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CONTENTS

PROPAGATION OF LESSER YAM (*DIOSCOREA ESCULENTA*) USING VINE CUTTINGS

S. Poloma, I.C. Onwueme and M. Johnston*

ABSTRACT

The traditional practice of propagating yams using setts consumes a significant proportion of harvested tubers. An attempt was made to root Dioscorea esculenta *(Lour.) Burk. vine cuttings as alternative planting material. Various rooting substances and sucrose solution were applied to five-month old yam vine cuttings. Sucrose solution prolonged the lifespan of 2-node cuttings up to 9 weeks. The cuttings (n=30) treated with sucrose (80 g l^{-1}) alone produced 13% rooting, while cuttings traeted with sucrose (80 g l^{-1}plus Serdix (3 g kg^{-1} beta - IBA) had 17% rooting. Those treated with sucrose (80 g l^{-1}) plus IBA (200 g l^{-1}) had 20% rooting. However, the growth of plants at the nursery and in the field was not vigorous, and the tubers produced weighed less than 20 g. It was demonstrated that* D. esculenta *vine cuttings can take root but could not substitute for tubers as commercial planting materials because of the low rooting percentage and poor growth in the field. It was suggested that experimenting with vine cuttings younger than 5 months might improve the vigour and yield of the yam.*

Key words: *Yam,* Dioscorea esculenta, *vine cuttings*

INTRODUCTION

Yams (*Dioscorea spp.*) are a reasonably important food crop in certain parts of Papua New Guinea. Yams figure prominently as a traditional food and in prestige systems in Papua New Guinea, as well as in Africa, the Caribbean and other Pacific Island nations (Onwueme 1994). Of the six species of yam grown in Papua New Guinea, *D. esculenta* is the most important in terms of area grown and food produced, although *D. alata* is often more important culturally (R.M. Bourke, per. com.). Traditionally, yam is propagated using tuber setts. This involves storing 20-40% of harvested tubers as planting materials for the next season. This practice reduces the amount of tubers available for food. Therefore, if an alternative method of providing planting material can be developed, all the tubers produced each season can be consumed.

Several methods have been considered. These include tissue culture (Lacointe and Zinsou 1987), yam seeds (Okoli 1975) and vine cuttings (Njoku 1963). Vine cuttings were first used for the edible yams *D. alata, D. dumetorum* and *D. rotundata* (Njoku 1963; Hill *et al.* 1981), and Vanderzaag and Fox (1981) also successfully rooted 1-6 node vine cuttings of the above three yam species. Wilson (1982) reported that cuttings of *D. alata, D. rotundata* and *D. cayenensis* can form roots in 10 to 20 days. In this trial no rooting hormones were used to initiate rooting, instead the cuttings were placed in a humid mist chamber at 80% relative humidity. The cuttings were arranged horizontally in tree-draining trays filled with clean river sand. The rooted cuttings were later transferred into soil pots, "hardened" and then planted in the field.

Most previous studies have concentrated on *D. alata, D. rotundata, D. cayenenis* and *D. dumetorum*. There have been very few reports of attempts to root vine cuttings of *D. esculenta*. Cabanillas and Martin (1978) attempted unsuccessfully to root the vine cuttings of *D. esculenta*. Therefore, the objectives of this study were to investigate whether *D. esculenta* could be rooted successfully, whether various readily available growth substances could facilitate rooting, and if vine cuttings of *D. esculenta* could substitute for tubers as planting material.

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MATERIALS AND METHODS

Vine cuttings of *D. esculenta* were taken from three sections of 5 months old plants. These were the extreme tip, the base and the middle portions. The cuttings were initially rooted in clean river sand (< 0.5 mm grain size) in four-litre pots, perforated at the base. Two-node cuttings were planted in a slightly slanting position such that one node was beneath the sand.

Two trials were conducted in an attempt to root *D. esculenta*. Trial 1 incorporated six treatments as listed in Table 1. Each treatment was replicated three times, with ten cuttings per replicate (n=30). In this trial most of the cuttings dried up after two weeks, except those receiving the sucrose treatment.

Table 1. *Treatments applied to initiate rooting of* D. esculenta *vine cuttings in Trial 1.*

Treatment number	Treatment
1	Seradix 3 g Kg^{-1} beta-IBA 3 g 1^{-1}
2	sucrose 80 g 1^{-1}
3	acetylene gas
4	napthalene acetic acid (NAA) 2 g 1^{-1}
5	indulbutyric acid (IBA) 200 g 1^{-1}
6	water (control)

In Trial 2, sucrose was combined with rooting substances; indulbutric acid (IBA), Seradix (a commercial rooting powder containing 3 g kg^{-1} beta-IBA), napthalene acetic acid (NAA), and acetylene gas (Table 2). The second trial was done to determine which of the rooting substances would be most effective in initiating roots. Sucrose, IBA and NAA were applied in solution to the cuttings after planting. Seradix was applied by dipping the wet end of the cuttings in Seradix powder up to the lower node before planting. The treatment with acetylene gas involved first producing the gas by placing 3 g of calcium carbide in a plastic weighing vessel containing a few drops of water. The acetylene gas was trapped in an enveloping plastic bag in which the cuttings were fumigated for twelve hours before planting.

Table 2. *Treatments applied to initiate rooting of* D. esculenta *vine cuttings in Trial 2.*

Treatment number	Treatment
1	Seradix 3 g 1^{-1}
2	sucrose 80 g 1^{-1}
3	NAA 2 g 1^{-1}
4	IBA 200 g 1^{-1}
5	sucrose 80 g 1^{-1} + IBA 200 g 1^{-1}
6	sucrose 80 g 1^{-1} + Seradix (3 g kg^{-1} beta-IBA) 200 g 1^{-1}
7	sucrose 80 g 1^{-1} + NAA 2 g 1^{-1}
8	sucrose 80 g 1^{-1} + acetylene gas
9	water (control)

Cuttings were inspected once each week. At each inspection, cuttings were carefully dug up and inpsected for signs of root development. After 9 weeks, the cuttings that had rooted were transferred to a 3:1 mixture of sterilised soil and chicken manure. The planted cuttings were raised in a nursery under 70% shade until shoots formed. After 8 weeks in the nursery, the small plants were moved to full sunlight for one week, and then planted in prepared soil in the field. Observations were made subsequently on the field performance of the plants.

RESULTS AND DISCUSSION

Observations from Trial 1 showed that sucrose (treatment 2) helped to prolong the lifespan of the two-node cuttings. This was evident from the 80% survival rate observed after 2 weeks. In Trial 2, treatments incorporating sucrose solution kept the cuttings alive for up to 9 weeks as compared with 2 weeks where only water was used. Cuttings taken from the extreme base and tip did not root at all, only cuttings from the middle portion of the vines rooted. It was observed that the treatment of sucrose + IBA produced roots on 20% of the cuttings, while sucrose alone produced roots on 13% of the cuttings and sucrose + Seradix produced roots on 17% of the cuttings (Table 3). None of the growth substances were able to cause rooting by themselves unless sucrose was also present. This shows the importance of sucrose in the rooting medium.

Table 3. *The effect of sucrose on root initiation of* D. esculenta *vine cuttings (n=30) in Trial 2.*

	Treatment		Percentage of cuttings rooted
1	Seradix	3 g l^{-1}	0
2	sucrose	80 g l^{-1}	13
3	NAA	2 g l^{-1}	0
4	IBA	200 g l^{-1}	0
5	sucrose	80 g l^{-1} + IBA 200 gl^{-1}	20
6	sucrose	80 g l^{-1} + Seradix (3 g kg^{-1} beta-IBA) 200 g l^{-1}	17
7	sucrose	80 g l^{-1} + NAA 2 g l^{-1}	0
8	sucrose	80 g l^{-1} + acetylene gas	0
9	water (control)		

Although the results indicate low percentages of rooting they show that *D. esculenta* vine cuttings can be rooted when sucrose and rooting substances like Seradix and IBA are applied. Wilson (1982) noted that other species (*D. alata*, *D. rotundata* and *D. cayenensis*) could root within 2 weeks. However, *D. esculenta* vine cuttings took 2 months to produce roots and showed a very low percentage of root initiation. Wilson (1982) did not report on the tuber formation of the vine cuttings. When the root cuttings were grown in the field, the resulting tubers after five months were very small and weighed less than 20 g each. This demonstrates that cuttings of *D. esculenta* are a poor substitute for tubers as planting materials for subsistence or commercial production.

It is possible that experimenting with younger plants and accounting for other variables, such as the nutrition of plants at the nursery and in the field, could yield more promising results.

CONCLUSION

The study showed that sucrose prolonged lifespan of vine cuttings and produced some rooted cuttings for this species, although, the percentage is still low. This is not improved much by using other agents such as Seradix and IBA. It is possible to get a small proportion of cuttings from the middle portion of vines to root, provided they are grown in sucrose solution and plants grown from vine cuttings produced very small tubers only. Hence the techniques investigated in this study have no immediate application by subsistence or commercial yam producers.

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EFFECT OF DIFFERENT TYPES OF FUNGICIDES ON EARLY BLIGHT AND YIELD OF TOMATO

Tony G. Gunua* and Pere Kokoa**

ABSTRACT

*Early blight (*Alternaria solani*) is an important foliar disease of tomato in Papua New Guinea. A trial was conducted to evaluate four broad-spectrum fungicides for their efficacy on Early blight disease and yield of tomato. Plots treated with three contact curative fungicides; Chlorothalonil (Bravo, 50% EC, 0.15% a.i.); Mancozeb (Dithane M-45, 80% WP, 0.16% a.i.) and Copper oxychloride (Champion copper 50% WP, 0.10% a.i.) effectively reduced the intensity of Early blight and yielded significantly higher than the systemic fungicide, Benomyl (Benlate 50% WP, 0.10% a.i.) and the unprotected. Yield from Benomyl treated plots were much lower than the untreated. The yield loss in unprotected plots was estimated to be 65.3% There was a positive relationship between coefficient of disease index (CODEX) and yield Thus, the highest yields were obtained where the CODEX were the lowest.*

Key words: *Tomato early blight* Alternaria solani, *fungicidal control*

INTRODUCTION

Tomato (*Lycoperiscon esculenta*. Mill) is an introduced vegetable in Papua New Guinea (PNG) where it initially was grown as a minor crop in backyard gardens. Its cultivation has now increased with available market facilities, especially near big cities and towns where the demand is high (Dodd 1979, Clarkson and Tomlison 1982).

Alternaria blight or Early blight of tomato caused by *Alternaria solani* Sarauer is the most serious disease that attacks the plant at any stage of development (Ellis and Gibson 1975; Datar and Mayee 1981; Sherif and Macnab 1986). The disease can affect the seedlings, stems, leaves and both ripe and unripe fruits. Organs at the ground level are usually affected first then the disease eventually spreads upwards. The pathogen is seed borne, spreads by wind and rain splash and survives in infected plant debris in the soil as long as three years (Basu 1971; Ellis and Gibson 1975; Howe 1983, Sherif and Macnab 1986). The disease was rated as very serious in India (Datar and Mayee 1981; Choulwar and Data 1988), in America (Sherif and Macnab 1986; Brammall 1993) and in PNG (Dodd 1979; Clarkson and Tomlinson 1982). The disease was first recorded in this country in 1963 (Shaw 1984).

The pathogen's inoculum spores can be reduced culturally by roughing and garden practice, chemically by fungicides, through quarantine by avoidance or restriction and genetically through the use of resistant or highly tolerant varieties. These varieties reported in other countries (Gardner 1988; Brammall 1993) are not available in PNG. Roughing has been reported to be effective on highly tolerant varieties (Brammall 1993). This method is not suitable for the susceptible varieties that PNG farmers are exposed to. Therefore, chemical control is seen as the most effective short term control method for aspiring farmers who grow tomatoes on a large scale near big cities where market is accessible and the disease is endemic.

Broad spectrum fungicides such as Chlorothalonil, Copper oxychloride, Mancozeb, Maneb and Captafol at manufacturers recommended rates have proved effective in Early blight control in other parts of the world (Datar and Mayee 1981; Howe 1983; Sherif and Macnab 1986, Choulwar and Datar 1988). In this country, Preston and Kowor (1988), used some of these fungicides to control Early blight on potato where the disease was very

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serious. Clarkson and Tomlinson (1983) recommended carbarnate fungicides (Maned, Zebeb abd Nabcizeb) at 150 g per 100 litres of water per hectare for the control of tomato Early blight disease in this country for large scale growers. This recommendation was made without any field trials under PNG conditions. Fungicides on the market need to be screened under local environmental conditions and only effective ones should be recommended.

Because of increased growing of tomato, the wide spread and endemic situation of the disease and the unavailability of information on effective fungicides for tomato early blight control in PNG highlands conditions, four broad spectrum fungicides were screened for their efficancy. The main objectives were to determine the best fungicides that reduce disease incidence and increase yield, to estimate the yield loss due to the disease and to predict whether there was any relationship between disease incidence/severity and yield.

MATERIALS AND METHODS

The trial was carried out at Aiyura at about 1650 m altitude. The long term average monthly rainfall between the months of April to September is between 125-140 mm. Long term average daily temperatures and relative humidity are between 20-30°C and 80-96% respectively. The soil type used was friable, clay loam and high in organic matter. The trial was planted on the 22nd of April and completed harvesting on the 2nd of September 1993.

The food variety, Grosse Lisse seeds were sown in steam sterilized soil mixture of 2:1:1 parts of top soil, chicken manure and river sand respectively. Seed trays were watered twice everyday from sowing until before transplanting. Prior to transplanting at 31 days after sowing (DAS), seedlings were hardened 3-4 hours in the afternoons under moderate sunlight for 7 days. Seedlings were planted in holes that had 20 gram of inorganic fertilizers NPK (12 parts nitrogen, 12 parts phosphorus, 17 parts potassium and 2 parts magnesium) and triple super phosphate (TRSP) were mixed in the ratio of 2:1. A 5x5 Latin square design was used for the trial. Plants were spaced at 0.6 m between plants and 1.0 m between rows. Plots and blocks were spaced at 1.5 m and 2.0 m respectively. A sample of four plants out of eight were used from each plot to assess the disease incidence and severity of leaves, fruit and yield. Plants were staked at 21 days after planting (DAP). Branches and shoots seen to be excessive were removed leaving standard two shoots per plant for fruit bearing. Weeds were removed manually by spade every week.

Foliar pests of tomato, especially larvae of Lepidoptera species, *Helicoverpa armigera* and *Spodoptera litura* were controlled by a broad spectrum insecticide (Orthene) at 3 g/L. First application was at 48 DAP, second was at 72 DAP and the third at 100 DAP. The insecticide was applied to reduce insect population in all plants.

Fungicide application

Three non-systemic and one systemic fungicides were screened for their efficacy in tomato early blight control. The systemic fungicide was Benomyl (Benlate, 50% WP, 0.1% a.i., 200 g/100 L/ha) and the non-systemic fungicides were; Chlorothalonil (Bravo, 50% EC, 0.15% a.i. 300 ml/100 L/ha), Mancozeb (Dithane M - 45, 80% WP, 0.16% a.i. 200 g/100 L/ha) and Copper oxychloride (Champion copper, 50% WP, 0.10% a.i. 200 g/100 L/ha). The fungicides were applied bi-monthly, starting first application at 29 DAP and ending 104 DAP before the last harvest. Four hand pump knapsack sprayers were used for each fungicide. The spray volume of 10 litres was increased to 15 litres at 63 DAP to compensate for the increase in foliage. Control plots were not sprayed.

Disease evaluation

Inoculation was achieved by naturally occurring inoculum. The field assessment of the disease was done first on the leaves at 83 DAP and on fruit at each picking. Pest damage on the fruits was also noted.

Leaf assessment

Four innermost plants were taken as a sample for each treatment and were assessed for the disease incidence and severity. Leaves, 70 cm from ground level were scored for early blight infection using modified disease rating scale of Singh and Shukla (1986). A scale between 0 and 4 was used, 0 for no lesions on leaves and 4 for 76-100% necrotic

area. Percent disease incidence (PDI) and percent disease severity (PDS) on the plants were determined using the formula by Datar and Mayee (1981). PDI is the number of affected plants or plant organs over the total. PDS is the extent of damage of the affected plant organ according to the above scale,
PDS vix; = where:

$$PDS = \frac{\text{Sum of ratings of leaves affected} \times 100}{\text{Number of Leaves observed} \times 4}$$

The Coeffecient of Disease Index (CODEX) was calculated to quantify the amount of infection, where:

$$CODEX = \frac{PDI \times PDS}{100}$$

Fruit assessment

Ripe fruits were first harvested at 96 DAP (27 July 1993) and continued weekly for five weeks, ending at 121 DAP (2 September 1993)

The same two parameters used to quantify the amount of infection on leaves were used on fruits at each picking since the fungus causes severe rots on ripe fruits. Fruits were classified as marketable and non-marketable according to appearance in size and health. They were scored zero (0) for no rots and a plus (+) sign with measured diameter in centimeters of necrotic lesions for rots. A score range of 0-4 was used to group infected fruits into classes. A score of 0 was given for fruits without lesion, a score of 1 for fruits with lesion diameter between 0.1 - 1.0 cm and a score of 4 was given where the lesion diameter was greater than 3 cm. Weights of both marketable and non marketable fruits were measured with an electronic top-pan balance.

Data analysis

Fruits were divided into four groups after weighing. The groups were non-diseased and not attacked by insect pest (NDNP); non-diseased but attacked by pest (NDP); diseased but not attacked by pest (DNP) and both diseased and attacked by pest (DP). The percentage of fruits in each group was calculated. To determine the efficacy of fungicides, total yield of NDNP group of marketable fruits expressed in tonnes per hectare were compared with CODEX of both leaves and fruits. For comparisons, yield of sprayed plots were compared with unsprayed. The yiel loss was determined as the difference between the highest yield of sprayed plots and the control over the highest yield expressed in percentage. Other comparisons made were between systemic and non-systemic and the cheapest and expensive fungicide(s). The cheapest being Copper oxychloride and the most expensive being Chlorothalonil. Yield of NDNP was analysed by analysis of variance and means seperated by Duncan's multiple range test. Total NDNP yield was regressed against CODEX to quantify the effect of disease on yield.

RESULTS

Fruit

Diseased fruit caused by tomato early blight was highest in Benomyl treated plots and lowest in Chlorothalonil sprayed plots (Table 1). Non-diseased marketable fruits affected by pest was higher in the second and third harvests in all treatments and declined in the last harvest. The number of diseased marketable fruits affected by pest decreased after the first harvest in all treatments. Plots treated with Chlorothalonil and Mancozeb had substantially lower number of diseased fruits affected by pests than the other treatments in all harvests. The CODEX of fruits was higher on Benomyl treated plots in the first three harvest and decreased in latter harvests (Table 2). Generally the CODEX of fruits on Chlorothalonil and Mancozeb treated plots were lower than the other treatments.

Leaves

Benomyl and untreated plants were severely affected and therefore the CODEX measured was 100% for each treatment, followed by copper oxychloride with 73%. The CODEX score for Chlorothalonil and Mancozeb were 52% and 38% percent respectively. These measurements were done after the 5th spray schedule.

Yield

In the analysis of variance of non-diseased non-pest infested group of marketable yield, significant

Table 1. *Number of marketable and non-marketable fruits as influenced by fungicidal sprays grouped into respective classes at each harvest.*

MARKETABLE					NON MARKETABLE				
Harvest date	Treat-ments	NDNP1	NDP2	DNP3	DP4	NDNP	NDP	DNP	DP
27/7/93	A	17(46)	0	6(16)	0	3(8)	0	9(24)	2(6)
	B	43(78)	0	4(7)	0	4(7)	0	3(6)	1(2)
	C	42(82)	0	3(6)	0	1(2)	0	5(10)	0
	D	56(71)	0	5(6)	0	3(4)	0	10(13)	5(6)
	E	36(48)	0	1(1)	0	7(9)	0	25(33)	7(9)
2/8/93	A	19(38)	1(2)	5(10	1(2)	0	4(8)	14(28)	6(12)
	B	34(58)	6(10)	2(3)	0	1(2)	12(20)	4(7)	0
	C	31(49)	7(11)	4(6)	3(5)	8(13)	2(3)	6(10)	2(3)
	D	35(54)	4(6)	5(8)	0	5(8)	7(11)	7(11)	1(2)
	E	18(47)	4(11)	4(11)	2(5)	0	5(13)	4(11)	1(2)
12/8/93	A	28(27)	1(1)	13(13)	1(1)	20(19)	8(8)	26(25)	6(6)
	B	148(73)	11(5)	7(3)	0	12(6)	6(3)	8(4)	10(5)
	C	75(67)	4(4)	5(5)	3(3)	7(6)	6(5)	7(6)	4(4)
	D	71(52)	10(8)	10(8)	5(4)	12(9)	7(5)	10(8)	8(6)
	E	17(32)	2(4)	4(8)	1(2)	10(20)	3(6)	5(9)	10(19)
19/8/93	A	10(20)	0	6(12)	0	11(23)	5(10)	14(29)	3(6)
	B	48(56)	3(3)	9(10)	3(3)	6(7)	2(2)	10(12)	6(7)
	C	47(63)	3(4)	2(3)	0	7(9)	6(8)	8(10)	2(3)
	D	18(33)	1(2)	8(15)	0	7(13)	1(2)	14(46)	5(9)
	E	21(47)	1(2)	8(18)	2(4)	7(16)	2(4)	1(2)	3(7)
26/8/93	A	4(12)	0	2(6)	0	14(43)	0	12(36)	1(3)
	B	25(46)	0	7(13)	0	7(13)	4(7)	10(19)	1(2)
	C	37(63)	1(2)	5(8)	1(2)	4(7)	0	10(16)	1(2)
	D	24(43)	2(4)	8(14)	0	13(24)	0	7(13)	1(2)
	E	8(33)	1(4)	0	0	4(17)	0	10(42)	1(4)

NB: Figures in parenthesis ( ) are expressed in percentage

A: Benomyl (Benlate)
B: Chlorothalonil (Bravo)
C: Mancozeb (Ditane M-45)
D: Copper oxychloride (champion copper)
E: Control (Unsprayed)

[1] Non-diseased and not attacked by pest
[2] Non-diseased but attacked by pest
[3] Diseased and not attacked by pest
[4] Diseased and attacked by pest

Table 2. *Coefficient of Disease Index (CODEX) of fruits at each harvest, leaves at 83 DAP and the yield as influenced by fungicidal sprays.*

	Benomyl	Chlorothalonil Mancozeb		Copper oxychloride	Control
CODEX Fruits at each harvest[a]					
27/7/93	41.5	4.5	0[6]	1.5	0
2/8/93	33.0	0	0	2.4	20 7
12/8/93	24.9	2.0	1.65	9 9	7.0
19/8/93	10.9	2.5	0	12.5	2 2
26/8/93	4.2	9.3	13.4	6.6	
CODEX of leaves at 83 DAP[b]	100.0	52.0	38 0	73.0	100.0
Total NDNP[9]					
Marketable Yield (t/ha)	5.79b	20.98a	20.94a	18 63a	7 27b

CV 15.8%
SE of mean 0.22
SE of difference 0.31
Figures in each row followed by the same letter do not differ signnificantly according to Duncans' multiple range test.

[a] **Disease severity rating : fruits**
0 = no lesions. 1=0.1-1.0 cm lesion diameter, 2 = 1.1-2 0 cm lesion diameter.
3 = 2.1 - 3.0 cm lesion diameter, 4 = > 3 cm lesion diameter.

[6] No diseased fruit

[7] No marketable fruits

[b] **Disease severity rating : leaves**
0 = no symptoms, 1=1-25% necrotic area, 2=26-50% necrotic area, 3=51-75% necrotic area, 4= 76-100% necrotic area and death.

[9] NDNP: Non-diseased and not attacked by pest.

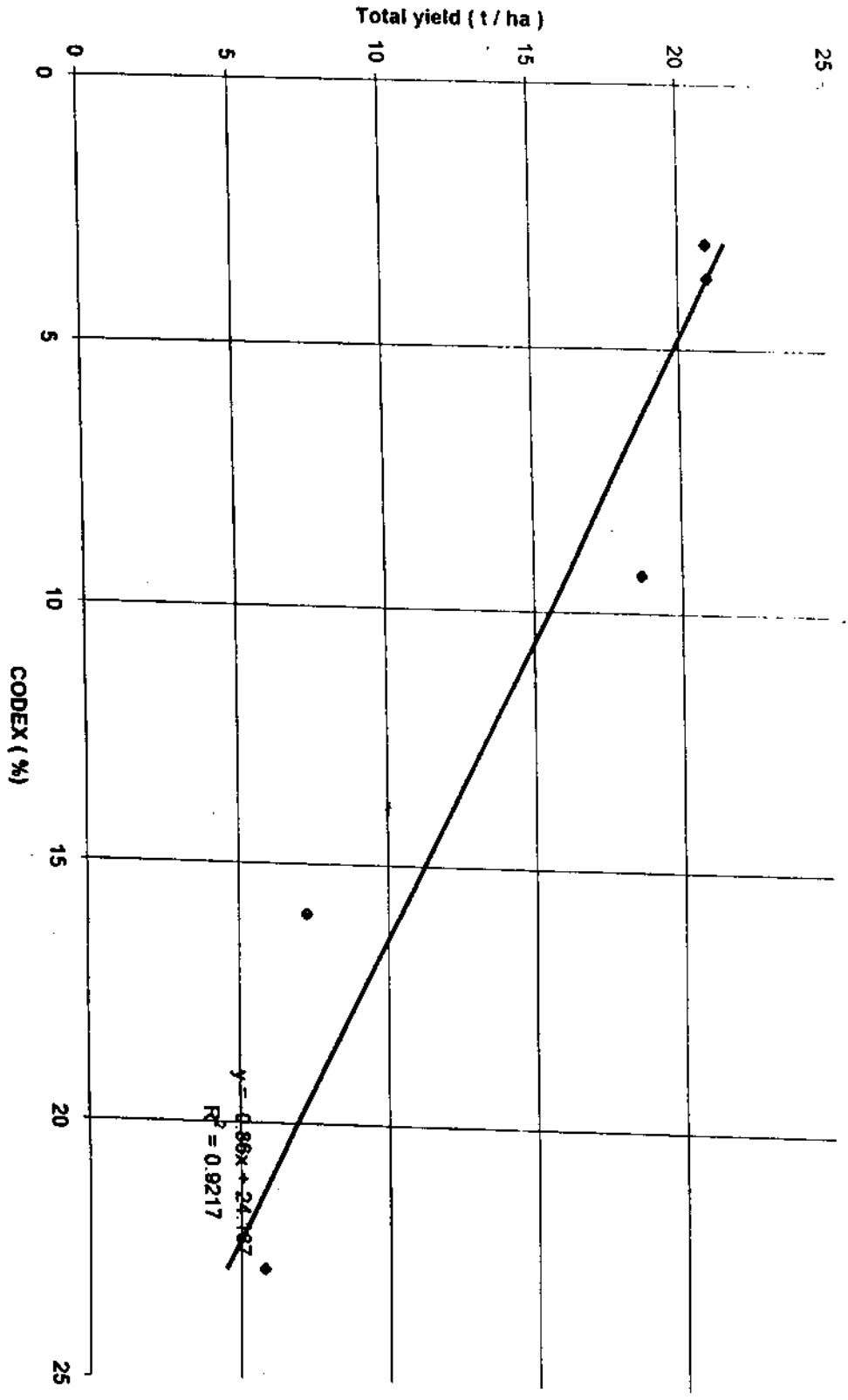

Figure 1. *Total yield (t/ha) of tomato against CODEX (%) as influenced by fungicidal sprays*

difference between treatments occurred at $p < 0.001$. Yield of treated plots, except Benomyl were significantly higher than the control (unsprayed). Yield of the contact fungicides *viz*; Chlorothalonil, Mancozeb and Copper oxy chloride were significantly higher than the systematic, Benomyl at $p < 0.001$. There was no significant difference in yield between the cheapest (copper oxy chloride) and the most expensive (Chlorothalonil) fungicides at $p < 0.001$ although there was marked difference of CODEX on leaves and fruits. Total yield was highest in Chlorothalonil treated plots with 20.98 t/ha followed by Mancozeb with 0.04 t/ha less, Copper oxychloride with 18.63 t/ha, unsprayed with 7.27 t/ha and the least being Benomyl with 5.89 t/ha (Table 2). Yield loss in non-protected plots were predicted as the difference between the control and the highest yield over the highest yield expressed in percentage. Yield loss in non protected plots in this trial was 65.3%. To quantify the effect of disease on yield, total yield (t/ha)(y) was regressed on the mean CODEX (x) of fruits. Yield (t/ha) was predicted by the equation, where: $y = 24.14 - 0.86 x$, $R^2 = 0.9217$ (Figure 1).

DISCUSSION

The tomato variety, Grosse Lisse, is very susceptible to Early blight. The disease has been reported to be very serious on tomato (M. Kanua, pers. comm) and potato (*Solanum tuberosum*) (Preston and Kowor 1988) in the Highlands of PNG. It is also reported to be serious in many other parts of the world. Although serious, conflicting reports exist on the effect of the disease on yield. In North America, control of early blight was not recommended because fruit load was established before the disease became established and thus the disease had little effect on the yield (Horsfall and Heuberger (1942). In Ontario, USA, most cultivars treated with fungicides did not improve yield although leaves were severely defoliated by Early blight (Brammall 1993). He mentioned that the local weather had an influence on the disease development. However the time blight became established and rate of subsequent disease progress were considered more important

At Aiyura the fungicide treatments yields were significantly higher than the control except for one Aiyura experiences annual rainfall of more than 2000 mm, average daily temperatures of between 20 - 30°C and relative humidity between 80-96%. The weather pattern here is ideal for early blight disease development and spread as reported by Ellis and Gibson (1975). Several workers have reported that fungicides have proven to reduce early blight severity and increase yield in places where they experience similar weather like Aiyura (Datar and Mayee 1981; Choulwar and Datar 1988; Preston and Kowor 1988 and Brammall 1993). Some of these workers also mentioned that under such weather regimes, proper timing of initial application of fungicides resulted in reduction of inoculum, and consequently reduced disease severity and increased yields.

In this investigation, Mancozeb, Chorothalonil and Copper oxychloride gave twice the yield of the control treatment. The fungicides were reported to be effective against Early blight disease control (Datar and Mayee 1984, Choulwar and Datar 1988). The three contact fungicides gave longer protection on the plants thus more marketable fruits were harvested in the last harvests than the systemic and control groups. By that time Benomyl and untreated plots had only a few heavily infested leaves remaining on the plants. Mancozeb and Chlorothalonil were effective in Early blight control and gave similar higher yields with Copper oxychloride being the next best. The yield loss due to early blight on tomato in this trial was estimated to be 65.3%. The yield loss estimated here is less than that observed by Datar and Mayee (1981) (78% loss) and greater than that reported by Sherif and Macnab (1986) (30% loss). There was a positive relationship between CODEX and yield. Highest yield were obtained where the CODEX were lowest indicating the efficacy of the tested fungicides.

Although Mancozeb is as effective as Chlorothalonil in controlling Early blight, tomato processors in Ontario, have questioned the regisration of Mancozeb and were not accepting tomatoes with Mancozeb which would not be recommended until it is cleared. So based on this trial, Chlorothalonil and Copper oxychloride could be recommended for Early blight control on tomato. Benomyl did not have any effect on the disease.

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ANTI-QUALITY AN TOXIC COMPONENTS IN SOME FOOD PLANTS CONSUMED BY HUMANS AND LIVESTOCK IN THE SOUTH PACIFIC REGION: A REVIEW

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ABSTRACT

*A number of foods in the South Pacific region are rich sources of carbohydrates and proteins. Most contain anti-quality and toxic components which make them unsafe as protein and carbohydrate sources in human and livestock nutrition. The presence of saponins, haemagglutinins, tannins (total and condensed), trypsin inhibitors, cyanogenic glucoside (HCN), alkaloids and other compounds in cassava and by-products (*Manihot esculenta *Crantiz); cocoyams: taro or tannia (*Colocasia esculenta *(L.) Schott and* Tannia (Xanthosoma*); cowpeas (*Vignia unguiculate *Walp); banana/plantains (*Musa *spp.); cocoa beans and cocoa husk (*Theobroma cacao*); coffee pulp meal (*Coffee arabica*) and copra meal and other coconut by-products (*Cocos nucifera*) are not uncommon. The presence of anti-quality and toxic components make diets prepared with them unpalatable and unacceptable to humans and livestock, and interfere with nutrient bioavailability and utilization. Cooking, drying, soaking, steeping and fermentation are simple means of detoxifying and reducing the presence of anti-quality and toxic components in these food sources*

Key words: *Anti-quality, toxic components, foods, human, livestock, South Pacific*

INTRODUCTION

Many food sources for humans and livestock contain anti-quality and toxic factors which when consumed could lead to toxicity and sudden death (Aregheore and Agunbiade 1991). Anti-quality components (factors) are substances which either by themselves, or through their metabolic products, interfere with food utilization and affect the health and production of animals (Makkar 1993) and humans. However, other anti-quality factors such as gossypol (from cotton seed meal) and HCN have direct effects on cellular function of animals and humans. Kumar (1992) defined them as "those substances generated as in natural feed stuffs by the normal metabolism of species and by different mechanisms which exert effects contrary to optimum nutrition". They reduce human and animal productivity and may also cause toxicity during periods of scarcity. This also applies to animals in confinement when feed rich in these substances are consumed in large quantities (Benjamin 1995). Efforts are being made to identify and detoxify the toxic and anti-quality factors in food and feed stuffs to improve their nutritional value using chemical or biotechnological means (Makkar 1993).

Anti-quality components in food and feed stuffs can affect protein utilization and digestion, metal on utilization, anti-vitamins and other metabolic processes (Makkar 1993) The mode of action of most toxic and anti-quality components have been documented by Makkar (1991) and their biosynthesis by Harborne (1989). This review deals specifically with those that affect protein utilization and metabolic processes. It is also aimed as a quick reference material for recommending the use of these food and feed stuffs as protein and carbohydrate sources to humans and small livestock owners.

In particular the review examines the implications of toxic and anti-quality components present in cassava and cassava leaf meal, (*Manihot esculenta* Crantx), cocoyams (*Colocasia* spp. and *Tannia xanthosoma*), cowpea (*Vignia unguiculate* Walp), banana/plantain (*Musa* spp.), cocoa beans and

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cocoa by-product meal (*Theobroma cacao*), coffee pulp meal (*Coffea arabica*) and copra meal and coconut by-products - penu (*Cocos nucifera*) used in the nutrition of humans and livestock. These cultivated plants grow abundantly in the South Pacific islands and simple methods that could be used for the detoxification of anti-quality and toxic components them are discussed.

CASSAVA

Cassava (*Manihoit esculenta* Crantz) is an important component of the diet in the South Pacific just as in other parts of the world. It is an ubiquitous crop and the demand for it is increasing particularly during the economic recession in most developing countries. Cassava's low cost has necessitated the increased use of it in both human and livestock nutrition. Except for the stem, virtually every part of cassava plant is used in human and livestock nutrition.

Cassava root meal

Fresh and dried cassava root is an excellent energy source for livestock (Naidu 1989). It has a high concentration of cyanogenetic glucosides (hydrogen cyanides, HCN), linamarin and lotaustralin. Nartey (1968), reported that linamarin accounts for 93% and lotaustralin, 7% of the total cyanogenetic glucosides present in cassava. Its pressence varies widely and is dependent on the variety (sweet or bitter), climate and cultural conditions. The inclusion of cassava in the diets of pigs and poultry at high concentrations resulted in reduced growth rate because of its low protein content (Job 1975).

Although there is little informaton on cyanide toxicity in livesotck (Aregheore 1992), Alfonso and Ayala (1991) gave the toxic level of cyanide in ruminant animal foods as 200 mg/kg fresh mass. Consequently, Montgomery (1965) and Oke (1969) have reviewed the basic role of HCN in human nutrition. The concentration of HCN which causes toxicity in man is not documented (Aregheore and Agunbiade 1991), however, HCN interferes with body's oxidative processes. Oyenuga (1968) reported that traces of HCN in the blood and cells of tissues paralyse the enzyme cytochrome oxidase and this suppresses tissue oxidative processes which lead to tissue suffocation and death.

The degree of cassava toxicity varies directly with the concentration of the free HCN present which may be between 10-370 mg HCN/kg of fresh root (Bolhuis 1954). Improper processing of cassava into the different consumable by-products may leave traces of HCN, in particular linamarin making the final product unsafe for consumption by humans and livestock. The use of cassava as a cheap source of carbnodydrate appears promising however, its toxic factors should be taken into account.

Cassava leaf meal

The leaves of cassava are relished as vegetable in human and livestock nutrition. It has been demonstrated that cassava leaf meal could be successfully used as a protein, mineral and xanthophyll source in poultry diets (Agudu 1972, Ravindran *et al.* 1986). Available ingredients determine the level of cassava leaf meal inclusion in poultry diets. Ross and Enrinquez (1969) demonstrated that at low levels of inclusion, the feeding value of the meal is similar to alfalfa meal. Also Ravindran *et al* (1986) and Ravindran (1993) indicated that as a substitute for coconut meal or cottonseed meal, it can be used up to levels of 10-15 g kg^{-1} (10-15%) with no adverse effects on performance of poultry. Cassava leaf meal has an appreciable amount of metabolizable energy for poultry with a range of 6.65-7.95 MJ kg^{-1} (Hutagalung *et al.* 1974). At high dietary levels, the meal has an unfavourable effects due to bulkiness, reduced energy intake and methionine deficiency.

In pigs, the feeding of fresh cassava leaves resulted in depressed palatability. Growth performance was also lowered with increasing proportions of leaves in diets (Manendranathan 1971; Alhassan and Odoi 1982). The adverse effects were evident due to high hydrocyanic acid levels in fresh leaves (Ravindran 1993). Although, cassava leaves have a great potential in human, monogastric and ruminant nutrition, the high fibre and cyanide contents limits their use as a major source of protein. The leaves of cassava also contain condensed tannins (Ravindran 1993), and their presence in cassava leaves is a concern (Reed *et al.* 1982) when used in monogastric or ruminant nutrition. Tannin contents in cassava leaves however, increase with maturity of the plant (Ravindran and Ravindran 1988) and also varies between cultivars (Padmaja 1989). Tannins have the ability to lower protein digestibility and amino

acid availability by forming indigestible complexes with dietary proteins or by inactivation of proteolytic enzymes (Kumar and Singh 1984, Makkar 1993). Cassava leaves are also known to have high fibre content and this affects its digestibility (Oke 1978).

Detoxification of cassava root meal and leaves

Processing is a key element in reducing HCN concentrations in cassava tubers and leaves. Chopping or grating the roots and sun drying (10-15 days) helps to remove toxic factors present in the root. Fermentation of the tubes after grating also helps to remove toxic components. Storage time has also proved to be effective in the detoxifixation of cassava leaf meal (Ravindran 1993) for livestock and humans. With proper fortification of cassava with high quality proteins such as sulphur amino acids might help to overcome toxicity problems. (Job 1975). Also the use of elemental sulphur is very effective with ruminants (Job 1975). The anti-quality and toxic components present in the leaves of cassava such as HCN and tannins can be removed or reduced to tolerable level by wilting of the fresh leaves. Simple sun drying also help to remove the mentioned components. The use of alkalis such as NaOH is very effect in removing tannins from tannin rich leaves (Makkar and Singh 1992), and this method could also be applied to remove tannins from cassava leaf meal.

COCOYAMS: TARO AND TANNIA

(*Colocasia esculenta* (L.) Schott and *Tannia xanthosoma*)

Almost all parts of cocoyams are of value in human and livestock nutrition. Cocoyam corm contains significant amounts of vitamin C, thiamine, riboflavin, niacin, and carotene. The starch content of taro is low and more easily digestible than those of yams, cassava or sweet potato. The young leaves are taken as spinach (vegetable), being a valuable source of protein, minerals and vitamins. The corms, cormels and leaves are also used in livestock feeding. The utilization of the entire plant directly from harvesting for livestock feeding warrants research in view of the potentially high calorific value of the plant.

However, there are some limitations to the nutritional value of cocoyams. Some sources of taro have high contents fo calcium oxalate in the form of raphides (Calcium stones) which have an irritating effect on the mucous membrane when consumed (Onwueme and Sinha 1991).

Detoxification

Coursey and Booth (1977) reported that in normal culinary practice, the calcium oxalate content can be reduced by prolonged boiling (30-45 minutes), followed by pounding or maceration. Also, Oyenuga (1968) suggested that cocoyams should be cooked before being fed to livestock, since the plant contain an acid substance which is irritating to the digestive tract and may be poisonous.

COWPEA (*Vignia unguiculata* (Ll) Walp)

The seeds of cowpea are used in human nutrition, while the stems/leaves and husk are used for livestock. The seeds are high in protein and soluble carbohydrate, low in fibre and oil, and contain a fair amount of minerals. The fresh seeds and immature pods are eaten as vegetables. Like soyabean, different by-products are derived from cowpea. The stems/leaves and husk are grazed in situ by livestock immediately after harvesting. In some situations they are harvested and fed to livestock in stalls especially during the dry season.

Being a legume, it contains various natural costituents which affect its nutritional qualiy. Some of these components are proteins which inhibit specific enzyme activities e.g. the inhibitors of proteases and amylases (Whitaker and Feeney 1973). Others are the haemaglutinins, saponins and anti-vitamins (Liener 1969). Phytic acid interferes with mineral element absorption and utilization, and reacts with proteins to form complex products which have inhibitory effects o peptic digestion (Cuthbertson 1968; Barre 1956). Some have polyphenols and trypsin inhibitors, and flatus producing raffinose oligosaccharides (Amuti and Pollard 1977). Also raw cowpeas contain small quantities of oxalic acid and minute to fairly high levels of HCN (Oke 1967).

Detoxification

Heat treatment will effectively eliminate most of these undesirable substances. Other processes such as cooking, soaking, steeping, decorticating and germination are effective in reducing toxic

components (Ologhobo and Fetuga 1983) and improves its digestibility.

BANANA/PLANTAINS (*Musa* spp.)

Banana/plantain is grown in many tropical countries and is an important source of carbohydrate for humans (Swennen 1990). Also, different parts of banana./plantain are used in ruminant and mongastric nutrition. While it is not advisable to feed banana/plantain pulp to livestock, their peels, leaves and stems could be processed and used as cheap sources of carbohydrates in their diets. In the unripe form the fingers, leaves and pseudostems of banana/plantain have bitter/ astringent taste suggesting the presence of tannins and saponins. Saponins are associated with bitterness in forages and herbs and their presence in forages reduces feed intake in animals. Saponins also exhibit characteristics such as strong foaming power in aqueous solutions. High levels of saponins impair growth and causes bloating in animals especially in ruminants (Milgate and Roberts 1995).

Detoxification

Cooking of the unripe fingers removes the bitter/ astringent taste and therefore remove tannins and saponins. Cutting of the fingers and storing them for a period of 2-3 days before feeding reduces the bitter/astrigent taste caused by presence of saponins and tannins (Aregheore 1998).

COCOA BY-PRODUCTS MEAL *(Theobroma cacao)*

After drying, cocoa beans are eaten as snacks by humans. Also several by-products that are of value to livestock are generated from the cocoa processing industry. Cocoa shells are waste from the chocolate manufacturing industry (Oyenuga 1968). The value of this fraction as a possible livestock feed has received very little attention in tropical countries. However, it is a good source of animal feed especially for ruminants (Oyenuga 1968). When fed to cows it increases the butter fat and vitamin D content of the milk. The bean of cocoa after fermentation and drying constitute the cocoa of commerce which is used in the manufacture of chocolate, cocoa beverage and cocoa butter (Oyenuga 1968). Cocoa bean is high in oil, therefore very small amount should be used in livestock rations to reduce the risk of rancidity.

Cocoa husk when dried and milled is a suitable meal to meet the maintenance and perhaps part of the production rations of sheep, goats and cattle (Aregheore 1994). It has also been used in poultry rations (Adeyanju *et al.* 1978). Cocoa beans and shells are high in the alkaloid, theobromine. The presence of this alkaloid reduces its incorporation in large quantities in compound rations. Theobromine has an unpalatable taste. Palatability and toxicity problems usually occur when large quantities of either the beans/or shells are used in stock nutrition (Devendra 1978). The husk is free of theobromine but high in fibre content and this is responsible for its less efficient utilization when incorporated in high levels in poultry rations (Devendra 1978). It has been suggested that the husk is better fed on a cafeteria basis since its inclusion on an isocaloric and isonitrogenous basis was consistently uneconomical (Sonaiya 1995).

Detoxification

Absolute drying removes to a large extent, the presence of theobromine and other alkaloids in the shells and beans. Inclusion level in ruminants diets should be between 25-35% (Aregheore 1994).

COFFEE PULP MEAL (*Coffee arabica*)

Coffee is one of the economic crops grown in the South Pacific. Its pulp represents a major agricultural waste of great potential for use as an animal feed. The pulp, a major waste from the wet processing method, forms 40% of the weight of the coffee fruit (Carlos *et al.* 1982). For economic and environmental reasons, attempts have been made to utilize coffee pulp as a feed for cattle, pig and poultry but with little success (Clifford and Ramirez-Martinez 1991). The use of coffee pulp as an animal feed is associated with a number of problems, although it has a good amino acids profile (Morgan and Trinder 1980). The fresh pulp has a cruide protein content that ranges between 2.1 - 3.2%, while the dehydrated pulp has 11.2 - 12% cruid protein. If coffee pulp is used in excess of 20% of normal rations, feed utilization and

growth rate are impaired due to the presence of ill-defined antiquality and toxic components.

Various components, including caffeine, low molecular mass phenols and tannins have been blamed for the undesirable effects. Caffeine level and its effects depend on the variety. In ruminants coffee pulp produces a diuretic effects reportedly due to caffeine and the unavailability of lignified protein (Mbugua 1985). Ruminant rations that contains more than 20% coffee pulp resulted in low voluntary feed intake due to poor palatablity. In pigs and poultry rations it cannot exceed 16 and 6-8%, respectively, due to the toxic effects of caffeine, chlorogenic acids, tannins and high fibre (Mbugua 1990). Tannins interfere with protein and dry matter digestibilities by inhibiting protease and other enzymes or by forming indigestible complexes with dietary protein.

Detoxification

Ensiling improves the digestibility of the pulp for ruminants. For monogastric animals it is advisable to use the fungi *Pleurotus flabllatus* (Oyster mushrooms) and *Penicicillium crustosum* in solid state fermentation to destroy the undesirable toxic components including the chlorogenic acids plus caffeine in the pulp. The use of culture derived from ensiled coffee pulp is most efficient in growth and acidification of coffee pulp (Morgan and Trinder 1980).

COPRA CAKE AND OTHER COCONUT BY-PRODUCTS *(Cocos nucifera)*

Copra cake, the residual product after the extaction of oil from the dried meat of coconut is the most abundant and perhaps the cheapest protein and energy source available in the South Pacific region (Ochetim 1987). Depending on the method of oil extraction the cake could contain between 20-30% protein, 1-7% oil and about 7-10% crude fibre (Creswell and Brooks 1971). Levels higher than 15% in poultry diets could result in poor growth, poor feed efficiency and high mortality (Ochetim 1987). Dietary fibre and rancidity are major problems associated with the cake. Copra cake is high in fibre. Dietary fibre interferes with the absorption of other nutrients and in their macro-molecular form are anti-nutritional due to gel formation (dehydrated polysaccharides). Also the residual oil in the cake has a tendency to become rancid thereby reducing appetite for diets prepared with it. As a feed ingredient for animals, it should not be more than 15% in the diet composition (Thomas and Scott 1962).

Detoxification

Effective drying is the only means through which its rancidity (free fatty acids) can be reduced. Milling of the dry product could help to break down the cell wall constituents and assist in the safe utilization of available dietary fibre by monogastric animals.

CONCLUSIONS

The presence of tannins, saponins, lectins, trysin inhibitors, cynogenic glucoside, phytate and other compounds reduce the use of food and feed stuffs in human and livestock nutrition. Most of the food and feed stuffs are rich in protein and carbohydrate. The presence of antiquality and toxic components reduce the bioavailability of protein and other nutrients when they are used in rations for livestock. Detoxification is the only alternative to make them safe for humans and livestock. Boiling, drying, soaking, steeping, and fermentation are recommended as means to reduce antiquality and toxic components. The indigenous food and feed stuffs are abundant in the South Pacific region and simple detoxification methods will make them safe and enhance their availability as plant protein sources.

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FIELD EVALUATION OF FUNGICIDES AGAINST PURPLE BLOTCH (*ALTERNARIA PORRI*) OF BULB ONION (*ALLIUM CEPA*)

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ABSTRACT

Seven fungicides were evaluated during a dry season and a wet season for efficacy on disease incidence and disease severity of purple blotch of bulb onion. The fungicides used were benomyl, 50% WP, 10% a.i.; mancozeb, 80% WP, 0.16% a.i.; captan, 80% WP, 0.10% a.i.; chlorothalonil, 50% EC, 0.10% a.i.; metalazyl, 72% WP, 0.036% a.i.; copper-oxychloride 50% WP, 0.10% a.i. and manzeb, 80% WP, 0.16% a.i. Fungicidal treatments reduced the rate of purple blotch incidence and severity in the wet season. All the fugicides tested resulted in higher yields. Mancozeb was most effective in both the dry and wet seasons. Yield losses in unprotected plots were estimated at 53.8% and 67.5% for the dry and wet seasons respectively. Yields were negatively correlated to coefficient of disease index (CODEX).

Key words: *Bulb onion. Purple blotch.* Alternaria porri. *Fungicidal control.*

INTRODUCTION

The purple blotch disease of bulb onion (*Allium cepa.* L.) caused by the fungus *Alternaria porri* (Ellis) cif. is one of the main diseases limiting onion production in the tropics (Pathak *et al.* 1996). Initial infestation shows small white sunken spots, which then enlarge, become zonated and eventually girdle the affected area. Purple spots on the affected area can be seen only in the wet season. The pathogen can affect any part of the plant under favourable conditions. The disease was recorded in Papua New Guinea (PNG) as early as 1963 (Shaw 1984) and is now reported to be widespread (Wiles 1992 a).

The disease was reported to be very destructive in Southern U.S.A., Puerto Rico, Kenya and India (Ellis and Holliday, 1970). In India, Sandhu *et al.* (1981), reported yield loss of more than 50% on seed crops. There are no estimates of yield loss due to the purple blotch disease of onion in PNG. As resistant varieties are not available in PNG, control of the disease by fungicides is seen as the most effective short term control method. Many fungicides have been used to control the disease in certain parts of the world where the disease was serious (Gupta and Pandey 1986; Gupta *et al.* 1991, Srivastava *et al.* 1991). Wiles (1992 a) recommended 2g/1 litre of Dithane M-45 and Benlate for the control of purple blotch in PNG. This recommendations were made without proper screening of fungicides available on the market in PNG at that time.

Many new fungicides have come on the market with little or no information on their effectiveness in controlling the disease under PNG conditions. As purple blotch disease is widespread in PNG, effective fungicides need to be determined for purple blotch control under our environmental conditions. Several selected fungicides; benomyl (Benlate), chlorothalonil (Bravo), captan (Captan), copper-oxychloride (Champion Copper), mancozeb (Dithane M-45), manzeb (Dithane M-22) and metalazyl (Ridomil) were screened in two seasons, wet and dry. The present study was conducted to find out which fungicides are effective for the control of purple blotch on onion, their effect on yield and to estimate the yield loss in the dry and wet seasons.

MATERIAL AND METHODS

The field trials were conducted between August 1994 and June 1995 at Brahman, (500 m.a.s.l), Upper Ramu in the Madang Province. The dry season trial was planted on August 5th, 1994 and

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harvested on December 2nd, 1994 (119 days growing period) and the wet season trial was planted on February 6th, 1995 and harvested on June 15th, 1995 (128 days growing period). The long term average monthly rainfall for the dry and wet season ranges from 50-150 mm and over 250 mm respectively. Both trials were conducted on soils that were cleared from secondary forest. The soil was friable, free draining and high in organic matter.

Bulb onion seeds of cultivar Tropic Brown were sown on steam sterilized seed beds of 1:2:1 parts of sand, top soil and chicken manure respectively. The seed beds were watered every afternoon. After 6 weeks the seedling were hardened for 2-3 hours in the afternoons for two weeks. At 8 weeks the seedlings were transplanted onto plots of 0.6 x 1.6 m size at a plant spacing of 0.40 m x 0.10 m. The trial design used was randomised complete block design (RCBD) of eight treatments, replicated four times.

First sprays were applied 30 days after planting (DAP) and sprayed bi-monthly untill two weeks before harvest. Active ingredient of fungicides used was that recommended by the manufactures (see Table 1) with 2 mls/L of the sticker Agral. Eight Knapsack sprayes were used, one for each fungicide. The control was sprayed with water. Weeds were removed manually every two weeks with the aid of a spade.

Percentage of purple blotch disease incidence (PDI) and severity (PDS) assessment on leaves of fifteen inner most plants was done before each spraying time. This assessment was done 6 times. The mean is presented in Table 1. The number of leaves infected and the area affected were assessed using the assessment key of James *et al.* (1978) for *Rhynchosporium* leaf blotch of barley. A score between 0-4 was used, where 0 for no infection and 4 for 75-100% necrotic infection. Coefficient of disease index (CODEX) by using the formula of Datar and Mayee (1981).

$$\text{CODEX} = \frac{\text{PDI X PDS}}{100}$$

where, PDI = frequency of leaves affected
PDS = Intensity/extent of damage of the affected area.

Table 1: *Effect of different fungicides on the control of purple blotch of bulb onion during dry and wet seasons at Brahman, Upper Ramu*

	Dry (1994)				Wet (1995)				
Fungicide	Doses a.i.(%)	Disease incidence. %	Disease severity 1%	Yield (kg/m^2) 2	Bulb weight (g)	Disease incidence. %	Disease severity 1%	Yield (kg/m^2) 2	Bulb weight (g)
Mancozeb	0.16	4.8	2.6	2.12a	33.9	34.90	12.10	3.91a	62.9
Ridomi	0.036	9.2	6.0	1.31b	20.9	47	15.90	1.99bc	31.9
Manzeb	0.16	8.6	5.8	1.32b	21.1	38.5	14.5	2.38abc	38.2
Benlate	0.10	9.4	6.4	1.29b	20.7	38.8	14.8	2.34abc	37.4
CuOCl	0.10	11.7	7.2	1.0b	16.0	42.6	15.2	2.07abc	33.1
Captan	0.10	6.4	4.8	1.38b	22.1	36.8	14.2	2.86ab	45.8
Bravo	0.10	8.4	5.6	1.35b	21.6	36	13.6	3.32ab	53.1
Control	-	12.2	8.4	0.98b	15.7	52.2	24.3	1.27b	20.4
CV				0.242				0.322	
LSD				0.626				1.559	

1. Disease severity rating system: 0 = No disease, 1 = 1-25% of area affected. 2 = 26-50%, 3 = 51.75%. 4 = 76-100% or dead.
2. Numbers in each column followed by the same letter do not differ significantly at p = 0.01 according to Duncan's multiple range test.

The bulbs were harvested from the soil manually. Undried leaves were removed with the aid of a kitchen knife after curing for two days. The bulbs were then weighed. Data for each season was analysed by analysis of variance and means separated by Duncan's Multiple Range Test (DMRT) at (P=0.05 x 0.01). Simple regression analysis was carried out on yield and disease intensity to determine the influence of fungicides.

RESULTS

The effect the seven fungicides had on yield, disease incidence and disease severity during the dry and wet seasons are shown in Table 1. In the dry season, plots treated with Mancozeb yielded significantly higher than the other treatments. They gave the biggest bulb weight and highest yield. No significant differences were observed in yield between the other treatments and the control in the dry season although the control treatment yielded the smallest bulbs and gave the lowest yield. In the wet season trial, Mancozeb treated plots again yielded significantly higher than Ridomil and the control (unsprayed) but not the other treatments. Bravo and Captan treated plots also yielded significantly higher than the control in the wet season. In general, disease incidence, disease severity, yield and bulb weight (kg/m^2) were lower in the dry season than the wet season.

Purple blotch was generally severe in the wet than the dry season. In both seasons, disease incidence and severity were lower in the sprayed plots than the control. All the fungicides screened performed well in the wet season except Ridomil. Yield losses in non-protected plots were predicted as the difference between the control and the highest yield divided by the highest yield multiplied by 100. Yield losses in non-protected plots were 53.8% and 67.5% in the dry and wet seasons respectively.

To quantify the effect of disease on yield, total yield (y) in (kg/m^2) were regressed on the coefficient of disease index (CODEX) (x) in percentage. In the dry season, yields (Y in Kg/m) were predicted by the equation:

$$y = 1.947 - 1.105x,\ R^2 = 0.7875.$$

In the wet season yields were predicted by the equation:

$$y = 4.073 - 0.245x,\ R^2 = 0.6786.$$

DISCUSSION

At Brahaman the variety Tropic Brown was very susceptible to purple blotch in a variety evaluation trial done earlier in 1991 (S. Ivahupa, unpub.). It was mentioned that purple blotch was the major disease that affected all the cultivars tested there.

The severity of the purple blotch depended on the season, the location of the trial and the fungicide used. In the dry season trial, the disease CODEX of the treatments were not significantly different, hence no significant differences were obtained in the yields. The effect of fungicides could not be properly understood in that season.

Plots used in both seasons were established close to each other and the increase in blight severity could be due to a higher level of initial disease in the wet season. This suggested that there was some spread of inoculum from the previous season since the pathogen is known to over - season in crop debris (Pandotra 1965, Gupta and Pathak 1988) and in soil (Basu 1971, Khare and Nema 1981).

The efficacy of fungicides on purple blotch disease was greater in the wet season than the dry season. There was significant reduction in disease incidence and severity in sprayed plots. The highest efficacy of fungicidal control was obtained in plots treated with Mancozeb. Captan and Bravo were also effective. These fungicides have been reported to be effective in purple blotch control in other countries (Gupta and Pandey 1986, Srivastava *et al.*, 1991). The yield per hectare of plots treated with mancozeb in this trial was higher than that recorded by Sowei (1994) and estimated by Wiles (1992b). Bulb yield were correlated with disease CODEX. The highest yields were obtained where the CODEX were lowest, thus reflecting that metalaxyl controls the disease effectively (Pandotra 1965; Srivastava *et al.*, 1991; Gupta and Pandey 1986, Wiles 1992a), they have not performed better than the control under Brahman conditions.

CONCLUSION

All the fungicides used in this trial have the potential for purple blotch control. They have increased bulb weights and improved yield over the control. For this trial, mancozeb (1.6 g/L) is recommended every 14 days starting 30 days after planting, both as curative and protective sprays where the disease has become endemic.

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PRODUCTIVITY OF LESSER YAM (*DIOSCOREA ESCULENTA*) IN PAPUA NEW GUINEA AS INFLUENCED BY SETT WEIGHT AND STAKING

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ABSTRACT

*Field experiments were conducted to determine the effects of sett weight and staking on the productivity of the lesser yam, (*Dioscorea esculenta. *(Lour.) Burk). Setts weighing 100 g, 200 g, 300 g, or 400 g were grown with or without staking. Increasing sett weight resulted in significant increases in total tuber yield (from 38 to 75 tonnes ha^{-1}), net tuber yield (harvest yield less the weight of planting material) (from 36 to 67 tonnes ha^{-1}), yield of marketable tubers (>100 g) (from 35 to 71 tonnes ha^{-1}), number of marketable tubers (from 5.0 to 6.5 plant^{-1}), and mean weight per marketable tuber (from 340 to 539 g tuber^{-1}). Staking also significantly increased each of these yield variables, as well as total tuber number per plant. The total tuber yield increased from 44 to 70 tonnes ha^{-1}, net tuber yield increased from 39 to 66 tonnes ha^{-1}, yield of marketable tubers (>100 g) increased from 41 to 66 tonnes ha^{-1}, total number of tubers increased from 10 to 12 plant^{-1}, number of marketable tubers increased from 5.1 to 6.1 plant^{-1}, and mean weight per marketable tuber increased from 468 to 611 g tuber^{-1} with staking. The multiplication ratio (tuber weight produced/tuber weight that was planted) declined as sett weight increased show that without staking small planting setts (100 g) produced a mean yield of marketable tubers of 27 tonnes ha Although this was significantly less than the 91 tonnes ha^{-1} marketable yield from the staked plants grown from larger setts (400 g). it is suggested that a producer after considering the economic and environmental savings due to not staking and the higher multiplication ratio from the smaller setts may be willing to tolerate a reduced yield.*

***Key words**: Yam, staple food, sett weight, staking.*

INTRODUCTION

Yams (*Dioscorea* spp.) are an important staple crop for millions of people living in the tropics. About 30 million tonnes are produced each year on approximately 3 million hectares of land around the world with an estimated production in Papua New Guinea (PNG) of 220,000 tonnes (FAO 1998).

About 250,000 rural people in PNG villages partly depend on yams as an important staple food, according to results from the Mapping Agricultural Systems Project. Yam (*Dioscorea esculenta*) is a particularly important food in the Prince Alexander foothills of East Sepik Province, the Bogia area of Madang Province, most islands and mainland locations of Milne Bay Province, parts of coastal Central Province, and the trans-Fly region between Balimo and Daru. In all locations, yams are eaten with other staple foods, such as taro, sweet potato and cassava. They are never the sole staple food (R.M. Bourke, pers. Comm.).

One of the central problems in yam production is the relatively large amount of planting material required, usually more than one tonne for each hectare. The problem is exacerbated by the high cost of the planting material, and the fact that the planted material is otherwise edible. The need to reduce the weight of the planted sett is therefore critical.

The search for a solution has led to numerious experments of the effect of sett weight on yam productivity. The findings have shown clearly that reduction in the weight of the planted sett invariably results in a reduction in yield (Enyi 1972; Onwueme 1972; Lyonga *et al.* 1973; Nwoke *et*

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al. 1973; Onwueme 1973; Onwueme & Fadayomi 1980). Most of the experiments were conducted in West Africa or the Caribean, with emphasis placed on *Dioscorea rotundata* Poir. or *D. alata* L. which are the dominant yam species in those regions. In parts of the Pacific were *D. esculenta* is the major yam for consumption, there is equal interest in the effect of sett weight on the performance of this species. There is a lack of reliable information on this. Dingal *et al.* (1987) worked in the Philippines on the effect of sett type (as opposed to sett weight) on *D. esculenta*, and found that whole tubers and heads (the part of the tuber closer to the primary nodal complex from which the tubers are formed) were the best sett types. One of the first reports on the influence of sett size on yam yield in PNG was by Green (1941). Based on the description of the yams given it is most likely that Green (1941) was referring to *D. esculenta*. Quinn (1985) also reported that sett weight has a significant influence on field yield and yield components of *D. esculenta*.

The necessity for staking in yam production constitutes a major input of cost and labour in the production process. Most of the experiments evaluating the effect of staking have found that failure to stake results in decreased yields (Waitt 1960; Chapman 1965; Igwilo 1989; King 1989; King & Risimeri, 1992). However, Lyonga and Ayuk-takem (1982) found that the yield of *D. dumetorum* Kunth was not affected by staking which constrasted with *D. cayenensis* Lam. and *D. rotundata* where staking significantly increased tuber yield.

Quinn (1985) described two main groups of *D. esculenta* cultivars grown in the Maprik District in East Sepik Province of PNG. The cultivars within one group are never staked while the cultivars within other group are usually staked. Quinn (1985) found that one cultivar of non staking yam (Takura) had superior or equal yielding ability to the staked cultivars examined. Quinn (1985) also conducted one trial and found there was no significant difference in the yield and yield components of 4 different cultivars of normally staked *D. esculenta* as a result of staking. However, King (1989) and King and Risimeri (1992) tested the effect of staking on *D. esculenta* in PNG and found that staked plants produced greater yields then those not staked. The possible effects of staking on different sett weights were not determined in these experiments.

The objective of this experiment was, to determine the influence of sett weight and staking, separately or jointly, on the productivity of *D. esculenta* under PNG conditions. Such information might lead to the development of more efficient production packages that will reduce the present high cost of using large setts and of utilizing stakes.

MATERIALS AND METHODS

Dioscorea esculenta (Unitech cultivar number 2) were grown at the University Farm in Lae, Morobe Province, Papua New Guinea. The farm is located 6°41' S, 146°98' E and is on an alluvial plain at an altitude of about 65 m a.s.l. Hartemink *et al.* (1997) described the soil at the farm as a sandy, mixed, isohyperthermic Typic Topofluvents (USDA Soil Taxonomy). Average daily temperatures are 26.3°C with a mean daily minimum of 22.9°C and maximum of 29.7°C (McAlpine *et al.*, 1975). The mean annual rainfall is 4420 mm which is fairly evenly distributed throughout the year. The annual evaporation is 2140 mm (USDA Class A pan), and the rainfall exceeds evaporation each month (McAlpine *et al.*, 1975). The mean total annual sunshine for Lae is 2012 hr with a maximum mean monthly sunshine of 6.9 hr per day in October and a minimum mean monthly sunshine of 3.5 hr per day in July (McAlpine *et al.* 1975). Lae receives between 180 and 170 W-h cm^{-2} $year^{-1}$ total annual solar radiation (McAlpine *et al.* 1983). The plants were grown from intact tubers weighing 100 g (50-150 g weight range), 200 g (150-250 g weight range), 300 g (250-350 g weight range) or 400 g (350-450 g weight range). Each sett weight group was grown both staked or not staked. Setts were planted on level soil (i.e. not mounded or ridged) in 18 m^2 plots at a spacing of 1x0.5 m, giving 16 experimental plants and a guard row per plot. Staked plots were staked with bamboo stakes at planting, with one stake for two plants. The length of the stakes above the ground was 2.5-3.5 m. Treatments were arranged factorially in a randomised complete block design with four replicates.

The land was prepared by ploughing and rotary hoeing. Fertilizer was incorporated into the soil at a rate of 200 kg/ha NPK (16:12:16) prior to

planting. Weeds were controlled by hand weeding when required. The plots relied solely on natural rainfall which ranged from 250 to 520 mm/month during the experimental period. Harvesting was done 39 weeks after planting. At harvest the weight of each tuber and the vine fresh weight for each plot were recorded. Data were analysed using Minitab Release 11 statistical software.

RESULTS

Tuber yield

The planting sett weight had a significant effect on the total tuber yield (Table 1). The total tuber yield increased steadily with increase in sett weight, with the 100 g setts yielding significantly lower than all the others, and the 400 g setts yielding significantly higher than all the others. The tuber yield from the 400 g setts was approximately twice that of the 100 g setts. The tuber yield from the 200 g and 300 g setts did not differ significantly from each other.

Staking resulted in a significantly higher total tuber yield than the unstaked (Table 1). However, there was no interaction of staking and sett weiight on the total tuber yield, suggesting that for each sett weight, staking increased total tuber yield in a similar way.

The results for net tuber yield (Table 1) followed the same pattern as for total tuber yield, although, as expected, the yield difference between the largest and smallest setts was smaller. The net yield results for staking and for the sett weight x staking interaction were identical for those already stated for total tuber yield.

The pattern of results for marketable tuber yield (i.e. tubers > 100 g) were identical to those for total tuber yield (Table 1). However, the non-marketable tuber yield was not significantly affected by either sett weight or staking or their interaction.

Tuber number

Staking (Table 2) significantly increased the total and marketable number of tubers. Sett weight effects were not significant for total tuber number. However, the smallest setts (100 g) gave significantly lower number of marketable tubers than the two largest sett weights. In all cases, the interaction of sett weight x staking was not significant.

Numbers of non-marketable tubers were not significantly affected by staking, sett weight or staking x sett weight interaction (Table 2).

Tuber weight at harvest

The size of the yam tuber is a very important yield criterion, given the preference of consumers for large tubers. The yield of large tubers in the harvest was improved by staking and increased sett weight (Fig. 1). A similar pattern emerges when the mean weight per marketable tuber is considered (Table 2). The mean weight per marketable tuber was significantly increased by staking. It was also significantly influenced by sett weight, with the largest sett (400 g) giving a significantly higher mean weight than each of the others, and the smallest sett (100 g) giving a significantly lower mean weight than each of the others. The 200 g and 300 g setts did not differ significantly from each other.

Multiplication Ratio

The multiplication ratio is the weight of tuber yield divided by the weight of tuber planted. The multiplication ratio decreased steadily as sett weight increased (Table 1). The two largest setts had significantly lower multiplication ratios than the smallest two, while the smallest sett (100 g) was significantly higher than all the others.

Staking (Table 1) also significantly increased multiplication ratio. However, the interaction of staking x sett weight was not significant.

Shoot weight at harvest

Shoot weight at harvest was significantly higher for the staked plants (Table 1 & 2). It was also significatly influenced by sett weight, with the 400 g sett resulting in a higher shoot weight at harvest than each of the others except the 200 g sett. The interaction of sett weight x staking was also significant, with an $LSD_{0.05}$ of 163 g plant^{-1} or 1.3 tonne ha^{-1}.

Table 1. *Effect of sett weight and staking on yield and tuber multiplication ratio.*

		Sett weight (g)				
		100	200	300	400	Staking means
Total tuber yield (tonnes ha^{-1})	Staked	45.2	70.8	70.5	95.6	70.5
	Unstaked	30.8	40.1	52.0	54.3	44.3
	Sett weight mean	38.0	55.4	61.3	74.9	
	LSD sett weight	11.6				
	LSD staking	8.2				
Net tuber yield (tonnes ha^{-1})	Staked	43.2	66.8	64.5	87.6	65.5
	Unstaked	28.8	36.1	46.0	46.3	39.3
	Sett weight mean	36.0	51.4	55.3	66.9	
	LSD sett weight	11.6				
	LSD staking	8.2				
Marketable tuber yield (tonnes ha^{-1})	Staked	41.9	62.6	67.0	91.5	65.7
	Unstaked	27 3	37 2	48.5	51 3	41.1
	Sett weight mean	34 6	49 9	57 7	71 4	
	LSD sett weight	12 0				
	LSD staking	8.5				
Non-marketable tuber yield (tonnes ha^{-1})	Staked	3.4	8.2	3.6	4.1	4.8
	Unstaked	3.5	2.9	3.5	3.0	3.2
	Sett weight mean	3.4	5.5	3.6	3.5	
	LSD sett weight	NS				
	LSD staking	NS				
Multiplication ratio	Staked	22.6	17.7	11.8	12.0	16.0
	Unstaked	15.4	10.0	8.7	6.7	10.2
	Sett weight mean	19.0	13.9	10.2	9.4	
	LSD sett weight	2.5				
	LSD staking	1.8				
Shoot yield (tonnes ha^{-1})	Staked	6.8	7.8	5.3	12.4	8.1
	Unstaked	5.3	5.1	5.4	4.8	5.2
	Sett weight mean	6.1	6.5	5.4	8.6	
	LSD set weight	2.3				
	LSD staking	1.6				
Total plant yield (tonnes ha^{-1})	Staked	52.0	78.5	75.9	108.0	78.6
	Unstaked	36.1	45.3	57.4	59.1	49.5
	Sett weight mean	44.1	61.9	66.6	83.6	
	LSD sett weight	11.4				
	LSD staking	8.1				

Note: For shoot yield and total plant yield the LSD for staking x sett weight interaction was 1.3 and 6.6 tonnes ha^{-1} respectively.

Table 2. *Effect of sett weight and staking on tuber number, mean weight per marketable tuber, and shoot weight at harvest.*

		Sett weight (g)				
		100	200	300	400	Staking means
Total tubers (number plant-1)	Staked	10.8	11.9	12.5	13.3	12.1
	Unstaked	9.8	9.7	11.1	10.0	10.4
	Sett weight mean	10.3	10.8	11.8	11.6	
	LSD sett weight	NS				
	LSD staking	1.7				
Marketable tuber (number plant-1)	Staked	5.5	6.5	6.5	7.5	6.5
	Unstaked	4.6	4.9	5.3	5.5	5.1
	Sett weight mean	5.0	5.7	5.9	6.5	
	LSD sett weight	0.9				
	LSD staking	0.6				
Non-marketable tuber (number plant-1)	Staked	5.2	5.5	6.0	5.8	5.6
	Unstaked	5.2	4.8	5.8	4.5	5.1
	Sett weight mean	5.2	5.1	5.9	5.2	
	LSD sett weight	NS				
	LSD staking	NS				
Mean weight per marketable tuber (g)	Staked	380	521	513	611	506
	Unstaked	300	380	442	568	397
	Sett weight mean	340	451	477	539	
	LSD sett weight	54				
	LSD staking	38				
Shoot weight at harvest (g plant^{-1})	Staked	339	389	267	622	404
	Unstaked	267	258	271	243	260
	Sett weight mean	303	323	269	532	
	LSD sett weight	115				
	LSD staking	82				

Note: For shoot weight at harvest the LSD for staking x sett weight interaction was 163 g/plant.

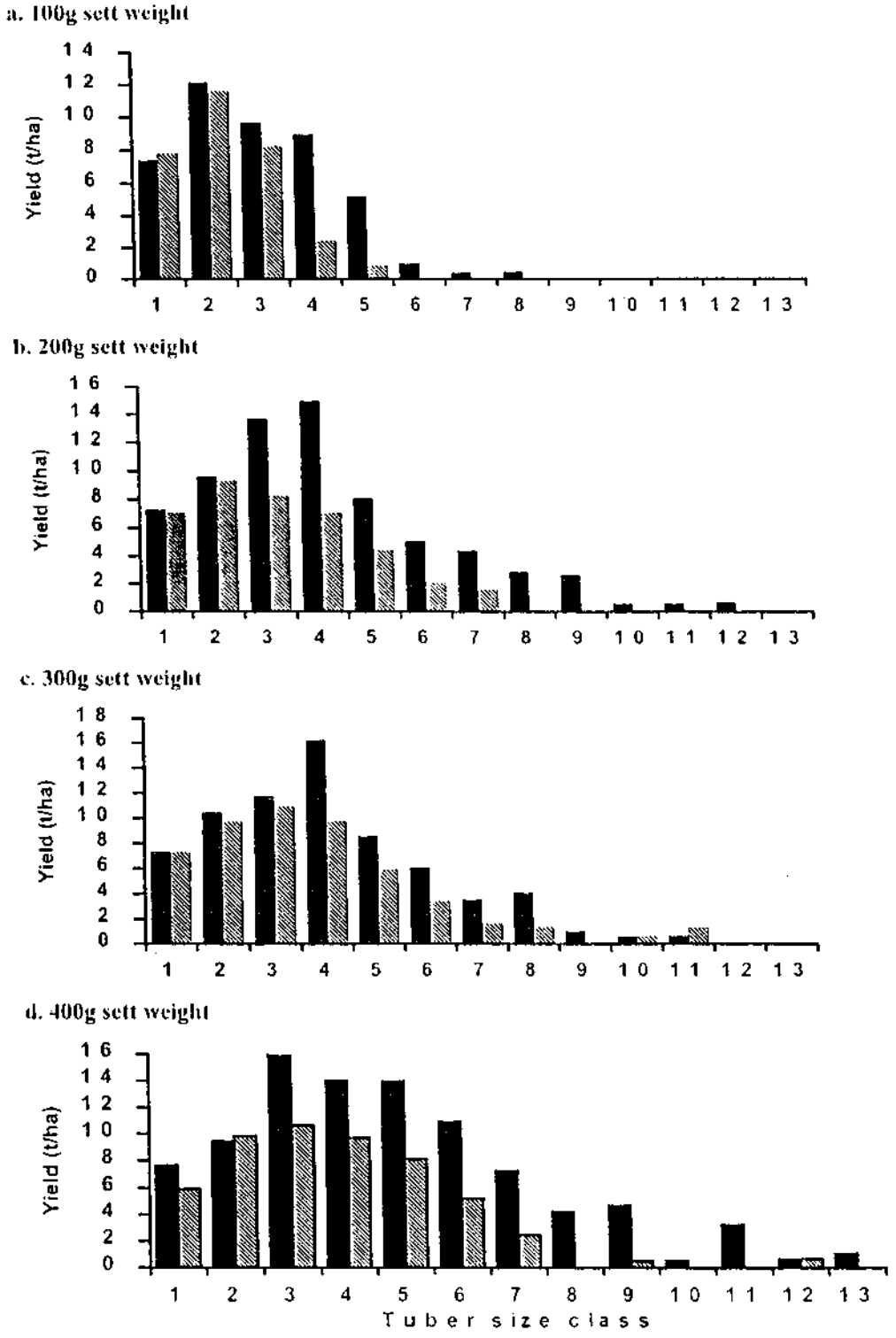
Total Plant Yield

The total plant yield showed a similar trend as the tuber yield, with larger planting setts and staking significantly increasing the total plant yield (Table 1). This would be expected as the tuber yield makes up about 90% of the total plant fresh weight yield at harvest. As reflected with the shoot weight there was also a significant interaction between sett weight and staking for total plant yield.

DISCUSSION

Tuber formation in *D. esculenta* differs from that in the other major yams (*D. rotundata* and *D. alata*) in two important respects. Firstly, the tubers of *D. esculenta* usually do not arise directly from the primary nodal complex, but are borne at the end of stolon-like structures which may be very short in some cultivars and relatively long in others. Each tuber, as it grows and matures, is therefore attached to the rest of the plant by a rope-like stalk. Secondly, unlike the other major yam species, each plant of *D. esculenta* tends to

Figure 1. *The effect of staking and sett weight on the tuber size. Solid bars represent staked plants, hatched bars represent non-staked plant for* **a.** *100 g sett weight,* **b.** *200 g set weight,* **c.** *300 g sett weight and* **d.** *40 g sett weight grown plants. The tuber size classes are as follows; 1, 0-100 g; 2, 100-200 g; 3, 200-300 g; 4, 300-400 g; 5, 400-500 g; 6, 500-600 g; 7, 600-700 g; 8, 700-800 g; 9, 800-900 g; 10, 900-1000 g; 11, 1000-1100 g; 12, 1100-1200 g; and 13, >1200 g.*



produce several tubers, with new ones being added progresively throughout the growing season. These qualitative and quantitative differences in tuber morphogenesis of *D. esculenta* have made it difficult to predict whether or not this species will behave like other species in terms of the effects of sett weight and staking.

The foregoing results indicated that the various tuber yield factors in *D. esculenta* increase as sett weight increases. This agree with previous results for *D. esculenta* (Green 1941; Enyi 1972; Quinn 1985) and with the pattern generally observed with *D. rotundata* and *D. alata* (Onwueme 1973; Onwueme and Fadayomi 1980). Marketable tuber numbers and weight were also influenced by sett weight, larger setts producing a greater mean weight of marketable tubers than small setts. In each case, there were nearly as many unmarketable tubers per plant as marketable ones. This is a reflection of the continued initiation of new tubers throughout the season, so that at harvest, there is always a large number of small tubers in various stages of formation. Even though the total yield of these small tubers is small, some Pacific farmers actually prune newly forming tubes once the main tubers have begun to bulk.

As with *D. rotundata* (Onwueme 1978), these results indicate that multiplication ratio for *D. esculenta* decreases as sett weight increases. In practical terms, this means that farmers cannot increase their sett weight indefinitely in an effort to realise higher yields. At the higher sett weights, the inefficiency of low multiplication ratio must be considered.

These results also show that staking resulted in an increase in tuber yield of 59%, 67% and 60% for total, net, and marketable tuber yields, respectively. This agrees with the findings of King and Risimeri (1992), but Quinn (1985) found there was no significant difference in the yield and yield components of the 4 cultivars of normally staked *D. esculenta* examined as a result of staking. Further investigation of the *D. esculenta* cultivar response to staking is required.

The above results, quite remarkably, show that staking also increased the multiplication ratio, and therefore, improved the efficiency of utilization of the planting material. Thus, while the yield advantage derived from large setts is somewhat negated by a decreased multiplication ratio, the yield advantage derved from staking is made additionally attractive by the increased multiplication ratio.

The use of staking in yam production is not without economic and environmental cost. Economically, the procurement and installation of stakes may require up to 60 person-days per hectare, accounting for about one-fifth of the total labour required for yam production (Phillips 1964; Nwosu 1975). With progressive increase in labour costs in most paces, the absolute and relative cost of using stakes in yam production is likely to continue to increase and is ultimately unsustainable (Onwueme 1994).

Fortunately, these results also show that even without staking, a mean yield of marketable tubers of 41 tonnes ha^{-1} could still be produced. Considering the economics of labour savings due to not staking, the producer might be willing to tolerate such a resulting yield level.

In conclusion this study indicates that *D. esculenta* growers in PNG can choose the system for growing the yam that best suits their requirements. If the requirement is to achieve maximum yield and there is abundant planting material then large planting setts (400 g) and staking should be used. If the emphasis is on getting a high multiplication rate when planting material is limited then smaller setts (100 g) and staking should be practiced. If either labour and/or yam stakes are limited or uneconomical then a substantial yield is still obtainable by growing the yams without staking. In this situation the larger setts will still produce significantly greater yields all though the multiplication ratio will be lower than that for the smaller setts.

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ORGANOLEPTIC CHARACTERISTICS OF *SAPAL*: A TRADITIONAL FERMENTED TARO (*COLOCASIA ESCULENTA*)' CORM AND COCONUT CREAM MIXTURE FROM PAPUA NEW GUINEA.

R. Gubag Sipou* and A.D. Omoloso[1]

ABSTRACT

Sapal *is a traditional food prepared from cooked and grated taro with coconut milk and allowed to ferment at ambient temperature. Sensory evaluation of this product showed that the coconut milk to taro ratio affected the acceptability of the final product. Four different coconut milk to taro ratios (1:1, 1:2, 1:3 and 1:4) were used to determine the most suitable in terms of texture, colour, odour and acceptability. Ratio 1:3 was significantly different (P<0.05) from 1:1 and 1:4 in colour and acceptability, and was also significantly different (P<0.05) from all the ratios in texture. There was no significant difference (P<0.5) in odour for all the different ratios used. A ratio of 1:3 (coconut milk to taro) produced* sapal *of the required quality in terms of texture, colour and acceptability.*

Key words: *Sapal, fermentation, taro, sensory evaluation.*

INTRODUCTION

Sapal is a traditional food produced by mixing cooked and grated taro (*Colocasia esculenta (L) Schott)* corm with coconut cream and allowed to ferment at ambient temperature. It is a creamy greyish coloured food consumed anytime during fermentation. The fermentation period can be as long as one month, depending on when the product is completely consumed.

Sapal is a ceremonial food produced only on very important occasions, for exchange as gift with neighbouring clans or villages or to show appreciation for a good harvest. It is produced only on the North Coast of Madang and the neighbouring islands such as Karkar Island. A similar type of product, *poi* is processed and consumed on a large scale in Hawaii (Allen and Allen 1933, Moy and Nip 1983, Frazier and Weshoff 1988). *Poi* is prepared by mixing water with cooked taro (Moy and Nip 1983) whilst coconut milk or cream is used instead of water for preparation of *sapal* prior to fermentation. The traditional method used for the production of *sapal* has been studied (Gubag *et al.* 1996). However, the traditional method does not define the proportion of taro to coconut cream, and consequently the quality of the final product is often inconsistent. Therefore, this study was done to determine a suitable coconut milk to taro ratio which will be used consistently to produce *sapal* of an acceptable quality.

METHODS

Preparation of *sapal*

The method used for the preparation of *sapal* was as described by Gubag *et al.* (1996) with few modifications. Taro corms were bought from Lae market. Two litre plastic containers were used for storing *sapal* instead of the usual traditional wooden bowls of about 50 litre volume, and muslin cloth was used for extraction of coconut milk.

Determination of coconut milk/taro (cooked) ratio

The following coconut milk to taro ratios were used during mixing: 1:1, 1:2,1:3, and 1:4. Each treatment was placed in a 2 L plastic container with lid and allowed to ferment at ambient temperature for 7 days.

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All treatments were evaluated for texture, colour, odour and acceptability by a trained panelists of 10 people. A score range of 0 to 5 (0 having the lowest and 5 having the highest) was used. Analysis of variance was done for data collected from the organoleptic examination. The analysis was performed to determine whether there were any significant differences in texture, colour and acceptability between *sapal* produced with different ratios of coconut milk and taro as judged by the 10 panelists. The data obtained was calculated to determine the F values (Larmond 1977, O'Mahoney 1986) between different treatments. The F values were then used to ascertain if there were any significant differences. Least significant difference values were also calculated to compare the means of different ratios.

RESULTS AND DISCUSSION

Physical observations based on colour and texture are presented in Table 1. The table shows that the colour immediately after mixing was creamy white for all the different ratios. Change in colour to yellowish grey and yellowish brown was observed for ratios 1:1 and 1:4 respectively on day 7. Ratios 1:2 and 1:3 however, retained most of the original colour except for a few patches to grey on the surface. Ratio 1:2 also turned slightly yellow during fermentation. The change of colour to yellowish brown observed for ratio 1:4 is due mainly to surface drying. The yellowish colour observed for all the ratios except for ratio 1:3 was most probably due to the growth of yeast on the surface of *sapal*. Studies on the microbial ecology of *sapal* showed yeast species to be predominantly of the genus *Candida* (Gubag *et al.* 1996).

The analysis of variance test (O'Mahoney 1986) on the organoleptic evaluation of *sapal* after 7 days of fermentation showed no significant differences in colour (Table 2) between ratios 1:2 and 1:3. However, they were significantly different ($P<0.05$) from 1:4. The texture likewise was affected by different coconut milk to taro ratios. Table 1

Table 1. *The effect of coconut milk/taro ratios on texture and colour of sapal during fermentation*

Ratio	Texture and colour on day 0	Texture on day 7	Colour on day 7
1:1	Very watery Creamy white	Watery and mushy	Yellowish grey
1:2	Watery Creamy white	Slightly watery	Creamy white with few patches of yellow and grey colour
1:3	Dry but slightly moist	Slightly moist	Creamy white with few patches of grey colour
1:4	Dry Creamy white	Very dry, particularly at the surface	Yellowish brown

Table 2. *Means of sensory evaluation of sapal after 7 days of fermentation produced using different coconut milk/taro ratios.*

Ratios	Texture	Colour	Odour	Acceptability
1:1	4.8bd	1.2b	1.2a	1.9c
1:2	3.7b	4.4a	4.4a	3.4ab
1:3	7.4a	3.8a	3.8a	4.3a
1:4	1.7c	2.7c	2.7a	2.8ba

Mean values within a column bearing the same subscript are not significantly different at 0.05 (5%) level of significance.

shows 1:1 ratio having watery texture throughout the fermentation period. Ratio of 1:3 likewise was moist but firmer than 1:1 and 1:2 and ratio 1:4 was drier than all the other treatments. Analysis of variance (Table 2) showed 1:3 to be significantly different ($P<0.05$) in texture from other treatments. Ratios 1:1 and 1:2 were similar in texture but were significantly different ($P<0.05$) from 1:4.

The texture of good quality *sapal* is moist, but firm. These observations show that *sapal* produced using 1:3 coconut milk to taro ratio had the required texture.

Unlike colour and texture, the statistical analysis on odour did not show significant differences ($P<0.05$) among the different treatments. *Sapal* has a milk or cream, acid-like odour. Odour therefore, was not affected by different coconut milk to taro ratios used during the production of *sapal*.

General acceptability by panelists based on these variables (odour, colour, texture) showed a mean score of 4.3 (scale 1-5, 5 having most liked) for ratio 1:3, followed by 1:2, 1:4 and 1:1. Ratio 1:3 was also significantly different ($P<0.05$) from 1:1 and 1:4 in acceptability but not different from 1:2 (Table 2). These findings on sensory evaluation of *sapal* during fermentation shows that the ratio of coconut milk to taro affects colour and texture but not odour. The acceptability of the product therefore, depends mainly on these variables. Ratio of 1:3 was more acceptable than the other three ratios. Furthermore, this treatment (1:3) was significantly different ($P<0.05$) from ratios 1:1 and 1:4 in colour.

CONCLUSION

Traditionally, texture is a common parameter used by *sapal* producers to determine the volume of coconut milk to be added during mixing with cooked taro. The traditional *sapal* producers use texture as the major quality determinant. Firm moist *sapal* with creamy greyish colour is of good or acceptable quality. From the above results, production of *sapal* with coconut milk/taro ratio of 1:3 is recommended.

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Research Note

HEAD CABBAGE VARIETY STUDY FOR TIPBURN RESISTANCE

J. Bamba, J.A. Cruz, O.H. Diambra and R. Muniappan[1]

In head cabbage, tipburn symptoms are concealed within the head. Tipburn refers to a brownish discoloration of the tips of leavesof head cabbage, Chinese cabbage and lettuce (Collier & Tibbitts 1982). In Northern Guam, severe symptoms of head cabbage tipburn were reported on "K-K cross" with subsequent economic losses in the past fifteen years (Cruz *et al.* 1987).

Mechanism by which tipburn occurs is not well understood. The occurrence of tipburn is attributed to several factors including calcium related disorder (Collier & Tibbits 1982), ammonium toxicity (Imai 1987) and salinity (Feigin *et al.* 1991). Today, more and more commercial seed companies are producing tipburn resistant varieties of head cabbage. The purpose of this study is to compare tipburn symptoms in four head cabbage varieties, grown to mature size (90 days) under Northern Guam soil conditions.

A field experiment was conducted at the Yigo Agricultural Experiment Station. Soil characteristics are classified as clayey, gibbsitic isohperthemic, Tropeptic Eutrustox very shallow, highly clacarious with limited moisture holding capacity. The experimental design consisted of 4 main plots with 4 subplots of 4 head cabbage varieties each: Scorpio, Pacifica, K-K Cross and Blue Vantage. Seedlings were transplanted on 30 m row irrigated with a double drip line of 30 cm spacing between plants and 1.5 m between rows. A basal fertilizer dressing with 10-20-20 was applied at a rate of 1.8 Kg/30 m (each row length) three days prior to transplanting. Fertilization was carried out every other week with 10-20-20 injected at a rate of 25g/100 litter of water. On one side of the experimental field (down wind side), one row each of Chinese cabbage, radish and Indian mustard control. Dibrom 8 emulsive (10 ml/L) was sprayed when needed to control the cutworm *Spodoptera litura*. Dipel (mm/L) was additionally used as needed to control diamondback moth.

A total of 160 cabbage heads (10 per variety for each row on all plots) were randomly harvested at 90 days, individually weighed, split longitudinally and assigned a tipburn score. Width and length of the longitudinal cross section were also measured. Incidence of tipburn was given a score after observing 5 consecutive leaves after the first leaf. No leaf showing discoloration is rated 0 while discolorationon all five leaves is rated 5. Data were analyzed using GLM procedure and LSD pairwise comparisons (SYSTAT 1992).

Table 1. *Incidence of tipburn, head cabbage weight, longitudinal cross section length and width of 4 varieties of cabbage.*

Variety	Tipburn (0 to 5)	Weight (g)	Length (cm)	Width (cm)
Scorpio	0.3[a]	1529[b]	13.35[c]	11.88[b]
Pacifica	0.3[a]	1339[a]	12.31[b]	11.12[a]
K-K Cross	1.7[b]	1507[ab]	11.76[a]	12.83[c]
Blue Vantage	2.8[c]	1503[ab]	13.05[c]	11.80[b]

[ab] *Mean values in each colomn with a different superscript are significantly different (P<.05).*

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Table 1 shows the incidence of tipburn, head cabbage weight, longitudinal cross section length and width on 4 varieties of head cabbage. Results indicated that varieties Scorpio and Pacifica showed resistance to tipburn while varieties K-K Cross and Blue Vantage showed high susceptibility to tipburn. These findings confirm the label of Scorpio as a tipburn resistant head cabbage but contrast with the claim that Blue Vantage is tipburn resistant. Previous studies (Cruz *et al.* 1997) reported high susceptibility of K-K Cross towards tipburn and it is confirmed by this study. Pracifica variety is known to be heat tolerant and resistant to Cabbage Yellows, and displayed a good resistance to tipburn under these experimental conditions. When weight, length and width are compared between tipburn resistant varieties, Scorpio scored significantly ($P < .05$) higher for weight, length and width as compared to Pacifica.

Based on these preliminary studies, the head cabbage variety Scorpio is a good choice for Guam as it exhibits resistance to tipburn, and desirable marketing traits such as longer and wider appearance of the head. In addition, Scorpio has indicated partial resistance to dismondback moth attack (Cruz *et al.* 1997). More field studies including yield and other economical parameters need to be evaluated in order to recommend varieties better suited for Guam.

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SUBJECT INDEX

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yr - year
wk - week
h - hour
min - minute
s - second
K - kina
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n.r. - not recorded
var - variance
s.d. - standard deviation
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