CARIBBEAN FOOD CROPS SOCIETY

23

Twenty Third
Annual Meeting 1987

Antigua

Vol. XXIII

An agro-economic evaluation of fertilization methods for White Potato (*Solanum tuberosum* L.) in Montserrat

R.E. Fletcher, C.S. Weekes

CARDI, P.O. Box 272, Plymouth, Montserrat

C. Douglas

CARDI P.O. Box 766, St. John's Antigua

Eight fertilizer regimes comprising traditional and recommended alternatives were evaluated on three farms during the 1985/86 cropping season. In terms of marketable yield, the currently recommended practice of pen manure with all P_2O_5 and one half N and K_2O at planting, with the remainder at first weeding was significantly better than all other treatments. The alternative, pen manure only, was second best, while the recommended practice without pen manure ranked third. However, in terms of economics, marginal rates of return for these treatments relative to the control were 649, 992 and 429 per cent, respectively. Although the riskiness of the treatments were not explicitly considered, the high marginal rates of return should motivate even risk averse farmers.

Keywords: White potato; *Solanum tuberosum*; fertilization

Introduction

The revived interest in commercialization of white potato (*Solanum tuberosum* L.) in several countries in the English speaking Caribbean has re-emphasised the need for a systematic approach toward developing an appropriate technological production package for the crop, applicable to small farm systems. Small farmers in Jamaica have been producing potato commercially for at least 3 decades (Stone, 1972) while other countries (Dominica, Barbados, Montserrat, St. Kitts, Trinidad and Tobago) have attempted production on a sporadic and rather disorganized basis in the past. (Fletcher and Weekes, 1985). Heavy capitalization costs and the high risk involved in producing the crop make it imperative that all crop husbandry components be suitably "fine-tuned" to ensure optimum returns to the farmer.

Fertilization is considered an important agronomic practice in potato production. The crop is a heavy feeder and highly responsive to balanced fertilizer regimes. Caribbean potato farmers have been taught the basics of potato fertilization which is based on the well known formula: all P plus 1/2 N and K at planting, and the balance at first weeding (3 weeks after germination). (Adams, 1975; Perrenond, 1983). In Montserrat, a study of potato fertilization practices in small farm commercial production brought out several variations which involved both timing and quantities of nutrients. (CARDI, Montserrat, 1984). It was also clear that farmers were modifying recommendations as financial or logistic short cuts in their production package, sometimes without adequate knowledge of the agro-economic

---

This paper is an output of the CARDI/USAID farming systems research and development project (FSRD #538-0099) and the Ministry of Agriculture, Montserrat.

implications. It was therefore considered necessary to examine the most common fertilizer regimes practised on-farm in order to derive accurate agro-economic parameters for their characterization.

Materials and methods

An on-farm trial was designed to evaluate eight fertilizer regimes on the potato crop in the 1985/86 growing season. The trial comprised a randomised block design with two replications on each of three farms in the Amersham and Rileys districts of Montserrat. Treatments were selected to test the effect of split applications of N and K against a single application at planting at two levels of fertilization. The effect of pen manure (PM) applied under the seed with and without NPK fertilizer was also tested.

Details of the treatments are given in Table 1. Treatments T1, T5, T7 and T8 represented practices used by farmers; T3 and T4 were new recommendations. The soils at all three trial locations are alfisols and mapped as Rileys sandy clay loam (Typic Tropudalf, fine-loamy, mixed). Properties are set out in Table 2. Farm location, altitude, planting and harvesting dates for the three trial locations are set out in Table 3.

The land was ploughed, harrowed and made into ridges 1m apart. Fertilizer treatments were applied before planting seed tubers (cv Desiree) 30cm apart, in single rows to the lower side of each ridge. This resulted in a plant population of approximately 33,000 plants/ha. Cultural practices, including weeding by hoe, hilling up and pest and disease control measures were standard. The second application of fertilizer, where required, was side dressed at the first weeding and hilling up operation, 3 weeks after germination of the tubers. The crop at all three locations was entirely rain-fed.

Harvested tubers were weighed and graded into marketable and unmarketable lots. All tubers below 3.5cm in diameter as well as diseased, cracked and damaged tubers were graded out. For the purposes of this trial, however, green skin (exposed) tubers of marketable size were included in marketable yields.

Activity budgets for each of the eight treatments tested were formulated to describe each technological alternative in terms of

(i) Mean marketable output (kg/ha);
(ii) The demands placed on farm-household resources throughout the production to disposal period;
(iii) The variable costs associated with each input in accordance with the period incurred.
(iv) The net benefit.

Net benefit in the budgets was based on the simplified relationship:

$$\text{Net Benefit (NB)} = P_y.Y_j - (P_j\text{-}X_i)$$

Where P = farm-gate price of output (assumed to be constant irrespective of the level of output).

Y = the mean yield of the jth treatment (j = 1, 2...8)

P = the price paid by farmers for the i th input (i = 1,2,...N) used in production of the crop.

X = the level of the ith input used (e.g. land, labour, materials, services, etc.)

Table 1 Details of nutrient treatments applied.

Treatment		NPK Fertilizer		Amount of nutrient applied (kg/ha) At planting				At 3 wks		
No	Code	Rate	Timing	N	P_2O_5	K_2O	PM[1)]	N	P_2O_5	K_2O
T1	Fp - PM	Full	At planting	120	96	150	0	0	0	0
T2	Fp + PM	Full	At planting	120	96	150	5000	0	0	0
T3	Fs - PM	Full	Split	58	96	78	0	62	0	0
T4	Fs + PM	Full	Split	58	96	78	5000	62	0	62
T5	Hp + PM	Half	At planting	60	48	75	5000	0	0	0
T6	Hs + PM	Half	Split	29	48	39	5000	31	0	36
T7	Control	None	-	0	0	0	0	0	0	0
T8	PM	None	-	0	0	0	5000	0	0	0

1) Partially decomposed sheep and goat dung (0.5 l/plant)

Table 2 Physical and chemical properties of Rileys sandy clay loam, (after Ahmad, 1983)

Particle size analysis						Chemical Analysis					
C'se sand	Fine sand	Silt	Clay	pH	CEC	Ca	Mg	K	Na	C/N Ratio	P
(%)					(m.e./100 gm)						(ppm)
23	19	14	41	6.0	9.81	4.97	3.52	0.12	0.28	11.3	7

Table 3 Details of trial locations, planting and harvesting dates

Detail	Farm 1	Farm 2	Farm 3
Location	Amersham	Rileys	Rileys
Farmer	Fergus	Collins	Osborne
Altitude (m)	250	400	450
No. of Reps.	2	2	2
Planting date	85-12-05	85-12-09	85-12-18
Harvesting date	86-03-20	86-03-14	86-03-20

The total variable cost and net benefits were used to perform dominance analysis on the eight treatments evaluated. This analysis is based on the assumption that dominated technological alternatives would never be chosen by farmers (or recommend by researchers), because there is at least one other alternative, which has a higher, or at least an equal, net benefit and a lower variable cost.

Results and discussion

Agronomic analysis

Table 4 reports yields of marketable tubers from the eight treatments on each of the three farms. The two treatments that yielded significantly higher than the rest were; full dose of NPK-split with pen manure (T4) and 1/2 dose NPK-split with pen manure (T6). Pen manure and splitting of N and K treatments showed the most profound effect on yield.

A comparison of Treatment 8 (PM) with the check (T7) shows a significant yield increase of 8,541 kg/ha. When this comparison is extended across all +PM treatments, the increase due to pen manure was 5,675 kg/ha. Similarly, a comparison of all at-planting vs. splitting treatments shows a yield increase of 3,084 kg/ha marketable potatoes for the split treatment, (Table 5). The yields from the full NPK and 1/2 NPK treatments were not significantly different and further detailed studies will have to be done to determine which of the individual elements or factors are non-responsive and what interactions if any, exist. In fact, the trial results indicate that there is little or no advantage in application of NPK when pen manure is applied, unless the dose is split.

The mean grade-out percent of harvested tubers was 89.8% and no significant difference in the grade-out among treatments was observed. Fertilizer treatments influenced tuber size significantly, the control treatment (T7) producing significantly smaller tubers than other treatments (Table 4). Treatment T4 produced a significantly higher number of tubers than all other treatments. In all cases, splitting the NPK application resulted in an increase in the tuber number per plant. The lowest number of marketable tubers per plant was obtained in the check treatment (T7) and the inclusion of pen manure (T8) significantly improved this figure from 4.19 to 5.93. High initial levels of NPK (T1, T2) appeared to depress tuber number.

Economic analysis

Table 6 presents data on costs and returns for field activities relevant to this trial. Mean yields (kg/ha), gross benefits (EC$/ha) and net benefits are reflected here. When a dominance analysis was performed on the yield data (see Figure 1) results suggested that T1, T2, T5 and T6 were dominated, while T3, T4, T7 and T8 were undominated.

To make recommendations regarding the undominated production opportunities it is important to allow for availability of capital, because scarcity of this resource is a general feature of small farmers. For example T4 would be relevant to farmers who can invest greater than EC$15,000/ha, whereas T3 would be acceptable for farmers who can invest close to EC$13,000/ha, and T8 would be an intermediate position between these two ranges.

Marginal analysis was applied to the net benefit curve of Figure 1 (i.e. to the undominated alternatives (T3, T4, T7 and T8) in order to evaluate the increase in net benefit obtainable from a given increment of investment. Reference to Table 7 shows a marginal rate of return of 649 per cent when the farmer changes from traditional practice (T7) to T3 (Fs-PM). The next change from T3 to T8 (PM) resulted in a marginal rate of return of 922 per cent. Finally, the change from T8 to T4 (Fs+PM) resulted in a marginal rate of return 429 per cent.

The above trend is similar to that depicted by the slope of the net benefit curve in Figure 1. First the curve rises steeply, then more steeply and finally rises at the slowest rate.

Table 4 Yield components and marketable yields

Treatment			Yield components	
No	Code	Marketable Yield (kg/ha)	Mean Tuber Size (g/tuber)	Mean Tuber Number (tuber/plant)
T1	Fp - PM	14,667 c[1)]	96.3 c	4.94 d
T2	Fp + PM	19,083 b	104.8 b	4.79 d
T3	Fs - PM	17,667 b	104.8 b	5.49 c
T4	Fs + PM	22,292 a	109.2 a	6.57 a
T5	Hp + PM	17,208 b	102.8 bc	5.43 c
T6	Hs + PM	20,250 ab	111.8 a	5.75 bc
T7	Control	10,167 d	76.5 d	4.19 c
T8	PM	18,708 b	103.0 bc	5.93 b
LSD (p = 0.05)		2,149	-	-

1) Figures in columns followed by the same letter are not significantly different (P = 0.05) according to multiple range test.

Table 5 Effect of pen manure and splitting fertilizer applications on marketable yields (kg/ha)

	Split application	Pen Manure
With	20,070	19,508
Without	16,986	13,833
Difference	+ 3,084	+ 5,675

The yield response (and consequent net benefit) of the PM treatment relative to T3 and the dominated treatments is somewhat surprising and merits some further investigation.

Conclusions and recommendations

This exploratory trial has confirmed one of the basic general principles of white potato fertilization i.e. the beneficial effects of split applications of N and K on yields. Potts et al (1983), working with potato farmers in the Philippines, found that application of commercial fertilizer to the seed bed prior to planting instead of as a side dressing resulted in a 15% increase in yields generally. This trial however suggests that further beneficial effects are possible if some or all of the N and K are sidedressed at first hilling up after all P has been applied at planting.

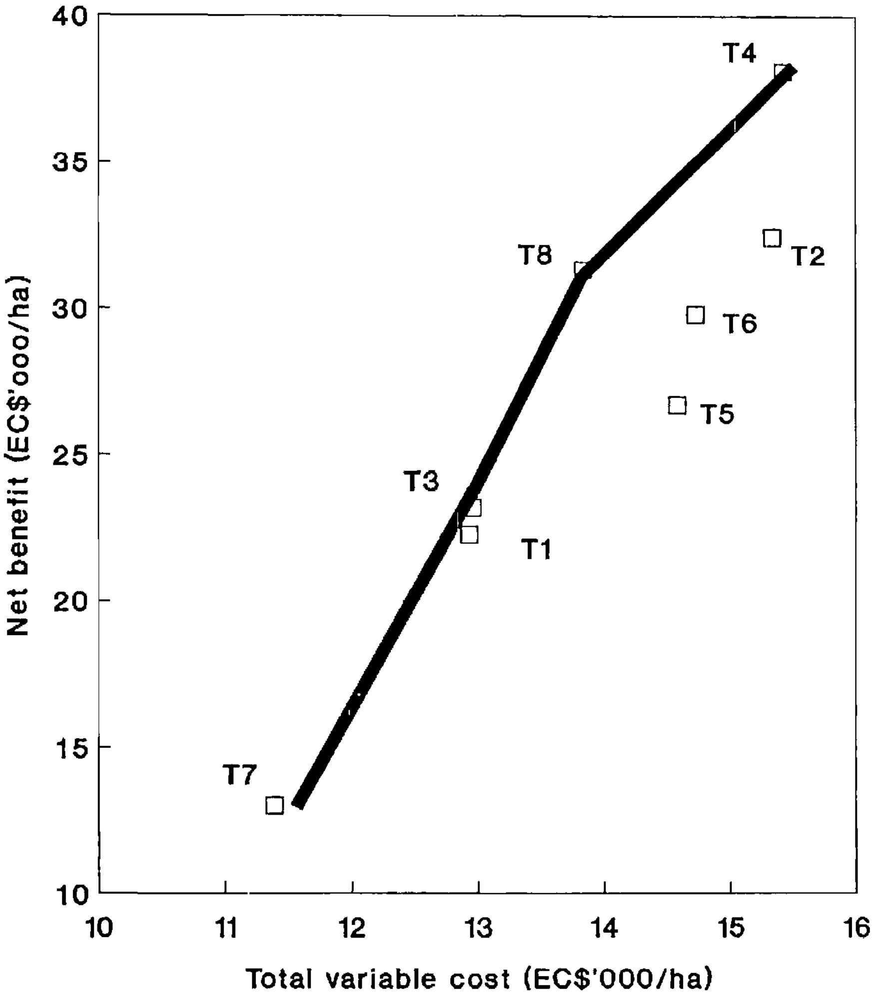

Figure 1 Dominance analysis of alternative fertilization technologies for potato in Montserrat

Pen manure had the most profound effect on yields. It may have exerted several influences which would be difficult to define conclusively in the absence of chemical analysis. It was devoid of straw or other crop residues. The rate of application was similar to the rate applied by farmers in the Philippines (Potts et al., (1983). In the small farmers production practices in the Philippines, the organic matter has had variable effect on yield and this has been attributed to varying soil conditions and climatic factors. In this trial the evidence suggests that pen manure may be influencing a more even and prolonged availability of N and other nutrients, as well as providing trace elements that may have been in short supply.

Table 6 Costs and returns according to treatments

Variables	Treatment costs and returns (EC$/ha							
	T1	T2	T3	T4	T5	T6	T7	T8
Yield (kg/ha)	14,650	19,900	15,050	22,300	17,200	18,550	10,150	18,800
Gross Benefit (kg/ha)	35,160	47,760	36,120	53,520	41,280	44,520	24,360	45,120
Cost of NPK ($/ha)	1,220	1,220	1.220	1,220	609	609	0	0
Cost of PM ($/ha)	0	1,600	0	1,600	1,600	1.600	0	1,600
Cost of applying NPK ($/ha)	248	248	652	628	492	632	0	0
Cost of applying PM ($/ha)	0	384	0	384	384	384	0	384
Total cost of Treatment ($/ha)	1,468	3,452	1,872	3,832	3,085	3,225	0	1,984
Total variable cost ($/ha)	12,929	15,331	12,954	15,420	14,580	14,725	11,385	13,834
Total labour used (hrs/ha)	1,274	1,370	1,292	1,388	1,348	1,383	1,212	1,308
Net Benefit ($/ha)	22,230	32,428	23,165	38,099	26,699	29,794	12,974	31,285

Table 7 Marginal analysis of undominated alternative treatments

Treatment	Net benefit		Variable costs		Incremental marginal rate of return
	Total (EC$)	Incremental (EC$)	Total (EC$)	Incremental (EC$)	(%)
T7(Control)	12,974	--	11,385	--	--
T3	23,165	10,191	12,954	1,569	649
T8	31,285	8,120	13,834	880	922
T4	38,099	6,814	15,420	1,586	429

a) EC$ 1.00 = US$ 0.38

It would seem logical to recommend a reduction in the level of NPK fertilization for farmers who supplement with pen manure and in such a situation the benefit of applying inorganic P and pen manure at planting and all inorganic N and K at the first side dressing needs to the investigated. For farmers not using pen manure, the full dose of NPK treatment may need to be modified to achieve a much lower initial application of N and K and an increase in the sidedress application.

With regard to the economic considerations and implications for the farmer in the use of the tested alternatives, it is probable that he will be influenced by the following five factors: (i) profitability (ii) divisibility (iii) resource requirements (iv) complexity or simplicity (v) riskiness.

The economic evaluation considered profitability using marginal analysis. Aspects of divisibility, resource requirements, and simplicity would be evident from activity budgets. Although the riskiness of the alternatives was not evaluated it is reasonable to argue that the high marginal rates of return could motivate even risk-averse farmers.

References

Adams, B.R. (1975) Farmers' guide to Irish potato production. Department of Agriculture - Montserrat. U.K. Tech. Assistance

Ahmad, N. (1983) "An Investigation of Soil Conditions of Farmers Holdings in Montserrat", USAID/CARDI Small Farms Study, Consultant Report No. 14

CARDI (1986) White potato crop report 1985/86, Montserrat

Fletcher, R.E. and Weekes C.S. (1985) Integration of White Potato (*Solanum tuberosum* L.) into the vegetable production systems of Montserrat. Caribbean Food Crops Soc. Proc. Vol. 21 216 -221

Perrenond, S. (1983) Fertilizing potato for high yields, International Potato Centre, Lima, Peru, Bulletin #8.

Potts *et al* (1983) "An Agro-economic assessment of white potato manurial trials: Benguet and mountain Provinces" On-farm potato research in the Philippines. International Potato Centre.

Stone, D.H. (1972) Irish potato: Assessment of varieties in Jamaica from 1948 onwards, Ministry of Agriculture, Jamaica (unpublished)