EFFECTS OF GOAT MANURE, NPK-FERTILIZER, INSECTICIDES AND FUNGICIDES, AND COMPOST ON POTATO YIELD AT THE YASUBI RURAL EXTENSION CENTRE

J.A. Pitala[1,2] and S. Sivasupiramaniam[1]

ABSTRACT

Two preliminary field trials were conducted at the Yasubi Rural Extension Centre in the South Fore Census Division of the Okapa District in the Eastern Highlands Province as a part of the ongoing research to develop a low input potato production system(s) for the Okapa SMAFSP area. In Trial 1, conducted during the dry period of March - July, application of goat manure increased marketable tuber yield and numbers significantly (P<0.01). Tuber yield increase was almost 200%. There was no response to either mixed NPK-fertilizer or routine spraying of insecticides and fungicides. In Trial 2, conducted during the wet period of November-March, application of 500 kg/ha of mixed NPK-fertilizer increased total tuber yield significantly (P<0.01). Increasing the fertilizer rate from 500 to 750 kg/ha did not increase the total tuber yield significantly (P<0.05). Application of additional P as triple superphosphate (TSP) and N as urea failed to influence total tuber yield significantly (P<0.05). There was no response to application of compost and the possible reason for this is discussed.

Key words: *South Fore, Okapa, potato, goat manure, NPK, insecticide, fungicide, compost.*

INTRODUCTION

The South Fore Census Division (CD) in the Okapa District of the Eastern Highlands Province is under the Smallholder Market Access and Food Supply Project (SMAFSP) area. SMAFSP is directed at less developed areas where economic and social development is generally lacking. Therefore, one of its main objectives is to increase and diversify opportunities for earning cash income. Improving the production and marketing of potato has been identified as one of the methods to achieve this objective in the Okapa SMAFSP area.

At present, Okapa district produces about 20% of the total potato produced in the country (Department of Agriculture and Livestock 1989) but most of it is cultivated in the North Fore which is outside the project area. Entire production is by small farmers. Although production data are unavailable at present, it is believed that yields are generally low due to low soil fertility, use of either no or little inorganic fertilizers, poor management, and perhaps lack of quality seed.

Potato usually responds to inorganic fertilizer application. In Papua New Guinea the general recommended rate of inorganic fertilizer is 750 kg of 12-12-17-2 NPK fertilizer mixture plus 250 kg of triple superphosphate (TSP) per hectare (SAPPRD 1986). However, farmers in Okapa generally do not use any inorganic fertilizers, insecticides and fungicides because of high cost of transport and lack of capital.

Using locally available organic fertilizers is an option to substitute expensive inorganic fertilizers. Quality seed potato is expensive and not freely available.Therefore, yields have to be increased to maximize returns for farmers' investments on seed. Using either optimum level of inorganic fertilizer or organic manure are two options available to the farmer to maximize re-

[1] Department of Agriculture and Livestock, P.O. Box 1075, Goroka, E.H.P, Papua New Guinea.
[2] Present address: Department of Agriculture and Livestock, P.O. Box 1984, Lae, Papua New Guinea.

turns. Hence, there is a need for low input technology for potato production to match the local physical and socio-economic environment.

This paper reports the results of two preliminary field trials conducted, as a part of the ongoing research, to develop a low input potato production system(s) for this area.

MATERIALS AND METHODS

Two trials were conducted at the Yasubi Rural Extension Centre in the South Fore CD of the Okapa District in the Eastern Highlands Province (1600 m a.s.l.). The first trial (Trial 1) was started in March and concluded in July, 1991 while the second trial (Trial 2) commenced in November, 1991 and terminated in March, 1992. The soil is a brown clay soil which is the dominant soil type in the area. The soil analysis data are presented in Table 1.0. The treatments in both trials included:

Trial 1

1. Control
2. 250 kg NPK/ha
3. 500 kg NPK/ha
4. 250 kg NPK/ha + Spraying
5. 500 kg NPK/ha + Spraying
6. 25 t manure/ha
7. 25 t manure/ha + Spraying

Trial 2

1. Control
2. 750 kg NPK/ha + 250 kg TSP/ha
3. 500 kg NPK/ha + 250 kg TSP/ha + 50 kg N/ha
4. 500 kg NPK/ha + 250 kg TSP/ha + 100 kg N/ha
5. 500 kg NPK/ha + 250 kg TSP/ha + 50 kg N/ha
6. 500 kg NPK/ha
7. Compost
8. Compost + 50 kg N/ha

In Trial 2, nitrogen application in treatments 3 and 4 were applied four weeks after planting whereas in treatments 5 and 8, nitrogen was applied at planting.

Trial 1 was laid out using a randomized complete block design (RCBD) with three replicates. The plots were raised beds and 8.0 m² in size. The manure treatment was applied in bands five weeks before planting and mixed thoroughly with the soil.The goat manure used was collected from the cement floor underneath the goat night house at Bena Bena Goat Breeding Station which is situated about 20 km south of Goroka along the highlands highway in the Eastern Highlands Province. It contained 1.98% nitrogen, 0.5% phosphorus and 3.47% potassium on a dry matter basis.

Five weeks after the application of manure, potato (*Solanum tuberosum* Linn.) cultivar Sequoia was planted in furrows. The spacing was 70 cm between and 30 cm within rows. The NPK-fertilizer was applied in furrows and mixed thoroughly with the soil. Immediately after the application of the NPK-fertilizer, potato seeds were planted in the same farrows. Insecticide (Orthene) and fungicide (Topsin-M DO) were applied to treatments 4, 5 and 7 at the recommended rates from the third week at ten days interval. The last spraying was done 88 days after planting.

In the second trial, the compost was applied two weeks before planting.The size of the plots, spacing, potato cultivar and the method used for fertilizer applications were the same as in Trial 1. However, the trial was laid out in a completely radomized design (RCD). Samples of the third compound leaf from the top of the plant from all plots were collected 60 days after planting for N, P and K determination. Normal cultural practices were employed during the duration of the respective trials. At maturity, 12 plants from the centre of the plots were harvested. In the first trial, tubers less than 30 g were considered as unmarketable. The data collected on the number and yield of tubers were subjected to the respective analysis of variances for RCBD (Trial 1) and RCD (Trial 2) and the means were tested using the least significance difference (LSD) test (Little and Hills 1978).

RESULTS

In Trial 1, application of goat manure at 25 t/ha significantly ($P<0.01$) increased the marketable tuber yield and numbers.The total number of tubers per plant was also increased significantly ($P<0.01$) (Tables 2 and 3). Application of mixed NPK-fertilizer at either 250 or 500 kg/ha failed to

Table 1. **Chemical Analysis of Soil Samples (0-15cm) from Yasubi Rural Extension Centre.**

ELEMENT		VALUE	INTERPRETATION
pH (1:2.5; soil:distilled water)		5.60	moderately acidic
Olsen Available P (mg/kg)		5.26	very low
Extractable Cations:			
Potassium (K) (me/100 g)		0.54	medium
Calcium (Ca) (me/100 g)		6.10	medium
Magnesium (Mg) (me/100 g)		2.16	medium
Sodium (Na) (me/100 g)		0.08	very low
Sulphate sulphur (mg/g)		18.00	medium
Boron (mg/g)		0.70	low
Cation Exchange Capacity (CEC)		21.00	medium
Percentage Saturation	K	2.50	desirable
	Ca	29.00	< desirable
	Mg	10.20	desirable
	Na	0.40	< desirable
Organic Matter (%)		8.80	medium
Total Nitrogen (%)		0.42	medium
Phosphate Retention (%)		56.00	medium

influence either tuber yield or numbers significantly (P<0.05). Spraying with insecticide and fungicide had no effect on tuber yield or numbers (Tables 2 and 3).

In Trial 2, application of 500 kg NPK/ha of mixed NPK-fertilizer increased total tuber yield significantly (P<0.01) (Table 4.0). Increasing the fertilizer rate from 500 to 750 kg/ha did not increase the total tuber yield significantly (P<0.05). Addition of additional P as TSP and N as urea and the time of N application failed to influence total tuber yield significantly (P<0.05). There was no response to application of compost (Table 4).

The nitrogen and phosphorus concentrations of leaf were not significantly (P<0.05) affected by the treatments applied (data not presented). However, the potassium concentration of the leaf showed significantly (P<0.05) higher levels in treatments 1, 7 and 8 (Table 5).

DISCUSSION

Generally, most nitrogen recommendations for potato in tropical areas are in the range of 80-150 kg/ha. For phosphorus and potassium, most recommendations are in the range of 100- 200 kg/ha and 60-180 kg/ha as P_2O_5 and K_2O, respectively (FAO 1984). The soil from the experimental site at Yasubi appears to be fertile. However, the phosphorus level is very low as indicated by the soil analysis data (Table 1).

Potato needs a good supply of readily available phosphorus and because its root system is not extensive, it does not readily utilize the less available forms of phosphorus. In most cases, therefore, phosphorus fertilizer applications are considerably higher than the 30-50 kg/ha of P_2O_5 taken up by the crop (FAO 1984).

The lack of response to NPK fertilizer in Trial 1 may be largely attributed to the dry conditions prevailed during the experimental period. Observations during this period indicated that plant canopy development was poor in the treatments

Table 2. **Effect of NPK-fertilizer, goat manure and spraying on the yield of potato tubers.**

TREATMENT	TUBER YIELD (t/ha)	
	MarketableTubers	Unmarketable Tubers
1. Control	9.33	0.59
2. 250 kg NPK/ha	8.04	0.82
3. 500 kg NPK/ha	7.09	0.95
4. 250 kgNPK/ha + Spraying	9.95	0.72
5. 500 kg NPK/ha + Spraying	11.63	0.92
6. 25 t Manure/ha	26.75	1.29
7. 25 t Manure/ha + Spraying	29.67	1.59
LSD (P < 0.05)	3.42	0.57
LSD (P < 0.01)	4.79	0.80
CV (%)	13.10	33.20

except those that received goat manure.The canopy duration too was relatively short as compared to that of the manurial treatments. For maximum light interception, better canopy development and longer duration are necessary (Mengel and Kirkby 1987).This in turn would enhance photosynthesis, and consequent translocation of photosynthates to tubers, resulting in increased tuber yield. Furthermore, it is generally accepted that there must be enough moisture available in the soil for a fertilizer to be efficiently utilized by a crop. Because of the prevailing dry conditions during that period, soil moisture may have been limiting, thereby contributing to the poor response of potato to the applied NPK fertilizer.

The highly significant response to manure may be attributed to the fact that since it was applied five weeks before planting, there was probably a high degree of breakdown by the micro-organisms which may have resulted in the mineralization of nutrients. This is highly possible because even though there were dry conditions, the residual moisture in the manure could have contributed to the favourable conditions for microbial activity to proceed, thus, rendering the nutrients available for plant uptake.

The significant response to NPK in Trial 2 which was conducted during the wet season demonstrates the importance of the time of planting of potato in this area. Also, the recommended rate of 750 kg NPK/ha + 250 kg TSP/ha (SAPPRD 1986), although gave higher tuber yield, it was not significantly (P<0.05) higher than those of treatments 3, 4, 5 and 6 (Table 4). Furthermore, because of the high cost of fertilizers, transport and lack of capital, it would be prohibitive for farmers in the South Fore area to use higher amounts of inorganic fertilizers.There appears to be little or no benefit in using NPK fertilizer rates of more than 500 kg/ha and using of additional TSP and urea.

In the current study, compost application failed to influence tuber yield. The nutrient content of the compost and the nutrients availability depend on the nature of the vegetation used and the stage of decomposition. The compost material used was obtained from fallen dry leaves which appear to be of low quality. The material was only partially decomposed when applied two weeks before planting. Due to the poor quality of the compost used the results from the compost treatments should be treated with caution, and the use of compost as an organic fertilizer requires further investigation.

Potassium concentration of the leaf showed no correlation with the total tuber yield (Tables 4 and 5). Tuber yields in the NPK-fertilizer treatments were significantly (P<0.01) higher than those of the compost and control treatments.

Table 3. **Effect of NPK-fertilizer, goat manure and spraying on the number of fresh potato tubers.**

TREATMENT	NUMBER OF TUBERS/PLANT		
	Total tubers per plant	Marketable tubers	Unmarketable tubers
1. Control	3.64	2.22	1.42
2. 250 kg NPKha	3.22	1.89	1.33
3. 500 kg NPK/ha	3.75	2.03	1.72
4. 250 kg NPK/ha + Spraying	3.52	2.19	1.33
5. 500 kg NPK/ha + Spraying	4.33	2.47	1.86
6. 25 t Manure/ha	8.55	5.61	2.94
7. 25 t Manure/ha + Spraying	8.41	5.83	2.58
LSD (P < 0.05)	1.84	1.17	1.13
LSD (P < 0.01)	2.59	1.65	1.59
CV (%)	20.50	20.80	33.80

Table 4. **Effect of NPK-fertilizer, TSP, N and Compost on the yield of potato tuber.**

TREATMENT	TOTAL TUBER YIELD (t/ha)
1. Control	12.43
2. 750 kg NPK/ha + 250 kg TSP/ha	37.03
3. 750 kg NPK/ha + 250 kg TSP/ha + 50 kg N/ha*	26.72
4. 500 kg NPK/ha + 250 kg TSP/ha + 100 kg N/ha	34.13
5. 500 kg NPK/ha + 250 kg TSP/ha + 50 kg N/ha	25.27
6. 500 kg NPK/ha	29.36
7. Compost	10.71
8. Compost + 50 kg N/ha	14.94
LSD (P < 0.05)	13.32
LSD (P < 0.01)	18.35
CV (%)	32.30

* N application in treatments 3 and 4 were applied four weeks after planting whereas in treatment 5 and 8, N was applied at planting time.

Table 5. **Potassium content (dry matter basis) of the third compound leaf at 60 days after planting.**

TREATMENT	POTASSIUM CONTENT (%)
1. Control	5.25
2. 750 kg NPK/ha + 250 kg TSP/ha	3.43
3. 500 kg NPK/ha + 250 kg TSP/ha + 50 kg N/ha*	3.07
4. 500 kg NPK/ha + 250 kg TSP/ha + 100kg N/ha	3.11
5. 500 kg NPK/ha + 250 kg TSP/ha + 50 kg N/ha	3.28
6. 500 kg NPK/ha	4.08
7. Compost	4.93
8. Compost + 50 kg N/ha	4.63
LSD ($P < 0.05$)	0.81
LSD ($P < 0.01$)	1.12
CV (%)	11.80

*** N application in treatment 3 and 4 were applied four weeks after planting whereas in treatment 5 and 8, N was applied at planting.**

This is in contrast to the findings of Sivasupiramaniam *et al.* (unpublished) who found significant correlations between potassium contents of leaf and potato tuber yield. The critical concentration to define the deficiency limit of potassium in leaf 50 days after planting was found to be 3.8% (Singh 1987). In the present study, the relative sufficiency level of potassium was observed in treatments 1, 6, 7 and 8. However, apart from treatment 6, treatments 1, 7 and 8 had significantly ($P < 0.01$) lower tuber yields. Therefore, it may be assumed that potassium was not the limiting nutrient. This is consistent with the soil analysis (Table 1).

CONCLUSION

The potential use of goat manure as a organic fertilizer for crops such as potato can not be overemphasized. However, at present goat (as well as sheep) population in the South Fore CD is very small. Therefore, the availability of manure and its potential use as a fertilizer source may not be fully realized in the immediate future.

Potato responded poorly to NPK-fertilizer during the dry season; but, in the wet season higher tuber yields were obtained. This indicates the proper time of planting potato in the South Fore area (October-March) for maximum tuber yields.

Application of additional P and/or N is not necessary. The present study indicates that application of insecticide and fungicide in a smallholder situation may not be necessary provided healthy seeds and normal cultural practices are employed. Further study is required on the use of compost on potato production in the South Fore area. Some aspects which need to be considered are the type of compost material used and the labour requirement for material collection.

ACKNOWLEDGEMENT

The authors are most grateful to Mr N. Korapa, Rural Development Technician, DPI, Department of Eastern Highlands for his assistance with the supervision of the trials.

REFERENCES

DEPARTMENT OF AGRICULTURE AND LIVESTOCK (1989). Smallholder Market Access and Food Supply Project (SMAFSP), Phase 3: 1990-1994, Vol. 1. Main Project Document. Konedobu, Papua New Guinea.

FAO. (1984). Fertilizer and plant nutrition guide. Fertilizer and Plant Nutrition Service. Land and Water Development Division. Rome, Italy

LITTLE, M.T. and HILLS, J.F. (1978). Agricultural Experimentation, Design and Analysis. John Wiley and Sons, Inc. N.Y. USA.

MENGEL, K. and KIRKBY, E.A. (1987). Principles of Plant Nutrition. 4th edn. International Potash Institute, Switzerland.

SINGH, J.P. (1987). Role of phosphorus and potassium content of leaf in maximising potato yield. *Indian Journal of Agricultural Science* 57(8): 565 -566.

SIVASUPIRAMANIAM, S.; BENJAMIN, A.K. and PITALA, J.A. (unpublished). Effect of sheep manure and phosphorus on potato and their residual effect on the succeeding maize and cassava crops.

SAPPRD (1986). Potato Production; *Technoguide*, Papua New Guinea.