapple cultivation for the past 32 years, hence the tendency of residual accumulation. The differences in K and P contents in all the experimental plots before the start of the study were statistically insignificant.

TABLE 1
Initial status of soil extractable P and K

Treatment	P	K
	mg/kg soil	
R1F1	30.78	402
R1F2	26.17	477
R1F3	27.71	575
R2F1	24.71	445
R2F2	33.34	450.50
R2F3	28.95	575.50
R3F1	40.01	564
R3F2	28.95	590
R3F3	34.44	534

Note: No significant difference between treatments using Duncan's Multiple Range Test $P \leq 0.05$ was observed for all the treatments

In situ burning of leaves, crowns, and peduncles recycled 1.31 Mg/ha of ash which contained 18.69 and 240.43 kg/ha P and K. In the case of *in situ* decomposition of leaves, crowns, and peduncles as much as 5.5 Mg/ha containing 6.10 and 13.81 kg/ha P and K were recycled. At the end of the study, the three different residue management practices (R1, R2, and R3) had significant effect on the soil extractable K and P contents; of which the P and K values of R1 (116.20, 729.67 mg/kg) were the highest followed by R3 (97.61, 658.67 mg/kg), and finally R2 (50.26, 533.83 mg/kg) (Table 2). Even though burning (R3) contributed relatively high amounts of P and K the lower concentrations of these macronutrients compared to R1 may be

TABLE 2
Influence of different pineapple residue management practices on the status of soil extractable P and K at harvest

Residue Management	P	K
	mg/kg soil	
R1	116.20[a]	729.67[a]
R2	50.26[c]	533.83[c]
R3	97.61[b]	658.67[b]

Note: Different letters within columns indicate significant difference between treatment means using single degree of freedom contrast $P \leq 0.05$.

partly due to losses through surface runoff and leaching. Unlike crop residues which release nutrients relatively slowly, the opposite is the case of ash, and since ash was added at the early growth period, a period when P and K uptake in pineapple is generally slow (Py *et al.* 1987) and coupled with annual rainfall of 1917 mm (Ahmed 1999), P and K loss through surface runoff and leaching was possible. The lower P and K concentrations under R2 may be due the method of residue application. In R2, pineapple leaves, crowns, and peduncles were slashed and raked from 0.9 m x 10 m beds, and stacked in 0.6 m x 10 m beds. This might have affected the rate of the decomposition of the residues. The differences in soil extractable P and K however did not reflect in K and P uptake or fruit yield as shown in Table 4.

For no apparent reason, the effect of the different fertilizer regimes F1, F2, and F3 on K and P concentrations under the different residue management practices, differed significantly for only R1 (Table 3). Those under R2 and R3 were not significant. The fertilizer regimes also did not have significant influence on both K and P uptake, and fruit yield (Table 5). Studies have shown that cultivar Gandul P requirement on peat is generally low (Tay 1972, 1973; Selamat and Ramlah 1993; Razzaque *et al.* 1999) and hence, rarely responds to P application, but the presence of P enhances or increases the absorption of K in peat (Dunsmore 1957). In the case of K, at lower rates (0, 102, 203, 305 K kg/ ha), Selamat and Ramlah (1993) observed a significant linear response for fruit weight but at higher rates (0, 221, 442, 662, 883, and 1104 K kg/ha), such relationship was not obtained but rather, K uptake and fruit yield depressed at higher doses particularly at 883 and 1104 K kg/ha (Razzaque 1999).

TABLE 3
Effect of fertilizer regimes under different pineapple residue management practices on the status soil extractable P and K at harvest

Treatment	P	K
	mg/kg soil	
R1F1	161.10a	957.50a
R1F2	90.64b	565.00b
R1F3	96.85b	666.50b
R2F1	42.84ns	566.50ns
R2F2	47.70ns	444.50ns
R2F3	60.24ns	590.50ns
R3F1	86.23ns	659.50ns
R3F2	88.72ns	664.00ns
R3F3	117.87ns	652.50ns

Note: Same letter within columns indicates insignificant difference between treatment means using single degree of freedom contrast $P \leq 0.05$.
ns: indicates no significance between treatments

TABLE 4
Influence of different pineapple residue management practices on P and K uptake and yield

Residue Management	P	K	Yield
	g/plant		kg/m²
R1	0.33	8.16	5.18
R2	0.36	8.93	5.09
R3	0.32	9.10	5.25

Note: No significant difference between residue management practices using single degree of freedom contrast $P \leq 0.05$ was observed for all the practices

TABLE 5
Effect of fertilizer regimes under different pineapple residue management practices on the uptake of P and K, and yield

Treatment Management	P	K	Yield
	g/plant		kg/m²
R1F1	0.30	7.00	5.30
R1F2	0.41	10.48	5.16
R1F3	0.27	7.00	5.09
R2F1	0.31	7.22	5.21
R2F2	0.43	10.74	5.03
R2F3	0.33	8.84	5.03
R3F1	0.32	8.29	5.18
R3F2	0.30	8.42	5.24
R3F3	0.46	10.58	5.34

Note: No significant difference between treatments using single degree of freedom contrast $P \leq 0.05$ was observed for all the treatments

Without regard to air pollution that burning of pineapple residues (normal practice) may cause to the environment, the most expensive residue management practice was R2 and second to it was R3 (Table 6). The least expensive residue management practice was R1. However, the reverse was the case when the cost of pollution (Husni *et al.* 1999) was taken into account (Table 6).

Comparing the costs associated with fertilizer regimes F2 (RM 390.99/ha) and F3 (RM 547.77/ha) to the usual fertilization schedule F1 (RM 578.97/ha), it was realized F2 is the most

TABLE 6
Present value (12 % interest) of costs associated with different pineapple residue management practices

Management Practice	Type of Cost						
	Slashing of Leaves	Raking and Packing	Burning	Weeding	Total (a)	Air Pollution	Total (b)
	RM/ha						
R1	0	0	0	28.45	28.45	0	28.45
R2	85.34	42.67	0	14.22	142.23	0	142.23
R3	0	0	14.22	28.45	42.67	2,382.47	2,425.14

TABLE 7
Present value (12 % interest) of costs associated with different pineapple fertilizer regimes

Fertilizer Regime	MoP	CPR	Fertilizer Application	Total
	RM/ha			
F1	389.28	65.69	124.00	578.97
F2	256.57	41.42	93.00	390.99
F3	389.28	65.69	93.00	547.77

TABLE 8
Present value (12 % interest) of the overall costs associated with different pineapple fertilizer regimes under different pineapple residue management practices

Treatment	Residue Management (R)	Fertilizer Regime (F)	Total (R + F)
		RM/ha	
R1F1	28.45	578.97	607.42
R1F2	28.45	390.99	419.44
R1F3	28.45	547.77	576.22
R2F1	142.23	578.97	721.12
R2F2	142.23	390.99	533.22
R2F3	142.23	547.77	690.10
R3F1	2425.14	578.97	3004.11
R3F2	2425.14	390.99	2816.13
R3F3	2425.14	547.77	2972.91

cost effective practice in which as much as RM 187.98/ha (RM 578 – RM 390.99/ha) could be saved compared to RM 31.20/ha (RM 578.97 – RM 547.77/ha) for F3 (Table 7). Table 8 shows the overall costs for each treatment combination. The costs for the treatment combinations; R3F1, R3F2, and R3F3 (different fertilization regimes under burning pineapple residue) were generally higher than those under the respective unburnt (R1 and R2) practices. Under any of these three residue management practices, costs associated with the combination with F2 (R1F2, R2F2, and R3F2) were consistently lower than the other combinations. Among all the treatment combinations, R1F2 emerged the most cost effective (RM 419.44/ha) practice. It must however be pointed out that all is not well with this practice. Under this practice, pineapple residues are left untouched to decompose in situ and the fear is that a prolonged adoption without proper handling of the residues might not only lead to possible fire, pests and diseases outbreak but there is also the problem of adding more organic matter to the already existing one. In the course of the study, it was observed that it takes not less than 10 months for the pineapple residues to decompose. Regardless of burning pineapple residues on tropical peat or removing them from the field, observation shows that there is no significant difference between P, and K uptake (Ahmed *et al.* 1999), yield, and cost of production except the cost of land preparation of RM 218.95/ha for the unburnt practice (Husni *et al.* 1999). A residue management practice of this kind may not only take care of the limitation associated with the residue management practice R1F2 but the possibility of adding value or developing products from the removed pineapple residues that may off set the cost of removing the residues and other on-farm activities is there.

CONCLUSION

Burning, stacking of pineapple residue in rows or leaving pineapple residue to decompose in situ does not improve K and P uptake as well as yield. The application of K (188 kg/ha) and P (7 kg/ha) fertilizers at 233rd day after planting is not necessary and as this practice could save as much as RM 187.98/ha. The application of muriate of potash and China phosphate rock at the 65th, 135th, and 191st days (F2) under *in situ* decomposition of pineapple residue (R1) looks promising in terms of cost effectiveness.

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REFERENCES

AGRIQUEST SDN. BHD. 1999/2000. *Malaysia Agricultural Directory and Index.* Kuala Lumpur: AGRIQUEST Sdn. Bhd.

AHMED, O. H., M. H. A. HUSNI, R.S. SYED OMAR and M. M. HANAFI. 2000. Nutrients distribution and cycling of pineapple planted on tropical peat. *Pertanika Journal of Tropical Agricultural Science* **23(1)** (in press).

AHMED, O. H., M. H. A. HUSNI, R.S. SYED OMAR, M. M. HANAFI and S. K. KOH. 1999. The effects of residue management practices on phosphorus and potassium uptake in pineapple. *Malaysian Journal of Soil Science* **3**: 29-37.

AHMED, O. H. 1999. Nutrients uptake and cycling of pineapple planted on tropical peat. Masters Thesis 95p. Universiti Putra Malaysia.

DAVIS, L. S. and K. N. JOHNSON. 1987. *Forest Management.* pp790. New York: McGraw-Hill, Inc.

DUNSMORE, J. R. 1957. Pineapple fertilizer in Malaysia. *Malay Agric. Journal* **40**: 159.

HUSNI, M. H. A.,O. H. AHMED, A.G. AWANG NOOR and S. K. KOH. 1999. Evaluation of burnt and unburnt pineapple residues management practices on tropical peat. In *Proc. Soil. Sc. Conf. of Malaysia 1999*, eds. J. Shamsuddin and J. Fauziah. pp. 125-132. Msss. Kuala Lumpur.

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

PY, C., J. J. LACOEUILHE and C. TEISSEN. 1987. *The Pineapple Cultivation and Uses* (translated by Daphe and J. Goodfellow. 15 rue Victor-Cousin, Paris (ve).

RAZZAQUE, A. H. M. 1999. Improvement of pineapple production on tropical peat through fertilizer use. Ph.D. Thesis, 361 p. Universiti Putra Malaysia.

SAMPSON, J. A. 1980. *Tropical Fruits.* London: Longman.

SELAMAT, M. M. and M. RAMLAH. 1993. The response of pineapple cv. Gandul to nitrogen, phosphorus, and potassium on peat soils in Malaysia. *ACTA Horticulturae* **334**: 247-254.

TAY, T. H. 1972. Comparative study of different types of fertilizers as sources of nitrogen, phosphorous, and potassium in pineapple cultivation. *Tropical Agriculture* (Trinidad) **49**: 51-59.

TAY, T. H. 1973. Response of an improved Singapore Spanish pineapple to nitrogen, phosphorous, and potassium fertilization. *Planter* **49**: 414-420.

VAN LIEROP, W., Y. A. MARTEL and M. P. CESCAS. 1980. Optimal soil, pH, and sufficiency concentrations of N, P, and K max. alfalfa and onion yields on acid organic soils. *Can. J. Soil Sci.:* 107-117.

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Response of *Azadirachta Indica* and *Eucalyptus tereticornis* to Bioinoculants (VAM, *Phosphobacterium* and *Azospirillum*) in Sewage Sludge Amended Soil

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Keywords: vesicular-arbuscular mycorrhiza, *phosphobacterium, azospirillum, Azadirachta indica* and *Eucalyptus tereticornis*

ABSTRAK

Ujian kultur pot telah dijalankan pada tanah peroi merah bagi menilai tindak balas pertumbuhan dan pengertian nutrien Azadirachta indica *dan* Eucalyptus tereticornis *yang tumbuh dalam tanah yang berbentuk asal dan tanah berlumpur yang telah diubah. Penggunaan lumpur telah mempertingkat pertumbuhan dan pengeluaran biojisim* A. indica *berbanding* E. tereticornis. *Gabungan inokulan terhasil dengan peningkatan signifikan pertumbuhan tanaman serta pengambilan nutrien. Keberkesanan inokulan lebih ketara pada spesies pokok yang tumbuh dalam tanah berlumpur. Ujian masa kini jelas menunjukkan kemungkinan penggunaan inokulasi sesuai bagi baja konvensional dalam memantapkan pokok-pokok hutan.*

ABSTRACT

Pot culture experiment was conducted in red loamy soil to evaluate the growth response and nutrient uptake of Azadirachta indica *and* Eucalyptus tereticornis *grown in non-amended and sludge amended soil. Sludge application enhanced growth and biomass production of* A. indica *compared to* E. tereticornis. *Combined inoculants resulted in a significant increase in plant growth and nutrient uptake. Inoculant effectiveness was higher in tree species grown in sludge-amended soil. The present experiment clearly indicates the feasibility of using inoculation as suitable for conventional fertilizers in the establishment of forest trees.*

INTRODUCTION

Urbanization and industrialization have lead to the generation of large volumes of wastewater. Huge quantities of wastewater and sludge produced from wastewater treatment plants pose problems of environment friendly disposal in many of the metros, corporations and municipalities. Often the heavy metals and pathogens present in the sludge represent a potential hazard to human if not properly handled. Therefore, it is always the interest of regulatory agencies as well as the public to search for an economic and environmentally sustainable option for sewage sludge disposal. Soil and its vegetation acts as a filter to clean the waste through uptake, accumulation and stockpiling of pollutants within their biomass (Perttu and Kowalik 1997).

Land application of sewage sludge is considered to be the best alternative, which provides scope not only to dispose the solid waste but also to exploit the nutrients in the sewage-sludge for productive purposes. Application of sewage sludge to land may be desirable in that it can improve the physical chemical and biological properties of the soils (Sauerbeck 1987), which in turn enhanced the plant growth and biomass production (Couillard and Grenier 1989; Labrecque *et al.* 1977). Sewage sludge often contained significant amounts of nitrogen, phosphorus, calcium, organic matter and trace elements such as Zn, Cu, and Mn and hence a good source of nutrients for plant growth (Tester 1990). In some bases, the biomass productivity of sludge-amended plots can be two to three times higher than that of control plots (Labrecque *et al.* 1995).

Numerous studies have been carried out on the utilization of sludge for agricultural crops. However, using sludge for forest species is more advantageous because it has the capabity to accumulate the toxic elements in its non-edible parts. As a result it diminishes the risk of human exposure to the harmful elements. In recents years, research has been focused on the use of sludge as a fertilizer with the aim of maximizing biomass production and natural recycling of nutrients. The use of tree plantations for the treatment of sludge and simultaneous production of forest produce (biomass) could become a viable method for waste management (Chakrabarti and Nashikkar 1994).

The aim of the present study was to assess the influence of bioinoculants and their interaction with sludge on growth response and nutrient uptake behaviour of two important forest tree species viz., *Azadirachta indica* and *Eucalyptus tereticornis.*

MATERIALS AND METHODS

A pot culture experiment was conducted in a factorical randomized block design with three replications in a nutrient deficient red sandy loan soil. The pots were divided into two groups. One group was not treated with this sewage sludge (non-amended soil), whereas the other group received sewage sludge at the rate of 100 kg/ha (dry weight basis) (sludge amended soil). The sludge was mixed throughly with soil before filling into the pots (11 kg/pot). The experiment consisted of two types of tree seedlings vic., *Azadirachta indica* and *Eucalyptus tereticornis* and eight treatments viz., vesicular-arbuscular mycorrhiza (VAM) (TI) (25 g/pot), *Phosphobacterium* (PB) (T2) (5g/pot), *azospirillum* (AZO) (T3) (25g/pot), VM+PB (T4) (25.5g/pot), VAM+AZO (T5) (25,5g/pot), PB+AZO (T6) (5,5g/pot), VAM+PB+AZO (T7) (25,5,5g/pot) and control (T8). The bioinoculants were purchased from Tamil Nadu Agricultural University, soil and sludge were analyzed for their lhysico-chemical properties by adopting the standard procedure of Hesse (1971).

The initial plant height and stem diameter was measured at the first day of planting. These parameters were monitored at monthly intervals. Seedlings were allowed to grow for ten months and then harvested. At harvest, the plants were separated into leaves, stems and roots. Biomass production (dry weight), leaf area, chlorophyll and nutrient contents were determined. The leaf area was measured using a LI-COR area meter. Chlorophyll was extrated using acetone and determined by spectrophotometric analysis (Arnon 1949). Leaf materials were dried, ground and digested for the determination of nutrients. Nitrogen was estimated by Kjeldah's method. Hesse (1971) methods were followed to estimate phosphorus, potassium and calcium and magnesium using colorimetry, flame photometry and titrimetry. Data on plant growth, dry weight, leaf area, total chlorophyll and leaf nutrient content were subjected to analysis of variance (ANOVA) and the means separated using Duncan's multiple range test at P = 0.05%.

TABLE 1

Parameters	Soil	Sludge
Textural group	Red sandy	-
Bulk density	1.47	-
Ph	6.30	7.6
Ec (m.mohs cm^{-1})	0.47	1.8
Available N (mg kg^{-1})	38	347.81
Available P (mg kg^{-1})	17.00	290.00
Available K (mg kg^{-1})	21.50	129.00
Extractable Ca (%)	0.24	1.20
Extractable Mg (%)	0.09	0.64

RESULTS

Plant Growth

Plant height and basal width of *E. tereticornis* on 290th day after planting were greater in sludge-amended soil (Table 2). Sludge amended significantly increased growth of *E. tereticornis* while in *A. indica* the growth rate was slightly higher than the non-amended soil. In *Azadirachta indica,* sludge amendment also resulted in significant differences among the treatments. All the treatments except VAM+PB and VAM+PB+AZO combination increased plant height in sludge-amended soil. In non-amended soil there were significant differences in plant height between treatments, with maximum height recorded from the control (152 cm). The results obtained for *E. tereticornis* contrast the results obtained for *Azadirachta indica.* The combination of VAM+PB+AZO significantly influenced plant growth of *E. tereticornis* (Table 2).

The increase in basal width was similar to that of plant height. In general, plants grown in sludge-amended soil had higher value than plants grown in non-amended soil. Maximum

TABLE 2
Effect of inoculants on growth and biomass production of *Azadirachta indica* and *Eucalyptus tereticornis* grown in sludge amended and non amended soils

Treatments	Non amended							Sludge amended soil						
	Plant Height (cm)	Basal Diameter (cm)	Biomass Leaf ($g\text{-}plant^{-1}$)	Biomass Stem ($g\text{-}plant^{-1}$)	Biomass Root ($g\text{-}plant^{-1}$)	Leaf area (cm^2)	Chlorophyll (a+b) (mgg^{-1})	Plant Height (cm)	Basal Diameter (cm)	Biomass Leaf ($g\text{-}plant^{-1}$)	Biomass Stem ($g\text{-}plant^{-1}$)	Biomass Root ($g\text{-}plant^{-1}$)	Leaf area (cm^2)	Chlorophyll (a+b) (mgg^{-1})
a) *Azadirachta indica*														
VAM	123.7 d	1.62 ab	21.0 a	63.3 bc	38.8 a-c	17.4 a	2.05 a	152.0 a	2.16 a	27.3 a	90.7 bc	34.0 c	18.4 a	2.63 a
PB	116.0 e	1.47 ab	17.7 c	57.0 c	35.0 ab	17.1 a	2.38 a	144.3 b	2.09 ab	31.3 a	88.3 b-d	45.7 bc	16.6 a	2.85 a
AZO	133.0 c	1.59 ab	17.0 a	68.7 a-c	20.7 c	17.9 a	1.95 a	147.3 ab	2.17 a	30.3 a	106.0 a	57.0 ab	18.8 a	2.48 a
VAM+PB	147.3 b	1.64 ab	19.3 a	64.3 a-c	7 a-c	16.6 a	1.90 a	136.0 d	2.08 ab	29.0 ab	98.0 ab	69.7 a	19.0 a	2.57 a
VAM+AZO	129.7 c	1.40 b	20.0 a	63.3 bc	21.7 bc	17.2 a	1.92 a	138.3 cd	1.91 a-c	27.0 a	91.3 bc	60.0 a	15.6 a	3.04 a
PB+AZO	118.0 e	1.39 b	16.7 a	56.3 c	27.7 a-c	16.5 a	2.02 a	143.0 bc	1.74 c	24.3 a	93.3 b	58.0 ab	17.6 a	2.70 a
VAM+PB+AZO	148.0 b	1.80 a	21.7 a	76.7 a	37.3 a	17.2 a	2.24 a	121.7 e	1.70 c	24.3 a	80.3 cd	40.7 c	18.2 a	2.71 a
Control	153.0 a	1.72 ab	23.3 a	72.3 ab	28.7 a-c	15.8 a	1.91 a	123.0 e	1.80 bc	23.3 a	76.7 d	39.3 c	15.3 a	1.84 b
b) *Eucalyptus tereticornis*														
VAM	215.0 b	1.80 a	41.0 a	86.0 a	54.3 a	41.9 ab	1.61 a	212.3 d	1.75 a-c	46.3 b	89.0 a	51.3 ab	50.1 bc	1.98 a
PB	192.0 d	1.72 b	41.7 b	77.7 a-c	52.7 ab	44.7 a	1.26 a	215.3 d	2.01 a	32.3 c	90.0 a	56.7 a	43.6 cd	1.80 ab
AZO	197.0 d	1.78 b	47.3 a	77.3 a-c	40.0 bc	35.9 bc	1.28 a	185.0 f	1.57 c	34.7 c	67.3 a	38.0 bc	47.9 bc	1.47 a-c
VAM+PB	161.0 e	1.49 b	32.0 b	70.0 bc	37.0 c	40.9 ab	1.41 a	171.3 g	1.51 c	29.0 c	65.7 a	40.7 bc	38.5 d	1.22 bc
VAM+AZO	217.0 b	1.71 b	26.7 b	71.7 bc	47.3 a-c	30.9 cd	1.04 a	192.7 e	1.17 d	49.3 b	83.0 a	41.7 bc	55.8 ab	1.72 a-c
PB+AZO	221.0 b	1.79 b	43.7 a	83.0 ab	43.7 a-c	43.4 ab	1.68 a	240.3 c	1.97 ab	61.3 a	87.3 a	47.3 ab	48.8 bc	1.80 ab
VAM+PB+AZO	228.0 a	1.70 b	28.0 b	75.7 a-c	33.7 c	39.8 ab	1.32 a	268.3 a	1.73 a-c	48.0 b	91.0 a	28.7 c	58.3 a	1.37 a-c
Control	205.0 c	1.59 b	29.3 b	67.3 c	36.3 c	27.2 d	1.34 a	247.3 b	1.65 bc	50.3 b	81.7 a	33.3 c	46.3 c	1.13 c

Mean followed by the same letter are nor significantly ($p<0.05$) different as determined by Duncan's Multiple Range Test in table and figure 1.

diameter increments were recorded in single inoculation of AZO on *A. indica* and PB inoculated pots on *E. tereticornis,* both in sludge-amended soils.

Dry Weights of Leaf, Stem and Roots

Inoculation did not show any pronounced effect on left dry weight when compared to the control in *A. indica.* The effect of inoculants was on par with control both in non-amended and sludge-amended soil. However, *E. tereticornis* in inoculant significantly increased leaf dry weight when compared to control. Higher leaf dry weight was recorded from plants inoculated with PB+AZO in sludge-amended soil, followed by VAM+AZO in the same group (Table 2).

The effect of inoculants on stem dry weight of *A. indica* showed significant variation among the treatments both in sludge and non-amended soil. VAM treatment significantly increased stem dry weight when compared to all the other inoculants in both soil amendments. In *E. tereticornis* higher stem dry weight was recorded in VAM inoculated pots grown in non-amended soil, while in the sludge amended soil the effect of inoculants were similar to that of control. In A. *indica,* association with VAM+PB recorded higher root dry weight in sludge amended soil than the other combinations. PB treated plants showed pronounced effect when compared to the other treatments in *E. tereticornis* (Table 2).

Leaf Area

There was a significant increase in the leaf area of both the tree species in sludge amended soil. In *A. indica* the trends were similar to that of chlorophyll. In *E. tereticornis* the effectiveness of the treatment VAM+PB+AZO increased leaf area of *E. tereticornis* (Table 2).

Total Chlorophyll

The total chlorophyll (a+b) content of *A. indica* was higher than *E. tereticornis.* Application of sludge increased chlorophyll content of both tree species. However, the inoculants did not influence the total chlorophyll content of *A. indica* but influence the chlorophyll content of *E. tereticornis.* Higher chlorophyll (1.98) was recorded in sludge amended soil inoculated with VAM. The lowest value was from the control the plants.

Leaf Nutrients

The nutrient contents in leaves of *A. indica* and *E.tereticornis* grown in non-amended and sludge amended soils showed that sludge application facilitated higher uptake of nutrients (N, Ca and Mg). Comparison between the two species revealed that *A. indica* benefited more than *E. tereticornis* with respect to phosporus, potassium and calcium. However, there is no significant variation in uptake of Mg between the two species. The inoculants showed variable effects on tree species and sludge amendment (Fig. 1).

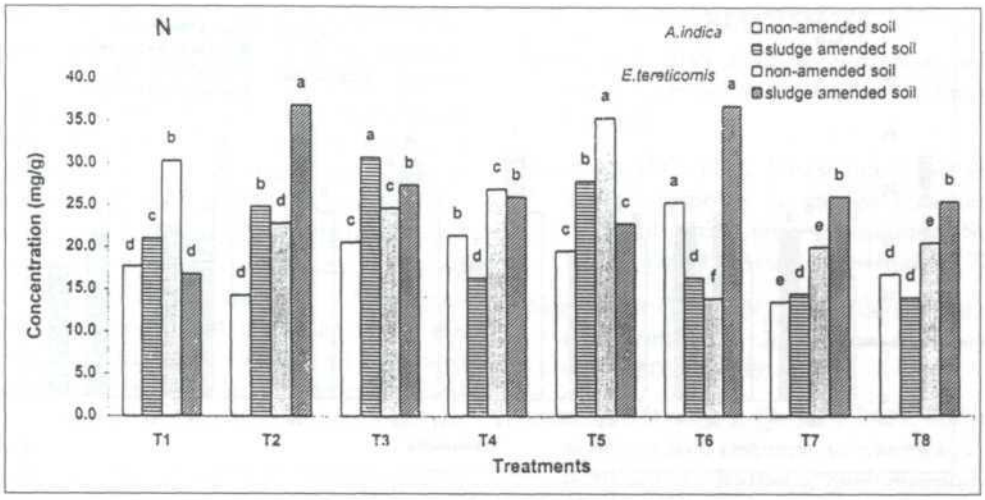
Dual inoculation significantly increased leaf nutrient concentrations. Significant increase in N, K and Ca was observed in plants inoculated with PB+AZO and VAM+PB. Combination of PB+AZO recorded higher uptake of Mg in *A. indica* grown in sludge-amended soil than the other treatments. Higher Mg uptake was observed in *E. tereticornis* sludge amended soil. (Fig. 1).

VAM inoculation recorded higher concentration of phoshorus in non-amended soil, but in sludge amended soil inoculation with PB resulted in higher levels of phosphorus concentration in the leaves. The plants in the control treatment recorded the least amount of P with an exception of *E. tereticornis* is non-amended soil (Fig. 1)

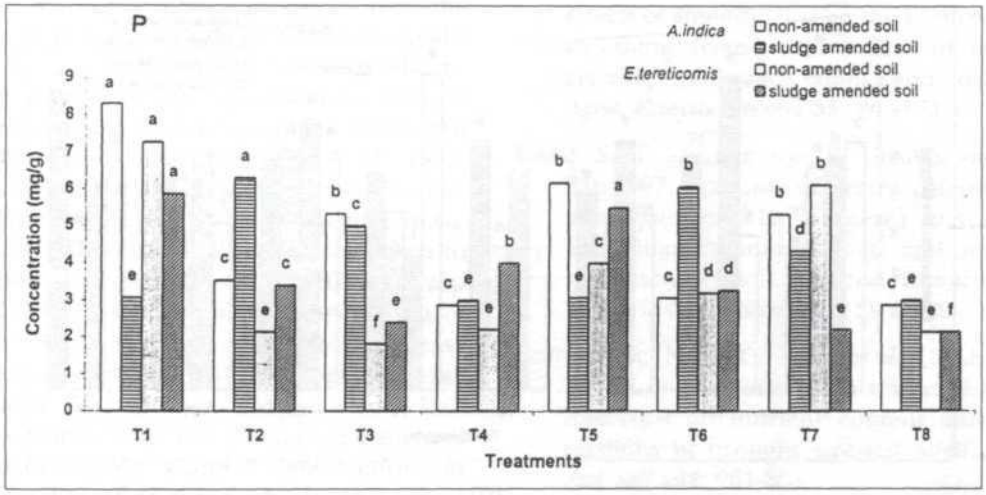
DISCUSSION

Results on the growth response revealed variability in plant height and increment for both *A. indica* and *E. tereticornis.* This probably indicates the dominance of inoculam species variability. In *A. indica,* maximum height was observed in VAM inoculated pots, while in *E. tereticornis,* it was in the VAM+PB+AZO treatment. The enhanced plant growth in sludge-amended soil was probably the result of increased availability of plant nutrients in the soil.

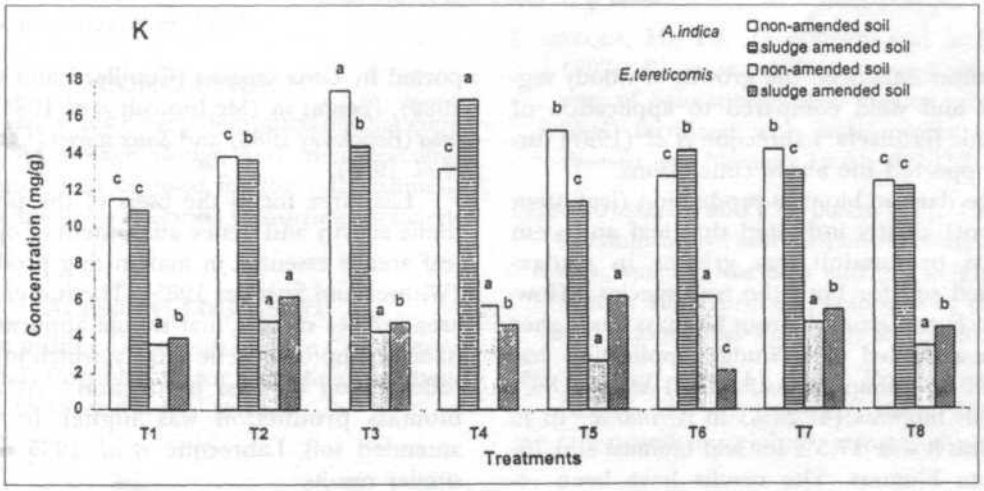
Schneider *et al.* (1991) reported that the survival, growth and vigor of hard wood and pine seedlings increased after sewage sludge application and that the growth of the hard wood and pine were not uniform. Danielson (1990) reported that addition of sewage sludge had a positive effect on growth and mycorrhizal development in Picea and Pinus spp. This effect however could not be wholly attributed to the amendment. Sopper (1992) reported that sludge


N
A.indica
non-amended soil
sludge amended soil
E.tereticornis
non-amended soil
sludge amended soil
Concentration (mg/g)
Treatments
T1
T2
T3
T4
T5
T6
T7
T8

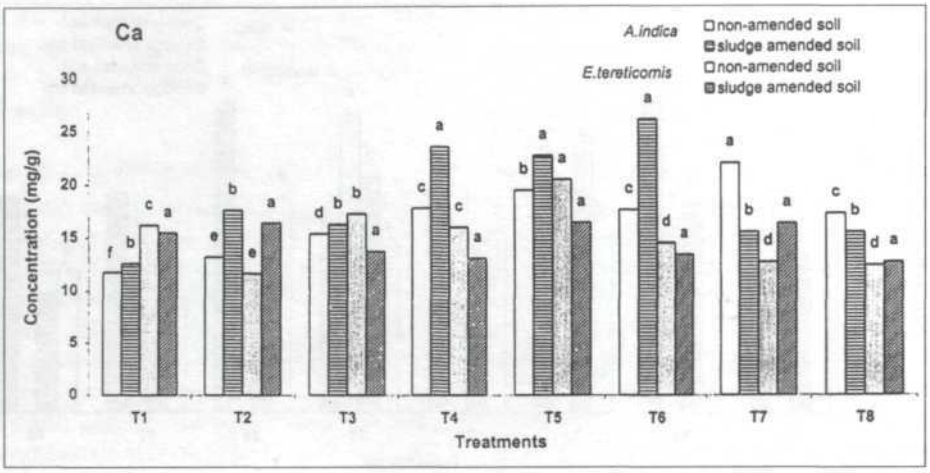
1(a)


P
A.indica
non-amended soil
sludge amended soil
E.tereticornis
non-amended soil
sludge amended soil
Concentration (mg/g)
Treatments
T1
T2
T3
T4
T5
T6
T7
T8

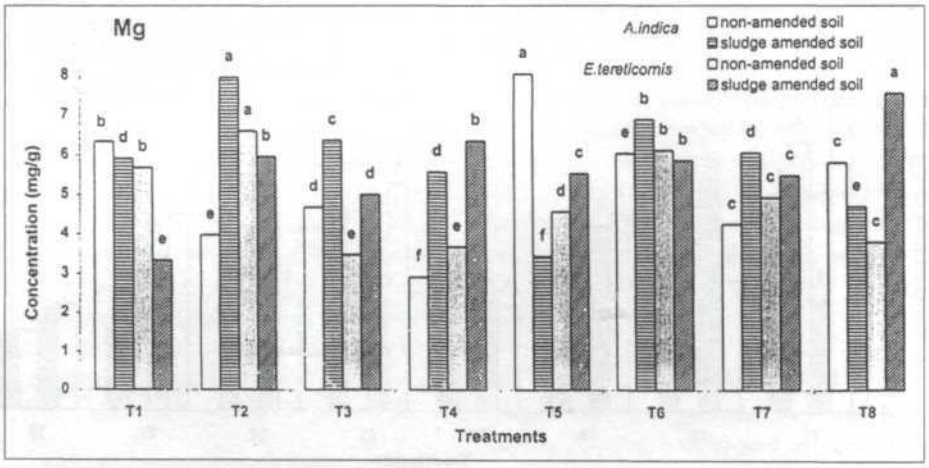
1(b)


K
A.indica
non-amended soil
sludge amended soil
E.tereticornis
non-amended soil
sludge amended soil
Concentration (mg/g)
Treatments
T1
T2
T3
T4
T5
T6
T7
T8

1(c)



1(d)



1(e)

Fig. 1. Influence of bio-inoculants on nutrient (N P K Ca Mg) status of A. indica and E. tereticornis

application enhanced the growth of woody vegetation and yield compared to application of inorganic fertilizers. Labrecque *et al.* (1997) further supported the above conclusions.

The data on biomass production (leaf, stem and root) clearly indicated that leaf and stem biomass production was greater in sludge-amended soil for both the tree species. However, in *E. tereticornis* the root biomass was higher in non-amended soil. Sludge application has resulted in enhanced leaf (27%) stem (28%) dan root biomass (41.25%) in *A. indica.* In *E. teréticornis* it was 17.5% for leaf biomass and 7% for stem biomass. The results have been reported in *Larix laricina* (Couillard and Grenier 1989), *Populus sp.* (Mc Inotosh *et al.* 1984), *Pinus aiba* (Brockway 1983) and *Salix species* (Labrecque *et al.* 1995).

Leaf area forms the basis of the photosynthetic activity and hence attainment of optimum leaf area is essential in maximizing productivity (Wittwer and Stringer 1985). The increased leaf area indices suggest that sludge application enhanced photosynthetic activity, which in turn is reflected on biomass production. As a result biomass production was higher in sludge-amended soil. Labrecque *et al.* 1995 reported similar results.

The nutrient status of the soil is one of the factors influencing the chlorophyll contents in the leaf (Lewandowska and Jarvis 1977). In the present study, cholorophyll levels were higher in sludge-amended soil, which could be attributed to the influence of available nutrients. Shrive *et al.* (1994) observed increased photosynthetic rate in res maple (*Acer rubrum L.*) and hybrid popular (*Populus sp. Nigra x maximowiczii*) irrigated with wastewater. They have concluded that vegetation species selection and the quantity of the leachate at landfills are the important factors to be considered for forest plantations established for the purpose of land application of municipal solid waste.

Sopper (1992) in his review has indicated that an increase in the major plant nutrients (N, P, K, Ca and Mg) is usually observed in crops grown in sludge-amended soils. Results from the present study revealed wide variations in uptake of N, P, K, Ca and Mg among the tree seedlings, with or without sludge amendments. Similar results were reported by many authors (Michelsen and Rosendhal 1990; Sanginga *et al.* 1995; Whitbread-Abrutat 1977). Increase in accumulation of nutrients was observed in plants inoculated with VAM+PB and PB+AZO compared to single inoculation. Piccini *et al.* (1988) and Greep *et al.* (1997) who observed that inoculation of VAM and *rhizobium spp* in sterilized soils increase the nutrient content in *Medicago sativa* L., (alfalfa) and *Macroptilium atropurpureum* Urb (siratro), respectively. The increase in elemental contents of Ca, Mg, k and P were reported in certain studies after the establishment of the fungal association with the various host plants and trees (Schwab *et al.* 1991; Osonubi *et al.* 1995; Goicoechea *et al.* 1997).

CONCLUSION

The present study clearly demonstrates that combination of sewage sludge and microbial and inoculants could be used for the establishment of forest species wastelands or nutrient deficient soil.

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REFERENCES

ARNON, D. I. 1949. *Biochemical Methods for Agricultural Sciences.* New Delhi: Wiley Estern Limited.

BROCKWAY, D.C. 1983. Forest floor, soil and vegetation response to sludge fertilization in red and white pine plantations. Soil Science. *Society of American Journal* **47**: 776-784.

CHAKRABARTI C. and V.J. NASHIKKAR. 1994. Forest tree fertilization with sewage. *Bioresource Technology* **50**: 185-187.

COUILLARD, D. and Y. GRENIER. 1989. Forest management tree response to wastewater sludge fertilization. *Journal of Environmental Quality* **28**: 235-242.

DANIELSON, R.M. 1990. Temporal changes and effects of amendments on the occurrence of sheathing (ecto-) mycorrhizas of conifers growing in oil sands tailings and coal spoil. *Agric. Ecosyst. Environ* **35**: 261-181.

GREEP. S., T. MUTHUKUMAR, K. UDAIYAN and V.N. BAI. 1997. Response of siratro (*Macroptilium atropurpureum* Urb. Rabaceae) to vesicular-arbuscular *mycorrhizal* fungi and *rhizobium* sp. in sterilized soil. *Pertanika Journal of Tropical Agricultural Science* **20(1)**: 19-29.

GOICOECHEA, N., M.C. ANTOLIN and M.S. DIAZ. 1997. Influence of arbuscular *mycorrhizae* and *Rhizobium* on nutrient content and water relations in drought stressed alfalfa. *Plant and Soil* **192**: 261-268.

HESSE P.R. 1971. *A Text Book of Soil Chemical Analysis.* London: John Murray.

LABRECQUE, M., T.I. TEODORESCU and S. DAIGLE. 1997. Biomass productivity and wood energy of *Salix* species after 2 years growth in SRIC fertilized with waste water sludge. *Biomass and Bioenergy* **12(6)**: 409-417.

LEWANDOWSKA, M. and P.G. JARVIS. 1977. Changes in cholorophyll and carotenoid content, specific, specific leaf area and dry weight fraction in Stika spruce in response to shading and season. *New Phytologist* **8**:125-126.

MC INOTOSH, M.S., J.E. FOSS, D.C. WOLF, K.R. BRANDT and R. DARMODY. 1984. Effect of composed municipal sewage sludge on

growth and elemental composition of white pine and hybrid poplar. *Journal of Environment Quality* **11**:60-62.

MICHELSEN, A. and S. ROSENDHAL. 1990. The effect of VA mycorrhizal fungi, phosphorus and drought stress on the growth of *Acacia nilotica* and *Leucaena leucucephala* seedlings. *Plant and Soil* **124**: 7-13.

OSONUBI, O., M.O. ATAYESE and K. MULONGOY. 1995. The effect of vesicular-arbuscular mycorrhizal inoculation on nutrient uptake and yield of alley-cropped cassava in a degraded Alfisol of southwestern Nigeria. *Biology and Fertility of Soil* **20**: 70-76.

PERTTU, K. L. and P. J. KOWAZIK. 1997. Salix vegetation filters for purification of waters and soils. *Biomass and Bioenergy* **12(1)**: 9-19

PICCINI, D., J. A. OCAMPO and E. J. BEDMAR. 1988. Possible influence of *Rhizobium* on VA mychorrhiza metabolic activity in double symbiosis of alfalfa plants (*Medicago sativa* L.,) grown in a pot experiments. *Biology and Fertility of Soils* **6**: 65-67.

SANGINGA, N., S.K.A. DANSO, F. ZAPATA and G.D. BOWEN. 1995. Phosphorus requirements and nitrogen accumulation by N2-fixing and Non-N_2-fixing leguminous tress growing in low P soils. *Biology and Fertility of Soils* **20**: 205-211.

SAUERBECK, D.R. 1987. *Effects of Agricultural Practices on the Physical, Chemical and Biological Properties of Soil: Part II, Use of Sewage Sludge and Agricultural Wastes.* p 181 - 210. London: Elsevier Applied Science.

SCHWAB, S.M., J.A. MENGE and P.B. TINKER. 1991. Regulation of nutrient transfer between host and fungus in vesicular-arbuscular mycorrhizas. *New Phytologist* **117**: 387-398.

SHRIVE, S., R.A. MCBRIDE and A.M. GORDON. 1994. Photosynthetic and growth respons of two broad-leaf tree species to irrigation with municipal landfills leachate. *Journal of Environment Quality* **23**: 534-542.

SOPPER, W.E. 1992. *Reclamation of Mine Land Using Municipal Sludge. Advances in Soil Sciences.* Vol. 17. New York: Springer-Verlag.

SCHNEIDER, K.R., R.J. WITTER and S.B. CARPENTER. 1991. Trees respond to sewage sludge reforestation of acid spoil. In *Proc. of Symp. On Surface Mining Hydrol., Sedimentol., and Reclamation*, p. 291-296. University of Kentucky, Lexington.

TESTER C.F. 1990. Tall fescue growth in greenhouse growth chamber and field polts amended with sludge compost and fertilizer. *Soil Science* **148**: 452-458.

WITTWER, R.F. and J.W. STRINDER. 1985. Biomass production and nutrient accumulation in seedling and coppice hardwood plantations. *Forest Ecology Management* **13**: 223-233.

WHITEBREAD-ABRUTAT, P.H. 1997. The potential of some soil amendments to improve tree growth on metalliferous mine wastes. *Plant and Soil:* 192-217.

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Effect of Genotypes on Soyabean Seed Quality Development under West African Rainfed Conditions

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Keywords: Glycine max$_2$ maturity stage, seed quality, soyabean, viability

ABSTRAK

Pemantauan telah dijalankan terhadap kesan genotip ke atas perkembangan kualiti biji benih kacang soya ketika musim hujan di Abeokuta antara Julai dan November 1997. Peningkatan berterusan dalam kadar percambahan normal dan kemunculan anak benih berlaku di awal penuaian. Kadar percambahan yang paling banyak, dikesan pada biji benih yang dituai pada peringkat-peringkat kematangan fisiologi (fungsian) dan penuaian (penuh). Secara signifikan, kemunculan anak benih dipengaruhi oleh tarikh penuaian biji benih kacang soya. Percambahan dan kemunculan meningkat semasa dalam proses perkembangan biji benih kacang soya, dan yang paling banyak ialah bagi biji benih yang dituai antara R7 dengan R8 dalam kesemua kaltivar kacang soya. Pengeringan kepada kandungan kelembapan 10% menggalakkan percambahan biji benih yang dituai di sekitar peringkat-peringkat kematangan fisiologi. Permulaan pengeringan adalah antara peringkat-peringkat kematangan fisioligi dan penuaian dalam keenam-enam kaltivar kacang soya. Kemerosotan secara mengejut kemunculan anak benih kering tiruan pada 50d selepas mtff seolah-olah bertentangan dengan 60d selepas mtff bagi percambahan biasa di makmal. Keadaan menunjukkan bahawa biji benih dari percambahan yang baik tidak semestinya menghasilkan anak benih di bawah keadaan pertumbuhan yang baik kerana genotip adalah berbeza-beza. Cantuman sifat-sifat biji benih seperti saiz, berat, kebolehcambahan dan keupayaan tumbuh sangat penting dalam pembiakbakaan kacang soya. Hal ini memudahkan pemilihan genotip dengan kualiti biji benih yang baik. Dengan itu juga mengurangkan kaedah perlindungan dan penyimpanan yang berlarutan.

ABSTRACT

Effect of genotypes on soyabean seed quality development was monitored under rainfed conditions at Abeokuta between July and November, 1997. A consistent increase in rate of normal germination and seedling emergence occurred among early harvests. Greatest germination rate was detected in seeds harvested around physiological (functional) and harvest (full) maturity stages. Seedling emergence was significantly influenced by seed harvest date in all soyabean entries. Germination and emergence increased as soyaben seed development progressed and was greatest for seeds harvested between R7 and R8 in all soyabean cultivars. Enforced desiccation to 10% moisture content promoted germination of seeds harvested around physiological maturity stages. The onset of desiccation tolerance fell between physiological and harvest maturity stages in all the six soyabean cultivars. The rapid decline in seedling emergence of artifically dried seeds at 50d after mtff as against 60d after mtff for normal laboratory gemination indicated that seedlots of initial good germination may not necessarily produce high seedling emergence under good seeding condition due to differences in genotypes. Association of seed characters such as seed size, seed weight, germinability and emergence ability is essential in soyabean breeding to facilitate selection of genotypes with good seed quality, thereby reducing elaborate storage and screening methods.

INTRODUCTION

Soyabean (*Glycine max* (L.) Merril) is a leguminous crop which has attracted active research recently in Africa. Soyabean was introduced into Tanzania in 1907, Nigeria in 1908 and Uganda in 1913. The leading soyabean producers in the continent include Nigeria, Egypt, Zambia, Zimbabwe and South Africa (Grumisiriza 1987). The nutritional values of whole soyabean seeds and soyabean meal are of great importance to man

and livestock. The composition of soyabean at harvest is as follows: 14 – 16% moisture, 40% protein, 20% oils and 35% carbohydrate (Anon 1987).

Soyabean can suffer considerable deterioration before harvest (Green *et al.* 1965; Tekrony *et al.* 1980a, b) as well as during and immediately after harvest (Green *et al.* 1966; Ojo 2000). Warm temperatures and high relative humidity in particular, make the subsequent maintenance of soyabean seed viability during storage difficult (Delouche 1974; IITA 1977; Ajala and Adebisi 1999). Mean air temperature, mean relative humidity and precipitation per day have been reported to have a high negative correlation with vigour. Thus, seed deterioration on mother plants in the field can be influenced by the same environment factors causing deterioration in storage (Tekrony *et al.* 1980a).

Several investigations have emphasized the need for prompt harvesting of the soyabean crop (Green *et al.* 1966; Delouche 1974). Harvest maturity which corresponds to the time the seeds dry to a moisture content of 41 to 15% has been suggested (Delouche 1974; Tekrony *et al.* 1980b; Ojo 2000). Serious field deterioration of soyabean seeds before and after harvest maturity has also been associated with increased incidence of seed borne fungal (*Phomopsis* sp) infection (Tekrony *et al.* 1984).

Delayed harvesting in soyabeans not only increases the rate of disease infection in the field (Tedia 1976), but results in embryo destruction (Moore 1971), lower seed germination and seed quality, and increases seed susceptibility to mechanical damage (Green *et al.* 1966).

The principal objective of this study was to examine the effect of genotypes on changes in seed quality of the mother plant during seed development and maturation. It was specifically intended to further distinguish between seedlots of high germinability. Result of the experiment would help (a) to clarify the best time West African soyabean producers should harvest their soyabeans in order to obtain high quality seeds, and (b) to advise soyabean breeders and agronomists on appropriate procedures for the selection of soyabean genotypes with potentially good emergence ability especially under humid West Africa field conditions.

MATERIALS AND METHODS

Effects of genotypes on soyabean seed quality development were monitored under rainfed conditions at Abeokuta, Nigeria between July and November, 1997. Normal laboratory germination and seedling emergence test were used as criteria for seed quality assessment. Following land preparation, 125 kgN/ha, 137kgP/ha and 125kgK/ha were applied in the form of compound fertilizer: N.P.K. 15:15:15 and single superphosphate. Soil samples were ground and sieved with 2mm and 0.5 mm sieves. The particle size, percentage nitrogen (N), phosphorus (P), and potassium (K) and the soil type were determined in the soil analyrical laboratory at IITA, Ibadan, Nigeria.

Each of the six soyabean genotypes was sown in non-replicated 10 row plots with inter-row spacing of 75cm. Each row was 10m long and distance within row was 5 cm. Pre-emergence herbicide mixture of Galex (metobromuron + metolaclor) and Gramoxone (paraquat dichloride) in a CP3 knapsack spryer at the rate of 5 and 3 litres per hectare respectively, were applied immediately after sowing.

Ten sequential harvest of pods from the middle eight rows of each plot were made at 5d intervals commencing from 30 – 40d after mean time to first flower depending on genotypes (R5) to a further 10d after full maturity stage (R8) (Fehr and Caviness 1977). Enough pods were harvested fresh and threshed by hand to obtain a seedlot of about 1,200 seeds from each soyabean genotype at each harvest.

Each seedlot was divided into two halves. The first half (600 seeds) was further divided into two sublots. Each sublot with 300 seeds was needed for the standard laboratory germination (Bp) tests (ISTA 1985a) and emergence test in sandy soil, i.e. for every sequential harvest, three replicates of 100 freshly-harvested seeds were needed for each of the laboratory and emergence test.

A second half of each of the original seedlot was dried artificially to about 10% moisture content in an air-conditioned room maintained at about 22o and 45% relative humidity with two sorption – type air dehumidifier (Ellis *et al.* 1985). A rotary fan was used to ensure air circulation. Viability of dried soyabean seeds was also determined by standard germination tests (ISTA 1985b) and emergence tests were conducted in

sandy soil in a manner similar to the freshly harvested seeds mentioned.

RESULTS

Table 1 presents the seed dry weight, time from sowing to first flower, maturity days and 100 seed-weight of six soyabean genotypes evaluated. All genotypes except TGX536-02D, TGX849-313D and TGX923-2E were significantly different from each other for seed dry weight. The time from sowing to first flower showed that TGX536-02D and TGX923-24 were different from other genotypes with reduced days to flowering (39d and 40d respectively), while TGX923-2E recorded highest days to flowering (48d). The six varieties were different from each other for maturity days and 100 seed-weight.

TABLE 1
Seed dry weight, time from sowing to fist flower, maturity days and 100-seed weight of six soyabean genotypes sown under rainfed conditions at Abeokuta in July, 1977 and harvested in November, 1997

Genotypes	sdw (mg/seed)	tff (days)	Seed maturity (days)	100-seed weight at 10% M.C. (mg)
Bossier	165.0	39	102	166
737p	113.3	40	99	115
TGX536-02D	121.7	43	107	121
TGX849-313D	126.7	46	109	135
TGX1448-2E	141.7	45	116	131
TGX923-2E	123.3	48	119	120
LSD (0.05)	8.1	1.2	0.99	0.30

Sdw = seed dry weight
Tff = time from sowing to first flower
Mc = moisture content

The quality of freshly-harvested seeds of soyabean genotypes Bossier, 737p, TGX536-02D and TGX849-313D (Fig. 1) started to show improvement in normal laboratory germination from about 35d after mtff. Seed quality was maximal (95-98%), at around mass maturity stage (R8) and subsequently declined. For genotype TGX923-2E, however, improvement in seed quality as indicated by percentage germination of freshly- harvested seeds commenced between R5 and R6 and was maximal (82-88%), between R7 and R8 reproductive stages and thereafter declined (Fig. 1). Deterioration and rate of decline in quality of freshly-harvested seeds after the R8 stage was more drastic in genotypes Bossier and TGX1448-2E than the other four genotypes (Fig. 1).

Normal germination of mature artificially-dried seeds of all six genotypes improved progressively and was maximal (55-90%) between R7 and R8 stages followed by a rapid decline to about 31% for Bossier and 0% for TGX1448-2E (Fig. 1). Effect of rapid artificial drying on genotype 737p, however, was not as devastating, as percentage normal germination dropped from a peak of 88% at around R8 stage to about 75% some 10d after harvest maturity (Fig. 1). Decline in normal germination started about 60d after mtff for freshly-harvested seeds in all genotypes. However, genotype 737p appeared to be desiccation tolerant when compared with the other five genotypes (Fig. 1).

Enforced desiccation to 10% moisture content had a lethal effect on green immature seeds rather than promoting germination of seeds harvested at around physiological maturity (R7 stage). The onset of desiccation tolerant, a period after which seeds survive enforced desiccation on removal from the the mother plant and the timing of peak seed quality (Pietafilho and Ellis 1991) fell between physiological maturity and harvest maturity stages in all six soyabean genotypes in this study (Figs. 1 and 2).

Seeding emergence was significantly influenced by seed harvest date in all soyabean entries. The ability of seeds to germinate and emerge from sandy soil increased as soyabean seeds developed and was greatest for seeds harvested between R7 and R8 reproductive stages in all six genotypes. For instance, soyabean seeds harvested fresh between R7 and R8 growth stages produced maximum seedling emergence of between 90 and 96% for all genotypes except TGX849-313D and TGX1448-2E, with 80 and 48% emergence, respectively (Fig. 2).

However, it was observed in this study that rapid artificial drying did not have any significant effect on seedling emergence of genotypes Bossier, 737p and TGX536-02, whereas it significantly improved seedling emergence (76-81%) of genotypes TGX849-313D, TGX1448-2E and TGX923-2E especially for seeds harvested after R7 reproductive stage (Fig. 2).

In the six genetypes, however, green seeds harvested between R5 and early R7 stages suffered severe desiccation after rapid artificial dry-

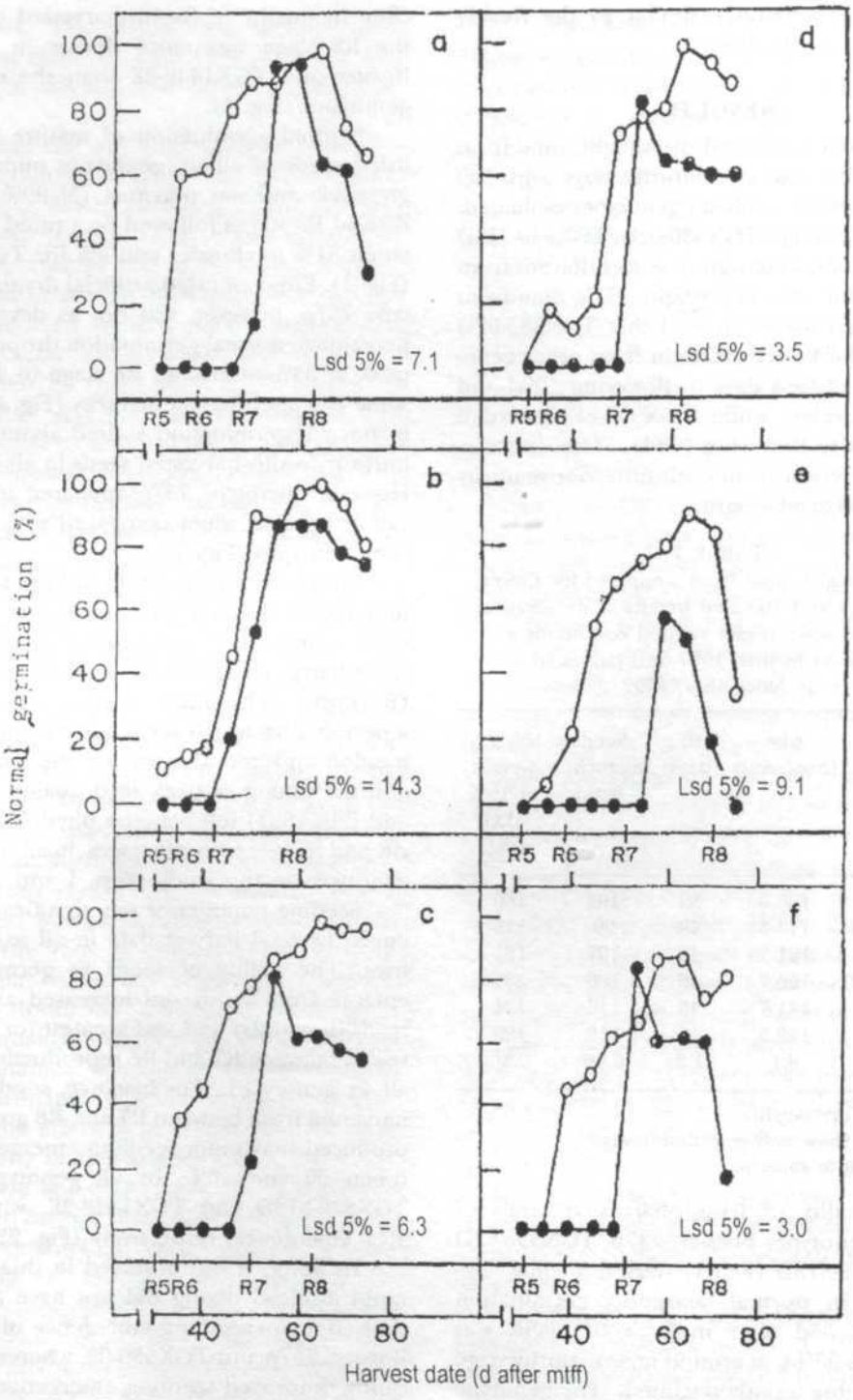

Fig. 1. Normal germination (%) of freshly-harvested (open circles) and artificially-dried (to 9–11% moisture content, f.wt. Basis) (solid circle) seeds of cvs Bossiar (a) 737p (b) TGx 536-02D (c) TGx 849-313D (d) TGx 1448-2E (e) and TGx 923-2E (f) Under rainfed conditions in 1997, in relation to harvest time (d after mtff). Growth stages (R5-R8) which correspond to harvest dates are shown

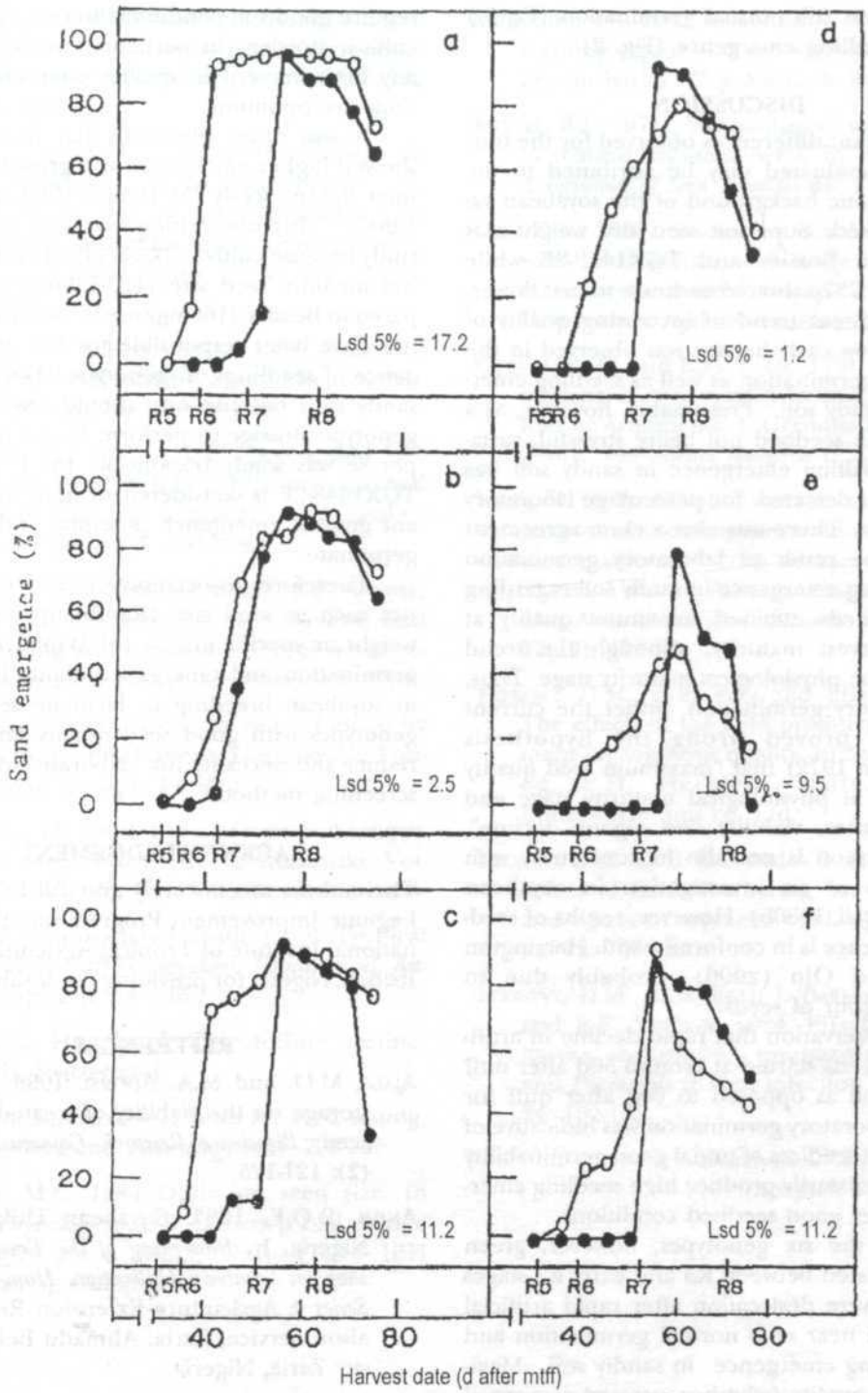

Fig. 2. Seedling emergence (%) in sand soil of freshly-harvesred (open circles) and artificially-dried (to 9-11% moisture content, f.wt. Basis) (solid circles) seeds of cus Bossier (a) 737p (b) TGx 536-02D (c) TGx 849-313D (d) TGx 1448-2E (e) and TGx 923-2E (f) Under rainfed conditions in 1997, in relation to harvest time (d after mtff). Growth stages (R5-R8) which correspond to harvest dates are shown.

ing with near 0% normal germination (Fig.1) and 0% seedling emergence (Fig. 2).

DISCUSSION

The significant differences observed for the four characters evaluated may be attributed to the diverse genetic background of the soyabean varieties studied. Superior seed dry weight was observed in Bossier and TGX1448-2E while Bossier and 737p showed earliness to first flower.

A consistent trend of increasing quality of seeds among early harvest was observed in the laboratory germination as well as seedling emergence in sandy soil. Presumably, however, as a result of the seedbed not being stressful, variations in seedling emergence in sandy soil was close to that detected for percentage laboratory germination. There was also a close agreement between the result of laboratory germination and seedling emergence in sandy soil regarding the time seeds attained maximum quality at around harvest maturity, although the trend started at the physiological maturity stage. Thus, the laboratory germination, under the current study has proved wrong the hypothesis (Harrington 1972) that "maximum seed quality is attained at physiological maturity stage and that thereafter, viability and vigour decline". This conclusion is not also in conformity with the results of an investigation in soyabean (Tekrony *et al.* 1980b). However, results of seedling emergence is in conformity with Harrington (1972) and Ojo (2000), probably due to reduced vigour of seeds.

The observation that rapid decline in artificial-dried seeds started at around 50d after mtff in sandy soil as opposed to 60d after mtff for normal laboratory germination was indicative of the fact that seedlots of initial good germinability may not necessarily produce high seedling emergence under good seedbed conditions.

In all the six genotypes, however, green seeds harvested between R5 and early R7 stages suffered severe desiccation after rapid artificial drying with near zero normal germination and zero seedling emergence in sandly soil. Maximum seed quality (whether assessed as normal germination ability or emergence ability) was attained at around harvest maturity stages and subsequently declined. The reason for the unexpected observations might be genetic, because some genotypes such as 737p and TGX849-313D reguire good soil conditions to do well, whereas cultivar Bossier in particular would not show any improvement in quality even when conditions are optimum.

It was often observed that heavier seeds showed higher emergence and growth potential than lighter seeds (McDaniel 1969; Kaufmann 1984). This observation was not true in this study because cultivar TGX1448-2E, for instance, has medium seed size (120-135mg/seed) compared to Bossier (166mg/seed). Seed size should not have been responsible for the good emergence of seedlings of genotype TGX1448-2E in sandy soils because one should have expected genotype Bossier to perform better if seed size per se was solely responsible for it. Genotype TGX1448-2E is considered to have some inherent genetic emergence potential and ability to germinate.

Therefore, association of seed characteristics such as seed size (Kaufmann 1984), seed weight or specific gravity (McDaniel 1969) with germination and emergence ability is essential in soyabean breeding to facilitate selection of genotypes with good seed quality and thereby reduce the necessity for elaborate storage and screening methods.

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REFERENCES

AJALA, M.O. and M.A. ADEBISI. 1999. Effects of storage on the viability of treated soyabean seed. *Bioscience Research Communication* **12 (2)**: 121-125.

ANON, B.O.E. 1987. Soyabean Utilization in Nigeria. In *Proceeding of the Training Workshop on Soyabean Utilization. Home Economics Series 4*: Agriculture Extension Research Liaison Service, Zaria, Ahmadu Bello University Zaria, Nigeria.

DELOUCHE J.C. 1974. Maintaining soyabean seed quality. Soyabean production, Marketing and Use. *Bulletin 1- 19*, p 46-62. National Fertilizer Development Center. Muscle Shoals, Alabama.

ELLIS, R.H., T.D. HONG and E.H. ROBERTS. 1985. Handbook of seed technology for genebanks. In *Principles and Methodology*. Vol. 1: I.B.P.G.R. Rome, Italy.

EMOVON, E. 1987. Utilization of soyabean in cottage industry. In *Soyabean Utilization* ed. B.O.E. Anon, p 9 - 12. *Home Economics Series 4.* Agricultural and Research Liaison Service, Zaria, Ahmadu Bello University, Zaria, Nigeria.

FEHR, W.R and C.E. CAVINESS. 1977. Stages of soyabean development. Special Report. No. 80. 11p. Iowa State Universiti.

GREEN, D.E., E.I. PINNEL, L.E. CANNAH and L.F. WILLIAMS. 1965. Effect of planting date and maturity date on soyabean seed quality. *Agronomy Journal* **5**: 165-168.

GREEN, D.E., L.E. CANANNAH and E.L. PINNEL. 1966. Effect of seed moisture content, field weathering and combine cylinder speed on soyabean seed quality. *Crop Science* **6**: 7-10.

GRUMISIRIZA, G. 1987. Genetics of seed longevity in soyabean. Ph.D. thesis, University of London, Wye College, London.

HARRINGTON, J.F. 1972. Seed storage and longevity. In *Seed Biology*, ed T.T Kozlowski. Vol. III, p. 145 - 245. New York Academic Press.

IITA. 1977. International Institute of Tropical Agriculture. 1977. *Soyabean Improvement, Annual Report*, p. 34 - 36.

IITA. 1985a. Handbook Tetrazolium testing. Zurich, Switzerland.

IITA. 1985b. International rules for seed testing. *Seed Science and Technology* **3(2)**: 299-355

KAUFMANN, M.L. 1984 Optimum seed size. In *Crop Physiology* ed. U.S. Gupara p 1-22. Advancing frontiers. India, Oxford and IBH Publishing Company.

MCDANIEL, R.G. 1969. Relationship of seed weight, seedling vigour and mitochondrial metabolism in barley. *Crop Science* **9**: 823-827

MOORE, R.P. 1971. Mechanism of water damage to mature soyabean seed. In *Proceedings of Association of Seed Analysis* **61**: 112-118.

OJO, D.K. 2000. Studies on soyabean (*Glycine max*) seed quality and longevity improvement in the humid tropics. Ph.D Thesis. University of Agriculture, Abeokuta, Nigeria.

PIETAFILHO, C. and R.H. ELLIS. 1991. The development of seed quality in spring barley in four environments. 1. Germination and longevity. *Seed Science Research* **1**: 173-177.

TEDIA, M. 1976. Effect of storage conditions and environment during maturation in soyabean seed quality and crop performance. Ph.D. Thesis. Univ. of Allinois, University Microfilm, Ann. Arbor Mich, Dissertation Abstract, **37(10)**: 4791-B.

TEKRONY, D.M., D.B. EGLI and J.BALLES. 1980a. The effects of the field production environment on soyabean quality. In *Seed Production* ed. P.D. Herbleth Waite. London: Butterworth and co. Ltd.

TEKRONY, D.M., D. B. EGLI and A.D. PHILIPS. 1980b. Effect of field weathering on the viability and vigour of soyabean seed. *Agronomy Journal* **72**: 749-753.

TEKRONY, D.M., D.B. EGLI, J. BARLEYS, L. TOMES and R.E. STUCKEY. 1984. Effect of date of harvest maturity on soyabean seed quality and *Phomopsis sp* seed infection. *Crop Science* **24**: 189-193.

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Frequencies of Feet Feathering and Comb Type Genes in the Nigerian Local Chicken

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Keywords: Nigerians local chicken, feet feathering, comb types genes

ABSTRAK

Kejadian pembuluan kaki, jenis balung yang berbeza dan frekuensi relatif baka yang mempengaruhi keadaan ini telah diuji pada 2,030 ayam tempatan. Kajian mendapati 14.78% ayam tempatan mempunyai kaki berbulu, manakala 85.22% tidak berbulu. Semasa kajian terhadap ayam dijalankan, jenis berbalung satu merupakan ayam jenis berbalung yang paling kerap diperhatikan. Didapati 94.73% ayam mempunyai balung satu manakala 3.20% dan 2.07% masing-masing mempunyai balung rose dan pea. Frekuensi baka bagi fsh alle yang dianggarkan mempengaruhi pembuluan kaki dalam pembiakbakaan ialah 0.08, sementara allele kemerosotan, fsh dianggarkan berfrekuensi 0.92. Allele P bagi balung pea dan allele R bagi balung rose masing-masing mempunyai frekuensi 0.02 dan 0.01, manakala bentuk kemerosotan, allele r dan p bagi balung satu masing-masing mempunyai frekuensi 0.99 dan 0.98. Anggaran frekuensi ini didapati akan menjadi bentuk yang berbeza daripada kadar yang dijangka berasaskan mod Mendelian warisan ciri-ciri ini.

ABSTRACT

Incidence of feet feathering condition, different comb types and the relative frequencies of the genes affecting these conditions were studied in 2030 local chickens. 14.78% of the local chicken surveyed had feathered feet, while 85.22% had non-feathered feet. The single comb type was the commonest of the comb type observed in the chickens surveyed. 94.73% of the chickens had single comb, while 3.20% and 2.07% had rose and pea combs respectively. The estimated gene frequency for fsh allele affecting feet feathering in the breed was 0.08, while its recessive allele, fsh an estimated frequency of 0.92. The P allele for pea comb and the R allele for rose comb had a frequency of 0.02 and 0.01 respectively, while the recessive forms, r and p alleles for single comb had frequencies of 0.99 and 0.98 respectively. These estimated frequencies were found to be significantly different from the expected ratio based on simple Mendelian mode of inheritance of these traits.

INTRODUCTION

Recent efforts to characterize the Nigerian local chicken and improve its productivity have involved mainly its health and nutritional status, its socio-economic potentials, and the optimum management approaches for increased productivity. Few reports have dealt with the occurrence of major genes influencing frizzling, naked neck, and dwarf condition in the breed (Ebozoje and Ikeobi 1995; Ikeobi *et al.* 1996) and of modifier genes influencing feet feathering and comb type in the breed (Ikeobi *et al.* 1997). These genes have been reported to be important in the adaptation and productivity of the breed in its native, hot humid environment, influencing either the meat characters or its egg-laying performance. Hutt (1949) described feed feathering as a condition in which the hock, the tarso-metatasus, and the outer toe of the chicken are feathered. It is, therefore, important that efforts to characterize and improve the Nigerian local chicken should entail the understanding of the roles of genes influencing the peculiar characteristics of the breed, their relative frequencies, and their possible utilization. Important in this regard are the genes controlling feet feathering and those influencing comb types in the breed. The present investigation was therefore carried out to determine the frequencies of these modifier genes in the

scavenging local chicken in South-Western Nigeria.

METHODOLOGY

The study was carried out in 1994 and 1995 and it involved 2030 local chickens reared under the predominant scavenging system of management in South-Western Nigeria. The study extended to eight states which were Lagos, Ogun, Ogy, Oshun, Ondo, Edo, Delta and Kwara. These areas are commonly characterized by high humidity, usually high bi-modal annual rainfall, and high temperature resulting from high solar radiation (Ebozoje 1992; Ikeobi 1994). Under the scavenging system of management, the chickens are exposed to extremes of weather conditions as they move about, feeding on crop residues, kitchen wastes, insects and leafy pastures. They, however, return to the homesteads at dusk where minimum shelters are sometimes provided.

Nine hundred and nine local cocks and one thousand one hundred and twenty one local hens were surveyed and classified on the basis of feet feathering as feathered and smooth, and on the basis of comb type as single, pea and rose. All these comb types were found in all the areas/states studied in trickles except the walnut. These birds are generally believed to be of European origin and they are dual-purpose breed. They are believed to have been imported by the first Portuguese settlers in Africa.

Estimation of the frequency of the feet feathering gene, *Fsh*, was based on the assumption that the feet feathering allele, *fsh* is dominant to the allele for smooth feet, *fsh*, as reported by Hutt (1949) and Shoffner *et al.* (1993). For the comb types, it was gene frequencies were estimated with the assumption that the two genes at the 2 loci, R-r and P-p segregate in Mendelian fashion. While R allele marks the presence of rose comb, P allele produces the pea comb type. The recessive forms of the two genes, *rrpp* mark the single comb. Gene frequencies were estimated by the Hardy-Weinberg procedure (Falconer 1989).The goodness – of – fit of the calculated values was tested against the expected Mendelian ratios using a simple chi-square test (Little and Hills 1978).

RESULT AND DISCUSSION

Feet Feathering

The percent incidence of the various conditions and the relative frequencies of the different genes influencing feet feathering and comb types are shown in Table 1. 14.78% of the local chickens surveyed had feathered feet while 85.22% had non feathered feet. Arising from that, the frequency of the Fsh gene influencing feet feathering was estimated from Hardy-Weinberg procedure to be 0.08, while the recessive allele, *fsh* had an estimated frequency of 0.92.

These values differed significantly from expected values (0.5 respectively). This was probably due to the combined inhibiting effects of social preferences, natural selection and adaptation. The local chicken with feathered feet are usually not as attractive as those with non-feathered feet as feathers appear on the hocks, the tarso-metatarsus, and on the outer toes. Hutt (1949) reported other conditions that would render the chicken with feathered feet very unattractive. These include the web of skin holding the middle and outer toes together and an unusual variation in the outer toe. It is, therefore likely that the scale of social preference

TABLE 1
Frequencies of the feet feathering and comb type in the local chicken

Trait	n	% Incidence	Gene Frequency	Phenotype Frequency
Feet Feathering				
Feathered feet	300	14.78	Fsh = 0.08	0.15
Smooth feet	1730	85.22	fsh = 0.92	0.85
Comb Type:				
Single	1923	94.73	r = 0.99, p = 0.98	0.95
Rose	65	3.20	R = 0.01,	0.03
Pea	42	2.07	P = 0.02	0.02
Walnut	0	0.00		0.00

n: Number of observations.

weight heavily against local chickens with feathered feet as people would shy away from maintaining them in their flocks. Furthermore, the hot humid conditions prevailing in South-Western Nigeria almost all the year round would entail a high heat load on the scavenging birds exposed to extremes of weather of weather conditions. In such situations, additional feathering on such normally smooth body parts as the hock, the tarso-metatarsus, and the outer toe would undermine efforts by the birds to dissipate excess body heat, thereby adversely affecting adaptation, survival and general performance of the birds. Ikeobi (1984) reported that sparse feathering was important for laying birds in Ibadan located in the same climatic zone as it enhanced production of significantly heavier eggs with thicker shells relative to fully-feathered birds. However, recent paper (Ikeobi *et al.* 1997) showed that while local birds with smooth feet had significantly higher egg production and hatching ability, those with feathered feet had better meat characters, including that the various genes could be utilized for various purposes in the Nigerian local chicken.

Comb Types

Of the 2030 birds surveyed in this study, 94.73% had single combs, 3.20% had rose combs, 2.07% had pea combs, while 0.00% had walnut combs. The single comb therefore is the commonest of the comb types in the Nigerian local chicken. Oluyemi and Roberts (1979) reported similar observations. The absence of the walnut comb type though very strange, could easily be accounted for by the societal preference attached to birds with so called strange comb for ritual purposes. In fact, must of the birds with peas and rose comb encountered in this study were found with traditional worshippers.

The frequency of the *R* allele for rose comb was calculated in this study to be 0.01 (Table 1). The recessive forms, *r* and *p* had frequency of 0.99 and 0.98 respectively. These estimates were found to be significantly different from the expected ratio under the Mendelian mode of inheriting these characters. The probable reason for this deviation may be adaptation and natural selection and social preference for these birds in the hot humid environment.

Combs are important avenues for heat loss in birds (Van Kampen 1974) and it is expected that this expected thermo-regulatory role would be keyed up in warm wet climates as is the case in South-Western Nigeria. Larger sizes of combs would therefore be important in ensuring the survival and production of the breed in such climates. The size of the comb has also been shown to affect the frequency of agonistic behaviors in birds (Dawson and Siegel 1962) in addition to determine the results of such encounters (Collias 1943). In the present study, the single comb which is the largest comb type was the most predominant in spite of the recessive genes controlling it. In which case, local birds with single combs would be favored in such agonistic encounters in the flighty and highly temperamental local chicken. Ikeobi (1984) found that birds with large combs had significantly heavier body and egg sizes which would be important under conditions of natural selection and adaptation.

CONCLUSION

The percentage incidence of the feet feathering conditions and the different comb types and the relative frequencies of the genes affecting these conditions were estimated in 2030 local chickens. The frequency of the *Fsh* gene affecting feet feathering in the breed was estimated to be 0.08 while its recessive allele, *fsh* had an estimated frequency 0.92. The *p* allele for pea comb and the *R* allele for rose comb had a frequency of 0.02 and 0.01, while the *r* and *p* alleles for single comb had a frequency of 0.99 and 0.98 respectively. These frequencies highlight the important roles played by social preference, natural selection and adaptation in the survival and evolution of the breed and also indicate the possible ways the genes can be utilized in efforts to improve the Nigerian local chicken.

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REFERENCES

Collias, N.E. 1943. Statistical analysis of factors which make for success in initial encounters between hens. *Amer. Nat.* **77**: 519-538.

Dawson, J.S. and H.S Siegel. 1962. Influence of comb removal and testosterone on agonistic

behavior in young fowl. *Poultry Science* **41**: 1103-1106.

EBOZOJE, M.O. 1992. Pre-weaning performance of West African Dwarf goats and West African Dwarf X Maradi half-bred goats in Ibadan, Nigeria. Ph.D. Thesis, University of Ibadan, Ibadan, Nigeria.

EBOZOJE, M.O. and C.O.N. IKEOBI. 1995. Productive performance and the occurrence of major genes in the Nigerian local chicken. *Nigerian J. of Genetics* **10**: 67-77.

FALCONER, D.S. 1989. *Introduction to Quantitative Genetics.* 3rd Edition. London: Longman.

HUTT, F.B. 1949. *Genetics of the Fowl.* 1st Edn. New York: McGraw-Hill Book Company.

IKEOBI, C.O.N. 1984. The relationship between the physical features of the fowl and its laying performance. M.Sc. Project Report, University of Ibadan, Ibadan, Nigeria.

IKEOBI, C.O.N. 1994. Seasonal changes in the live weight of cattle in Ogun State, Nigeria. *Int. J. Ani. Sci.* **9**: 52-54.

IKEOBI, C.O.N., M.O. EBOJOZE, O.A ADEBAMBO, and J.A ADENOWO. 1997. Modifier genes and their effect in the Nigerian local chicken: ptilopody and comb type. Paper accepted for the 6th *World Congress on Genetics Applied to Livestock Production.* Armidale, Australia.

LITTLE, T.M. and F.J. HILLS. 1978. *Agricultural Experimentation: Design and Analysis.* Canada: John Wiley and Sons Inc.

OLUYEMI, J.A and F.A ROBERTS. 1979. *Poultry Production in Warm Wet Climates.* London: McMillan Publishers Ltd.

SHOFFNER, R.N., J.S OTIS and V.A GARWOOD. 1993. Association of dominant marker traits and metric traits in chickens. *Poultry Science* **72**: 1405-1410.

VAN KAMPEN, M. 1974. Physical Factors Affecting Energy Expenditure. In *Energy Requirements of Poultry* eds. T.R. Morris and B.M Freeman. Edinburgh British Poultry Science Ltd.

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Properties of Particleboard Manufactured from Commonly Utilized Malaysian Bamboo (*Gigantochloa scortechinii*)

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ABSTRACT

Buluh semantan (Gigantochloa scortechinii), *one of the most widespread bamboo species in Peninsular Malaysia was investigated for its suitability as a raw material for particleboard production. A total of 120 bamboo culms from three different age group (1-,2 and 3-y-old) were harvested from managed bamboo clumps in FRIM. The bamboo particles produced from the flaking process were used in the making of single- and three-layer urea formaldehyde particleboards. The particleboard produced were then tested for their mechanical properties and dimensional stability according to British Standard Methods. The result showed that age, resin content and board density significantly affected the single-layer particleboard properties, while for three-layer particleboard the effect of age, core particle size and wax addition on the board properties were also found to be significant. Irrespective of bamboo age, particles of* Gigantochloa scortechinii *are suitable for the manufacture of urea formaldehyde particleboards.*

ABSTRAK

Buluh semantan (Gigantochloa scortechinii) *salah satu buluh yang terdapat secara meluas di Semenanjung Malaysia telah diselidiki akan kebolehgunaannya sebagai bahan mentah untuk penghasilan papan serpai. Sejumlah 120 batang buluh yang terhasil daripada proses pengempingan kemudian digunakan untuk pembuatan papan serpai. Papan serpai yang dihasilkan diuji sifat kekuatan dan kestabilan mengikut piawaian tatacara British. Keputusan ujian menunjukkan umur, kandungan perekat dan ketumpatan papan serpai mempengaruhi dengan ketara sifat papan serpai satu lapis manakala bagi papan serpai tiga lapis, kesan umur, saiz partikel kor dan penambahan lilin ke atas sifat papan serpai juga dipengaruhi secara ketara. Tidak kira peringkat umur buluh, partikel dari buluh semantan sesuai sebagai bahan mentah untuk penghasilan papan serpai urea formaldehid.*

INTRODUCTION

Malaysian bamboo is classified as a minor forest product and is traditionally considered as a weed interfering with the normal regeneration, development and maintenance of the main timber species (Medway 1973; Ng 1980; Salleh and Wong 1987). In the past, attempts were made to control their growth but now, due to the rapid extension of bamboo-based industries, they have become the second most important non-timber produce in Malaysia after rattan (Aminuddin Abd. Latif 1991). They played an important role in the lives of the local people, particularly those in the rural areas and are usually being used for making basket-ware, cords and toys, furniture and houses. The bamboo industry has developed into a multi-million dollar industry with their products enjoying very high demand domestically as well as internationally. However, in producing the various products, much bamboo

wastes is generated, excluding those that are discarded during harvesting and transporting; and if no action is taken the bamboo would be heading towards its downfall. Therefore, the optimum use of this resource lies in the production of reconstituted products such as particleboard. With the abundant amount of bamboo resources that are currently being underutilized as well as the need to improve panel product properties and developement, particleboards offer tremendous potential and opportunity towards its fullest utilization. This paper highlights the properties of single - and three- layered urea formaldehyde particleboards produced from *G. scortechinii.* The effect of age, board density, core particle size and resin content on the board properties are discussed.

MATERIALS AND METHODS

Forty culms each from 1- 2- and 3-y-old *G. Scortechinii* were obtained from the bamboo plantation of Forest Research Institute of Malaysia (FRIM), Kepong, Selangor. All branches present were removed and the clean culms were subjected to longitudinal splitting. Each age group of bamboo splits were then fed into a Pallman drum chipper. The chips produced were then flaked in a Pallman knife-ring flaker and the particles produced were screened into 0.5, 0.5-1.0,1.0-2.0 and >2.0 mm sizes before being ovendried at 60° C to a moisture content of about 5%.

Single-layer particleboard of 12 mm thickness of size 340× 340 mm was made at three density level (561, 641, and 721 kg/m^3 and three resin contents of 8, 10 and 12%. A measured quantity of flakes was sprayed with a resin mix containing urea-formaldehyde (solid content of 65%), hardener and water within a glue blender. The particles used consisted of 60% of 1.0-2.0 mm, 30% of 0.5-1.0 mm and 10% of > 2.0 mm particle size. The sprayed particles were then laid in a wooden mould and prepressed at 3.5 MPa for about 30 seconds. The consolidated mat was finally pressed for 6 minutes at 160°C in a Taihei hot-press at 120 kg/cm^2.

Three-layer particleboard of 12 mm thickness of size 340 × 340 mm at a density of 721 kg/m3 were made from two different particle size (1.0 and 2.0 mm) for the core materials and 0.5 mm particle size for the surface materials. Resin content of 12% was used for the surface materials and 10% for the core. An amount of 1% wax content (65% solid content) was added to the mixture. Three boards were produced for both the single- and three-layer particleboards for each combination of density level and resin content used.

The strength and dimensional properties, viz. thickness swelling (TS), water absorption (WA), modulus of rupture (MOR), modulus of elasticity (MOE) and internal bond (IB) were tested according to the British Standard: BS EN (1993). Screw-withdrawal edge (SWE) and screw-withdrawal surface (SWS) were tested according to the BS 5669 (1989).

RESULTS AND DISCUSSION

Single-layer Particleboard

The strength and dimensional properties of single-layer particleboard are shown in Table 1. All boards produced with a minimum resin content of 8% at a board density of 641 kg/m^3 were able to meet the minimum strength requirement of BS 5669. Boards made from one year-old bamboo particles with a 12% resin and a density of721kg/m^3 were observed to possess the highest values of MOR (28.52 MPa) and MOE (3613 MPa), two-year-old bamboo had the highest IB(1.11 MPa) while three-year-old having the highest SWS (957 N) and SWE (676 N) values. In general, bamboo particleboard produced from one year-old and older; and with the combination of more than 8% resin content (board density > 641 kg/m^3) surpassed the minimum strength requirement of the BS. However, only boards produced from one year-old bamboo at a density of 561 kg/m^3 and a resin content of 12% was able to meet the TS requirement of 8.0%. All other boards failed to do so.

The summary of analysis of variance (ANOVA) on the effect of age, resin content and board density on the particleboard properties are shown in Table 2. All the main variables of age, density and resin have significant effects on all the board properties.

Age showed a significant effect on all the board properties (Table 3). Jamaludin *et al.* (1997) also found a similar pattern in their study of particleboard from *Bambusa vulgaris.* Correlation analysis (Table 4) further revealed that the WA and MOR decreased insignificantly, while MOE and TS increased insignificantly with age. However, the strength properties of IB, SWS and SWE were observed to increase significantly with age. According to Moslemi (1974)

the adhesive spread per unit area of the particles could be the controlling factor on the effect of age on the strength and dimensional properties of particleboard.

Increments of resin content showed significant effect on all the board properties (Table 3). The correlation analysis also indicates that MOR, MOE, IB, SWS, and SWE increased significantly while WA and TS decreased with an increase in resin content. With more resin available at higher resin content, more bonding sites are made available, thus improving the strength properties and increased their dimensional stability, significantly. Similar observations on the strength properties-resin contents relationship were also reported by other work on wood (Talbott & Maloney 1957, Moslemi 1974, Kelly 1976), bamboo (Chen *et al.* 1991) and oil palm fruit bunches (Shaikh *et al.* 1997).

The strength and dimensional properties of particleboard are directly influenced by board density (Moslemi 1974). This is particularly true since higher density is usually associated with higher strength properties. Table 3 shows that all the MOR, MOE, IB, SWS and SWE values increase with a linear increase in board density.

TABLE 1
Physical and strength properties of single-layer UF particleboards

Age (yrs)	Resin (%)	Board Density (kg/m³)	MOR (MPa)	MOE (MPa)	IB (MPa)	SWS (N)	SWE (N)	WA (%)	TS (%)
1	8	561	9.18	1598	0.23	182	137	38.48	1077
	10		9.91	1675	0.32	2.15	163	36.41	8.50
	12		11.32	1734	0.44	249	169	34.22	7.31
	8	641	15.83	2480	0.39	539	417	63.57	24.46
	10		20.21	2759	0.59	458	461	51.89	13.84
	12		18.03	2649	0.67	598	526	49.39	11.57
	8	721	21.33	3059	0.50	535	458	52.31	23.88
	10		24.40	3330	0.68	684	545	42.91	15.08
	12		28.52	3613	0.69	719	622	36.33	12.42
2	8	561	9.77	1759	0.39	307	223	49.07	16.39
	10		11.27	1896	0.51	358	275	41.27	11.96
	12		13.37	2083	0.61	405	325	36.00	7.60
	8	641	17.87	2891	0.66	542	428	59.89	22.18
	10		20.98	3071	0.78	583	497	53.80	16.21
	12		21.04	2989	0.94	711	549	45.94	13.40
	8	721	17.37	2542	0.77	656	484	48.38	20.45
	10		23.94	3214	0.99	788	616	40.20	15.17
	12		22.04	3132	1.11	747	655	36.85	11.54
3	8	561	11.56	1985	0.48	489	358	52.68	17.16
	10		12.52	1959	0.45	476	376	45.75	11.07
	12		13.68	2168	0.67	531	381	34.93	9.17
	8	641	17.05	2538	0.58	629	459	46.43	17.81
	10		17.95	2684	0.72	558	497	39.52	11.60
	12		19.12	2913	0.86	663	471	34.09	10.55
	8	721	18.28	2696	0.71	724	576	42.40	20.94
	10		20.21	2934	0.88	803	574	37.16	12.69
	12		24.16	3544	1.04	957	676	34.05	11.80
BS 5669			min. 13.8	min. 2000	min. 0.34	min. 470	min. 360	n.a	max. 8.00

Values are average of six determinations

TABLE 2
Summary of the analysis of variance on the board properties

SOV	Df	MOR	MOE	IB	SWS	SWE	WA	TS
Age (a)	2	8.95*	3.2E6**	0.87**	3.6E5**	1.2E5**	216.9**	22.58**
Density (D)	2	1668.3**	2.2E7**	1.37**	1.6E6**	1.4E6**	1972**	514.7**
Resin (R)	2	197.60**	1.6E6**	0.66**	1.3E5**	1.0E5**	1517**	888.6**
A x D	4	58.30**	6.5E4**	0.00ns	3.3E4**	2.9E4**	443**	43.15**
A x R	4	6.81*	1.0E5**	0.32**	5122ns	5014ns	13.48ns	2.65ns
D x R	4	10.64**	1.0E5**	0.00ns	3.6E4**	1.1E4**	16.23ns	53.76**
A X D x R	8	0.77ns	0.00ns	0.01ns	5124ns	1806ns	46.78ns	15.24**

Note: ns- not significant, *- significant at P < 0.05 and **- highly significant at P < 0.01

TABLE 3
Summaries of the Duncan multiple range t-tests on the effect of age, density and resin on the board properties

Age (yrs)	MOR (MPa)	MOE (MPa)	IB (MPa)	SWS (N)	SWE (N)	WA (%)	TS (%)
1	17.50b	2524b	0.51c	473c	389b	44.78a	13.96b
2	18.31a	2708a	0.78a	592b	472a	46.16a	15.36a
3	17.17b	2602b	0.71b	648a	485a	40.78b	13.65b
Resin (%)	**MOR**	**MOE**	**IB**	**SWS**	**SWE**	**WA**	**TS**
8	15.10c	2354c	0.47c	484c	374c	50.73a	19.35a
10	18.20b	2620b	0.61b	520b	426b	43.47b	12.75b
12	19.27a	2736a	0.72a	593a	470a	38.84c	10.60c
Density (kg/m^3)	**MOR**	**MOE**	**IB**	**SWS**	**SWE**	**WA**	**TS**
561	10.88c	1782c	0.40c	303c	220c	38.92c	10.08c
641	18042b	2717b	0.61b	565b	474b	51.62a	16.09a
721	23.93a	3215a	0.76a	699a	564a	41.53b	16.10a

Means having the same letter down the column are not significantly different (P<0.05)

The increase in strength properties could be probably associated with higher compaction ratio at higher density. Other researchers (Chen *et al.* 1991; Chew *et al.* 1992; Shaikh *et al.* 1997)also reported similar findings. Table 4 also shows that board density has a high significant correlation with the strength properties. However, the increase in board density also leads to higher TS since a higher compressive set exists in higher density boards resulting in higher swelling as stresses are relieved (Gatchell *et al.* 1966 and Roffael and Rauch 1972).

Three Layer Particleboard

The properties of the three-layer particleboard are given in Table 5. Highest MOR (29.30 MPa)

TABLE 4
Correlation coefficients of age, density, and resin on the properties

SOV	MOR	MOE	IB	SWS	SWE	WA	TS
AGE	-0.01 ns	0.07 ns	0.43**	0.37**	0.25**	-0.13 ns	0.003 ns
DENSITY	0.87**	0.89**	0.64**	0.79**	0.83**	0.11 ns	0.46**
RESIN	0.29**	0.23**	0.45**	0.22**	0.23**	-0.48**	-0.67**

Note; SOV- source of variance, ns- not significant, * significant at P < 0.05,
** significant at P < 0.01

are exhibited by particleboard produced from 2-y-old bamboo with core particle size of 1.0 mm without wax while highest MOE (3977 Mpa) are shown by 3-y-old (1.0 mm core) with 1% wax addition. Two-year-old bamboo particles (1.0 mm core)and without wax produced particleboards with the highest IB (0.94 MPa), SWS (1013 N) and SWE (796 N) value. However they also exhibited the highest WA (70.17%). The highest TS (24.76%) value are shown by particleboards produced from 3-y-old bamboo (2.0 mm core) without wax addition. In general all boards with or without wax addition with core particles of 1.0 and 2.0 mm meet the minimum strength requirements of the BS 5669 but all boards regardless of age and wax addition failed to meet the 8% TS value stipulated in the BS 5669.

Table 6 shows the analysis of variance (ANOVA) of the board properties. All the main variables showed a significant effect on the board properties (except for core particle size on SWE and Wax on MOR). The effect of age on the dimensional and strength properties are shown in Table 7. Age had a significant effect on all the board properties. Three-year-old bamboo produces particleboard with worst WA and TS values but comparable strength properties with the other age groups. Table 8 further reveals the correlation coefficients of age on the board properties.

Core particle size (Psize) also showed a significant influence on the board properties.

TABLE 5
Strength and dimensional properties of three-layer formaldehyde-particleboard

Age (yrs)	Psize (mm)	Wax (%)	MOR (MPa)	MOE (MPa)	IB (MPa)	SWS (N)	SWE (N)	WA (%)	TS (%)
1	1	1	29.07	3717	0.75	836	566	29.15	10.15
2	1	1	29.33	3533	0.58	755	557	36.95	12.78
3	1	1	28.34	3977	0.49	772	543	35.16	14.13
1	1	0	28.90	3539	0.87	863	685	63.86	19.32
2	1	0	29.30	3475	0.94	1013	769	70.17	20.69
3	1	0	28.42	3910	0.89	831	724	64.44	23.73
1	2	1	24.00	3608	0.48	827	531	30.33	9.45
2	2	1	27.32	3626	0.70	800	615	26.88	10.05
3	2	1	27.21	3756	0.57	813	527	29.97	11.34
1	2	0	25.51	3462	0.63	970	701	64.01	21.30
2	2	0	26.77	3712	0.84	1005	760	59.84	16.54
3	2	0	27.48	3645	0.87	939	732	67.22	24.76
BS	5669		>13.8	>2000	>0.34	>470	>360	na	<8.00

Values are average of six determinations.
Psize - Core particle size

TABLE 6
Summaries of the ANOVA on the board properties

SOV	Df	MOR	MOE	IB	SWS	SWE	WA	TS
Age (A)	2	9.10*	3.8E5**	0.04*	1.5R4	1.6E*	29.11ns	79.70**
Psize (P)	1	93.4**	4.9Ens	0.07**	3.3E4*	190.8ns	192.2**	22.54**
Wax (W)	1	0.62ns	9.4E4	0.91**	2.8E5**	4.4E5**	1.7E4**	1423**
A x P	2	13.03*	2.1E5**	0.13**	3917ns	1668ns	168.6**	21.17**
A x W	2	1.03ns	3.9E4ns	0.05**	3.9E4**	3117ns	1.75ns	25.46**
P x W	1	0.63ns	7260ns	0.03ns	6998ns	22.82ns	18.63ns	10.74ns
A xP x W	2	1.68ns	1.1E4ns	0.02ns	9456ns	4771ns	31.13ns	9.47*

ns- not significantat $P < 0.05$, * - significant at $P < 0.05$ and ** highly significant at $P < 0.01$

TABLE 7
Effect of age, particle size and wax content on the board properties

Age (yrs)	MOR (MPa)	MOE (MPa)	IB (Mpa)	SWS (N)	SWE (N)	WA (%)	TS (%)
1	26.87b	3582b	0.68b	874ab	621b		15.06b
2	28.16a	3587b	0.77a	894a	676a	48.46a	15.02b
3	27.87ab	3822a	0.70b	838b	632ab	49.20a	18.49a
Psize(mm)							
1.0	28.88a	3692a	0.75a	845b	641a	49.96a	16.80a
2.0	26.38b	3635a	0.68b	892a	645a	46.38b	15.57b
Wax (%)							
0	27.73a	3624b	0.84a	937a	729a	64.92a	21.06a
1	27.53a	3703a	0.59b	800b	557b	31.41b	11.32b

Means having the same letter down the column are not significantly different

TABLE 8
Correlation analysis of age, particle size and wax content on the board properties

Variable	MOR	MOE	IB	SWS	SWE	WA	TS
Age	0.18ns	0.50**	0.04ns	-0.13ns	0.04ns	0.06ns	0.26*
Psize	-0.54**	-0.14ns	-0.20ns	0.22ns	0.02ns	-0.10ns	-0.11ns
Wax	-0.04ns	0.20ns	-0.69**	-0.63**	-0.76**	-0.96**	-0.88**

Particleboards produced using 1.0 mm size particle gives better MOR and IB but higher WA and TS values when compared with cores produced using 2.0 mm particle size. The higher WA and TS are due to the higher surface area of the core particles produced using 1.0 mm particle size size thus increasing its capacity to absorb more water. Correlation analysis from the Table 8 showed that particle size significantly decreases the MOR while the other board properties were insignificantly affected.

Wax is used to confer a degree of water repellency on the board. Table 6 shows that addition of 1% wax gives better WA and TS values. Addition of 1% wax decreases more than 50% the WA and TS. However, wax addition also decreases all the strength properties. Jamaludin *et al.* (1997) also reported a similar trend in their strudy. The descrease in strength properties is probably due to the resistance wax offers during gluing. Table 8 further revealed the correlation effect of wax on the board properties.

CONCLUSIONS

In the manufacture of single-layer particleboard, age, resin content and board density are found to significantly affect board properties. Particleboards produced from all age groups at a density of over 641 kg/ m^3 and at all resin contents were able to meet the strength requirements specified in BS 5669. Age, core particle size and wax affect the properties of three-layer particle board significantly. All boards made from all age groups surpassed all the strength and physical properties studied (MOR, MOE, IB, SWS and SWE) as stipulated in BS 5669. Particleboards of core particlesize of 1.0mm showed higher WA and TS values compared to particleboard of core particle size of 2.0 mm. However with 1% wax addition, the WA and TS were greatly reduced.

In terms of strength properties, all the bamboo particles from all age group of *G. schortehinii* are suitable for particleboard manufacture. However, the high values obtained for 24-hour thickness swell would require further studies before this species could be used for particleboard production.

REFERENCES

AMINUDDIN, M and M. ABD. LATIF. 1991. Non-wood Resource and Produce of Peninsular Malaysia: Its status and Future Trends in Research. Paper presented at *Winrock International F/Fred Utilization Research Programme Development Workshop*, 21-25 January, Taipei, Taiwan.

BS 5669: Part 2: 1989. Particleboard. Specification for Wood Chipboard and Methods of Test for Particleboard. 45 pp. London: British Standards Institution.

CHEN, F. W., K. JAMALUDIN and L. T. CHEW. 1991. Particleboard from bamboo, FRIM Reports No. 56. Pp. 35-44. Forest Research Institute Malaysia, Kepong.

CHEW, L. T, S. RAHIM, and K. JAMALUDIN. 1992. Bambusa vulgaris for urea and cementbond particleboard manufacture. *J. Trop. Forest Science* **4(3):** 249-256.

EN 310: 1993. Wood-based panels-Determination of modulus of elasticity in bending and bending strength. European Committe for Standardization. 5 pp.

EN 317: 1993. Particleboards and fibreboards-Determination of swelling in thickness after immersion in water. European Committee of Standardization. 9 pp.

EN 319: 1993. Particleboard and fibreboards-Determination of tensile strength perpendicular to the plane of the board. European Committee of Standardization. 11 pp.

GATECHELL, C. J., B. G. HEEBINK and F. V. HEFTY. 1966. Influence of component variables on the properties of particleboard for exterior use. *Forest Product Journal* **16 (4)**: 46-59

JAMALUDIN, K., M. ABD. LATIF, M. N. NURULHUDA and H. JAMALUDDIN. 1997. Effect of age, resin and wax contents on the properties of particleboard from 1-, 2-, 3-, and 4-y-old *Bambusa vulgaris*. *JTFP* **3(2):** 178-185

KELLY, M. W. 1976. Review of Particleboard Manufacturer and Processing. In *Wood Technology: Chemical Aspect*, ed. S. G. Irving ACS Symposium Series.

MOSLEMI, A.A 1974. Particleboard Vol. 1: Materials, 241 pp. Southern Illinios University, USA.

MEDWAY, L. 1973. Research at the University of Malaya Field Studies Center, Ulu Gombak-bamboo control. *Malaysian Forester* **33(1)**: 70-77.

NG, F.S.P. 1980. Bamboo Research in Malaysia. In *Proceedings of the Seminar on Bamboo Research in Asia.* Lessard, G & Chouinard, A. (Eds.) Pp. 91-95 May 28-30, 1980. Singapore.

ROFFAEL, E. and W. RAUCH. 1972. Influence of density on the swelling behaviour of phenolic resin-bonded particleboards. *Holz als Rohund Werkstoff* **30(5)**: 178-181.

SALLEH , M.N. and K.M. WONG. 1987. The Bamboo Resource in Malaysia: Strategies for Development. In *Proceedings of the International Bamboo Workshop.* Rao, G. Dhanarajan and C. B. Sastry (Eds.) Pp. 45-49 October 6-14, 1985. Hangzhou, China.

SHAIKH, A. K. Y., A. ABDUL JALIL and K. JAMALUDIN. 1997. The Properties of Particleboard from Oil Palm Empty Fruit Bunches. Paper presented at the School of Applied Science Seminar Series. MARA Institute of Technology, Shah Alam.

TALBOTT, J.W. and T.M. MALONEY. 1997. Effect of several production variables on MOR and IB strength of boards made of Green Gouglas-fir planer shavings. *Forest Product Journal* **7(10)**: 395-398.

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Pyridoxine Requirement of Broilers on Fed Guinea Corn-Palm Kernel Meal Based Diet

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Keywords: pyridoxine, broiler chicken, guinea corn, palm kernel meal

ABSTRAK

Uji kaji telah dijalankan bagi memantapkan keperluan piridoksin makanan salai pada catuan yang praktikal. Lapan kumpulan yang sama daripada 25 anak ayam yang dikomersil, diberi makan inti sawit-jagung berasaskan pemakanan sampingan yang paras piridoksin digred (4.5, 5.0, 5.5, 6.0, 7.0, 7.5 dan 8.0 mg/ makanan) sejak hari yang pertama hingga hari yang ke-42. Data penggunaan makanan, penahanan nutrien dan ciri-ciri karkas menunjukkan bahawa 6.0 mg piridoksin/makanan adalah keperluan minimum, sedangkan 5.5 mg/kg makanan diperlukan bagi mengelak kematian dan mengekalkan kepekatan hemoglobin, isi padu sel terpadat (PVC) dan aktiviti aminotransferas aspartat di dalam serum dan hati.

ABSTRACT

A trial was conducted to establish pyridoxine requirement of broilers fed on practical ration, in which 8 duplicate groups of 25 commercial broiler chicks were fed guinea corn-palm kernel meal based diet supplemented with graded levels of pyridoxine (4.5, 5.0, 5.5, 6.0, 7.0, 7.5 and 8.0 mg/kg feed) from day-one to 42 days. Data on feed utilisation, nutrient retention and carcass characteristics showed that 6.0mg pyridoxine/kg feed is the minimum requirement whereas 5.5mg/kg feed was required for prevention of mortality and maintenance of normal haemoglobin concentration, packed cell volume (PCV) and aspartate aminotransferase activities in serum and liver.

INTRODUCTION

Dietary essentiality of pyridoxine for optimum productive performance of broilers had been established (ARC 1975). However, because of its relatively poor bioavailability and varied contents in feed ingredients, and also because of its involvement in amino acid metabolism and protein utilisation, estimated requirement figures varied widely depending on the type of test diet and the dietary protein content and method of processing of feed ingredients such as soybean, cottonseed and safflower used in the test diets (Whitehead 1982). It seemed therefore that to ensure adequate pyridoxine supplement for broilers under a practical feeding regime in a particular region, it is necessary to establish the bird's requirement using rations formulated with locally available feed ingredients. Indeed, in Nigeria, Ogunmodede (1981) had established pyridoxine requirement of broilers feed ration based on groundnut cake (GNC), which hitherto was the most commonly used feed protein source in the country. In recent times, poultry diets in the country had undergone drastic changes in composition due to replacement of high-cost traditional feed protein sources with lower-cost alternatives. In this regard, the use of palm kernel meal (PKM) in lieu of GNC is gaining popularity as an alternative, which offers a significant protein cost advantage in broiler rations. However, information on the pyridoxine demand of broilers fed PKM based ration is lacking.

The objective of this study was to establish pyridoxine supplement required for optimum performance of broilers, fed guinea corn-PKM based diet. Guinea corn was included in the ration because it is a major feed energy source in broiler rations in Nigeria.

MATERIALS AND METHODS

Duplicate groups of day-old commercial broiler with 25 chicks per group were given a basal practical diet based on guinea corn-PKM (Table 1). On the whole, 400 day-old chicks were used in this study. The diet was supplemented with pyridoxine to achieve graded levels of 4.5, 5.0, 5.5, 6.0, 6.5, 7.0, 7.5 and 8.0 mg pyridoxine/kg feed. Pyridoxine content of basel diet was estimated (Association of Vitamin Chemists Inc. 1966) prior to vitamin supplementation. The chicks were housed in deep litter pens, each of 5.5m^2 floor area and containing dry wood shavings litter, two 4-litre plastic drinkers, a through feeder and a 200-W tungsten filament lamp. Birds were maintained on the respective dietary treatments for a period of 42 days during which they had free access to feed and water and routine vaccinations were administered. Feed intake, body weight gain and feed efficiency were recorded on a weekly basis. Birds were observed regularly for clinical signs of anaemia and symptoms of pyridoxine deficiency in the chickens (Gries and Scott 1972). All birds that died were sent to the Veterinary Clinic of the State's Ministry of Agriculture and Natural Resources for post mortem examination. Mortality due to pyridoxine deficiency was recorded.

TABLE 1
Composition of the basal diet

Constituent	g/kg
Guinea corn	500
Palm kernel meal	200
Blood meal	67
Fish meal	45
Brewer's grain	125
Palm kernel oil	20
Vitamin/mineral premix*	1
Oyster shell	10
Bone meal	20
L-Lysine	5
DL-Methionine	5
NaCl	2
TOTAL	1000
Chemical analysis	
Crude protein (%)	21.2
Crude fat (%)	4.2
Gross energy (Kcal/kg)	3068.6
Pyridoxine (mg/kg)	4.02

* vitamin/mineral premix supplied the following vitamin and minerals per kg of feed: 1200 IU Vit. A; 2500 IU Vit D; 10 IU Vit E; 1.5 mg Menadione sodium bisulphite; 2.5 mg Vit. B1; 5 mg Vit. 52; 500 mg Choline chloride; 10 mg Calcium d-panthothenate; 35 mg Nicotinic acid; 0.02 mg Vit. B12; 0.16 mg Biotin; 1 mg Folic asid; 50 mg iron; 150 mg Manganese; 2.5 mg cooper; 45 mg zinc; 0.2 mg Cobalt; 0.08 mg Selenium; 1.4 mg Iodine.

In the last three weeks of experimentation, metabolic studies were conducted with four replicate samples of birds randomly selected from the respective treatment groups at the beginning of the fourth week. The birds were housed in single-bird cages, 400 x 300 mm, with wire floors allowing for separate collection of excreta. The cages had individual feed and water troughs. In accordance with the total collection procedure, excreta samples were collected daily from each treatment group on 14 successive days during the fifth and sixth week for nutrient analysis. Feed and excreta were analysed for nitrogen and lipid (AOAC 1980). Gross energy values were determined using the Ballistic bomb calorimeter and apparent metabolizable energy values of the diets were calculated. Apparent retention of nitrogen and lipid were calculated as the difference between the amount of the constituent in the diet and excreta samples collected (Oloyo 1997).

At the end of the feeding trial, four replicate samples of birds were selected randomly from the respective treatment groups in the floor pens for blood collection and subsequent slaughtering. Blood samples were taken from the wing veins of each bird and kept for measurement of haemoglobin content and packed cell volume, PCV (Lamb 1981) and aspartate aminotransferase (L-aspartate: 2-oxoglutarate aminotro-ansferase [EC 2.6.1]) activity (Reitman and Frankel 1957). Selected birds were killed by cervical dislocation, the livers were removed for the measurement of asparate aminotransferase activity (Tonhazy *et al.* 1950) and were dressed for carcass characteristics evaluation (Oloyo and Ogunmodede 1990).

Results obtained in the trial were subjected to analysis of variance (Steel and Torrie 1960), and differences between treatment means were tested using the multiple range test of Duncan (1955).

RESULTS AND DISCUSSION

Results of feed utilisation (Table 2) indicated that groups of birds that received from 4.5 to 5.5 pyridoxine/kg feed consumed less feed, gained less body weight and had poorer efficiency of

feed conversion than those given 6.0 – 8.0 mg of the vitamin per kg of feed. Poorer feed consumption observed in birds given 4.5 – 5.5 mg pyridoxine/kg feed might be due to inability of the birds to move freely because anaemic conditions set in making them sluggish and easily fatigued. Results from this study tend to show that 6.0mg pyridoxine /kg was the lowest dietary level required for optimum feed intake and growth rate.

Starvation, a consequence of depressed appetite was believed to be the cause of death in pyridoxine-deficient chickens (Gries and Scott 1972). Indeed, mortality due to pyridoxine (ARC 1975) recorded in the present study was noted among groups of birds fed 4.5 – 5.0 mg pyridoxine/kg (Table 2). In addition these groups consumed significantly less feed. Trembling fits and convulsions preceded death in most cases. Postmortem examination indicated gizzard erosion and haemorrhagic patches around the follicles of the wing feathers.

Pyridoxine-deficient chicken became anaemic due to a failure in the normal mechanism of haemoglobin synthesis (Scott *et al.* 1982) and showed marked reduction in plasma proteins and in aspartate aminotransferase activities in serum and liver (Kirchgessner and Maier 1968; Ogunmodede 1981) and Cheney *et al.* (1965) concluded that serum transaminase activity is a sensitive indicator of pyridoxine status. In support of earlier reports, the results of the present study indicated that birds fed 4.5-5.0 pyrodoxine/kg feed developed anaemic condition as indicated by having lower haemoglobin concentration and PCV than those given higher dietary pyridoxine levels (Table 2). In the case of enzyme activities in birds (Table 3), there was marked reduction in aspartate aminotransferase activity in serum and livers of groups of birds given 4.5 – 5.0 mg pyridoxine/kg feed than those fed higher dietary levels of the vitamin. The results of mortality, haemoglobin concentration, PCV and transaminase activities in serum and livers appeared to suggest that guinea corn-PKM diet should be supplemented with pyridoxine up to 5.5 mg per kg of feed for promotion of good health in broiler chicken.

Apparent nutrient retention in experimental broilers was signficantly affected by the dietary treatments where higher dietary levels of pyridoxine in the diet resulted in remarkable utilisation of nitrogen, lipid and metabolizable energy (Table 2). This result is in agreement with the findings of earlier reports that deficiency of pyridoxine led to an impairment of the utilisation of protein (Fuller 1964) and lipid (Ogunmodede 1981). The results of the present study indicated that supplementation of the diet with vitamins up to 6.0 mg/kg seemed adequate for optimum utilisation of the nutrients.

The importance of producing carcass of desirable quality in the economics of broiler production underline the need for the assessment of carcass characteristics of experimental chickens. Information is however lacking on the pyridoxine requirement for broiler carcass characteristics evaluated in this study. The results in Table 4 indicate that good carcass characteristics require pyridoxine as evident from the significant dietary treatment effect on the parameters. It appears that while supplementation of the practical guinea corn-PKM diet with pyridoxine up to 5.5 mg/kg seemed inadequate for carcass weight, total edible meat weight, total bone weight and meat: bone ratio, it was marginal for dressing percentage and meat and bone expressed as proportions of carcass weight.

Variations in the amounts of pyridoxine required by experimental broiler chicken for productive performance (i.e., feed utilisation, nutrient retention and carcass quality), health (mortality, haemoglobin concentration and PCV) and enzyme activities (aspartate transaminase

TABLE 3
Effect of dietary pyridoxine on aspartate aminotransferase activities in serum and livers of experimental broiler chickens

Pyridoxine (mg/kg feed)	Aspartate aminotransferase activity in	
	Serum (units/cm^3)	liver (units/mg dry tissue)
4.5	118c*	243
5.0	121bc	239b
5.5	172a	396a
6.0	174a	314a
6.5	182a	311a
7.0	177a	309a
7.5	176a	316a
8.0	178a	312a
±SEM**	12.42	16.10

* Values in a column bearing different superscripts are significantly (P<0.05) different.
** SEM, Standard error of the mean

TABLE 2
Feed utilisation, health performance and nutrient retention of broilers fed guinea corn-PKM based diet with supplementation of pyridoxine at 42 days

Parameter	Pyridoxine (mg/kg feed)								
	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	SEM**
Feed utilisation:									
Live weigh at 42 days (g)	914.4^{c*}	976.4^{bc}	1053.0^{bc}	1313.4^{a}	1300.8^{a}	1316.6^{a}	1351.2^{a}	1330.2^{a}	84.66
Daily weight gain (g/bird)	20.7^{b}	22.2^{b}	24.0^{b}	30.2^{a}	29.9^{a}	30.3^{a}	31.1^{a}	30.6^{a}	2.01
Daily feed intake (g/bird)	81.8^{b}	83.5^{b}	87.8^{b}	98.6^{a}	100.6^{a}	101.8^{a}	103.5^{a}	101.2^{a}	4.18
Feed efficiency (g gain/g feed)	0.25^{b}	0.27^{b}	0.27^{b}	0.31^{a}	0.30^{a}	0.30^{a}	0.30^{a}	0.30^{a}	9.92E-03
Health performance									
Mortality (%)	5.00^{a}	2.50^{b}	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}	0^{c}	1.23
Haemoglobin (g/100cm^{3})	2.90^{c}	4.76^{b}	7.89^{a}	8.20^{a}	8.24^{a}	8.15^{a}	8.10^{a}	8.32^{a}	0.97
PCV (%)	7.2^{c}	12.8^{b}	27.4^{a}	28.1^{a}	28.0^{a}	27.6^{a}	27.8^{a}	28.2^{a}	3.93
Nutrient retention									
Nitrogen retention (%)	54.6^{b}	55.2^{b}	56.5^{b}	62.9^{a}	62.08^{a}	63.2^{a}	64.1^{a}	63.7a	1.94
Lipid retention (%)	69.2^{c}	74.1^{b}	80.8^{ab}	83.1^{a}	82.9^{a}	83.7^{a}	83.4^{a}	83.8^{a}	2.56
Metabolizable energy (Kcal/kg)	2750.2^{b}	2755.0^{b}	2784.4^{b}	2849.1^{a}	2843.5^{a}	2836.2^{a}	2843.6^{a}	2832.8^{a}	20.89

* Values in a row bearing different superscripts are significantly (P,0.05) different
** SEM, Standard error of the mean

TABLE 4
Carcass characteristics of broilers fed guinea corn-PKM diet and graded levels of pyridoxine at 42 days

Parameter	Pyridoxine (mg/kg feed)								
	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0	SEM**
Carcass weight (g)	567.84^{b*}	603.42^{b}	688.66^{b}	895.74^{a}	898.85^{a}	916.35^{a}	929.63^{a}	911.19^{a}	72.15
Dressing percentage	62.1^{b}	61.8^{b}	65.4^{a}	68.2^{a}	69.1^{a}	69.6^{a}	68.8^{a}	68.5^{a}	1.49
Total edible meat (g)	359.44^{b}	378.95^{b}	442.12^{b}	595.67^{a}	599.53^{a}	617.62^{a}	615.42^{a}	611.41^{a}	53.13
Meat (% carcass weight)	63.3^{b}	62.8^{b}	62.4^{ab}	66.5^{a}	66.7^{a}	67.4^{a}	66.2^{a}	67.1^{a}	0.85
Total bone (g)	208.40^{b}	224.47^{b}	246.54^{b}	300.07^{a}	299.32^{a}	298.73^{a}	314.21^{a}	299.78^{a}	19.14
Bone (% carcass weight)	36.7^{a}	37.2^{a}	35.8^{ab}	33.5^{b}	33.3^{b}	32.6^{b}	33.8^{b}	32.9^{b}	0.85
Meat: bone ratio	1.72^{b}	1.69^{b}	1.79^{b}	1.99^{a}	2.00^{a}	2.07^{a}	1.96^{a}	2.04^{a}	0.07

* Values in a row bearing different superscripts are significantly (P<0.05)
** SEM, Standard error of the mean

activities in serum and livers) might be due to differences in the sensitivities of the parameters to the pyridoxine status of the birds. Indeed, Whitehead (1982) reported that the first effect of vitamin deficiency is a retardation of performance; lesions and death only occur when the deficiency is more severe or prolonged. Thus health is generally less sensitive than productive performance as an indicator of requirement. It was also noted that enzyme activity as criterion of establishing vitamin requirement is not clear cut because some enzyme activities may not be optimal with vitamin intake adequate for productive purposes. Nutrient retention, on the other hand, was considered highly valid since it is linked with ultimate objective of feeding the chicken.

From the foregoing, it may be concluded that for optimum performance, broilers require at least 6.0 mg pyridoxine per kg of guinea corn PKM based diet. The achieved requirement estimate of the vitamin for broilers in the present study falls within the range or requirement values recommended earlier i.e. 1.2 – 7.3 mg/kg (Ogunmodede 1981, Whitehead 1982; NRC 1994). Variations in the earlier reported requirement estimates have been attributed to the involvement of pyridoxine in protein metabolism and the sources of dietary protein. Soybean, cottonseed, safflower and groundnut were the main protein sources in the various test diets in earlier studies on which requirement estimates were based. All the protein sources except soybean differ in their amino acid profiles from PKM, the plant protein source in the present study. Futhermore, higher dietary fibre content of PKM suppressed hydrolysis of its protein and consequently caused reduction in the bioavailability of its amino acids (Babatunde *et al.* 1975; Nwokolo *et al.* 1977). In addition, Best (1993) noted that dietary fibre affected the functioning of the gut microflora with consequent alteration of micronutrient requirement of birds. Dietary protein contributed by guinea corn, the major energy source in the diet, is also characterised by poor digestibility and reduced bioavailability of its amino acids (Nelson *et al.* 1975) which might have influenced the estimated pyridoxine requirement of broilers in this study.

REFERENCES

AOAC. 1980. *Official Methods of Analysis.* 13th edn. Association of Official Analytical Chemists. Washington DC.

ANON. 1975. The Nutrient Requirements of Farm Livestock. No. 1 Agricultural Research Council Poultry. London.

ANON. 1966. *Methods of Vitamin Assay.* 3rd edn. Association of Vitamin Chemists Inc. New York: NY Interscience Publishers.

ANON. 1994. *Nutrient Requirement of Poultry.* 9th edn. National Research Council Washington Dc. National Academy of Sciences.

BABATUNDE, G.M., B.L. FETUGA, O. ODUMOSU and V.A. OYENUGA. 1975. Palm kernel meal as a major protein concentrate in the diets of pigs in the tropics. *Journal of Science of Food and Agriculture* **26**: 1279-1291.

BEST, P. 1993. Ingredients for Broiler Diets: Choose wheat by its fibre fraction? *Feed International.* December 1993. A Watt Publication.

CHENEY, M.C., D.M. CURRY and G.H DEATON. 1965. Blood transaminase activities in vitamin B6 deficiency. *Canadian Journal of Physiology Pharmacology* **4**: 579-589.

DUNCAN, D.B. 1995. Multiple range and multiple F test. *Biometrics* **11**: 1-42.

FULLER, H.L. 1964. Vitamin B_6 in farm animal nutrition and pets. *Vitamins and Hormones* **22**: 659-676.

GRIES, C.L and M.L. SCOTT. 1972. The pathology of pyridoxine deficiency in chicks. *Journal of Nutrition* **102**: 1259-1268.

KIRCHGESSNER, M. and D.A MAIER. 1968. Zu Bestimung des Vitamin B6 bedarfs von Geflug. *Archiv fur Tierenahrung* **18**: 300-308.

LAMB. G.M 1981. *Manual of Veterinary Laboratory Techniques.* Kenya, CIBA-Geigy.

NELSON, T.S., E.L. STEPHENSON, A. BURGOS, J. PLOYD and J.O YORK. 1975. Effect of tannin content and dry matter digestion on energy utilisation and average amino acid availability in hybird sorghum grains. *Poultry Science* **54**: 1620-1623.

NWOKOLO, E.N., D.B BRAGG, and H.S SABEN. 1977. A nutrive evaluation of palm kernel meal for use in poultry rations. *Tropical Science* **19**: 147-154.

OGUNMODEDE. B.K. 1981. Supplementation of groundnut-based broiler chick diet with pyridoxine. *British Poultry Science* **22**: 241-246.

OLOYO, R.A. 1997. Effect of guineacorn/palm kernel meal based diet with niacin supplementation on the performance of broilers. *Indian Journal of Animal Science* **67**: 442-425.

OLOYO, R.A and B.K OGUNMODEDE. 1990. Performance of broilers fed varying levels of biotin and palm kernel oil. *Journal of Animal Production Research* I **10**: 67-77.

REITMAN, S. and S. FRANKEL. 1957. A colometric method for the determination of serum glumatic oxalacetic and glumatic pyruvic transaminase. *American Journal of Clinical Pathology* **28**: 56-63.

SCOTT, M.L., M.C. NESHEIM, and R.J. YOUNG. 1982. *Nutrition of the Chicken.* Ithaca, New York: M.L Scott and Associates.

STEEL, R.G.D. and J.H. TORRIE. 1960. *Principles and Procedures of Statistics.* NY York: Mc-Graw Hill Book Company.

TONHAZY, N.E, N.G. WHITE and W.W. UMBREIT. 1950. A rapid method for the estimation of the glumatic aspartic transaminase in tissues. *Archieve of Biochemistry* **28**: 36-42.

WHITEHEAD, C.C. 1982. *B-Vitamin Nutrition in Poultry.* Information Service. Basle Hoffmann-La Roche.

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COMMUNICATION

Parasitism of *Bradybaeneus similaris* Ferussas (Gastropoda: Bradybaenidae) by *Megaselia Scalaris Loew* (Diptera: Phoridae): A New Record

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The *Bradybaena similaris* Ferussas, commonly called round snail, is a terresterial species, considered as an oppurtinist pest in the trophics especially at altitude of over 1,000 meters above sea level (Nor' Aini *et al.* 1995). The snails has a potential to become an important agricultural pest especially on *Brassica* crops such as *B. chinensis* L. and *B. juncea* Cosson (Murali 1991; Ahmad and Ho 1980). Our field observations showed that damaged on growing cabbage by *B. similaris* was comparable to damage by larvae of the diamonback moth, *Plutella xylostella* L., the major insect pest of cabbage.

B. similaris are currently controlled by baited metaldehyde (Siputox) at 3% and 5%. However, evidence of increasing resistence of the snails to this mulloscicide (Salmijah *et al.* 1996) is supported by decreasing field efficacy of the baited Siputox at 3% and increasing usage at 5% by the farmers of Cameron Highlands. Laboratory studies by Noran *et al.* (1992) showed that only 1.5% of *B. similaris* was killed by metaldehyde and that they were unaffected by bioinsecticide treatment, extract of *Azadirachta indica* leaves, which was toxic to the aquatic snails *Indoplanorbis exustus.* Currently, there is no report of any effective biocontrol methods against it, but screening of our laboratory cultured population revealed that the snails were parasitized by a dipteran fly, *Megalasia scalaris* Loew (Phoridae). In West Malaysia, Ahmad and Ho (1980) reported that the giant African snail, *Achatina fulica* Ferussas (Achatinidae) were parasitized by the Phorids (*Aphiochaeta scallaris* loew and *Spiniphora genetalis* Schmitt), Ephydrid (*Discomyza maculipennis* wied) and Calliphorid (*Sacrophaga* dux Thoms). However, there was no report on parasitism of *B. similaris* by any Dipteran parastoids. Therefore, this is a new record of dipteran parasitising *B. similaris* . The objective of this study was to determine the percent parasitism of *B. similaris* by the phorid fly, *M. scalaris,* and the life cycle of the parasitoid.

To measure parasitism rate of the snails by *M. scalaris* in the field, we collected 430 snails from our randomly selected cabbage field in the Cameron Highlands, Pahang, Malaysia. The snails were then reared in four empty fish aquariums (20 cm x 15 cm x 30 cm), fed fresh cabbage leaf raised in the glass house and kept at laboratory condition for at least 10 days. Number of dead snails having the *M. scalaris* were recorded. To make sure those fly larvae were *M. scalaris* and for easier identification we continued rearing them on snails until hatched and emerged as adult flies. Mean percent parasitism was calculated as the number of dead snails with fly larvae, divided by the total number of snails collected x 100.

To study the *M. scalaris* life cycle and parasitism rate we used in the laboratory a total of 50 snails and 10 female flies (collected from the same field as above). Five snails and one female fly (per replicate) were put in each plastic container (500 ml) for 2 days, after which the fly was taken out. Adult flies were fed with 20% sucrose solution wetted on the cotton wool and put in 5 cm diameter petri dish placed in the same plastic container. Number of snails with fly eggs were recorded and used in calculating the percent parasitism. They were then kept in the same container until the eggs hatched. Number of larvae produced per snail was recorded. Larvae were transferred to petri dish (10 cm diameter) half-filled with nutrient agar (3% Gelose nutritive + distilled water, w/v) as food and kept

until pupation. The pupae were placed in plastic container similar to the above until adult emergence. A high humidity environment was maintained by placing wetted cotton wool inside the container and covering its top with aluminium foil. The emerged adults were also placed in a similar type of container and fed as above until they died. The time taken for larvae to reach pupa stage, and number of pupae formed, adult emerged and adult longevity (days from the date of emergence until they died) were recorded. The experiment was arranged following a Complete Randomize Design with 10 replicates.

The rate of parasitism in field population and laboratory reared *B. similaris* parasitized by the phorid fly were 35.0 ± 4.3 and 55.0 ± 6.8 respectively. On average, 28.8 larvae were produced per parasitized snail. Some 85.9% (±9.5) larvae survived successfully to form pupae, and of this, 76.7% (± 8.6) managed to produce healthy adults. The time taken for eggs to hatch, larval development time (to form pupae), adult emergence and longevity were 2.2, 5.5, 11.2 and 24.3 days respectively.

Our results indicate that the fly has a potential to be used in controlling the snail pest especially in combination with other controlling methods such as chemicals (molluscicides) and cultural methods as the field parasitism rate is relatively low. An augmention of field population of *M. scalaris* is possible because it is relatively easy to culture them in the laboratory. In addition, its host, *B. similaris,* for the mass rearing of the fly, the snails can be easily maintained under prolonged captivity compared with other snails.

The use of pesticides for controlling other pests in the field may affect the role of *M. scalaris* as a biocontrol agent of *B. similaris.* As such, the cabbage growers should adopt judicious use of chemical pesticides. Study on the host-parasite relationship between the snails and fly in the field should be conducted as the result could be used as an indicator as to the fly population that is affected by the heavy use of pesticides. Study should also be initiated to determine the main hosts of *M. scalaris* and its biological aspects such as longevity and fecundity. Information on *M. scalaris* ecology and biology is important because it could help us in augmenting and conserving its natural population that indirectly reduces pesticide dependence in controlling *B. similaris.*

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REFERENCES

AHMAD, Y, and T.H.HO. 1980. List of economic pests, host plants, parasites and predators in west Malaysia. *Min. Agric. Bull.* **No. 153**: 538 pp.

MURALI, P. 1991. Ekologi siput *Bradybaena similaris* di kawasan pertanian Cameron Highlands. Bachelor Thesis, Universiti Kebangsaan Malaysia. 99 pp.

NORAN, A. M., M. Z. H. HANIZA, S. SALMIJAH, M. ABDULLAH, H. L. P. AZIMAHTOL and D. NOR' AINI. 1992. The effectiveness of metaldehyde versus cabaryl in controlling *Bradybaena similaris.* In *Proceedings of the Seventeenth Malaysian Biochemical Society Conference,* pp 197-204. 23-24 Sept. 1992.

NORAN, A. M., R. A. AHMAD and M. ZAID ISMAIL. 1995. Molluscicidal efficacy of Azadirachta indica extract. *Mal. App. Biol.* **24 (1)**: 29-34

NOR'AINI, D., M. ABDULLAH, P. MURALI and M. SULAIMAN. 1995. Distribution and abundance of round snails in the agriculture gardens of Cameron Highlands, Pahang. *Mal. App. Biol.* **24(2)**: 89-94.

NOR'AINI, D., M. ABDULLAH and M. SULAIMAN. 1995. Notes on some land mollusc at Malaysian Agricultural Park, Shah Alam, Selangor. *Malaysian Applied Biology* **24(2)**: 101-104.

SALMIJAH S., S. P. SAY, and M. ABDULLAH. 1996. Tolerance development in *B. similaris* towards metaldehayde. Seminar on Pesticides in Agroenvironmental, Fate and Impact, 16 pp. 12 August, 1996. University Malaya.

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