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FOOT ROT VACCINE TRIAL AT MENIFO SHEEP BREEDING AND DISTRIBUTION CENTRE, PAPUA NEW GUINEA

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ABSTRACT

Foot rot is a problem with sheep at Menifo Sheep Breeding and Distribution Centre in the Eastern Highlands Province of Papua New Guinea. This experiment was conducted in 1987 and 1988 to find out the effects of the foot rot vaccine Vaxall Norot *(Websters) against other management practices. There was loss of live weight in the vaccinated group of sheep, while no significant differences were observed between the treatment groups. This suggests that other control and management practices are adequate for controlling foot rot at Menifo and other sheep multiplication and distribution centers throughout Papua New Guinea.*

Key words: *Disease, bacteria, Vaxall Norot, foot bath, Eastern Highlands, not significant*

INTRODUCTION

Foot rot is a contagious disease of ruminants caused by the bacteria *Bacteroides nodosus* and *Fusobacterium necrophorum*. The disease occurs as a result of the combined interaction of these and other micro-organisms such as *Coryriebacterium pyogenes*. The disease is present in Australia, New Zealand, United Kingdom and other parts of the world (Egerton 1981, Claxton and Steward 1982, Morgan 1987) including Papua New Guinea (PNG).

Therefore this experiment was done to investigate the effect of the foot rot vaccine Vaxall Norot (Websters) against other control and management practices at Menifo.

METHODS

The experiment conducted in 1987 and 1988. because Menifo is the largest sheep distributing centre in PNG and foot rot on sheep is present there. Vaccination of sheep could become part of the control measures at Menifo and other sheep distributing centers in the country.

One hundred and fifty Highlands half bred ewes were randomly selected and provided by Menifo Sheep Breeding and Research Centre. Zinc sulphate solution (10%) and Vaxall Norot – Polyvalent Ovine Vaccine (Websters) were obtained from the Goroka Vetinary Clinic.

On day 1, 150 Highlands, half bred 2 tooth ewes were randomly selected. They were then subdivided into three groups of 50 sheep each.

Group 1 was foot trimmed and vaccinated (1ml/ sheep) with Vaxall Norot on the left side of the neck. Group 2 was foot trimmed only. Group 3 acted as control. For each group, all ewes were weighed, body conditioned, sheared and any foot lesions present scored according to Stewart *et al.* 1982. All the ewes were put on 10% zinc sulphate solution footbath for 30 minutes. The whole group was put into a separate paddock for closer monitoring throughout the experimental period and from day 2-13th daily inspections and physical recording were done. The size and nature (close rupture) of the vaccine reactions were recorded and inspected for any fly strike. The size of the reactions were estimated by digital palpation.

At day 14, second treatment were given, that is repeated the first day treatments. The vaccinated group were injected on the right side of the neck. From day 15-20, daily inspections and recordings were done. At day 21, day 1 treatments were repeated, except that group one were not vaccinated. From day 22-27, daily inspections and recordings were done, except on Christmas Eve and Christmas day. At day 28, day 1 treatment were repeated, except that group 1 were not vaccinated and reweighed.

Then all the sheep had a detailed weekly examination for ten (10) weeks. During this period all the groups of sheep were weighed and body condition scored. Final weighing and body conditions were done at the end of the trial.

RESULT AND DISCUSSION

Foot Lesions

The foot rot challenge was significantly low presumably due to unfavourable environment conditions and the treatment given.

Table 1. **Rainfall (mm) at Menifo during the trial period**

	Dec.	Jan.	Feb.	March
Number of Rainy days/month	14	12	11	17
Total Rain fall	799			
Mean rain days/month	14.01			

Live Weight Change (kg)

The mean weight of group 1 was 3.5 kg, group two 6.2 kg, and group three 6.9 kg. This shows that group 2 and group 3 are not significantly different from group 1.

From the analysis of variance, the treatments caused difference in live weight gain by 0.2%. The variance between groups 1 and group 2 was singnificant at 0.1% and between group 2 and group 3 was significant at 10%.

Table 2. **Live weight change (kg)**

	Mean	Sum of X	Sum of Square
Group 1	3.5	157.5	716.25
Group 2	6.2	293.0	1994.50
Control	6.9	345.5	2665.75

Table 3. **Changes in Body Condition of Sheep**

	Mean	Sum of X	Sum of Square
Foot trimmed & vacinated	0.411	18.50	23.75
Foot trimmed only	0.989	46.50	58.25
Control	0.78	39.00	47.50

Similar findings as for the live weight change. The means of group 2 and group 3 are not significant as compared with group 1. From the analysis of variance, the treatments caused difference in the change in the body condition. Scores by 0.1%. The variance between vaccinated and non-vaccinated was 0.1% whereas between group 2 and group 3 was 0.1% and within the groups was 5%. It can be concluded that vaccination caused a smaller increase in body condition scores. Foot trimming may have caused an increase in the body condition score changes.

Vaccine Reactions

Lots of animals showed reactions to both the first and second injections. Most of them ruptured and healed at different times. The size of the reactions varied from 1-6 cm in diameter. There was no fly strike recorded, presumably due to close attention paid to the wounds.

DISCUSSION

The observed foot rot challenge was low, presumably due to the fact that the environmental conditions were not favourable throughout the experimental period. The total rainfall was 799 ml and number of rain days ranged from 12 – 17 (Table 1). The rain was not continuous, there were intermittent dry spells. Work by Benjamin A. (1986 unpublished) at Menifo showed that there was no significant relationship between rainfall, number of rain days and foot scald.

Wet and warm conditions will favour the incidence of the disease. Studies in Australia Claxton P.D. and Steward, D.J. 1982, Morgan, K. 1987 showed that the spread of foot rot requires temperatures in excess of 10°C. Both moist and warm conditions favour persistence of the bacteria in the pasture and increase susceptibility of the feet to the injury and dermatitis thus facilitating spread of the disease from carrier sheep.

Hot, dry conditions and healing of the feet are unfavourable for the bacteria to persist on the pasture.

All the sheep, including the control group were put on 10% zinc sulphate solution for 30 minutes every time the treatment was repeated. This could be one of the reasons for the low incidence of infection. Zinc sulphate penetrates ovine of horn more readily then other antibacterial agents like formalin (Skerman *et al.* 1983). A field trial conducted at Wallaceville Animal Research Centre, NZ (Skerman *et al.* 1983), comparing formalin and zinc sulphate showed significant curative effects on foot rot infection of a wide range of severity by zinc sulphate. Skerman *et al.* 1983, also stated that cross and Parker in 1981 showed a pounced recovery rates even without preliminary paring of affected feed or other additional treatments. Similar findings were found by Skerman *et al.* (1983) with combination of foot paring and foot bathing with zinc sulphate.

Vaccination caused a reduction in weight gain whereas foot trimmed only did not. This is presumably an indirect effect of the vaccine reactions. The sheep were injected on both sides of the neck and 96.6% reacted. Those that reached 88% ruptured and healed at different times. Assumption can be made that the vaccine reactions were painful which affected the grazing ability, leading to lower live weight gain.

Similar findings were reported in clinical trials in Australia with Foot Vax Coopers Animal Health (Morgan 1987), 86% of the animals reacted and their were still apparent six to twelve weeks after injection. Vaccination abscesses are features of the use of oil adjuvant vaccines and the data sheet warns against use of Foot Vax prior to shearing, and it is contraindicated in miilking sheep where it causes a drastic fall in yield (Morgan 1987).

According to Blood *et al.* (1983), occasionally vaccination may exacerbate the lameness and sudden development of severe foot abscess.

Changes in body condition scores were similar to the live weight gain change. It is presumed to be due to the same explanation given to live weight change.

CONCLUSION

There was no significant difference between the treatments and the control groups of animals. The only effects was loss in live weight of the vaccinated group of animals. There were more local tissue reactions which led directly or indirectly to lower live weight gain. Other control or management practices are adequate if strict attentions are paid to.

The vaccine should not be used soley to combat the foot rot problem at Menifo for the following reasons;

i. Vaccines are expensive and the immunity provided is short lived, 12 weeks at the maximum, Morgan, 1987.
ii. Severe local tissue reactions occur at the site of vaccination.

ACKNOWLEDGEMENT

We thank Dr. Timothy Leyland for continued inspection and recording during our absent. Sheep shepherds at Menifo for their assistance at foot paring. Baniva Fivila for providing the sheep and the facilities; Shane Cridland for statistical analysis and S. Supiramanian for useful comments on the script.

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TIPBURN - A MAJOR PROBLEM OF CABBAGE IN THE HIGHLANDS AND SOME RECOMMENDATIONS FOR ITS CONTROL.

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ABSTRACT

Tipburn is a disorder of cabbages, cauliflower and lettuce usually caused by deficiency of calcium. A trial carried out on cabbage (Var. Green Coronet) showed that all treatments containing boron (in the form of Solubor) significantly reduced the number of plants affected by tipburn. The reason for this is that the efficient uptake and transport of calcium depends on boron availability. Both boron and calcium are generally deficient in soils in the highlands of Papua New Guinea.

Key words: *Tipburn, cabbage, boron, calcium*

INTRODUCTION

Nutrient deficiencies as possible causes of tipburn.

Calcium is a main constituent of cell walls and membranes. When in short supply cell membranes become leaky, cell division and the development of the growing point and root tips are affected. Calcium plays a key role in protecting the cell from toxins and in slowing the aging process. Calcium is not very mobile in the plant, so deficiency symptoms typically show as the death of the growing point, root tips, young leaves or developing fruits.

Tipburn (Figure 1) is a disorder of cabbage, cauliflower and lettuce caused by calcium deficiency (Weir & Cresswell 1993, Simon 1978). Calcium deficiency is also responsible for blossom end rot in tomatoes and capsicum, black heart in celery and internal browning in Brussels sprouts.

Calcium deficiency in crops like tomatoes and capsicum (blossom end rot) and cauliflower (tipburn) can be controlled by weekly sprays of calcium nitrate or calcium chloride applied throughout fruit formation in the case of tomato and capsicum, or from three weeks before flowering begins until three weeks before harvesting in the case of cauliflower. These sprays are ineffective for hearting vegetables such as lettuce, brussels sprouts and cabbage, as the calcium solution cannot reach the enclosed leaves, which are most prone to injury (Weir & Cresswell 1993).

Control of tipburn in cabbage is achieved by selection of tolerant varieties, better irrigation (severity of tipburn is positively correlated with soil moisture levels at harvest) and other management practices including carefully monitored fertiliser usage, and liming the soil where the soil is excessively acidic (Weir & Cresswell 1993; Walker *et. al.* 1961, Imai *et. al.* 1988). There is also some evidence to suggest that the disorder is more prevalent in plants that have been left for a longer time in the field, such as cabbages used in the manufacture of sauerkraut (Walker *et. al.* 1961).

Urea may increase the severity of tipburn as it promotes the sudden rapid growth of leaves which may result in localized calcium deficiency at the leaf margins as calcium is not readily transported from older to younger tissues. It has also been suggested that excessive nitrogenous fertlisers may inhibit the uptake of calcium from the soil. This is particularly true for NH_4^+ - nitrogen fertilisers (Imai *et. al.* 1988), possibly because calcium and ammonium - nitrogen fertilisers appear to compete with each other for entry sites into the plant (Chattergee 1988). It has been widely reported that the efficient uptake and transport of calcium by the plant depends on boron availability (Incitec 1992). This is further backed up by experiments carried out on cabbage plants grown in Hoagland solutions with normal and reduced levels of boron. Plants grown with insufficient boron showed slightly higher severity of tipburn (Walker *et. al.* 1961). Boron deficiency in a number of vegetable crops has been described by Gupta (1979). It has been linked to tipburn in strawberry (Mason & Guttridge 1974) and lettuce (Crisp *et al.* 1976).

Tipburn problems in the PNG highlands.

Tipburn has become a major problem with cabbage grown in the highlands of Papua New Guinea. The reasons for this are:

1. The disorder can only be detected by cutting the cabbage open and looking to see if the symptoms are present (i.e. destructive testing), and then obviously the cabbage cannot be sold.

2. Not all of the cabbages will be affected to the same degree. Within the trial a wide variation in severity scores within the same plot was

noticed.

The nature of this disorder leads to problems affecting the whole cabbage growing and marketing industry in PNG. The farmers were supplying cabbages that were affected by tipburn, but the wholesalers were unable to ascertain how severe the problem was until the cabbages were sold, and then rejected by the consumers (after the wholesaler had incurred large transport costs). These costs were being recouped by dropping the price of the cabbages from around 40t/kg to as little as 18t/kg (source: AD, Goroka 1996) reducing the farmers profit margin. This caused many farmers who had been growing cabbage to give up[1]

The Trial

A trial to investigate the effects of boron, calcium and urea application on the number of plants affected by tipburn and its severity was carried out at Mr. John Wak's farm in Kelowa No. 2, 10 km north of Mount Hagen. Mr. Wak has been growing cabbages commercially for about eight years.

Cabbage (cv. Green Coronet) which had been raised in an open nursery by Mr. Wak were planted in 1 metre wide beds with a plant spacing of 75 cms x 40 cms. Each plant received a basal dressing of 30 g NPK (12:12:17 + 2.5 MgO). The trial used a randomised complete block design with four replicates and eight treatments.

The treatments used were calcium applied as either a side dressing or a foliar spray, foliar applied boron as Solubor (H" 20 % boron), urea as a side dressing, or a combination of these. (Note: combinations of two side dressings or two foliar sprays were not used in the trial). Calcium was applied either as a side dressing or a foliar spray, but not both. An untreated control was included for comparison (Table 1).

RATES

Boron Spray - 37g Solubor in 15l water with 10ml SPREADSTIK. Applied 21 days after transplanting.*

* 1 litre of each solution was sufficient to spray approximately 25 plants (0.1g Solubor / plant or 0.7 kg / ha boron, and 0.32g $CaNO_3$ / plant or 4.3 kg / ha calcium).

Calcium nitrate spray - 120g Calcium nitrate in 15l water with 10ml SPREADSTIK. Applied 21 days after transplanting. *

Urea Side Dressing - 150 kg / ha = 4g / plant. Applied 20 days after transplanting.

Calcium ammonium nitrate (CAN) Side Dressing - 480 kg / ha = 13g / plant. Applied 20 days after transplanting.

At harvest all of the cabbages were cut open and the severity of tipburn was scored on a scale of 0 to 10, 0 being no tipburn and 10 being severe tipburn. The weight of each cabbage was also recorded.

Table 1. **Trial treatments.**

TRT	sprays		side dressing	
No.	Solubor	$CaNO_3$	Urea	CAN
1	Control			
2			P	
3				P
4	P		P	
5	P			P
6		P	P	
7	P			
8		P		

RESULTS AND DISCUSSION

None of the treatments had a significant effect on the average yield per plot.

All treatments containing boron had significantly lower numbers of plants affected by tipburn (Table 2). This in turn reduced the average severity of tipburn in the boron treatments.

It should be noted that in the treatments Boron & Urea (treatment 4), and Boron (treatment 7) only two and one plants per entire treatment showed any signs of being affected by tipburn respectively, and the Boron & CAN treatment had no plants affected by tipburn.

The urea alone (treatment 2) had fewer plants affected by tipburn than all other treatments that did not receive boron, but a higher number than all treatments that did receive boron, although these differences were not statistically significant. The reason for this is unclear, and it had been suggested that increased N might promote tipburn (Klaas Osinga, personal communication). This result could be in part due to the fact that the urea benefited the

[1] This problem is exacerbated in PNG as the majority of the farmers are not keeping any record of their finances over successive crops, but rather they tend to consider each crop as a single "batch" and have to feel that they make a profit on each of them (personal observation). It may be argued that if the farmers that gave up had kept better financial records, or were better able to understand them, they would be able to survive the poor prices paid during periods where tipburn was prevalent.

Figure 1. **Tip burn cabbage (a) and healthy cabbage (b)**

(a)

(b)

Table 2. **The effect of different nutrient applications on the occurrence and severity of tipburn.**

Treatment	% Plant affected	Average tipburn severity
Boron & CAN	0.0	0.00
Boron	5.0	0.10
Boron & Urea	8.3	0.29
Urea	38.3	1.32
Calcium nitrate & Urea	51.3	2.44
Calcium nitrate	53.3	2.31
Control (untreated)	73.3	2.24
CAN	75.0	4.49
L.S.D. (5%)	47.6	2.65

Scores: 0 - no tipburn, 10 - severe tipburn.

plants overall health, enabling them to partially overcome the effects of boron deficiency. Since the differences between all treatments were not significant one should not read too much into the slight reduction of tipburn incidence in the plots which received urea.

The CAN alone (treatment 3) showed significantly higher severity of tipburn than treatments 2, 4, 5, and 7. It has been reported (Imai *et. al.*, 1988) that NH_4 - Nitrogen applications are associated with increased tipburn severity. This could be borne in mind when carrying out further trials on tipburn, as it should be possible to increase the chances of inducing tipburn in a trial, which may be necessary as tipburn appears so sporadically.

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PRACTICAL METHODS TO PREVENT SOIL EROSION

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ABSTRACT

Agriculture production can be sustained on a long-term basis if the soil, water and forest on which it is based are not degraded. In recent years, growing population has increased cultivation and moved onto marginal lands prone to erosion. Erosion makes it more difficult for roothold, nutrient uptake, and makes soil less able to retain water which results in decline of productivity.

To use land to our advantage, we must begin to identifying simple, less expensive and practical methods of preventing soil erosion. Soil retention fences have been very effective traditional methods in some parts of Papua New Guinea, and with modification by use of contour planting, cover crop, deep ripping the prevention method be more effective. However the method used in one area may not apply significantly or achieve meaningful results and may have to be remedied to suit the local needs that are based on availability of materials and most important prevailing features.

KEYWORDS: *Soil erosion, shifting agriculture, soil fertility, soil retention method*

INTRODUCTION

In an undisturbed plant community most of the nutrients circulate between plants and the soil. Therefore, the environmental functions are in a balanced state. But this natural cycle of nutrient exchange is broken when man or other natural events like fire, storm or landslide disturbes the environment.

Man's continued agricultural practises has contributed much to soil erosion. The clearing of land exposes the top soil to natural elements such as wind, sun and water. Where there is no plant cover, the top soil is dried up by the sun. It then is blown off by the wind and washed off by rain water. Also, repeated short fallow shifting cultivation uses up soil nutrients and crop yield eventually decreases.

The problems associated with soil erosion and soil nutrient depletion are related. Therefore, this paper outlines practical methods that farmers in Papua New Guinea (PNG) could use to prevent serious soil erosion problems.

AGRICULTURAL SYSTEMS IN PNG

More than 85% of the PNG population practises subsistence agriculture, and is the biggest industry in existence in rural areas. Most of these subsistence farming are under shifting cultication interspaced with short periods of fallow. The fallows usually consist of perenial herbs, followed by grasses and woody plants.

Vegetation cover is usually burnt when clearing land for agriculture and is sometimes considered the main activity contributing to the loss of forest vegetation cover in PNG. Soil erosion as a result follows, especially on slope land throughout PNG. About 30 tonnes of soil was found to be lost through rain water on slope land due to land clearing in the Simbu Province, and severe erosion on bare slopes more than 20 meters long in other highlands provinces (Humphries 1984).

In the Gazelle Peninsula soil erosion is accelerated on slopes of 29° if the garden is clean-weeded (removing of weed debris and soil bared).

PREVENTION OF SOIL EROSION

Traditional methods and their modified versions can be used to prevent severe soil erosion. These include:

1. logs, fence, walls along contour
2. control of vegetation cover
3. terracing
4. moulding
5. ditching

SHIFTING CULTIVATION

This is a method of agriculture that has been adopted in many tropical and temperate countries. In PNG most subsistence agriculture is under a system of shifting cultivation.

The system essentially consists of clearing/cutting and burning the forest and subsequently planting successive batches of annual crops on the cleared area. The same piece of land can be used for several years or a short period of time as the farmer desires. The land is usually kept in production for as long as a worthwhile yield is obtainable. When production starts to decline the farmer shifts to a new area. The abandoned area grows to secondary vegetation and later to forest at which time the process is repeated.

There are certain conditions that attest to why the system has been sustainable and they emphasize the fact that through shifting cultivation by subsistence farmers, certain things are achieved. These include:

a). Maintenance of soil fertility - forms of crop rotation
b). Nutrients which have leached to lower levels are recycled or pulled up by deep rooted plants and stored in plant tissues.
c). Long term fallow systems control pest and diseases build up.
d). No over cultivation.
e). Minimise erosion.

TYPICAL GARDEN PATTERN IN PNG

Subsistence shifting cultivation is nowadays practiced on mountain slopes that have steepness ranging from lowest of 20-25° to the highest gradient at 50-60°. Gardening practices on such slopes has come about forcefully because all available flat land is under perennial cash crops, especially coffee, tea, cocoa, coconut, oil palm, rubber and livestock.

Traditionally, the selection of garden sites, clearing, burning, cultivation and planting occur in the sequence of events in the gardening pattern of the area. Normally after clearing and burning the farmer lays smaller logs both vertically and horizontally to make rectangular pattern of blocks of almost equal spacing (Fig 1) to either allocate or subdivide land between members of the family or to allocate for specific crops. By doing so, the people do not see or even realise that they are actually preventing serious soil erosion, but they believe by having this little rectangular areas, they would estimate or calculate the progress or speed a man can work in a day - probably to calculate man-days.

PREVENTING SOIL EROSION

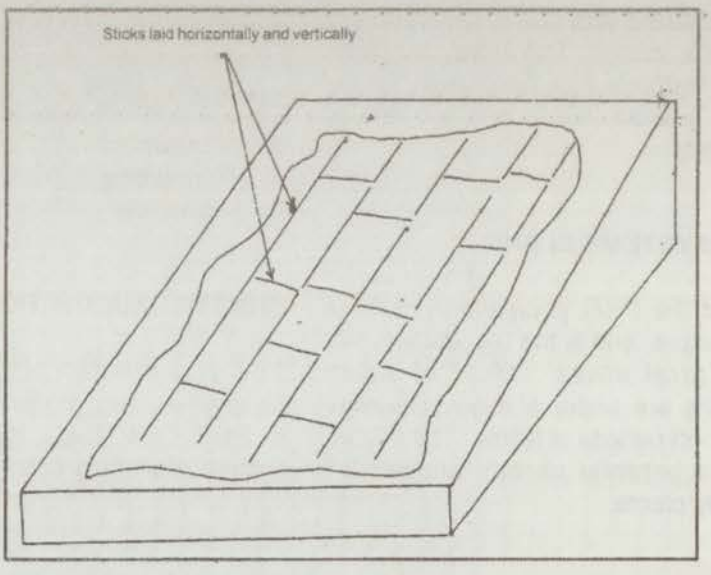
Agriculture within PNG, especially the vast rural sector, is traditionally based on some system of shifting cultivation. In such shifting cultivation the farmers are easing many problems that could arise from intensive type of gardening. The advantages of shifting agriculture are: -

a). Maintenance of soil fertility in form of crop rotation.
b). Minimise soil erosion.
c). No over cultivation.
d). Pest and disease control.

However, there are also disadvantages encountered in the shifting cultivation type of agriculture.

a. Large areas of land are needed.
b. Burning is frequent - destroys organic matter.
c. Population increases leads to over-use of land (short fallow).

Figure 1. **Typical garden site on mountain slope.**

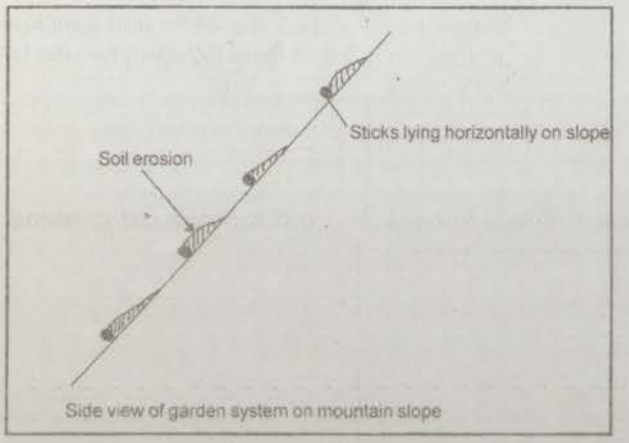


d. Erosion may be a problem as steep slopes are cultivated.

STEEP SLOPE CULTIVATION

Although people cultivate whatever portion of arable land on steep slopes of mountainsides is available, they have practiced some form of soil erosion prevention long since. As they lay the vertical and horizontal logs on cultivated garden area; those that lay across the slope stop soil from washing away (Fig 2). This is actually seen in gardens where the soil has been retained behind these logs.

Figure 2. **Preventing serious soil erosion problems.**



However, not all soil washed down by water is prevented from being lost. In some places some logs do not touch or lay perfectly on the ground, therefore about 50-70% is still washed down-slope. Nevertheless, some additional soil erosion prevention methods can be imposed and practiced by farmers if accepted and adopted into their gardening system. How to improve the present method?

TO IMPROVE PRESENT SITUATION

In addition to the current gardening practices the farmers should adopt other acceptable methods in order to improve and retain the rich topsoils being removed by water.

One of the better and most effective systems would be that practiced in Chimbu Province, where small "fences" or "Giu" are constructed across the slope. These fences are seldom more than 9 to 12 inches (22.5 to 30.0 cm) high and after one gardening cycle, are generally fully sedimented on the upslope side of fence by topsoil, thereby proving their effectiveness (Fig 3).

OTHER METHODS OF PREVENTING SERIOUS SOIL EROSION

Apart from the simple methods of preventing soil erosion currently used by the farmers and the slightly more improved methods used in the Simbu Province, there are some other practices which can be adopted.

Other possible methods of slowing down soil erosion could be as illustrated in (Fig 4).

a. Plant perennial crops on sloping land possibly with a legume cover crop/or pasture in between.
b. On the hillsides plant on contour.
c. Possibly all subsistence farming should be on flat lands.
d. Banks (ridges-mounds) constructed across slope to slow down rate of flow of water.
e. "Deep Ripping" if necessary, to soak in water and prevents run-off of water on soil surface.

Figure 3. **Small retention fences build across slopes.**

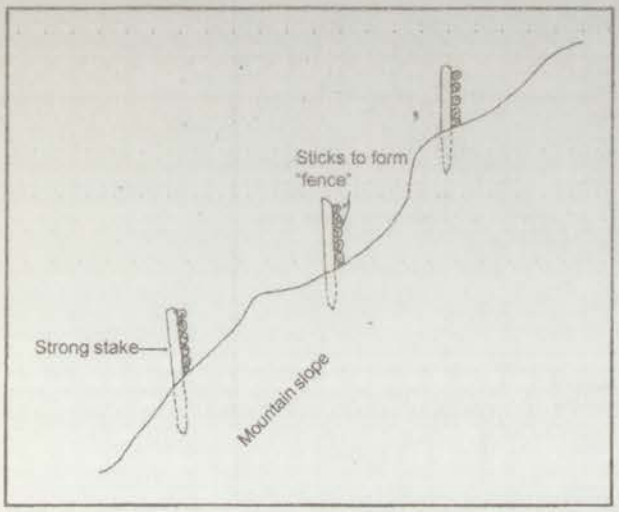
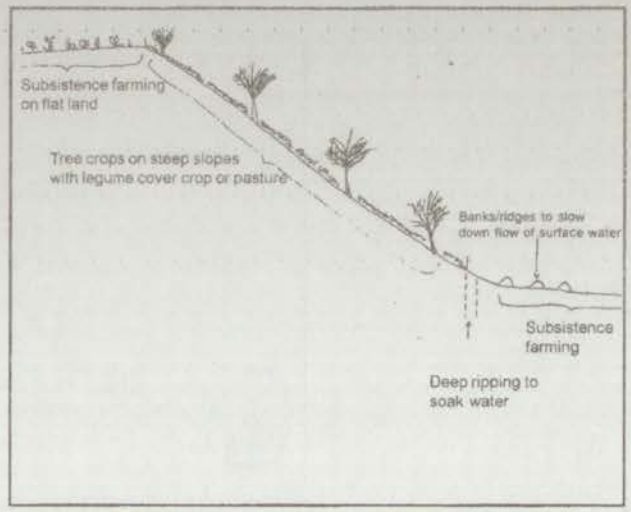


Figure 4. **Other means of preventing soil erosion.**



RECOMMENDATION AND CONCLUSION

Those subsistence farmers who face problems in maintaining the present gardening system would obtain greatest benefit from the available good land by adjusting to the methods recommended below.

The major problem areas faced by these farmers could be:

a. Land shortages due to clearing virgin forest for gardens.

b. Having fairly short fallow periods.

c. Limited area for either:
   - subsistence farming
   - perennial cash cropping.

d. Now forced to garden on slopes of mountains.

The farmers will make best use of whatever available land they have by cropping both annual and perennial crops on one piece of land (Fig 5 and 6).

i.e. On mountain slopes the perennial crops be planted on contour leaving sufficient space, about 15-20 metres in between each contour of perennial crop. The inter-row areas can then be utilised for annual crops gardening on rotation basis. Topsoil, which tends to be washed down will be trapped by the rows of permanent tree crops. In this way the soil will not be fully depleted and soil fertility is retained. Legume crops will also return nitrogen to soil if cultivated in the inter-row during resting periods.

With such practices the soil will be better conserved since:

1. Perennial crops will hold soil firmly by their vigorous root system.

2. Shade tree such as leucaena and gliricidia provide shade and fixed nitrogen for use by both crops.

Figure 5. **Contour planting of tree crop with sufficient space in between contour for food gardens.**

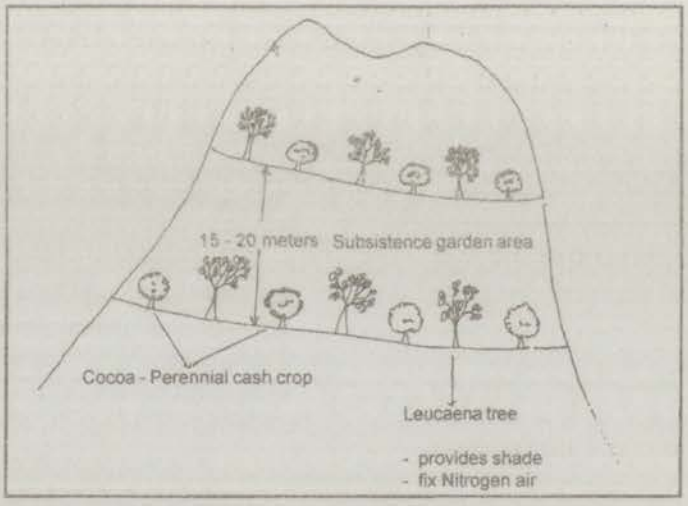
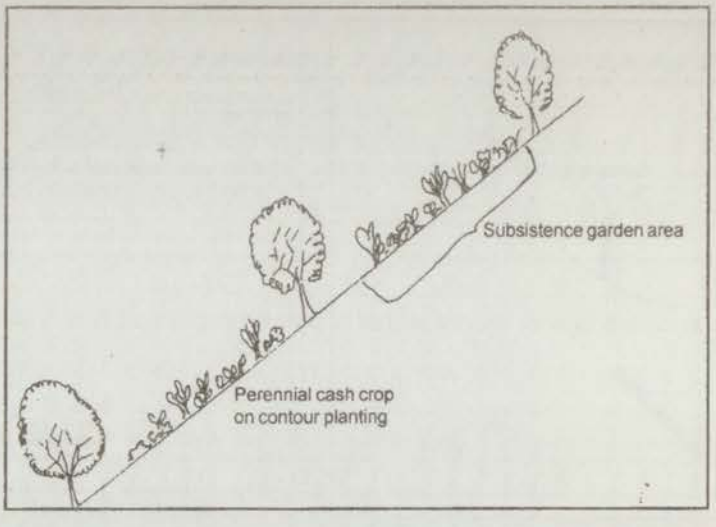


Figure 6. **Side view of intercropping on mountain slope.**



3. From one cropping area of land cash income can be obtained from tree crops while farmer lives off the subsistence crops.

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VILLAGE AND FARM SCHOOLS SHOW GREAT SUCCESS IN THE PROMOTION OF EXTENSION TECHNOLOGIES IN THE MARKHAM VALLEY, PAPUA NEW GUINEA

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ABSTRACT

Discussed below is the process of empowering farmers directly through training. The leader farmers were also encouraged and assisted to train others. The method was resorted to as a result of inadequate agricultural extension in the Huon and Kaiapit program areas. The results obtained indicated that village level training has economic benefits to rural households.

Key words: *Village and farm schools, Farmer leaders, model farms, extension visit, community groups, village level training.*

INTRODUCTION

In PNG the population is growing at 3.2 %, (NSO 2001) while agricultural production is said to be growing at only 1.6% (NADS 2001). About 82% of the population is rural and subsistence. Agricultural extension is limiting in numbers as well as quality. Coupled with poor road and transport infrastructure in many rural areas, these create big difficulty in reaching farmers with extension technologies and advice. Hence one of the problems for the declining productivity and production in agriculture is lack of adequate technology and information at the farm level by majority of the farmers.

As part of the Food and Agricultural Organization (FAO) of the United Nations Global drive to address Food Insecurity in Low Income and Food Deficit Developing Countries [LIFDC], a Pilot Phase of a Special Program In Support of Food Security [SPFS] was launched and implemented in the Marhkam Valley of Morobe Province in Papua New Guinea from 1996-2000. It was a joint program of the FAO, the Department of Agriculture and Livestock and the Farmers in the Program areas of Huon and Kaiapit districts. The program was set up to address food security needs on a limited scale in the selected sites. It was expected that achievements and lessons learnt from this pilot phase would be a guide in the extension and expansion of the program to other districts in Papua New Guinea in the future.

The Program begun with an Initial Farming Systems Analysis using Rapid Rural Appraisal/Participatory Rural Appraisal [RRA/PRA] methods, and it was identified that in view of the shortage of extension information at the field level and the inefficiency of the extension delivery system[Bammann H. *et al.* 1996, Dekuku. R. C 1997, Dekuku *et al.* 1999] , farmer training should be a major component of the pilot phase program [Bammann. H. *et al.* 1996]. As such, one of the recommendations was that 'model farms' be established on-station and on farmers fields for demonstration and extension purposes, so as to reach more farmers.

Discussed below is the implementation of such model training program and some of the achievements. The model emphasises learning through experience and experimentation of real field related problems. The training according to such principle implies facilitation of the learning process, rather than instruction, and is based in all cases more on hands-on practical experiences [learning by doing and doing by learning].

Main Villages involved

The Program was implemented in four villages in the Kaiapit District, and five villages in the Huon district, all in the Markham Valley. The agricultural activities were centered around, rice, vegetables, aquaculture, irrigation and yams [Table 1]

The levels of farmer training

Three level of farmer training were identified and implemented, as follows;

Level 1. Training the Farmer Leaders [Trainer-Trainees] on Station and on-farm

Key farmers were identified in each village, through consultation with the Village Farmer Association and the District Extension personnel. These farmers become the Farmer Leaders in the particular field

of training. Training on station takes 2-3 weeks, and the number of participants is limited to less than 40 farmers/course session.

On station training looks at the whole crop from seed to seed [planting to harvesting], using pre-planted fields with plants at various growth stages. Lectures are given in simple English, and field work accounts for approximately 70% of the time, and 'classroom' work for the other 30% of the time. Accommodation, three meals a day and transportation are provided to the trainer-trainees

Level 2. Extension staff and Farmer Leaders train the Farmers on Farm /Village

On return from the training, the Trained Farmer Leaders team up with the SPFS Extension /Technical personnel in training the other farmers in the villages. Trained Farmer Leaders were encouraged as resource personnel to take the lead in the training, while the SPFS Team provide back up support.

This village level training in terms of crops takes 1-2 days at a time, while aquaculture training takes one week. The numbers of participants are not limited. Instructions/demonstrations are in simple English /Pidgin [local language].

Demonstrations, field work and discussions take 85-95% of the time, while 'lectures' take 5-15% of the time. Training on crop husbandry is done in stages at various field operation or plant growth stages, such as; land preparation, planting, weed control, fertilization, harvest and post harvest times. Aquaculture training takes a week and covers all operational functions, using existing and new ponds.

Farmers stay home and come in the morning and disperse after the day's work. Snacks and soft drinks are provided at lunch time.

Since the village level training operation take place during the crop season, the farmers go back and as soon as possible put into practice what they learnt on their own fields. The trained Farmer Leaders jointly with the SPFS Staff supervise the field operation of the other farmers when they go to put into operation the new knowledge. By so doing, the Farmers Leaders gain more experience and confidence in the technologies themselves. At the same time, the other farmers look upon them as their peer and supervisors on whom they could rely on for direction. This creates a strong bond within members of the community and a sense of mutual respect among them.

At the same time, it creates some level of expertise and first level of 'extension farmer officers' at the grass roots or village level, and serves as the first 'port of call' for other farmers seeking advice.

Level 3. Farmer Leaders and Farmers train the other Farmers on Farm

Farmer Leaders and other trained or pioneer farmers that benefited from levels 1 and 2 above, provide voluntary training to their relatives and friends on farm. They choose their own free time. They normally share a meal, because the new farmers assist the trainers in their field operations, as part of the learning process. These new farmers, after the partial and voluntary 'apprenticeship' on the farm of the others, go to put their acquired skills into practice on their own farms.

For the period August 1996 to August 2000, 1,626 farmer leaders and farmers were trained directly by the SPFS Team and Farmer Leaders. While another 1,626 farmers were trained by the Farmer Leaders/ Pioneer Farmers. This makes a total of at least 3,352 trained farmers. If we take into consideration that the average household size in PNG is 6 , based on the 2000 Census, and that children in farm households learn by doing, the overall number of

***Table 1.* The Special Program in Support of Food Security Pilot Sites and Activities**

Huon District	Activities	Kaiapit District	Activities
1. Gabsonkeg	Aquaculture	6. Naratumua	Rice
2. Nasuampun	Aquaculture	7. Minimian	Rice
3. Yalu	Aquaculture	8. Ragiampun	Rice, vegetables and irrigation
4. Mare	Aquaculture	9. Intoap	Rice, vegetables, irrigation & yams
5. Wampup	Vegetables & irrigation		

individuals that benefited from this village level training is far in excess of the total of 3,352.

Significance of regular extension visits to the farmers.

In addition to training, the SPFS staff paid regular extension visits to the program sites. The local District Extension staffs visit the sites at least one to two times each week, and the Erap SPFS Program Manager and staff visit each village/site once a week, in this case every Wednesday to provide back up support to the farmers. Fixed day visits were preferred by the farmers and the extension staff instead of unplanned and varying days. Fixed day visits allowed the farmers as well as the extension officer to plan their other activities for the other days.

We found out that, the farmers appreciated greatly the regular extension visits. They devoted these days to discuss their problems and to get solutions, show off and discuss their achievements in the field or in storage on timely basis, and to discuss and request for new training in other areas of need. The visits also assisted the farmers in the sense that they do not have to waste their funds and time travelling away from their work individually to reach us at the SPFS Headquarters at Erap which might result in waste of a half to whole day as a result of irregular public transportation.

Access to market

In the promotion of training for participation in food and livestock production, it was realised that excess production beyond family needs would result. The need to help farmers dispose of the excess production was a component of the production promoting process. The SPFS and collaborating partners therefore assisted the farmers in identifying market sources and demands, in terms of what to produce and where to market their produce / products, quantity and the prices. Trainings in quality of marketed produce / product management were also conducted for the selected farmers.

The result was that different farmers have decided, based on their awareness, as to what marketed crops to cultivate, the time and quantity to cultivate. This has led to diversified and specialised production by various farmers. For example in vegetables some of the farmers specialised in capsicum, others in bulb onion, tomatoes, water melon, leafy vegetables. This guides them to avoid excess production beyond home and market demands.

Since late 1997, our Markham Valley farmers have become some of the key suppliers of vegetable to local and supermarkets and hotels in Lae. Before then, most of the vegetable come from the Highlands; Goroka and Mt. Hagen. This demand for the Markham produce and the access to market has encouraged our trained farmers to continue production beyond home consumption levels and to now earn cash income unlike before.

The formation of farmer groups contributed to the success of extension and to farmers welfare

We realise very early in the Program formulation and the initial farming systems analysis study that it would be easier to work with farmer groups, than with many individual farmers scattered all over the Markham Valley Program area. We discussed and encouraged farmers to form Village level groups, for ease of channel of communication, assembly, collective problem discussions, training, participation and decision making.

Five permanent farmer groups were formed, at Naratumua, Ragiampun, Intoap, Minimian and Wampup, with executives; Chairman, Secretary and Treasurer. The formation of the groups had further strengthened the collaboration and cohesion and a sense of belonging and cooperation within the farmers and between them and the Program Staff. This allows us to plan and run many training courses on farm and on –station with maximum collaboration and attendance.

The Group formation also allows for procurement of inputs, sharing of production and processing equipment, transportation arrangements and group marketing of produce, which were in the past difficult on individual basis.

It is expected that these Groups would become the pioneers of Farmer Cooperative in the near future.

Some results achieved by our Farmers after training

The result of the training is an overall increased awareness and increased production and productivity in the program sites, as indicated in the SPFS Overview Report [Dekuku. R.C. 2001] and component of which are presented below.

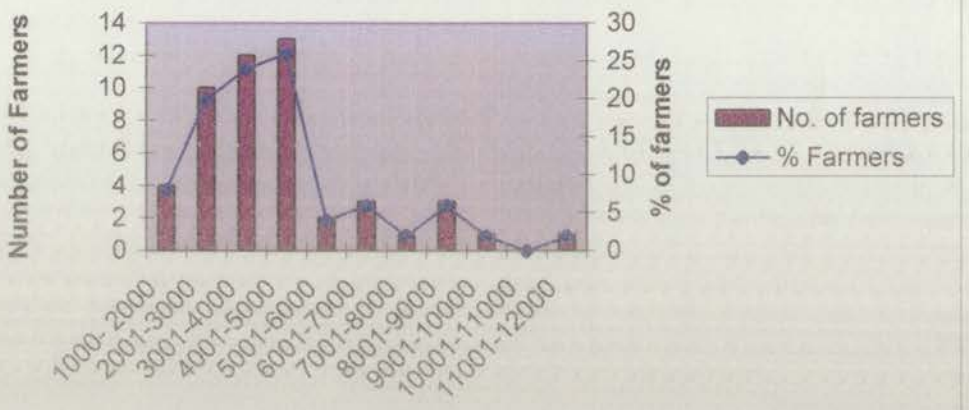
Naratumua 1997/98 Rice Production

The SPFS first village level training of farmers was in Naratumua Village in rice cultivation. As in most parts of the Upper Markham Valley, the predominant farming activities at Naratumua and other surrounding villages are peanut cultivation for cash income, and the cultivation of taro, banana and leafy vegetables for home consumption. Income from peanut is used for the purchase of store goods, meet other necessities and paying of bills. In 1997, a

serious drought brought about by El-Nino affected most parts of Papua New Guinea, including the Markham Valley. The farmers of Naratumua and surrounding villages could only grow and harvest one crop of peanuts, instead of the normal three per year. Short of cash and food, the farmer Leaders approached the SPFS to help them cultivate rice for food once the rain starts. The farmers were trained to grow rice following the 3 levels discussed above.

Members of Mamaferan Clan agreed to accept the other clans to participate with them and share the benefits from the model farm. Members from eleven clans comprising over 481 farm households were involved. The model farm was set up in July/August 1998, initially as a venue to learn modern agriculture production techniques. Vegetable crops, irrigated and rainfed rices, fish, ducks and aquaculture were included in the demonstration. On – site hands on training was given around each crop and livestock

Fig. 1. Naratumua Rice yields kg/ha in 1998



Rice yields were high, ranging from 1,000 - 12,000 kg/ha (1.0 - 12.0 tons/ha) with means yield of 3.96 tons/ha (Figure 1).

Gross margins indicated that small scale rainfed rice production is economical [Fig.6], with highest gross margin of 300-400%.

Ragiampun 1998 model farm summary report

The Ragiampun Model Farm was our second village level on-farm training program. Eleven Clan groups were involved [Tab. 2]. It was a training Program that united people by breaking through traditional 'Clan barriers', whereby people from various Clans work together voluntarily in this case.

A collaborative approach was used in setting up the model, demonstration and training farm at Ragiampun Village. This was based on the community's request, after seeing the success of rice work at the neighboring Naratumua Village. The FAO/DAL Special Program in Support of Food Security, invited the R.O.C [Taiwan] Technical Mission and The DAL-Mutzing Extension Division to join in the program.

following the crop/livestock growth cycle. Farmers sleep at home and report for training and work on selected days of the week. Initially all farmers were involved, but subsequently were divided to work on alternating days. This way, they could also attend to their other domestic needs on the other days. The farmers learned and provided labor on the management of the model farm. At harvest time, they were provided access to market and marketed some of their produce and used the rest for home consumption. The Member of Parliament for Markham was happy with the Model farm concept and the performance of the clan members, and donated to them a two-ton truck to help their operations, especially inputs procurement and marketing of produce.

A successful field day was held on 16/10/98, to coincide with the World Food Day, and to show case their work and achievements to others. Approximately 1, 500 people attended the field day, made up of 80% interested and curious farmers from other sites. Other participants were; politicians, scientists, administrators, extension workers, students and the general public **[In a country of**

Table 2. **Summary of Farmer Leaders and Farmer Training Courses Conducted by the SPFP/ PNG/4501 Program, August 1996 to August 2000**

No.	Course Title	No. of Participants	Description
1	Farming systems development training	200	Farmer Leaders & farmers from two districts
2	Rabbit husbandry	42	Farmer Leaders and farmers
3	Aquaculture	74	Farmers Markham farmers
4	Vegetable production	36	Farmer Leaders
5	Vegetable production	261	Farmers from 2 districts in 2 batches
6	Rice culture [Naratumua, Ragiampun, Intoap, Minimian Villages]	450	Farmer Leaders and farmers covering 4 locations and involving 20 Clans
7	Food technology	12	Farmer Leaders
8	Sheep and goats husbandry	40	Markham farmers
9	Peanut fertilization	24	Markham farmers
10	Hands on on-farm irrigation	100	Ragiampun Farmer Leaders & farmers [involving 14 Clans]
11	Shallow well construction	8	Intoap Farm families
12	Operation of water pumps	8	Intoap farm Families
13	Aquaculture, for farmer leaders	16	Farmer Leaders
14	Yam Miniset Technique	12	Key farmers
15	Aquaculture , for farmers	29	Gabsonkeg farmers
16	Aquaculture for farmers	45	Nasuapum farmers
17	Training in rice culture	50	New Intoap families
18	Training in Agriculture & Food processing	25	Morobe Women Leaders
19	Training in Rice top dressing	50	Intoap farmers
20	Training in aquaculture	54	Farmers from Yalu.
21	Training in aquaculture	68	Mare farmers
22	Rice post harvest/rice mill course	22	Markham Farmer Leaders
	Total Direct Training	**1626**	
28	Indirect Training [by farmer, leaders and pioneer farmers through learning by doing]1:1 ratio	1626	Children, relatives & others etc.
	Total Direct / Indirect Training	**3352**	

Table 3. **Clans involved in the Ragiampun Model Farm Training Program in 1998**

No.	Clan Name	Clan Leader
1	Mamaferan	John Nario
2	Mayangcharia	Ima Gainde
3	Itat	Rarang Anangk
4	Muim	Bogen Buga
5	Gananggadang	Tuna Jamoam
6	Garamurum	Maruwin Gadi
7	Arifiwat	Chiram Mimari
8	Uramragin	Rawi James
9	Dampidampi	Gabi Urubit
10	Buni	Ita Sambanga
11	Muntua	Klemens Nglring

only 5.13 Million people scattered over many islands, the turn out was high].

Record of production and farm income (but not exclusive) were done (Table 3). The production records obtained here serves as a sample of the minimum funds achieved, since some of the produces were harvested for home consumption and also as gifts. Estimated income was K 17, 785 for the first harvest of crops. The Farmers were surprised, amazed and very happy to have such much income within a very short time of 3-4 months.

To date, the Mamaferan Clan farming community had accepted the initiative of the model farm. They have expressed this through their dedicated daily commitment and interest by their full participation. They cultivate the plots 2-3 times a year. The SPFS has since installed a 5Hp water pump to help them expand on the irrigated fields for more food production.

The other Clans have gone back to their traditional lands to practice what they have acquired.

Training and Rice Production in other sites

Work at Erap, Naratumua and Ragiampun had further indicated that rice has potential in the Markham Valley. Other farmers from Minimian and Intoap and later Wampup also joined and embraced the rice technology, and are also producing rice for home consumption and saving money for not having to buy rice often anymore. Our results, based on data from 128 farms in the Markham Valley within the period 1998 to 2000; indicated that, even without irrigation, average yield of 2.000 - 3000 kg/ha could be obtained, and yield equivalents above 5 tons/ha are common [Fig.2,] The yields are high compared to those for rainfed rices world wide, which indicated a high quality of adoption and adaptation of the optimum production processes by the Markham Farmers.

The Special Program has since purchased four rice mills and installed them at four sites in the Markham Valley, so as to help farmers have access to mills, for processing. Farmers are happy with the rice program, as they now produce rice for home consumption and sharing with their extended families.

Yams

Yam species ***Dioscorea rotundata*** [Guinea or African Yam] was introduced to farmers in the valley, by the SPFP Team, because of its good taste, higher yields and relatively long storage period [two to six months] and relative drought tolerance. Farmers were taught to propagate their yams using the 'minisett technique'.

Very good results were obtained by the pioneer 11 farmers, and the yams and technology of propagation has started to spread widely in and around the Markham Valley and the number of farmers increased from 11 to 349 in the second season, and further to 1,000 by year 3 [table 4]. The additional farmers after year 1 were trained by the Farmer Leaders and other pioneer farmers. This is a good reflection on our village level expertise development program.

From less than hundred plants per farmer in the first year, the initial 11 farmers increased their yam plantings in year 2; the 2000/01 crop season [Table 6].

Fig. 2. Mean Rice Yields in Markham Valley, 1998 to 2000

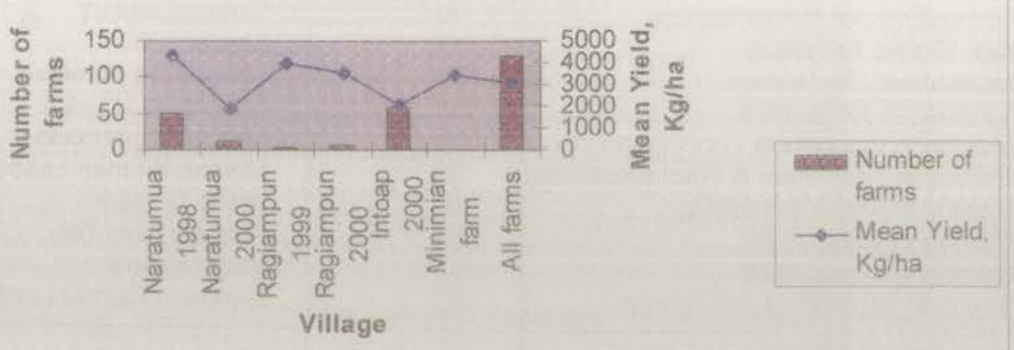


Table 4. **Ragiampun 1998 Model Farm Data**

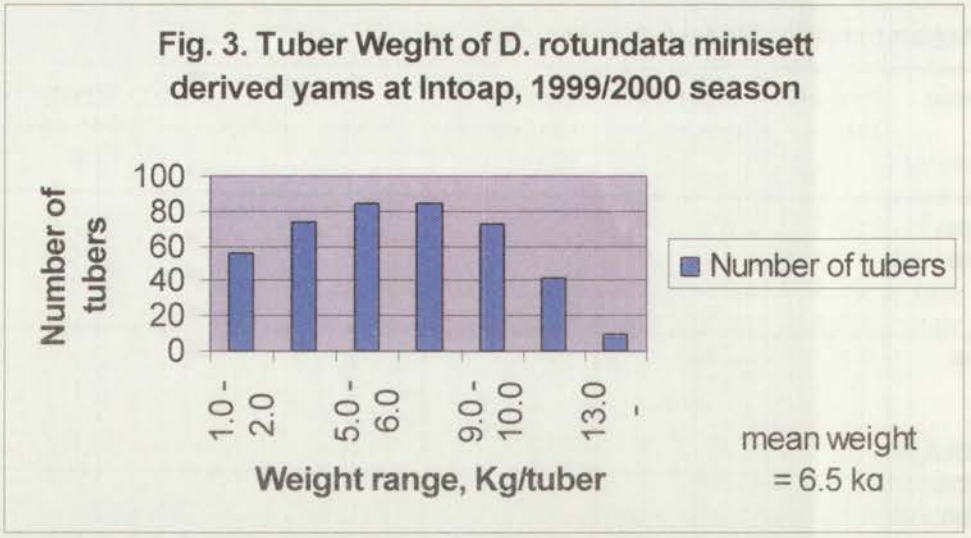
Crops Planted	Plot size Ha.	Actual Yield Tons	Income equivalent Kina	Yield/ha basis	Price /ton Kina	Income on per ha basis Kina
Irrigated rice	0.35	2.03	812	5.8	400	2,320
Rainfed rice	1.85	4.16	1,665	2.2	400	880
Tomatoes	0.09	1.65	825	18.3	500	9,150
Capsicum	0.51	1.075	537.5	2.1	500	1,050
Long Beans	0.42	0.946	473	2.3	500	1,150
Okra	0.18	0.426	340.8	2.4	800	1,920
Cucumber	0.78	1.95	1,560	2.5	800	2,000
English cabbage	0.21	3.78	2,268	18.0	600	10,800
Spring Onion	0.33	0.396	1,584	1.2	4,000	4,800
Water Melon Sugar baby	0.18	850 pieces	3.400	4,722	4/piece	18,888
Water melon M. glory	0.27	386 pieces	4.320	14,42	1.1/piece	15,872
Total income	**5.17**		**17,785.30**			**68,830**

Table 5. **Introduced *Dioscorea rotundata* [African Yam] Farmers in MarkhamValley in three crop seasons**

1	Number of Farmers in 1999/2000 season	**11**
2	Number of Farmers in 2000/2001 season	349
3	Number of Farmers in 2001/2002 season	**1,000**

Table 6. **African Yam Impact Evaluation for Two Crop Seasons in Intoap Village.**

		Number of Yams [Mounds]	
No.	**Name**	**1999/2000 Season**	**2000/2001Season**
1	Asam Kasi	103	2900
2	Maria & Peter Linibi	870	878
3	Ka Gaunga	2	310
4	John Linibi	190	480
5	Timothy Guru	50	300
6	Tau Busil	200	1000
7	Buya Timothy	200	500
8	Giram Maning	200	1000
9	Giamoki Buri	20	70
10	Gore and Yarambi	54	210
11	Tande Linibi	10	403
	Total	**1899**	**8051**
	Percent increase over	**1999/2000 season**	**424.38%**



Yam yields were found to be high. Tuber weights ranged from 1 to 14 kg, with a mean of 6.5kg/tuber [Fig 3]. Occasional weights of up to 20kg/tuber were obtained in some fields.

Yam yield data from selected farmers gave yield equivalents of 49,334 kg/ha to 75,208 kg/ha. These correspond to potential income equivalent of K49,334 to K150,416, depending on if the yams are sold at the current village and market prices of 1Kina/Kg or 2 Kina/Kg[table 6], Dekuku, R.C 2001b estimated that yam production costs could be relatively high; K22,550/ha, if based on hired labour. But even in this case he reported Gross Margin or Profit to be 314%. Considering that cultivation of food crops including yams in the Markham Valley are usually done using family labour or 'sweat equity' without cash payment, the actual production costs would be far lower than the reported estimated production cost. This would make yam production even more profitable.

Thus in the deep Markham Valley soils, D. rotundata is showing great promise, as a potential crop for food security and hunger elimination. The long storage period of the yam, 2- 6 months, gives it an added advantage over the other traditional staples, such as taro, bananas and sweet potatoes that have less storage time. This makes it a crop with potential for long storage and distance markets. As such, the Yam Technology is spreading like wild fire and there is very high demand from other farmers for this particular yam variety and the propagation method introduced to the farmers by the SPFS Team.

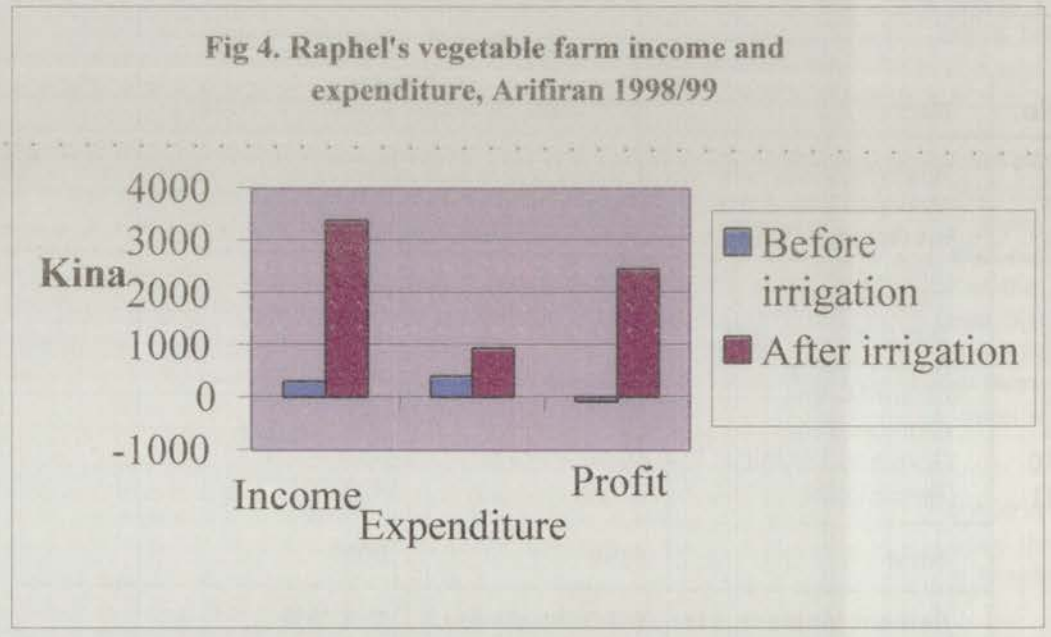


Table 7. **Yam Production Data From Selected Farmers, Intoap Village 2000**

Farmer	Number of tubers sampled	Total Weight, Kg	Weight on per ha. basis*	Potential minimum Income, Kina	Potential maximum Income, Kina
Buyai	62	400	64,516	64,516	129,032
Giram	64	414	64,688	64,688	129,371
Yalambing	48	332	69,168	69,168	138,336
Asam	64	431	67,344	67,344	134,688
Tau	96	722	75,208	75,208	150,416
John	90	444	49,334	49,334	98,668

* Based on 1m x 1m planting distance [minimum of 10,000 plants [tubers] per ha. Minimum income based on K1/Kg and maximum income on K2/Kg

Some Vegetable Production Results

Thirty Six Farmer Leaders were trained on Station by the SPFS Team covering most aspects of vegetable production including quality and packaging. On return the Farmer Leaders assisted by the SPFS Team trained 261 farmers at the village level. Vegetables have become a major cash crop for our farmers. They have been supplying commercial houses and Hotels in Lae, since 1997, as a result of the training and subsequent irrigation provided them by the SPFP.

Results presented [tables 8 to 11 and figure 4) indicate that vegetable production by our trained farmers is profitable. Production with supplemental irrigation gives better results.

The crops identified with high income potential are; Water melon, Chinese cabbage, English cabbage, Tomato, Eggplant and Capsicum

A Typical small farmer sales and expenditure data indicated that semi-commercial vegetable production, in this case Capsicum, even in the 1997 drought year with limited supplementary irrigation gave promising results and revenue. By investing some of the capsicum income into chicken and second hand clothing, the farmer further improved on his income [Table 10]

Training in Small Scale Irrigation Development and Management

With the serious effect of the 1997 El Nino vividly in the minds of the SPFS Team and the farmers, a program for small irrigation development was formulated and funded. In order to keep the irrigation development costs low, the farmers were reasoned with to play significant parts in the irrigation development. For example, farmers were taught to make liners for their shallow tube wells. They dug their tube wells and also trenches for the laying of pipelines under training and supervision by the Experts. They were also taught how to handle and maintain and service their water pumps. The result was that irrigation development costs were reduced [Table 12], due to active farmer participation in the development.

The farmers were expected to pay back 80% of material costs, as they provided their own labour. Without training and active farmer participation, costs would have been higher.

The irrigation programs have been found very useful, as indicated for vegetables above. They are also source of domestic water supply to the farm families.

AQUACULTURE RESULTS

Aquaculture is one of our major thrusts. The idea is to train farmers, to produce fish in ponds, and to supplement/ meet their protein needs. The surplus could then be marketed. The Program train farmers for a week, supervised them to dig ponds, supply them Tilapia or Carp fingerlings, and provide extension support. Up to date 286 farmers have been trained and over 202 [71%] of them that completed their ponds were supplied fingerlings. Over 18,790 fingerlings have been distributed free of charge to the farmers so far [Table 13]. The Special Program provides extension support. Fish are fed on household food surpluses, such as rice, potatoes, rice bran, bananas etc and supplemented by chicken pellets.

The earlier farmers have fish weighing between 250-700 grams and are harvesting them for home consumption and sale to neighbours [table 14]. Aquaculture has great potential to improve on the

Table 8. **Comparative income for vegetable production under rainfed and irrigated systems in the Markham Valley in 1999-2000, in Kina/ha basis[1]**

Crop	Village	Rainfed	Supplementary irrigated
Water melon	Arifiran	1,200	
Water melon	Arifiran		30,400
Water melon	Ragiampun		18,888
Water melon	Ragiampun		15,872
Cucumber	Arifiran	8,800	
Cucumber	Ragiampun		2,000
Cabbage[pakchoi]	Arifiran		28,400
English cabbage	Ragiampun		10,800
Spring onion	Arifiran	3,200	
Spring onion	Arifiran		2,600
Spring onion	Ragiampun		4,800
Tomato	Arifiran	5,900	
Tomato	Ragiampun		9,150
Egg plant	Arifiran		10,400
Capsicum	Ragiampun		10,400
Capsicum	Intoap		15,537

1: Based on production and sales figures from collaborating farmers, adjusted to per ha. basis

Table 9. **Wampup vegetable production results**

Tab. Revenue[1] from vegetables within one season, Wampup 2000, PNG Kina						
No	Crop	Area, m2 basis	Area in hectares	Revenue on plot basis	Revenue on per ha. basis	
1	Chinese cabbage	3169	0.32	4,680	14,768	picked once
2	Tomato	2915	0.29	6,560	22,504	picked 4 times
3	Capsicum	1037	0.1	3,480	33,558	picked 3 times
4	Water melon	580	0.058	2,400	41,379	picked once
5	Round cabbage	317	0.032	920	29,022	picked once
	Total	**8018**	**0.8**	**18,040**	**141,231**	
Less Land development and seed costs				-1,118.19		
	Profit from 0.8 ha field			**16,921.81**		

1. **Note: Some farmers were reluctant to declare their income. So this figure is not maximum value.**

2. **Sales were done in Lae Main Market, Anderson, Erap road and Trukai Industries Office**

Table 10. **Summary of Asam Kasi's Capsicum sales and expenditure during the 1997 drought year***

Month	Income [PNG Kina]	Transport, food and other Expenditure**
January	555.4	67
February	665.4	194
March	400.8	197
April	616.5	76
May	396	68
June	450	53
July	414	73
August	515.4	42
September	1202	277.5
October	805	61
November	308	138
December	1439.2	155
Capsicum Total	**7767.7**	**1401.5**
Other revenue using Capsicum income for investment		
Sale of chicken/Sale of 2nd hand clothes	8,000/2,500	1301.7/660
Total other Capsicum supported income	**10,500**	**1,961.7**
Total Capsicum related income	**18,267.7**	**3,363.2**
Net Income	**14,904.5**	

Note.

*. Based on two 1/5th ha Capsicum plots during the severe 1997 drought year, with twice a week shallow supplementary irrigation only.

**. Other expenses include use of vegetable money as capital in investing into day-old chicks and second hand clothing for re-sale later on. It includes also other household expenses, and fuel for supplementary irrigation.

Table 11. **Vegatable income figures for Raphel's farm in 1999 with and without irrigation.**

Production System / Crop	Without irrigation				With irrigation			
Crop	**Area**	**Amount, Kina**	**Kina/m2**	**Kina /ha. basis**	**Area**	**Amount/ Kina**	**Kina / m2**	**Kina/ha. basis**
Water melon	520 m²	62	0.12	**1,200**	920m²	2,800	3.04	**30,400**
Cucumber	40m²	35	0.88	**8,800**				
Cabbage [pakchoi]					198m²	563	2.84	**28,400**
Spring onion	224m²	72	0.32	**3,200**	560m²	150	0.26	**2,600**
Tomato	80m²	47	0.59	**5,900**				
Egg plant					80m²	83	1.04	**10,400**
Capsicum					108m²			
TOTAL		**216**				**3,596**		

nutrition and income of the households, and interest continues to be high.

A faster growing Tilapia species [Nile Tilapia, Gift Strain {Oreochromis niloticus}] has been introduced for trials in the valley. Initial results at Erap and Gabsonkeg gave promising fish weights of 220-300 g within 4 months. This new specie would be distributed to the farmers after the necessary introductory quarantine clearance.

An example of a our trained Farmer Leaders contribution in helping other farmers

The successful contribution of one of our trained Farmer Leaders, Mrs. Maria Linibi to other farmers in support of their food security needs in the Markham Valley is narrated below.
Mrs. Maria Linibi was trained by the SPFS on Station as one of **the Farmer Leaders** in vegetable production in 1997, in rabbits, rice and irrigation development and management in 1998 and in yam mini-sett techniques in 1999. In all cases, on return, the SPFS supported her to train other farmers in her group [Intoap Farmer's Group] of which she is the Secretary. Even after the pilot phase, the other farmers in the community look to her for guidance in their agricultural development needs.

Mrs Linibi's capabilities were realised by other agricultural programs in the area, and she was contracted by the Small Scale Subsistence Pilot Phase Program[SSSPP] agricultural contracting project in Lae, Morobe Province to train other farmers.

In 2001 1ST four months she;

1. Trained 239 farmers on water melon and Bulb onion cultivation
2. Trained 241 farmers in Rice Production
3. She and the members of her group are cultivating and eating their own rice. They have milled over 100 tons of rice so far for home consumption [from their 1998 to 2001 rice harvest]. They are keeping the other rice harvests for later milling [there was no rice production in the area prior to the SPFS training and introduction of rice to the farmers]
4. She and 6 members of her group have distributed 3855 tubers of yams [of various weights] to other farmers [3,000]. These were harvests from their own farms from mini-setts.
5. The National Agricultural Research Institute is using Maria and her husband Peter Linibi [also one of our farmer leaders] as their village level extension advisers on rice in the Intoap area.
6. She and her family are continuing to cultivate vegetables that they sell to the Lae Hotels and Supermarkets.

Table 12. **Costs of irrigation development at Intoap in the Markham Valley, 1999 in PNG Kina.**

Name	No of Taps	Unit price 1)	Pump	Unit price	No. of wells	Unit price	Total costs	No of Ha	Cost / Ha	80% Cost
Peter & Maria	5	302	1.00	2561.00	1.00	450	**4521.00**	1.82	**2484.07**	**3616.8**
Tande 2)	3	302	0.50	2561.00	0.50	450	**2411.50**	1.06	**2275.00**	**1929.2**
John 2)	4	302	0.50	2561.00	0.50	450	**2713.50**	1.29	**2103.49**	**2170**
Giram 3)	4	302	0.50	2561.00	0.50	450	**2713.50**	1.42	**1910.92**	**2170**
Narura 3)	4	302	0.50	2561.00	0.50	450	**2713.50**	1.27	**2136.61**	**2170.8**
Timothy	4	302	1.00	2561.00	1.00	450	**4219.00**	1.47	**2870.07**	**3375.2**
Tau Busil 4)	4	302	1.00	2561.00	1.00	450	**4219.00**	1.50	**2812.67**	**3375.20**
Asam Panda	4	302	1.00	2561.00	1.00	450	**4219.00**	4.31	**978.89**	**3375.2**
Ungkul 5)	3	302	0.33	2561.00	0.33	450	**1909.67**	0.96	**1989.24**	**1527.7**
Michael Sam 5)	3	302	0.33	2561.00	0.33	450	**1909.67**	0.96	**1989.24**	**1527.7**
Buri Ungkul 5)	3	302	0.33	2561.00	0.33	450	**1909.67**	0.96	**1989.24**	**1527.7**
Peter	5	302	1.00	2561.00	1.00	450	**4521.00**	1.43	**3161.54**	**3616.8**
Total							**37980.00**	18.45		**30382.3**

1) Unit price for taps includes all fittings, pipes etcetera
2) Tande & John share their well and the pump
3) Giram & Narura share the well and the pump
5) Panda Ungkul, Michael Sam and Buri Ungkul share their well and pump

Table 13. **The Special Program Aquaculture Projects in the Markham Valley as at 30/12/2000**

A.	Kaiapit District				
No.	**Village**	**Number of Farmers**	**Number of Ponds**	**Number of Fish**	**Fish Type**
1	Waritsian	2	2	395	Carp / Tilapia
2	Naratumua	1	2	350	Carp/Tilapia
3	Ragiampun	1	7	77	Carp
4	Inpoap	1	2	27	Carp
5	Sampugan	1	1	200	Carp
6	Sauruen	1	1	96	Carp
	Sub Total	**7**	**15**	**1145**	
B.	**Huon District**				**Carp**
No.	**Village**	**Number of Farmers**	**Number of Ponds**	**Number of Fish**	**Fish Type**
1	Gabsonkeg	26	28	3424	Carp/ Tilapia
2	Nasuapum	18	21	1926	Carp
3	Yalu	19	19	1521	Carp
4	Mare	50	50	5000	Carp
5	Tararan	1	1	210	Carp
6	Wawin	1	1	180	Carp
7	Fayang	1	1	100	Carp
8	Naramonki	2	4	401	Carp
9	Munkip	7	11	1198	Carp
10	Gabmanzung	1	1	280	Carp
11	Munum	1	1	100	Carp
12	Wampup	1	1	300	Carp
13	Sifu	1	1	100	Carp
	Sub Total	**129**	**140**	**14740**	
C.	**Nawae District**				
1	Wasin	2	2	80	Carp
2	Kasin	31	31	1174	Carp
3	Kain	2	2	90	Carp
4	Guffin	4	4	243	Carp
5	Moembling	1	1	70	Carp
6	Fii	2	2	122	Carp
7	Sibi	5	5	227	Carp
8	Banzain	1	1	32	Carp
9	Boana	1	1	50	Carp
10	Tinibe	2	2	98	Carp
11	Mungreng	2	2	115	Carp
12	Badibo	1	1	54	Carp
13	Peli	1	1	42	Carp
14	Kasuka	9	9	401	Carp
15	Wambangan	1	1	67	Carp
16	Migima	1	1	42	
	Sub Total	**66**	**66**	**2907**	
	TOTAL	**202**	**221**	**18,792**	

Table 14. **Fish Production by Selected Farmers in the Markham Valley**

No.	Name	Village	Weight range, grams	Mean weight, grams
1	Yariman Pumu	Waritsian	240 - 270	252
2	Henry	Waritsian	160 - 260	212
3	Mare Tepo	Gabsonkeg	260 - 360	316
4	Seth Tepo	Gabsonkeg	320 - 580	468
5	Zobbie Yaffon	Gabsonkeg	180 - 680	328
6	Elijah David	Gabsonkeg	200 - 700	392
7	Andrew Ruben	Gabsonkeg	240 - 320	296
	Total			**2264**
	Mean			**323**

Note: Age of fish 8-10 months

The above achievements were a result of the SPFS making her what she is now. She was a retrenched Officer, practicing only subsistence farming. Now she is happy with her achievements, and is producing and marketing her agricultural products, as well as helping others to understand the agricultural practices better. Thanks to the SPFS.

Advantages of Village Level Training

We found out that Village level training is **Economical,** we save on housing, meals and some transportation costs, compared to on station training, and **many more farmers could be trained** within a short time. It **fits into farmers own terrain and time.** Farmers have time **to attend to their other activities** in between training periods. Farmers do not have **to be locked away from their families** [which most of them resent]. Village level training **promotes community spirit, pride and also a stronger bond between the farmers and the Training Team.** It also promoted **competitiveness among the farmers** as each goes to prove that they could do better. It also **promotes experts at the village level.** Above all it **contributes to better farming and food security of the community**.

CONCLUSION

The Special Program in Food Security Pilot Phase Team in the Markham Valley identified at the start of the Program that poor farmer knowledge and inadequate extension delivery hamper agricultural development in the Markham Valley.

Training of Staff and farmers on Station and on farm were pursued to promote better understanding of farming in the program areas. Village level training was the predominant. The results indicated improved production and productivity in the villages involved. The SPFS Team recommends to other extension programs to consider Village Level training as a major component of their programs/ projects, as the achievements are numerous as indicated above

ACKNOWLEDGEMENT

We acknowledge the tireless contribution of the following in our farmer training and extension programs. They are; Messrs Weni Yabi and Dakia Wokio, DAL-Mutzing, Mr. Dan Lung Chyau of R.O.C Taiwan, Bubia, Mrs Rudy Atrango of Fresh Produce Development Company, Erap, and Farmer Leaders of Naratumua, Ragiampun, Intoap, Minimian and Arifarin.

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HOW TO PRODUCE MANY YAMS FROM A TUBER

The yam mini-sett technique

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ABSTRACT

A simple method of propagating many yams from a tuber is discussed below. The yam Mini-Sett technique is an improvement of traditional methods used by farmers in West Africa. The technique was improved upon by the National Root Crops Research Institute, Umdike Nigeria and the International Institute of Tropical Agriculture, Ibadan Nigeria. This method which is currently being practiced in PNG by some farmers with promising results is discussed below.

Key words: *Seedling, cutting, Dioscorea rotundata, staking, harvesting, yield*

INTRODUCTION

The yam mini-sett technique allows you to propagate many yam seedlings, and subsequently many yams from a single tuber, unlike before, where only one, two or a few yams are propagated from a tuber

The yam mini-sett technique is an improvement on traditional farmers' method of big or jumbo yam setts, first by the National Root Crops Research Institute, Umdike Nigeria and subsequently by, the International Institute of Tropical Agriculture (IITA). The technique was introduced to Papua New Guinea (PNG) in the 1990s and is showing great promise and acceptatnce. This paper discusse the yam Mini-sett technique in order to reach as many yam farmers as possible in PNG.

MATERIALS NEEDED

- Saw dust/ dry grass,
- clean and healthy yam tuber(s),
- knife,
- wood ash or fungicide.

Seedling Nursery and Care.

Prepare a seed bed of soil (preferably sandy to silt loam soil) and sawdust or dry grass cuttings in the ratio of 1:1, 2:1, or 3:1 respectively, depending on quantity of sawdust or grass, preferably in partial shade [30-50%] not in thick shade that cuts off light completely or in direct sunlight.

Cutting and Treating Yam Setts

(a) Start with clean and healthy sprouting yam(s), and knife.

(b) Cut the yam into many small cylindrical pieces, about 4-5 cm in length.

(c) Then *mini-sett* each cylindrical piece further into 30-80 gm pieces having 'skin and flesh portions'.

(d) Spray or smear the cut surfaces with wood ash (dry or diluted) or fungicide.

(e) Spread your treated mini-setts in a shaded environment (not in the sun), and allow the cut surfaces to dry for at least 2 hours or even over night (this would prevent or reduce infection).

(f) Experience has shown that you may air-dry your setts without the fungicide or wood ash treatment and still get good results - provided you start with clean and healthy tuber, clean knife and hands and clean environment.

Seeding or Planting in the Nursery.

You may pre-sprout your sets in the nursery, or plant direct. Pre-sprouting is however recommended.

To pre-sprout your sets in the nursery, prepare your seed bed of soil and saw dust in the ratio of 1:1, 2:1 or 3:1 soil/sawdust or dry grass cuttings.

Where there is no sawdust or grass, a good loamy-soils could do.

Make your nursery bed slightly raised above the surrounding ground to allow for drainage. A one-meter wide seedbed of 15-30cm in height is recommended.

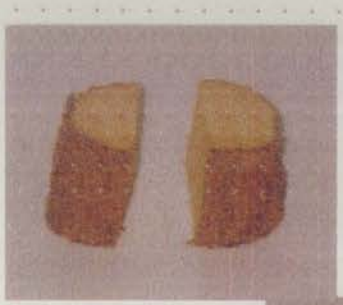
The length would depend on the quantity of mini-setts you have to nurse.

The nursery should be sited in a shady place or you erect shade for it (about 30-50% shade).

1. Start with clean and healthy spouting yam(s)

2. Cut yams into mini-setts (DAL-Erap)

3. Cut yam into small cylindrical piecies about 4-5 cmm in length. Retail the 'head' and plant as head piece



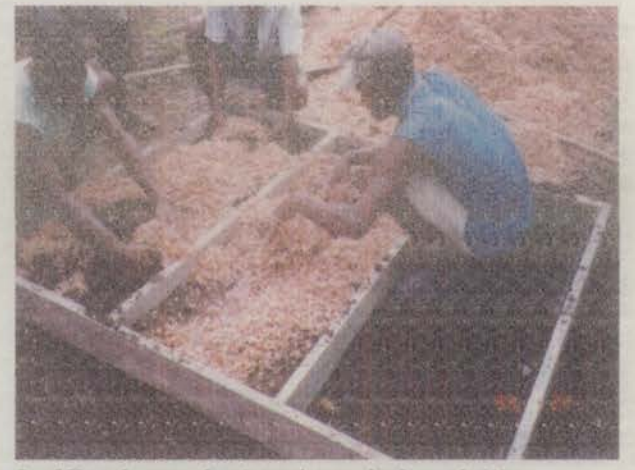
4. Then mini-sett each cylindrical piece further into two

5. Then into 4 or even up 10 pieces depend ing on the size of your yam

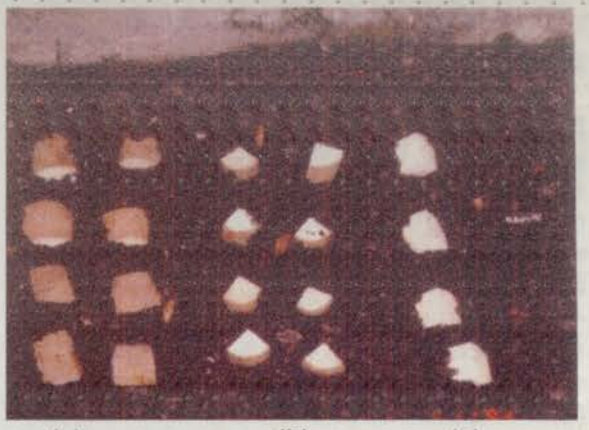
6. Mini-setts from each cylindrical piece

7. Air-cure your cut pieces (2-12 hrs) in shade before putting into the nursery

8. Mini-setts showing skin (brown) and flesh (white) portions



9. Mixed saw dust and sand gives better growth medium



(a) (b) (c)

10. Yams in beds: (a) skin side up, (b) skin side side ways, (c) skin side down

Nurse your mini-setts within 2 - 24hrs.

Insert your yam setts side by side into the nursery bed. In any of the three possible ways:

a. with the skin portion up,
b. with skin portion slanted sideways
c. or insert with the skin portion down.

You would find out with experience what method works best for you. Inserting with skin portion up is however recommended (this allows the shoot to easily sprout and come out from the top).

Cover up inserted mini-setts lightly with soil followed with saw dust or grass and water regularly and maintain adequate moisture through the nursery period.

The mini-setts would sprout within 3-8 weeks depending on yam variety, each specific tuber and portion of tuber it came from, as well as your nursery management practices.

Yam seedlings would be ready for field planting (transplanting) about the 3-6 leaf stage about 20-25 cm in height, when the leaves are just unfolding or expanding.

A week before transplanting, reduce the quantity and/or duration of watering. You may also reduce your shade level at this time. This allows for the seedlings to be 'hardened', and thereby reduce the transplanting shock in the open field.

Farm Site Selection

Select sites on your field that are well drained, loamy (sandy loam to silt loam).

However, where water (moisture) availability might be a problem, for a significant part of the growing season, clay loam soils with better moisture may be preferred. Avoid waterlogged sites

Select areas with less stone, and where the soils are deep [a deep soil means you do not meet stones or other obstacles in the soil as you dig downwards].

Whatever site you select, look for sites with moderate to high organic matter since they contribute to soil fertility.

Planting

Dig holes of at least 50cm deep and 25 - 30 cm wide.

Where you have enough labor you may dig holes bigger than this [remember that the bigger your hole, the better your yield].

Put the topsoil [the darker more fertile part] on one side, and the sub-soil on another side. After digging, return the topsoil and other topsoil around and fill back the hole very close to the top. (The idea of digging and filling back is to loosen the soil for easy root/tuber penetration).

As the seedlings get ready in the nursery, loosen the soil gently and remove them carefully with the sett and roots. If the roots are too deep you may cut part of it off, making sure not to damage the other seedlings

Where you have water, you may add water to the soil, for easier removal of the seedlings.

Since all seedlings would nor sprout and be ready on the same day, you may need to transplant in two or three batches within a period of two -three weeks.

Should you for any reason not be able to plant on time, and your seedlings become too old, prune [cut off] the top portions of the vine, leaving only two to three nodes with leaves at planting time. This would temporarily slow growth and later help reduce the transplanting shock, but expect smaller tubers in this case.

For best results, transplant on time, because older seedlings [with fully expanded leaves] perform poorer when transplanted.

Immerse your seedling 5-10 cm deep in the middle portion of your hole and fill up with more soil, but with part of the vine and leaves exposed. Press the soil slightly around the stem.

You stand a better recovery by transplanting when the soil is moist [after it rained], than in dry soil, and transplant in the morning or late afternoon than in the hot sun.

You may mulch [add grass] around the stem, on top of the mound, to conserve moisture, especially when planted in the dry period. Mulch also helps reduce soil temperature, suppress weeds and add organic matter.

You may need to replant mounds with dead seedlings/setts as and when you noticed them. Remove the dead or rotten setts and replace with live ones.

Planting distance of 1m x1m or 1m x 0.5 m is recommended. Note as you reduce your planting distance your may increase your tuber numbers, but with reduced tuber sizes. So the choice is up to you to make.

Weeding

Keep your farm free of weed, as you would do for

11. Transplant at 3-5 leaf stage when leaves are just unfolding

12. Sprouting mini-setts (*a bit late to transplant*)

13. Harvested tubers (Dioscorea rotundata) from mini-setts yams

14. Farmers happy with their harvested yams (Dioscorea rotundata)

your other crops. Remember that weeds compete with your crops and reduce your yield.

As you weed, and remove soil in the process, or where rain and wind reduces your mound size, heap up by adding more soil. Mound size may also affect yield. Average to big mounds give better yield than small ones (you'll determine your optimum mound size in time, based on your own experience).

Staking

Stake your plants [erect them poles for the vines to climb around]. One stake per plant is the ideal, but if that is not possible, a stake for two plants would do.

Stake early, before the vines start spreading on the ground. Staking prevents over-shading and allows for optimum capture and use of sunlight, for making the plant food. Long poles may give you better yield than short poles.

Train your vines to climb on the stakes. Note that the African yam *(D. rotundata)* and the water yam *D. alata* climb from right to left (counter-clockwise), while the lesser yam (*D. esculenta*) climbs from left to right (clockwise). Remember that if you try to train them wrongly, they will not climb.

Harvesting and Storage

The yams are ready for harvesting when the leaves turn yellow to brown. You may allow the leaves to completely dry before you harvest. But in very moist and rainy areas, if you delay harvesting, the yams may start sprouting (germinating), so guide against this by harvesting early.

To harvest, dig gently starting away from the yam and gradually moving towards the yam, so as not to damage the tubers. Note that damaged tubers store poorly and also have lower market value.

Store your yams in shade, in dry and not damp environment. Do not heap on each other, and allow air to circulate. This way your yams would store longer.

Yams have dormancy (a period between harvesting and time of sprouting). This varies with variety, climate and storage conditions. Dormancy period vary, from 1 - 5 months.

Your yam is ready for planting when the dormancy is broken, that is when it starts to sprout.

For market yam, sell before the dormancy is broken. This is because the chemical changes that take place in long term storage and breaking of dormancy affects the taste and food quality of the yam, making it less palatable.

Where to grow your yams

Note that, most yams are tropical crops, and may not do well in high altitude and cold climates. Our experience in Markham valley indicate that temperatures of 20 to 33 ^{0}C seem ideal for cultivation of African yam and the other yams based on the relatively high yields obtained for even mini-setted yams; average of 6 kilograms/tuber. Yams are thus recommended for most of the lowlands tropical regions where soil texture and fertility are good.

Advantage of the Mini-sett Technique

a) It is simple

b) Multiplicative.

c) It reduces on the cost of yam production.

d) You need only a small nursery space for your many seedlings, which also reduces management costs.

e) It allows for good field crop establishment.

f) Gives you a head start, as you may nurse in the dry season and transplant at the onset of the rains and thus also shortens the field duration

Impact of the Yam Mini-sett Technique and the African Yam in the Markham Valley.

In 1999, the FAO /DAL Food Security Program based at DAL-Erap near Lae, trained 11 farmers at Intoap Village in the Yam Mini-sett Rapid Multiplication Technique. They also introduced the farmers to a 'new variety' of yam called the African yam *(Dioscorea rotundata)*. The farmers nursed the mini-setts using the new yam variety and later on divided the seedlings among themselves and planted those in their gardens.

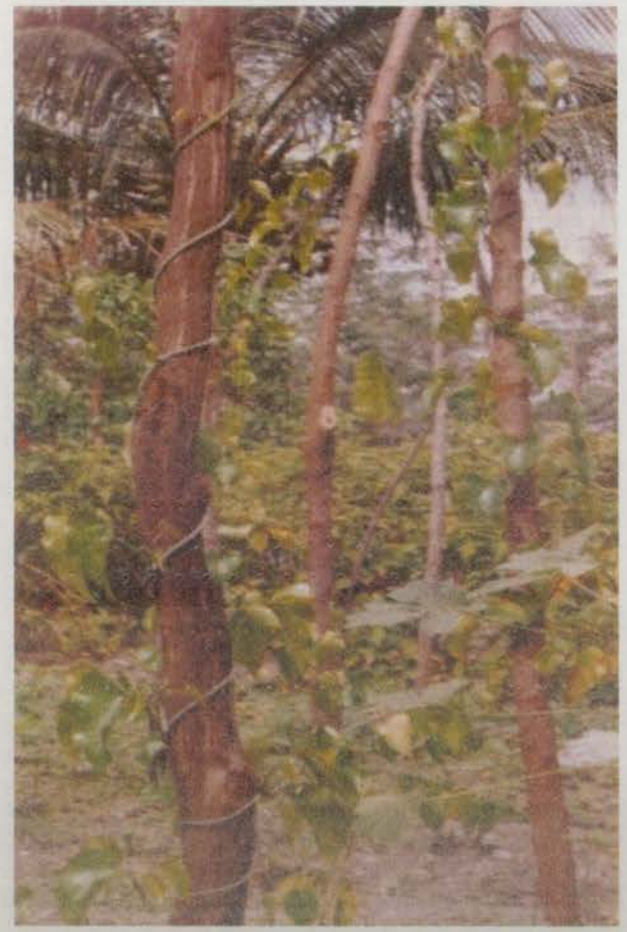
Yam yields were good, and tuber weights ranged between 1-13 kg/tuber, with an average yield of 6.5 kg/tuber. The new variety was also assessed to be very sweet and sweater than the locally grown yam varieties. The 11 farmers shared the yams with their relatives and friends, and the whole village became interested in the African yam as well as the mini-sett technique.

In year 2000/01 crop season the 11 farmers voluntarily trained other farmers, and supplied them yams to plant also. Three hundred farmers planted the yams in the 2000/01 season. The original eleven farmers also increased their farm size on the aver-

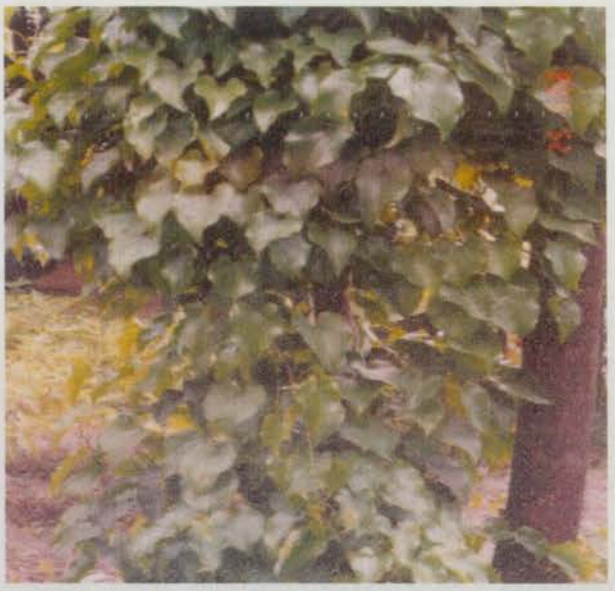
15. Port Moresby farmer in a mixed garden of D. rotundata, D. alata and D. esculenta

16. Note leaf shape of D. alata

17. Note the vine of D. alata climbs from right to left up the stake (support stick)

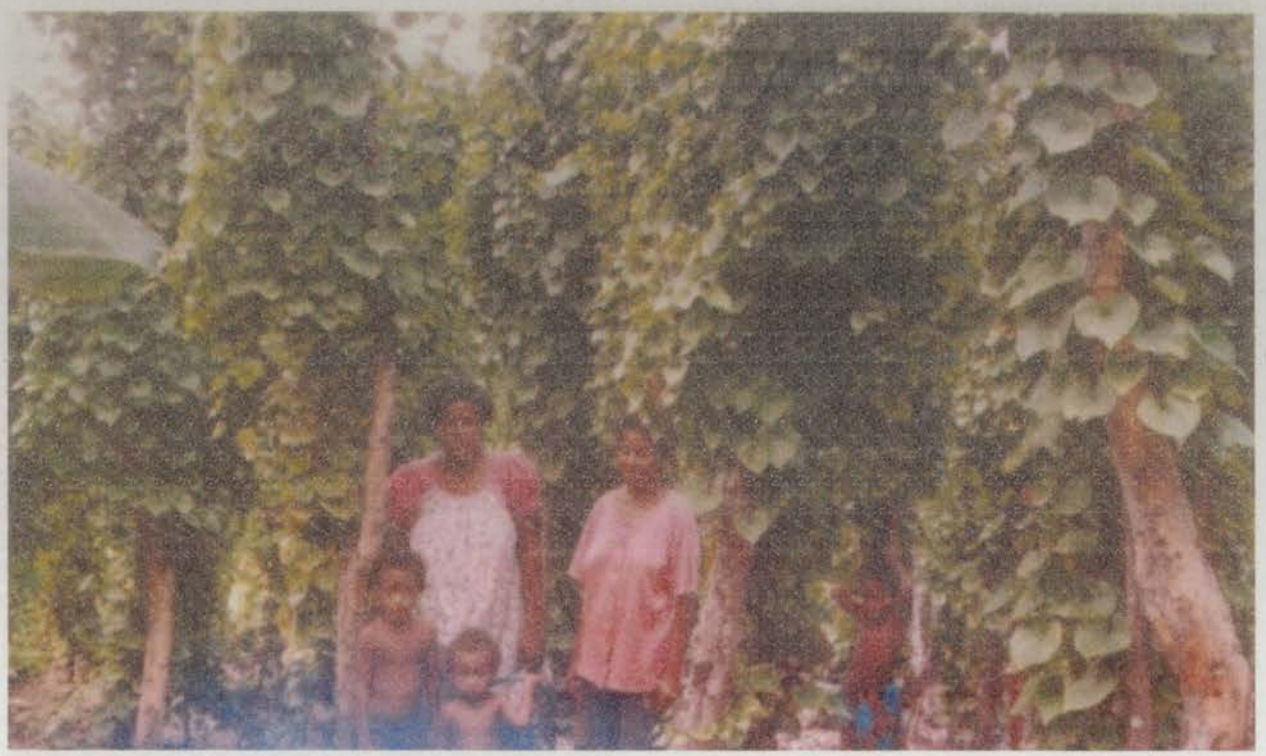


18. D. rotundata vines climb from right to left



19. Note D. rotundata leaf shape

20. Leaf shapes



21. Garden of D. esculenta with farm farmers and children. The vine of D. esculenta climb from left to right.

age by 400% over the 1999/2000 crop season. Harvest data showed that bigger tubers weighing 10-20kg/tuber are common.

Yam yield data ranged from the equivalent of 49,000 to 75,000 kg on per hectare basis In income terms at sale price of at least K1/kilogram of yam, farmers would get between K49,000 -K75,000 farm gate price/ha. for their yams. If yams are sold at K2/kg tuber, the income would double. Labour use at Intoap yam garden is all family labour, just like for the other garden crops. Thus yams particularly the African yam [D. rotundata] shows promise in the Markham Valley and is being promoted.

The community interest in the new yam is very high and many more farmers are acquiring the yams for planting later this year.

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PART OF THE REASON WHY FOOD CROPS AND LIVESTOCK EXTENSION IN PNG IS DECLINING

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ABSTRACT

Food Crops and Livestock production and productivity is at a standstill and declining for some components in Papua New Guinea, and part of the blame is attributed to failing extension delivery among other factors. This paper reasons that part of the failures in agricultural extension are due to the low number of extension staff and low financial resource allocation to support extension. In a country so diversified, and having poor road and transport and marketing infrastructure and in addition to relatively high illiteracy rate, increased investment in agriculture is needed for addressing rural food security, income and rural poverty.

Key Words: *Agricultural production, agricultural extension, gross domestic product, farmer extension officer ratio, farm households to extension officer ratio*

INTRODUCTION

Majority of Papua New Guineans are engaged in agriculture; 82.3% are employed by **occupation** in agriculture, animal and fishery work and 71.1% are employed by **industry** in agriculture, hunting and forestry [NSO 2000 Census report].Yet Papua New Guinea is one of 83 countries classified by the Food and Agriculture Organization [FAO] of the United Nations as a Low Income and Food Deficit Country [LIFDC]. This is based on increasing food import volumes. This reflects decline in food production and / or lack of access to food and income to buy food. With population growth rate of 3.1%, agriculture is estimated to be growing between 1-1.6% only [NADSH 2002]. Unless a drastic action is taken, to improve on agricultural growth, agriculture would continue to lag behind population growth, and this would further aggravate the issues of food insecurity, hunger and malnutrition and affect the sustainable livelihood of many citizens in the future. The decentralization of Agricultural Extension after Independence has been identified as one of the major contributing factors in the decline of agricultural production and productivity in PNG.

Agricultural extension is to provide information, advice and assistance to farmers to help them identify and analyze their production, processing, packaging, storage and marketing problems and to become aware of opportunities and options. In developing countries such as PNG, the important role of agricultural extension can not be overlooked, as it is the major source of agricultural information to the majority [82.3%] of the rural and agricultural population. This paper would discuss the failures from the points of extension staff numbers and resource allocations based on information from eleven provinces.

Background on PNG's Agricultural Extension Services

Prior to Independence in 1975 and up to 1977, agricultural extension was unified and was the responsibility of the Department of [stocks] and Primary Industries [DPI] now called the Department of Agriculture and Livestock. The DPI operates from Port Moresby with the help of four Regional Officers [Controllers]. The Extension services had well qualified and disciplined staff, well funded and managed.

The Organic Law on Provincial Governments enacted in 1997, led to the creation of 19 Provinces and Governments and the delegation **[relegation?]** of responsibility of agricultural extension to them. The establishment of Provincial Administrations and supporting staff and responsibilities had absorbed a high share of staff capacity, funds and time previously devoted to agricultural extension. This coupled with exodus of experienced and expatriate staff had led to declining and inexperienced agricultural extension staff numbers and had begun the decline in the extension services. Links with research stations and information became less and less with increasing distances from the sources in the major cities. Younger and inexperienced extension staff had difficulties of being accepted and trusted by farmers. Since many officers operate in regions and areas where they have kinship ties, this in some cases had also contributed to reduced performances. Without directions and proper guidance and management, and in addition to issues mentioned above, the provincial extension services began to decline after 1977.

Reports by Mc Killop [1982,], ANZDEC [1990] Bammann *et al* [1997], Dekuku [1998,2001], Dekuku

et al. [2001] and Caven and McKillop 2001 indicated that agricultural extension services in PNG has constraints and had declined since independence and are relatively inefficient and ineffective. Indications are that agricultural extension as at now has gone from 'bad to worse since independence' [Kagena 2001].

Over the years since independence, the agriculture sector's contribution to the GDP has declined from a high of 36.7% in 1977 to 23.9% in 1999, and rose slightly to 25.1% in 2000 and decline again in 2001 [Table 1]. The downward trend is partly a consequence of the sector's performance as dictated by declining productivity and production, fluctuating world market prices for agricultural commodities [as well as increases in non-agricultural exports, such as crude oil and minerals].

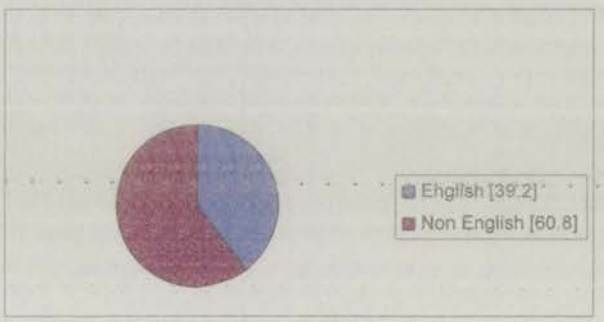
Agricultural extension and literacy

According to the 2000 Census, English literacy in PNG is only 39.2% [Fig. 1], and we do not expect any significant change in the very near future, because a relatively high number of school age citizen [44%] not attending school [Table 2]. Yet the majority of agricultural extension materials are in English. This means that, the best way to address the greater numbers of the rural people, [assumed relatively English illiterate], is through an effective extension system, where extension officers would use the local dialects in communicating the needed extension information and technologies to them. It is high time that relevant extension information / technologies be written or translated into the local languages for relevance to a wider audience.

Table 1. **Percent contribution of agriculture to gross domestic product in PNG**

Year	Agriculture as % of GDP	Year	Agriculture as % of GDP	Year	Agriculture as % of GDP
1974	26.2	1983	30.7	1992	24.7
1975	26.7	1984	33.5	1993	25.8
1976	26.6	1985	33.3	1994	25.7
1977	**36.7**	1986	32.2	1995	26.8
1978	35.2	1987	29.9	1996	26.5
1979	33.9	1988	29.1	1997	27.4
1980	33.7	1989	28.1	1998	24.4
1981	33.6	1990	28.2	1999	23.9
1982	33	1991	26	2000	25.1

Figure 1. **PNG citizen 10 years and over in private dwelling by english literacy in 2000.**



A look at numerical Aspects of Agricultural Extension in Selected Provinces in PNG

Eleven Provinces from which agricultural budget allocation data was provided to the author are highlighted in this study. The 2002 Census data for these Provinces were also consulted and utilised for the analysis reported here. The Provinces are;

Table 2. **PNG citizen population aged 5-29 years in private dwelling by school attendance in 2000.**

Classification	Number	Percentage
Attending school now [26%]	727,888	26
Attended in the past [28.4%]	794,045	28
Never attended [44.1%]	1,233,629	44
Not stated [1.5%]	42,750	2
Total	2,798,312	

Manus and New Ireland covering the Islands Region, Madang, Morobe, East and West Sepik for Morobe, Central, Milne Bay and Northern for Southern Region and Chimbu and Enga for Highlands region.

Number of Households in Agriculture and Fisheries

A look and analysis of the 2002 Census data indicated that, of the total number of households surveyed, 77.7% [New Ireland] to 89.2% [West Sepik] are engaged in agriculture, animal and fisheries work [Table 3]. This is a considerable high number of the population. Improving the lives of these rural people may result in significant improvement in the rural and national economy. For this to happen, PNG needs to invest highly in agricultural extension. This is even more important, if we take into consideration, the poor road and transport infrastructure, poor communication, diverse and difficult to reach terrains, location and environments, also relatively moderate to high illiteracy.

Budget Allocation to Agricultural Extension in Selected Provinces

Government Budget allocations to agricultural extension [DPI'S] in the various Provinces,[as supplied by them] for the period 1997 to 2002 indicated very low amounts[Table 4]., relative to the population engaged and to be addressed in agriculture [Table 5].

In Kina value, on the average, Morobe Province provided the highest funding to agricultural extension, K1,253, 000 /year, while the lowest were Chimbu K250,000/year and Manus K117,300 / year [Table 4].

Table 3. PNG citizen households in private dwellings by agricultural/fisheries activity in selected provinces, based on 2000 census

Category	Manus	New Ireland	East Sepik	Madang	Morobe	West Sepik	Central	Milne Bay	North-ern	Chimbu	Enga
Agriculture Animal and Fishery workers	12,547	34,787	121,056	128,029	185,019	67,528	72,121	82,044	49,211	125,880	140,550
Total Households Surveyed	15,437	44,880	137,858	151,294	234,814	75,704	83,124	96,812	57,164	142,636	162,433
Percent households [%], of Agric. Animal & Fishery	81.3	77.5	87.8	84.6	78.8	89.2	86.8	84.7	86.1	88.25	86.53

Table 4. **Budget allocation to selected provincial agricultural programs from 1997 to 2002 [in K'000]***

Province	1997	1998	1999	2000	2001	2002	Province Total	Average/year
Central	450	424	430	450	482	450	**2686**	**447.7**
Milne Bay	205	225	235	238	425.1	717.2	**2045.3**	**340.9**
Northern	505.7	533.7	548.7	578.1	604.9	482.9	**3254**	**542.3**
Enga	71	337.56	110	1,024.40	843.2		**2386.16**	**397.7**
Chimbu	85.2	44.6	185.9	216.6	120.3	347.9	**1000.5**	**250**
Morobe	1,057	855.9	1,193.80	1,433.70	1,488.80	1,488.80	**7,518**	**1253**
Madang	664.1	406.6	266.6	486.5	85	545.5	**2454.3**	**409**
East Sepik	1,226	428.9	193.5	373	213.6	466.4	**2,901**	**483**
West Sepik	108.5	89.5	112.2	67.7	238.7	89.5	**706.1**	**117.7**
Manus	105	166.3	170.5	189	105	175	**910.8**	**151.8**
New Ireland	461	141.89	197.2	158.7	748.2	617.5	**2324.49**	**387.4**
Year Total	**4938.5**	**3653.95**	**3643.4**	**5215.7**	**5354.8**	**5380.7**	**28187.05**	**427.1**

* Derived from budget allocation figures provided by Provinces in June 2002

Since agricultural extension is targeted at helping farmers, one would expect that in allocating funds, the number of farmers in the Provinces would be taken into consideration. This paper would look at funding to agricultural extension versus the farm population in eleven Provinces in PNG, as a component of the extension delivery system.

The Number of Extension Staff in the Selected Provinces as at June 2002 and the ratio of Extension staff to Agricultural Food Production Households and Farmers

The number of agricultural extension staff as at June 2002 in the Provinces [table 5] ranged from 19 [Manus] to 68 [Morobe], with an average of 32.

The Number of Households engaged in various agricultural activities provided indicated that, the highest numbers were involved in Food crops and vegetable production [Table 5], as compared to Livestock and Poultry production.

In order to work out the number of extension staff and households ratio, the author made the following assumptions;

1.That most households are engaged in multiple farming activities. That is, that some of the food crop/ vegetable producers **are the same people** engaged in livestock and poultry production. This is based on the general knowledge that food production is the first agricultural activity of rural households. Thus taking the **number of food and vegetable producers** would approximate to the **Agricultural Food Producers** [food crops/ vegetables, livestock and poultry] in each Province.
2. That most of the extension staffs are predominantly engaged in Agricultural Food Production extension. Although a few may provide export tree crop extension occasionally in some provinces that lack adequate numbers of export tree crop staff, they in addition also provide extension to Agricultural Food Producers.

Ratio of Extension Staff to Agricultural Food Producing Households per Province

Based on the above assumptions, the number of **Agricultural Food Production Households** to **an extension staff** in each Province was calculated, as;

c = a/b, ——————————————— **i**

where a = Food Crops and Vegetable Households,
b = number of extension staff , and
c = is the number of Agricultural Food Production Households to One Extension Staff.

Table 5, indicated very high number of households per One Extension Staff. Manus has the lowest or best [1: 285], and Chimbu, the highest or worst ratio [1: 2,213]..
In simple terms, this means that one extension staff needs to address the needs of 286 households in Manus, while in Chimbu, the number of households is 2, 213..

The Figures for the Provinces, from relatively best to relatively worst are; Manus [285] New Ireland [570], Northern [571], Central [658], West Sepik [793], Enga [962], Morobe [974], Milne Bay [1290], Madang [1362], East Sepik [1829], Chimbu [2213]

With the low funds allocated to agriculture, the difficult road and transport and other infrastructure, poor literacy, one wonders as to how extension officers would be effective with these relatively high number of households per extension officer.

Ratio of Extension Staff to Agricultural Food Producing Farmers per Extension Staff in the Provinces

The Household size per province indicated the average of 5 or 6 persons per Province [table 5]. If we assume that two people in each household are not engaged in agriculture [doing other activities or too young] then the assumed Active Agricultural population per household is 3 or 4 depending on the Province [table 5]. Using these figures [Table 5], we could also work out the number of Active Agricultural population per One Extension Staff or **Number of Food Producing Farmers** per One Extension Staff for each Province as follows;

e = c x d ——————————————— **ii**

Where **e** = Number of Food Producing Farmers per one Extension Staff, **c** = the number of Agricultural Food Producing Households to one Extension Staff, and **d** = active agricultural population per household

Table 5, indicated that the **Number of Food Producing Farmers** to be addressed by each extension officer is so high in all the Provinces, and possibly impossible to be achieved effectively unless funding, road and transport infrastructure are adequate'.

The corresponding figures are; Manus [855] New Ireland [1710], Northern [2284], Central [2632], West Sepik [3172], Enga [3848], Milne Bay [3870], Morobe [3896], Madang [5448], East Sepik [5487] and Chimbu [6639].

Thus, an extension Officer in Manus would have to address 855 farmers, while those in Chimbu would

Table 5. **PNG citizen households in private dwellings by type of agricultural activity in selected provinces, based on 2000 census and number of households and farmers per extension staff in 2001/2002**

Category	Manus	New Ireland	East Sepik	Madang	Morobe	West Sepik	Central	Milne Bay	North-ern	Chimbu	Enga
Livestock households	1,098	7,359	7,028	23,830	33,068	8,064	10,326	14,365	6,105	39,641	35,453
Poultry households	1,377	6,104	12,542	19,371	19,523	6,963	5,404	15,078	5,344	13,967	10,211
Food crops/ vegetables households [a]	**5,409**	**16,549**	**49,378**	**46,322**	**66,240**	**23,808**	**22,386**	**32,251**	**16,014**	**44,250**	**40,391**
Number of Extension Staff in June 2001[b]	**19**	**29**	**27**	**34**	**68**	**30**	**34**	**25**	**28**	**20**	**42**
Number of Food Crops and vegetable Households per extension Officer [c]	**285**	**570**	**1,829**	**1,362**	**974**	**793**	**658**	**1,290**	**571**	**2213**	**962**
Average number of individuals/ household	5	5	5	6	6	6	6	5	6	5	6
Assumed Agriculturally active population per household [d]	3	3	3	4	4	4	4	3	4	3	4
Number of Food Producing Farmers per extension staff [e]	**855**	**1710**	**5487**	**5448**	**3896**	**3172**	**2632**	**3870**	**2284**	**6639**	**3848**

need to address 6639 farmers each per year [table 5].

These high numbers of farmers to extension officer meant that majority of them may not be reached by extension, and if at all very really or irregularly. This leads to lack of appropriate information and technologies in many rural environments and on timely basis and the result may be lack of productivity in those areas.

Government Financial Investment in Agriculture per Each Food Producing Household and Farmer Basis

Government contribution to Agriculture is depicted in Table 4. Using the average contribution per Province for the period 1997 to 2002 alongside the 2002 Census figures on households and farmers in agriculture would give approximate information on financial contribution to agricultural extension by the Government.

Government contribution to Agricultural Extension per Household **[g]** was calculated as such;

g = f / a ——————————— **iii**

Where f = The Mean budget allocated per year, and a = Agricultural Food Production Households per province

Table 6, shows that Government investment in agricultural Extension on household basis ranged from a very low K4.9 / Agricultural Food Producing Household per year in West Sepik to low K33.9 / Agricultural Food Producing Household per year in Northern Province.

If we expand the calculations to **Food Producing Farmers basis** using the formula

i = f /h, ——————————— **iv**

Where **i** = Government Kina Invested in extension per each Food Producing Farmer / year, **f** = The Mean budget allocated per year, and **h** = Number of Food Producing Farmers per Province [where **h = a x d** [table 7]

Government financial contribution to agricultural extension on farmer basis [Table 7] indicated very low financial investment on farmers by Government in all Provinces. West Sepik ranked lowest with only K1,24/ Farmer / year and Manus tops but also with low value of K9.35/farmer / year. This goes to support the case of low government support to agricultural extension.

Since the funding goes to support extension staff salaries and wages, accommodation, repairs and maintenance, transport and fuel, equipment and machinery, field supplies and other extension related items, it is no doubt the DPI systems in the Provinces are under performing. The funding situation is so low that village, farm and field visits by extension staff are seldom done, if at all, to only a few villages. This denies majority of farmers access to new or updated agricultural information and knowledge. This is part of the reason for the observed average poor performance by farmers and their farms.

Implications of the findings

In developing countries, improvement in agriculture is one of the best ways to kick start rural development in rural areas where the majority of the population is engaged.

Table 6. **PNG citizen households in private dwellings in food production and by government extension support per each agricultural food producing household [K/Year] for the period 1997 to 2002**

Category	Manus	New Ireland	East Sepik	Madang	Morobe	West Sepik	Central	Milne Bay	North-ern	Chimbu	Enga
Agricultural Food Producing Households / Province [a]	5,409	16,549	49,378	46,322	66,240	23,808	22,386	32,251	16,014	44,250	40,391
Mean of 6 year Budget allocation K'000 per Province [f]	151.8	387.4	483	409	1253	117.7	447.7	340.9	542.3	250	397.7
Government Kina Invested in extension per each Agricultural Food Producing Household per year [g]	28.1	23.4	9.8	8.8	18.9	4.9	20.0	10.6	33.9	5.6	9.8

Table 7. **Average government kina investment in agricultural extension per each agricultural food producing farmer/ year in selected provinces for the period 1997 to 2002**

Category	Manus	New Ireland	East Sepik	Madang	Morobe	West Sepik	Central	Milne Bay	North -ern	Chimbu	Enga
Agricultural Food Producing Households **[a]**	5,409	16,549	49,378	46,322	66,240	23,808	22,386	32,251	16,014	44,250	40,391
Number of Food Producing Farmers per Household **[d]**	3	3	3	4	4	4	4	3	4	3	4
Number of Food Producing Farmers per Province [h]	**16227**	**49647**	**148134**	**185288**	**264960**	**95232**	**89544**	**96752**	**64056**	**132750**	**61564**
Mean of 6 year Budget allocation K'000 **[f]**	151.8	387.4	483	409	1253	117.7	447.7	340.9	542.3	250	397.7
Government Kina Invested in extension per each Food Producing Farmer **[l]**	**9.35**	**7.80**	**3.26**	**2.21**	**4.73**	**1.24**	**5.0**	**3.52**	**8.47**	**1.88**	**2.46**

Based on the wide gap in agricultural knowledge, many of our farmers have remained subsistence producers. Even in some cases the subsistence production is unable to meet the households' food consumption requirements. Provision of needed information and training of farmers in the various components of agriculture, [production, processing, packaging, storage and marketing] requires the presence and inputs from qualified extension personnel and on timely and regular basis.

Dekuku *et al* 2001, in their report on Constraints Analysis of the Food Industry in Papua New Guinea indicated among other issues that, for **sufficient domestic food production to be achieved**, it is important that adequate research results and technology are available and this needs to be combined with an **effective agricultural extension delivery system.** They also identified that ineffective agricultural extension delivery system results from; high number of farmers to extension officer ratio, low education level of farmers, lack of farmer training, inadequate finance and inappropriate language of technical information. These in turn are influenced greatly by the poor financial support to extension by Districts, Provinces and the National Government.

Agricultural research findings and technologies are useless and not beneficial to farmers if they could not access them or be reached by extension and trained, advised, or demonstrated to on how to apply them successfully. Agricultural extension is the major link between most farmers and the researchers, information and product producers, inventors, investors, processors, packaging and marketing agents, especially in rural areas of developing countries

Failures in agricultural extension delivery in rural areas in developing countries affect production, productivity and also denies the population in those

areas an avenue to improve on and enhance their livelihood.

Failures in agricultural extension in PNG is one of the reasons why the country continues to import food items [crops and livestock produce and products] even for crops and livestock that do well in the country.

The information in this report supports components of the constraints analysis report by Dekuku et al 2001, that, the ratio of farmers or farm households to extension staff is too big, for extension personnel to make serious impact on the majority. Funding to agricultural extension for food [crops and livestock] extension is also grossly very low. Putting the two together; that is the high number of farmers to extension officer and the lack of finance/resources [in a country so dispersed, has poor, transport, storage and marketing infrastructure, and relatively high illiteracy rate] are recipes for low agricultural performance, which is the case of food and livestock production in PNG at the moment.

CONCLUSION

Food crops and livestock extension services in Papua New Guinea lacks funding and manpower as indicated by the analysis. This report suggests that;

1. Agricultural extension needs to be given serious consideration, in terms of numbers for them to play a significant role in PNG's rural development. Staff ratios are not optimum to allow for a good and effective extension delivery system. Vacant staff positions should be filled and /or additional staff ceilings be explored.

2. Financial Support to Food Crops and Livestock Extension programs is too low to promote efficient extension system. This needs to be reviewed.

3. However, since resources [funds and personnel] may not always be adequate, Agricultural Managers also needs to prioritize food and livestock components that this country could make faster gains on [have high financial returns or economic advantage] and help develop and promote these first, instead of spreading thinly and trying to do all things at the same time with limiting resources.

4. In addition, areas like agricultural processing, packaging and marketing needs to be developed to help farmers earn income as well as to be persistent in their production activities. For access to market would help stimulate production and productivity and above all provide income, jobs and employment to rural people.

5. Agricultural extension to consider organizing farmers into groups at village levels, for group extension delivery purposes, for it is easier and more economical to organize extension advice for groups than on one and one basis.

6. Agricultural Extension Managers should develop systems/programs for identifying and training Farmer Leaders, and empower these Leaders to provide extension support to their colleagues in their respective villages and districts. This would help reduce the load on extension officers trying to visit many sites or people which looks impossible at the moment. In addition village people would have their own 'wantok extension managers' as their 'first port of call' when they need extension advice.

7. Consideration should be given to the translation and publishing of relevant extension materials in the major local languages for wider dissemination of information and technologies

8. The Provincial and National Governments need to support food and livestock agricultural extension more than is being done now. Improvement in food and livestock extension would lead to increased productivity and production, which may help the country reduce on its food import bills. Export of the surplus would also earn the country additional revenue. It is no secret that many food crops and livestock grow well here in PNG. We need to empower the extension system, which would stimulate and empower the farmers with information and technologies and help them to deliver the goods.

9. In developing countries, well functioning agricultural extension delivery is very essential for rural development and PNG could benefit from this too. **It is not too late to address the issues. The time is now.**

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ha	- hectare
mm	- millimetre
m	- metre
a,s.l.	-above sea level yr -year
wk	- week h -hour
min	- minute
s	- second
K	- kina
n.a	- not applicable or available
n.r	- not recorded
var	- variance
s,d	- standard deviation
s.e.m.	- standard error of means
se.d.	- standard error of difference
d.f.	**- degrees of freedom**

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