An Economic Evaluation of a Phosphate Basal Dressing Scheme for the Niamey Department

by

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ABSTRACT

An Economic Evaluation of a Phosphate Basal Dressing Scheme for the Niamey Department*

Coarse grain yields have remained relatively constant and production has stagnated in Niger during the past six years, while the population has risen. This paper examines one proposed government intervention to increase cereal production: the application of a one-time basal dressing using phosphate fertilizers. This intervention may provide a means of raising production to keep pace with increasing cereal demand; it may also augment soil fertility in the short run.

This evaluation presents a preliminary economic analysis and suggests areas for further work towards a phosphate basal dressing scheme. In order to simplify the analysis, the scheme is only considered for millet production in the Niamey Department. Sections II and III examine the technical issues of a phosphate basal dressing scheme, and derive the assumptions concerning the effects of such a scheme which are made for the base case analysis. Section IV presents the economic evaluation; and Section V draws conclusions and recommendations from the analysis.

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I. Introduction

Coarse grain yields have remained relatively constant and production has stagnated in Niger during the past six years. Simultaneously, the population has risen at an estimated 2.7% annually. In this context, the Government of Niger is concerned about increasing food production, especially in light of expectations that land fertility may also be declining.

To address this concern, several strategies have sought food self-sufficiency through state interventions in cereal production and marketing. This paper examines one proposed intervention: the application of a one-time basal dressing using phosphate fertilizers. This intervention may provide a means of raising production to keep pace with increasing cereal demand; it may also augment soil fertility in the short run.

This evaluation presents a preliminary economic analysis and suggests areas for further work towards a phosphate basal dressing scheme. In order to simplify the analysis, the scheme is only considered for millet production in the Niamey Department. The analysis focuses on millet because good agronomic data exists for millet and because millet production accounts for about 70% of total crop production in Niger. The pilot scheme is limited to Niamey Department due to its proximity to the Parc-W phosphate site and to the Niamey "port" for imports, and because Niamey Department's more developed physical infrastructure and proximity to agricultural research facilities make it a preferred region for a pilot project.

The economic profitability of the proposed scheme is examined with respect to six variables which significantly affect the viability of the scheme and for whose values there is a considerable range of speculation:

1. The millet yield response to phosphate fertilizer,
2. The price of grain,
3. The cost of the phosphate fertilizer,
4. The cost of distribution of fertilizer,
5. The value of additional by-product production,
6. The effects of a drought.

These variables are considered individually against a base case which represents our best estimate of most likely values for these variables.

Section II examines the technical issues of a phosphate basal dressing scheme, and derives the central assumptions concerning the effects of such a scheme which are made for the base case analysis. Section III presents other technical assumptions made for the analysis. Section IV presents an economic evaluation, with a sub-section examining each of the variables cited above. Section V draws conclusions and recommendations from the analysis.

II. The Potential of Phosphate Fertilizers in Niger

A. Experience with Phosphate Fertilizer in Niger

There is a relatively long history of experimentation from which to evaluate the effects of fertilizer on yields in Niger; these trials have concentrated primarily on compound mixtures and on annual applications of various fertilizers. However, in recent trials, several forms of phosphate fertilizer have been tested alone with respect to crop yield responses. They include Super Simple Phosphate (SSP), Triple Super Phosphate (TSP), partially acidulated phosphate rock (PAPR) from Tahoua and Parc-W, and crushed phosphate rock (PR). For all of these phosphate fertilizers, the amount of available P_2O_5 in the fertilizer is the principal determinant of crop yield response. P_2O_5 availability is in turn a function of the type of phosphate used, the degree of acidulation of the phosphate and the form in which the phosphate is applied.[1] Rock phosphates, for example, contain between 20% and 25% P_2O_5 depending on the degree of acidulation and original quality. In processed phosphates, because the P_2O_5 content is more soluble, the yield effect is more immediate but also more transitory. Experimentation in Niger has found that the best crop yield responses have been obtained from imported SSP. TSP produces responses which are about 10-15% lower than SSP. PAPR at 50% acidulation gives responses almost identical to TSP responses, while unacidulated PR gives the lowest yield. However, unacidulated PR is thought to have longer residual effects on soil fertility and plant growth.

In Niger, there are at least two significant deposits of phosphate rock, Tahoua and Parc-W. International Fertilizer Development Center (IFDC) testing has found that PAPR-50% from Parc-W gives yield responses which are about the same as imported TSP, while Tahoua rock does not give good results after acidulation due to trace minerals which retard the response effect.[2] A separate evaluation by M. Roesch, and J. Pichot, also found that crushed Tahoua PR did not show good

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[1] Acidulation is a process by which phosphate rock is treated with an acid to convert phosphate compounds to P_2O_5, a more soluble form which is more accessible to plants.

[2] IFDC/ICRISAT 1986 Annual Report on the Fertilizer Research Programme in Niger, ICRISAT Sahelian Center, Niamey, Niger, 1987.

results in lab testing. However, in field trials in acidic sandy soils common to Niger, untreated Tahoua rock produced promising results under improved management conditions.[3]

From a commercial point of view, Tahoua phosphate is less attractive than Parc-W phosphate because the proven deposits are much smaller, are in a more isolated area, and would require special treatment to acidulate.[4] For these reasons, in light of the favorable response rates which have been obtained for partially acidulated PR from Parc-W, and due to the availability of a prefeasibility analysis of the economic costs of production, PAPR-50% from Parc-W has been assumed in the base case analysis.

B. Grain Yield Response to Phosphates

The analysis bases its estimation of millet yield response to phosphate fertilizer on three years of research conducted by IFDC at the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) Sahelian Center in Niger.[5] These trials have gone through three levels of testing: 1) on-station trials at the ICRISAT station at Sadore (Niamey Department) in 1984, 1985 and 1986; 2) researcher managed on-farm trials at Gobere (Niamey Department) in 1985 and 1986; and 3) farmer managed on-farm trials at Gobere in 1986. For the first two trial levels, results are available in the form of response equations which estimate the additional yield response to increasing dosages of P_2O_5 applied per hectare for various fertilizer types. Graph A plots response curves for first and second year effects of an initial PAPR-50% application for increasing dosage assumptions.[6]

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[3] M. Roesch, and J. Pichot, "Utilisation du phosphate naturel de Tahoua en fumure de fond et en fumure d'entretien dans les sols sableux du Niger" L'Agronomie Tropicale, 1985 Vol. 40 # 2. pp. 89-97.

[4] Parc-W reserves of phosphate have been estimated at 1.25 billion tons with an average P_2O_5 concentration of 23%. Etude pour l'Elaboration d'un Programme Intégré de Production et de Distribution d'Engrais dans le CEAO, CEAO contrat # 007/86 SG/DDI, CEGI Janvier 1987.

[5] IFDC/ICRISAT Annual Report for 1985 and 1986. The information taken from these documents has been largely the results of research carried out by André Bationo. The authors would like to express their gratitude to him for sharing his data and for his comments on the analysis.

[6] These response curves use the average of two years' coefficients for the response of millet to PAPR-50. The equation for the first year response is:

$$Y = 120.5 + 197 \ln (D)$$

The equations which define the curves in Graph A have been used to derive hypothetical first, second and third year millet yield responses in each arrondissement. These yield responses are based on response rates which are defined as the millet yield response to a given dosage of P_2O_5 generated by the regression equation divided by the average millet yield for Niamey department. Each response rate (for 1st, 2nd and 3rd year responses) is expressed as a percentage of this long run average yield.[7]

To calibrate the response curves to the long run average millet yield, the response curve derived amount of fertilizer necessary to give that yield has been subtracted from the dose rate. This quantity of fertilizer is assumed to already be present in the soil due to current average fertilizer use or simply as a characteristic of the soil. The effect of this adjustment is to set a new index for estimation of response rates. This procedure is illustrated in Graph B. Assuming that B marks the average yield for the department, AC shows the implied dose of P_2O_5 necessary to produce that yield. This dose translates into a fertilizer quantity assumed to be already present in the local soils. The distribution of an additional quantity of fertilizer may be represented by CD. This additional quantity raises yields to AE. The derived response rate for the addition of dose CD is then calculated as BE/AB representing the ratio of additional yield to base yield.

Two further adjustments have been made to response rates. In order to adjust the derived response yields to the variation in climatic and soil conditions of each arrondissement, the yield response for each year and arrondissement is weighted by the ratio of the average arrondissement yield to the departmental average. Lastly, to account for the expected drop in performance between experiment station and on-farm yield, a coefficient called the "Actual/Experimental Response Ratio" (A/E Ratio hereafter) has been included in the analysis. In the base case this coefficient is given the value of 0.5, representing a 50% drop in performance in the on-farm

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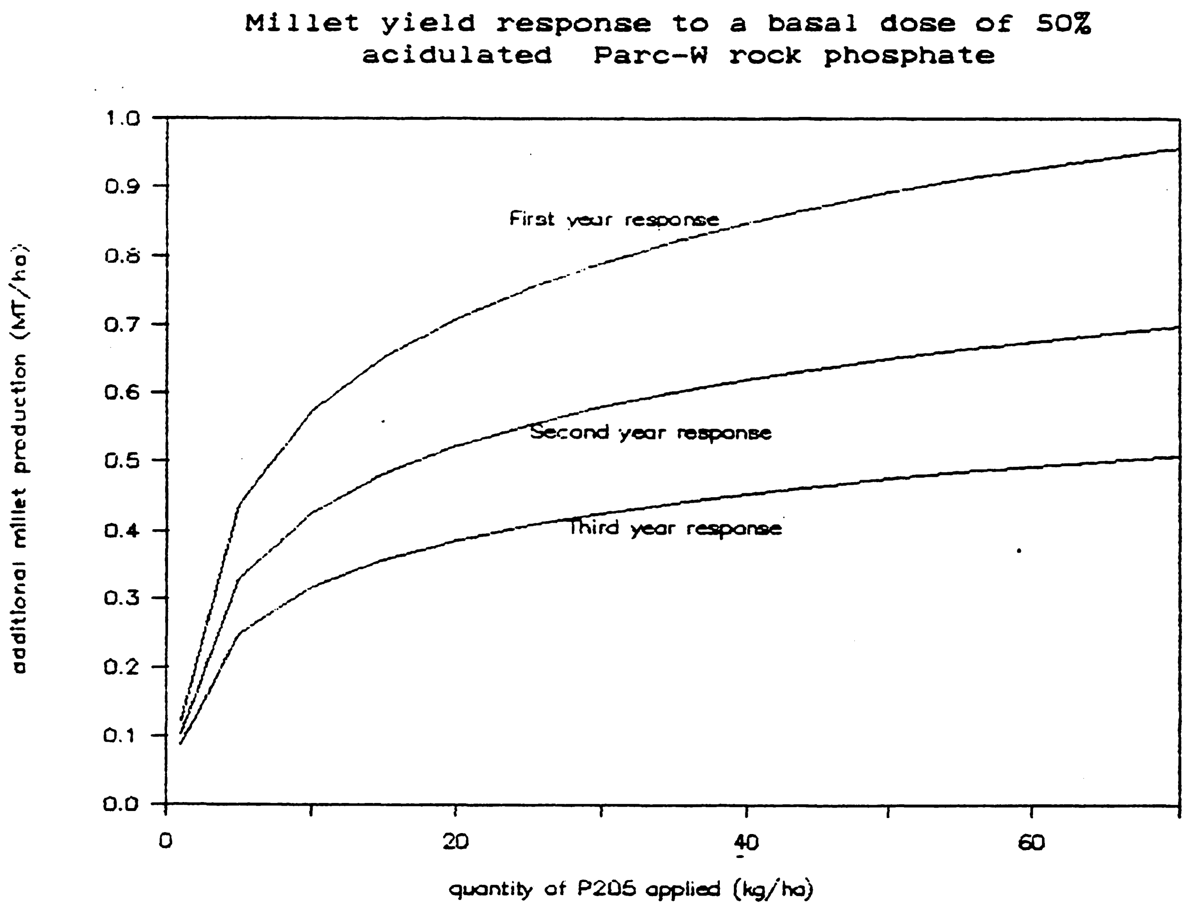
and, for the second year:

$$Y = 102.5 + 140.5 \ln(D)$$

where: Y is the millet yield in kg/ha,
D is the dose of P2O5 applied (kg/ha).

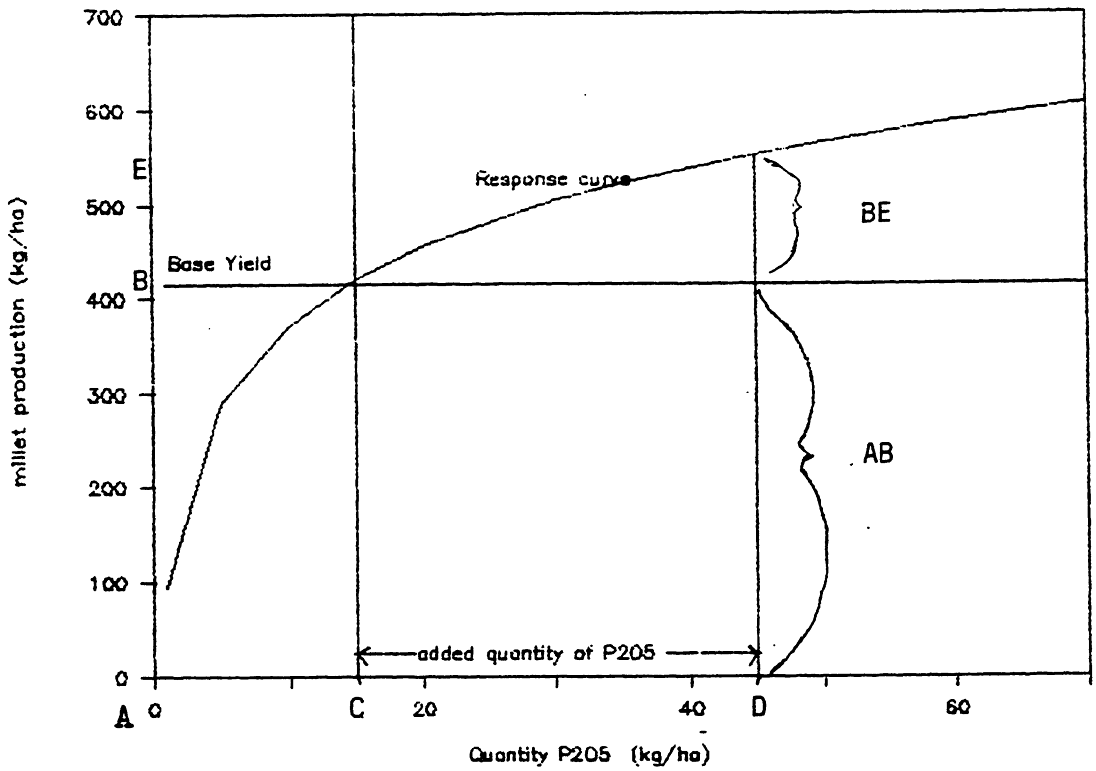
[7] Because response curves for third year effects of PAPR-50% are not yet available, third year responses have been derived by weighting the second year response rates downward by the same percent drop as occurred between first and second year response rates.

Graph A


Millet yield response to a basal dose of 50%
acidulated Parc-W rock phosphate
additional millet production (MT/ha)
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
First year response
Second year response
Third year response
0
20
40
60
quantity of P205 applied (kg/ha)

Graph B

Derivation of response rates
by reindexing the yield response curve to average yields
in the Niamey Department



The response rate = BE / AB

situation.[8] In Scenario II this coefficient is varied to evaluate the sensitivity of the analysis to different degrees of success in on-farm replication of experimental results.

In summary, the effect of the procedure described above is, first, to recalibrate experimental yield response to account for differences between experimental control and actual base yields. Second, it adjusts the expected results in proportion to the average yield in each arrondissement to reflect differences between arrondissements in the production of millet (e.g. rainfall, and soil types). Lastly, it makes explicit the response reduction expected in the transfer from an experimental to an on-farm situation.

Table 1 plots the "experimental" and derived "actual" response rates and the resultant additional millet yield assumed for increasing dosages of P_2O_5 in the analysis which follows.

Table 1: Yield Response Rates and Quantities to Increasing Amounts of Phosphate Fertilizer (PAPR-50%)

Fertilizer (kg/ha)	P205 (kg/ha)	1st year rate experi. (%)	1st year rate actual (%)	Add'l yield (kg/ha)	2nd year rate experi. (%)	2nd year rate actual (%)	Add'l yield (kg/ha)	3rd year rate experi. (%)	3rd year rate actual (%)	Add'l yield (kg/ha)	Total add'l yield (kg/ha)
20	4	32	16	65	0	0	0	0	0	0	65
40	8	50	25	103	11	6	23	3	1	5	132
60	12	64	32	130	21	11	43	7	3	14	188
80	16	75	37	152	29	14	59	11	6	22	233
100	20	83	42	170	35	17	71	15	7	30	271
120	24	91	45	185	40	20	82	18	9	36	303
160	32	103	51	210	49	24	99	23	12	47	356
200	40	112	56	229	55	28	113	27	14	55	398
240	48	120	60	246	61	31	125	31	16	64	434

In comparison to existing experimental data, the additional yields derived above appear to be in the right range, though little on-farm experience exists for comparison. In 1986 (a good rainfall year), IFDC/ICRISAT farmer-managed on-farm trials at Gobere produced yield increases of over 300% for an application of 30 kg/ha of P_2O_5, which is more than double the experimental response rate assumed

[8] Though obviously an arbitrary figure, this ratio is based on actual observations of consistent differences between farmer-managed on-farm results and research station trials. C.f. Peter Matlon et al., Coming Full Circle: Farmers' Participation in the Development of Technology, International Development Research Center, (Ottawa, Canada; 1984).

in the analysis for the first year at the same phosphate dosage.[9] Other highly variable results of phosphate trials are reported in the CEGI report, ranging from yield increases of as much as 293 kg/ha for applications of 6 kg/ha P_2O_5 to no increase for applications of 20 kg/ha P_2O_5.[10] In on-farm trials, the "3M" project in Zinder obtained yield results varying between 75 and 300 kg/ha for application of 40 kg of P_2O_5 and 15 kg of nitrogen. Overall, the study reports mean first year millet yield gains of 293 kg/ha for initial applications of 46kg of P_2O_5 (100 kg of TSP) for southern zones and 123 kg/ha millet for northern zones. By comparison, for the same application of P_2O_5,the model projects a first year on-farm millet yield increase of 242 kg/ha.

C. Optimal Phosphate Fertilizer Dosage

For the analysis the optimal fertilizer application rate was chosen to be the dose which gives the highest net present value to the scheme. In effect this is the dose rate at which marginal benefits equate to marginal costs. Graph C plots the change in the net present value and several other important variables as the fertilizer application rate is increased. As Graph C shows, the highest net present value is achieved at a fertilizer dose of about 80 Kg/ha of fertilizer, representing 16 Kg/ha of P_2O_5. Above this level, fertilizer application is suboptimal because the value of the marginal yield response to additional fertilizer becomes less than the added cost of applying it. This declining value is due both to decreasing marginal returns to additional phosphate demonstrated in Graph A, and to the projected reduction in the millet price as production is increased.

The projected optimal dose, 80 kg/Ha of PAPR-50% is therefore the dose used as the base case fertilizer application rate in the analysis. This dosage is approximately the same dose as has been recommended by Niger's Ministry of Agriculture for annual application on millet (15kg/ha), but it appears low for a basal dressing.[11] Roesch and Picot's research found that of the doses tested, 50 kg/ha

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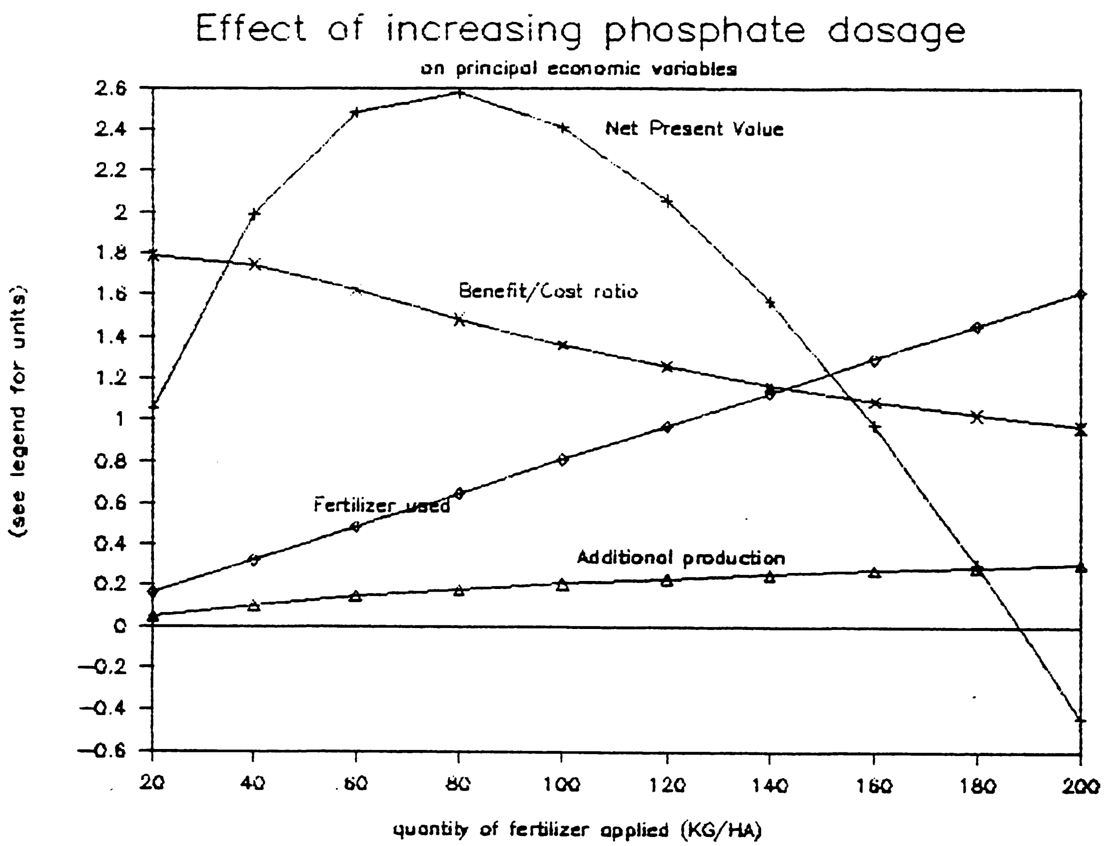
[9] Personal communication with André Bationo.

[10] CEGI pp. 40-51.

[11] "Etude pour l'Elaboration d'un Programme Intégré de Production et de Distribution d'Engrais Dans les Pays Membres de la Communauté Economique de L'Afrique de l'Ouest" Tome 2, prepared by Compagnie d'Etudes Economiques et de Gestion Industrielle, Paris, Janvier 1987, p. N40.

Graph C



Legend

Indicator	Units scale
Net present value	100,000,000 FCFA
Benefit/Cost ratio	1
Fertilizer used	10,000 tons
Additional production	100,000 tons

P_2O_5 proved the most economic. However, this dose was the lowest they tested, implying that even lower doses may have been more economic. Recommendations of some technical studies for higher doses may therefore reflect technical optima, but not necessarily the economic optimum due to the strongly diminishing marginal returns which occur with increasing dose rates.

III. Assumptions of the Analysis

A. Area and Base Yield Assumptions

Area planted and base yields for millet are based on a seven year average from 1980-86 for the Niamey Department as reported by the Ministry of Agriculture. Only pure-stand millet production is considered in the model, although large areas of millet are intercropped with sorghum or cowpeas. The base area figures given therefore overestimate millet area because intercropped fields are included in the area estimates.

In order to reduce the scheme to a reasonable size for a pilot project, the analysis assumes that in each arrondissement, one quarter of total millet area planted will be affected by the scheme. This reduction is arbitrary, but considered reasonable in light of logistical difficulties foreseen in distributing the quantities of fertilizer required by the scheme.[12]

B. Millet and By-product Prices

The base case analysis values millet at the farm gate at 50 FCFA per kilo, representing the long run average producer price in the Niamey department.[13] However, since the proposed scheme will raise millet production in the region, the millet price will have to drop to stimulate consumers to buy the additional millet and

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[12] These problems are discussed in Section IV.A and in the conclusions. In addition to logistical problems, the assumption that the fertilizer will be distributed through the cooperative structure implies an immediate reduction in the number of farms reached, since currently not all cooperatives are functional, and not all cooperative members can be expected to participate.

[13] This price estimate was derived from quarterly and monthly retail prices for Niamey Department from 1970-1986. These were inflated to 1986 prices, giving an average retail price of 141 CFA/Kg. The producer price was assumed to be 35% of the retail price. The remaining 65% represents the commercial margin between producer and urban consumer. This coefficient is taken from the "The Joint Program Assessment of Grain Marketing in Niger (USAID/Government of Niger) December, 1983."

thereby clear the market. To reflect this "demand elasticity" effect, the millet price is lowered in the analysis each year on the basis of the percentage increase in production implied by that year's additional production.[14] To make this adjustment, the price elasticity of demand for coarse grains in Niger is assumed to be -0.5.[15] This coefficient implies that to stimulate a one percent increase in demand for millet, the millet price must drop by two percent. In comparison with other literature on demand elasticities, -0.5 is at the low end of the spectrum. The World Bank, for example, cites own price elasticities of demand for coarse grains in Africa between -0.5 and -0.15. However, it is expected that millet trade with other regions of Niger and neighboring countries will tend to lower the elasticity coefficient, as will substitution out of other cereal crops.

By-products are assumed to have no value in the base case analysis, on the assumption that in a normal year there are more than enough crop by-products to go around. In Scenario VII, however, by-products are given a value to reflect their potential utility as animal feed and as a green fertilizer.

C. Fertilizer Prices

The price of PAPR-50% fertilizer from Parc-W has been derived from estimates calculated by an IFDC prefeasibility study which assumes that a mining and transformation plant is built at Say for Parc-W phosphates.[16] The study's price estimate of 64 FCFA/kg assumes a 15% return on capital for the venture. These estimates have been adjusted to reflect 1987 prices.[17]

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[14] This lower millet price is only used to value additional production generated by the scheme and not existing production in the region since from an economic standpoint losses of producer surplus to nonmarginal production due to the price fall are offset by gains to consumers.

[15] "Analyse de l'Evolution à Moyen Terme des Cours Cerealiers au Niger et Leur Variabilité par rapport aux Niveau de Production," DEPSA/MAE, Service de l'Analyse des Politiques Agricole, Rep. du Niger, Juin 1987.

[16] "Prefeasibility Study for a Partially Acidulated Phosphate Rock (PAPR) Plant in Niger," International Fertilizer Development Center, Muscle Shoals, Alabama, December, 1984.

[17] Currently, SSP is available from Nigeria at about 25 CFA/kg. However this price is subsidized by the Nigerian government (on the order of 75%) and exports to Niger are illegal. This option has not been considered as a source of phosphates in the long run since it is likely that Nigeria will remove at least part of the subsidy and may attempt to enforce its export restrictions on fertilizer.

D. Fertilizer Distribution Costs

The Base Case Scenario assumes that all fertilizer will be delivered from a transformation/acidulation plant near Say (or port, in the case of imported fertilizer, Scenario IV.A) to the arrondissement USRC and then to village cooperatives by truck. Lastly, farmers are assumed to provide their own donkey cart transport from cooperatives to their fields.

Delivery costs assume roundtrip voyages since backhaul freight is not foreseen. Truck transport costs are based on prices paid by the Centrale d'Approvisionnement (CA) for truck delivery of imported fertilizers (28 FCFA/MT/KM). The costs of handling, storage, and losses are taken from other feasibility studies.

IV. Analysis of Results

The evaluation of the viability of the phosphate basal dressing scheme is based on an analysis of the costs and benefits of the scheme under a variety of assumptions. Table 2 summarizes the principal assumptions and results for various scenarios. To compare the economic attractiveness of the alternatives it provides three summary statistics:

1. Additional Production: The additional quantity of grain produced over a three year period as a result of the scheme is provided by this variable (in tons). This is the basis for the calculation of benefits of each scheme. However the correlation between production and benefits is not proportional, since as production rises, its marginal value falls.
2. Net Present Value: This figure represents the net present value of the scheme in 1987 FCFA (millions). It provides the best indication of economic value and is therefore the principal basis for evaluation between schemes.
3. Benefit/Cost Ratio: This ratio compares gross benefits to gross costs for each scheme. It provides a measure of the proportion of returns to initial costs, and thus provides a gauge of the margin of the security which each scenario offers against losses.

In Table 3 detailed calculations of benefits and costs are provided for the Base Case Scenario by arrondissement. The Annex presents the same tables for the other scenarios for those who wish to examine the details of each calculation.

A. Scenario I: The Base Case Analysis

The base case analysis suggests that a phosphate basal dressing scheme on one tenth of the area planted in millet in Niamey Department would entail the

TABLE 2

COMPARISON OF SCENARIO RESULTS FOR A PHOSPHATE BASAL DRESSING SCHEME FOR NIAMEY DEPARTMENT

SCENARIO ---››	unit	I	II A	II B	II C	II D	III A	III B	IV A	IV B	V	VI	VII
		Base Case	Actual/Experimental Response Ratio 100%	35%	20%	Base yield lowered 25%	Base Millet Price reduced: 25%	50%	Use Imported Fertilizer	Double local Prod'n cost	Double Transport Costs	Byproduct value added	Drought Scenario
PRINCIPAL ASSUMPTIONS													
Quantity of fertilizer	kg/ha	80	80	80	80	80	80	80	80	80	80	80	80
Expected yield increase: 1st yr	% base yld	37%	75%	26%	15%	64%	37%	37%	37%	37%	37%	37%	15%
2nd yr	% base yld	14%	29%	10%	6%	34%	14%	14%	14%	14%	14%	14%	6%
3rd yr	% base yld	5%	11%	4%	2%	18%	5%	5%	5%	5%	5%	5%	2%
Actual/Experimental Response	%	50%	100%	35%	20%	50%	50%	50%	50%	50%	50%	50%	20%
Base Millet Price	cfa/kg	50	50	50	50	50	37.5	25	50	50	50	50	80
1st harvest price	cfa/kg	46	43	47	49	45	35	23	46	46	46	46	78
2st harvest price	cfa/kg	49	47	49	49	47	36	24	49	49	49	49	79
3st harvest price	cfa/kg	49	49	50	50	49	37	25	49	49	49	49	80
Phospate price	cfa/kg	64	64	64	64	64	64	64	86	128	64	64	64
Transport costs	cfa/mt/km	28	28	28	28	28	28	28	28	28	56	28	28
SUMMARY STATISTICS													
Additional production	tons	17821	35642	12475	7128	26931	17821	17821	17821	17821	17821	17821	7128
Net Present Value	million cfa	258	950	31	-205	618	60	-138	114	-160	200	406	140
Benefit/Cost ratio	--	1.48	2.78	1.06	0.62	2.16	1.11	0.74	1.17	0.83	1.34	1.76	1.26

TABLE 3

CALCULATION OF COSTS AND BENEFITS BY ARRONDISSEMENT

Scenario I: The base case

ARROND.	AREA TREATED (hectares)	BENEFITS (million CFA): PRESENT VALUE OF EXTRA PRODUCTION (million FCFA) 1st YEAR	2nd YEAR	3rd YEAR	TOTAL BENEFITS	COSTS (million CFA): FERTILIZER QUANTITY (mt)	FERTILIZER COST	DISTANCE (KM)	TRANSPORT COSTS	USRC, COOPERATIVE COSTS	FARM COSTS	TOTAL COSTS	NET BENEFIT: NET BENEFIT	BENEFIT COST RATIO
Filingué	22096	127	44	15	186	1,768	113	366	18	8	13	152	35	1.23
Kollo	14609	126	44	15	185	1,169	75	60	2	5	8	90	94	2.04
Ouallam	12994	62	22	7	91	1,040	67	194	6	5	8	84	6	1.08
Say	6287	64	22	8	93	503	32	110	2	2	4	40	54	2.36
Téra	16621	105	37	12	155	1,330	85	352	13	6	10	114	41	1.36
Tillabéry	8179	56	19	7	82	654	42	228	4	3	5	54	28	1.52
TOTAL DEPT	80,786	539	189	64	791	6,463	414		45	29	47	533	258	1.48

ASSUMPTIONS FOR ECONOMIC ANALYSIS
IN THE BASE CASE SCENARIO

SCENARIO

	units	value	notes
PRICES			
Byproduct price	cfa/kg	0	See text
Base Millet price	cfa/kg	50	See text
1st year millet price	cfa/kg	46	
2nd year millet price	cfa/kg	49	
3rd year millet price	cfa/kg	49	
Fertilizer price	cfa/kg	64	See text
FERTILIZER QUANTITY			
Initial Dose of P2O5	kg/ha	16	See text
Quantity Fertilizer applied	kg/ha	80	See text
COEFFICIENTS			
Actual/Experimental Response Coeff.	%	50%	See text
Coeff. gross fert. wt./ P2O5 wt.	kg/kg	5	See text
Annual discount factor	%	15%	See text
Price elasticity of demand for millet		-0.5	See text
Affected area/Total area		0.1	

	units	value	notes
TRANSPORT COST			
Transport from source to USRC	cfa/mt/km	28	C.A. data for average distance and cost.
USRC AND COOP COSTS			
Handling and storage (USRC)	cfa/mt	1000	Load-unload manually & stored outside at no cost.
Transport from USRC to cooperative	cfa/mt/km	28	C.A. data for average distance and cost.
Distance USRC - cooperative	km	75	" " "
Handling and storage (cooperative)	cfa/mt	1000	Load-unload manually & stored outside at no cost.
Losses in transit	kg/tn	5	
TOTAL USRC and COOP COSTS	cfa/tn	4420	
FARM COSTS			
Transport cooperative to farm	cfa/mt/km	250	Assumes use of donkey cart for transport.
Distance cooperative - farm	km	10	
On-farm losses	kg/mt	5	
Labor costs for application	cfa/mt	1600	Assumes 4 mandays/ton @ 400 CFA/manday
Additional harvest labor req'ts	cfa/mt	2800	Assumes 7 mandays/ton @ 400 CFA/manday
TOTAL Farm Costs	cfa/mt	7220	

distribution of approximately 6,500 tons of phosphate fertilizer under the assumptions given in the last section. In return, the scheme would produce an additional 13,000 tons of millet over three years, representing a two and a half fold return to each kilogram of phosphate applied. The scheme would entail an initial investment of approximately 530 million FCFA and generate gross benefits of 790 million FCFA, thus yielding a net benefit to Niger over three years on the order of 260 million FCFA (1987). The resultant benefit cost ratio of 1.5 implies that the scheme would produce substantial net benefits per unit cost which suggests that even with a wide margin of error in the analysis, the scheme could be attractive.

Table 3 shows a disaggregation of costs and benefits by type and arrondissement. The costs for the Department as a whole in the base scenario breakdown as follows:

Cost Category	Total (million FCFA)	% of Total
Fert. production	414	77.6
Transport to Arrond.	45	8.4
USRC/Cooperative	29	5.3
Farm	47	8.7
	-------	-------
Total	533	100.0

As the above breakdown demonstrates, the production cost of the phosphate fertilizer represents 78% of total scheme costs, while 22% of total costs are attributed to the expenses of distributing and applying the fertilizer.

The volume of fertilizer required in the base case represents over 60% of the amount handled by the Centrale d'Approvisionnement (CA) for the entire country in 1986. Moreover, of the amount handled by the CA, 50% (5000 mts) went to irrigated perimeters in the Niamey Department. Accounting for this addition, the total amount of fertilizer required by the scheme for Niamey Department alone would come closer to 12,000 metric tons. Given this magnitude of increase in distribution requirements, and the fact that in 1986 the CA could not even meet all of its deliveries to the Niamey irrigated perimeters, it appears obvious that the base case scheme would quickly run into a logistical bottleneck if it depended solely on the CA for distribution.

Benefits in the base case are expected to result from the three harvests which follow the fertilizer distribution. The increases in production assumed correspond to response rates of 37%, 14% and 5% respectively in these three years. These are weighted by yearly prices which are 92%, 98% and 99% respectively of the base price of 50 FCFA/kg, reflecting the price response to increased production. The calculated value of production is then discounted to present values at a rate of 15% annually, thereby partially offsetting the effects of increasing prices in out years. Thus the present value of the resultant benefits closely reflects the initial yield response rates; more than two thirds the benefits (68%) accrue from the first harvest after the fertilizer distribution, another 24% result from the second harvest's additional production, and the remaining 8% accrue in the third year after the harvest.

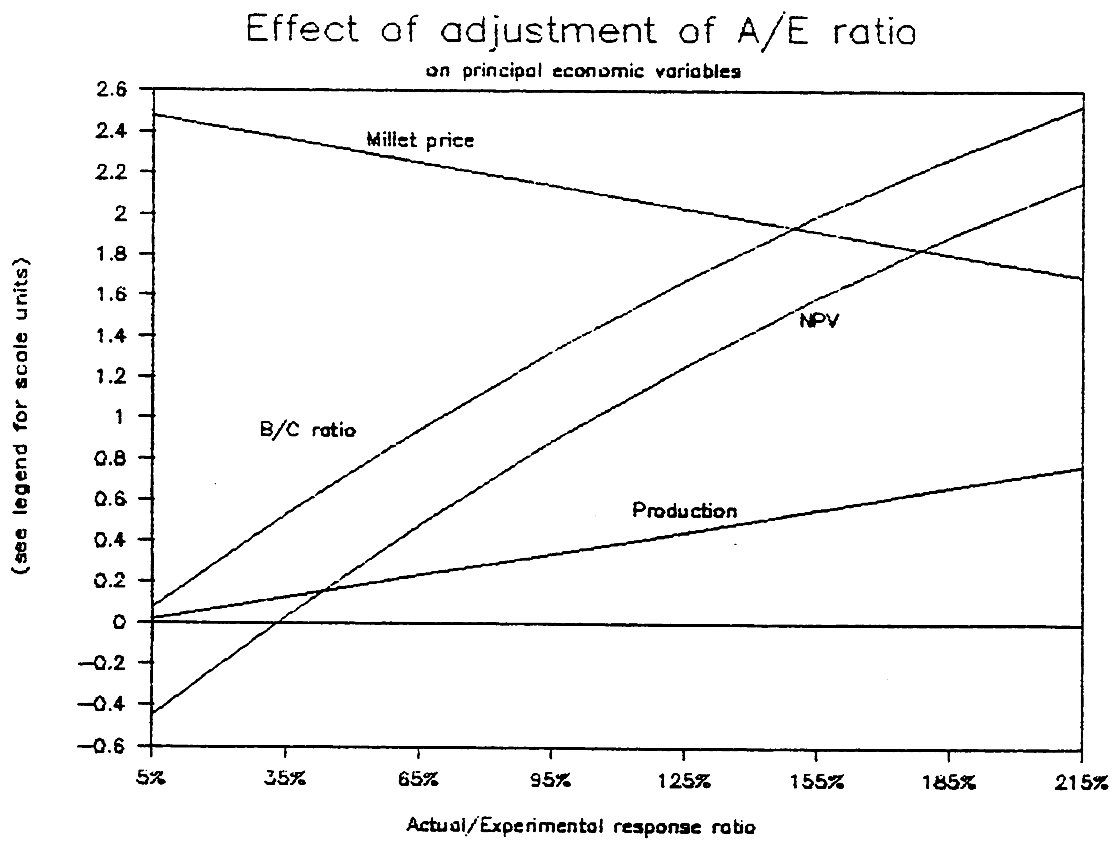
An examination of the scheme across arrondissements shows, as would be expected, that those arrondissements with less rainfall (and therefore lower base yields), and those further from the source of the fertilizer have lower net returns to the scheme. Say Arrondissement is the most attractive site for the scheme due to its proximity to the fertilizer source and its high average millet yields. However, Ouallam, the least attractive site, shows only a slight positive return to the scheme with a benefit/cost ratio of 1.08.

B. Scenario II: Adjustment of the Yield Response Rates

The benefit/cost ratio and the net present value of the scheme are very sensitive to the millet response rates. Scenario II.A suggests that a 100% transfer of experimental results to the farm would result in a doubling of the benefit cost ratio and an increase in the net present value of the scheme to nearly 1 billion FCFA. Graph D plots the changes in these two indicators, as well as the price of millet, for adjustments in the Actual/Experimental Response Ratio (A/E Ratio). This adjustment represents a proportional change in the response rate for each of the three yearly response rates. Graph D and Scenario II.B and II.C in Table 2 suggest that the phosphate basal dressing scheme remains attractive for very low rates of transfer of experiment station results to the farm. The scheme does not become economically unattractive until the A/E ratio falls to about 30%.

Graph D also shows that improvements in on-farm performance (increases in the A/E ratio) produce declining marginal additions to the net present value of the scheme. This is because the resultant production increases due to improved on farm performance cause the millet price to fall, thereby reducing the value of additional production. This effect is minor here, but becomes much more noticeable if the size of the scheme increases, thereby increasing its effect on total regional

Graph D



Legend

Indicator	Units scale
Net present value	100,000,000 FCFA
Benefit/Cost ratio	1/2
Millet price	20 FCFA/kg
Additional production	100,000 tons

production. For example, Graph E shows the same adjustments in the A/E ratio for a scheme extending to one quarter of millet production area in Niamey Department. Paradoxically, the curve implies that eventually improvements in response rates become detrimental to the scheme because of declining millet prices due to inelastic demand. In fact under such conditions of rising productivity in millet production, one might expect a contraction in the area devoted to millet thereby countering the expansion in supply. Nonetheless, this exercise demonstrates the importance of considering the final demand for millet on the viability of efforts to raise millet production.

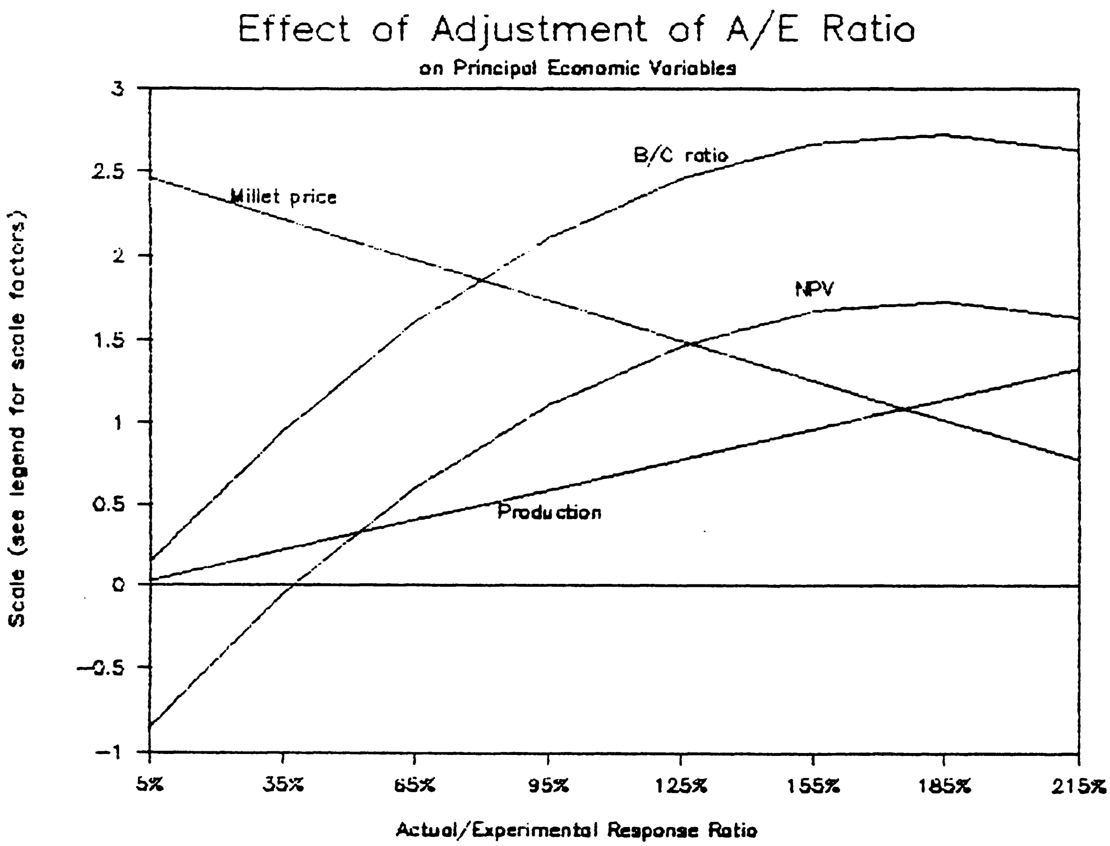
As was shown in the derivation of response rates in Section II.B, a second critical factor in the determination of the real response rate is the assumption made as to where the index point is set from which response rates are calculated. In the base case, the index base yield was set at 409 kg/ha because this represented the estimated departmental average. However, this procedure attributes the entire difference in base yields between the departmental average and the experimental control to existing phosphate levels in the soil. In so doing, it ignores other factors which may contribute to this difference, and so exaggerates the contribution of pre-existing phosphate. This bias results in an exaggerated initial displacement along the response curve in setting the new index point, and therefore an underestimation of additional yield responses due to additional phosphate.

To adjust for this bias the analysis in Scenario II.D has adjusted the long run average downward by 25%. Thus, the 6 year average yield for Niamey Department of 409 Kg/ha has been reduced to 306 Kg/Ha. This adjustment is considered reasonable because base yields for "typical" fields were about 300 Kg/ha for the IFDC trials conducted each year.[18]

The analysis shows that under this assumption of lower base yields in the department, a basal dressing has a greater benefit, since the marginal returns to the phosphate are higher. Thus for a reduction in base yields of 25%, Scenario II.D shows a rise in net present value to the scheme on the order of 240% and a rise in the Benefit/Cost ratio to 2.16. Though this scenario may overestimate response

[18] Here "typical" fields refers to fields cultivated in the traditional manner. They differed from the control fields of the trials in that the control fields had all crop by-products removed after harvest, whereas these by-products are left on traditional fields. In a separate analysis, A. Bationo has shown that these by-products can contribute significantly to yields. (See discussion in Scenario VI on crop by-products.)

Graph E



Legend

Indicator	Units scale
Net present value	200,000,000 FCFA
Benefit/Cost ratio	1
Millet price	20 FCFA/kg
Additional production	100,000 tons

rates, it does demonstrate the crucial need for more accurate information on long term average base yields and probable response rates to phosphate fertilizer at the farm level.

C. Scenario III: Adjustment of Millet Prices

Scenario III examines the effect of a decrease in the assumed "base" producer price of millet in the Niamey Department. The "base" price refers to the price which would pertain in the producer market without the scheme. Thus, these reductions are made prior to the additional price reductions modeled in the analysis as result of increased production. (See Section III.B above).

Table 2 presents the results of a base price decrease of 25% (Scenario III.A) resulting in a new base price of 37.5 FCFA, and of 50% (Scenario III.B) giving a new base price of 25 FCFA. The results suggest that overall the scheme is still viable with a reduction of the base millet price of 25%. However a reduction of 50% is nonviable. Graph F traces the decline in the benefit cost ratio and the net present value of the scheme with declining base millet prices. It shows that the declines in the net present value and the benefit/cost ratio are directly proportional to the assumed decrease in the base producer price of millet. Moreover it suggests that at a base price decrease of 32% (to 34 FCFA/kg) the scheme becomes nonviable.

In the context of the coarse grain market in Niger, a reduction in millet prices of up to 50% projected in Scenario III.B is not uncommon. The 17 year average millet price used as the base price shows a standard deviation of 13 FCFA. This suggests that there is about a 10% probability of a drop in prices below 34 FCFA, the cutoff point derived in the base case analysis above. Between 1985 and 1986, two years of relatively average rainfall, retail millet prices in Niamey Department ranged from 73 to 200 FCFA/KG. Assuming a 65% marketing margin from farm to market, producer prices ranged from 25.5 to 70 FCFA/KG. Moreover, between the months of November 1985 and August 1986, producer prices averaged 28 FCFA/KG.[19] At these prices, and assuming a further reduction in price due to the additional production generated, the scheme would be uneconomic. In general, however, these prices are thought to be unusually low, already incorporating a price response to increased supply due to the two years of relatively good production in 1985 and

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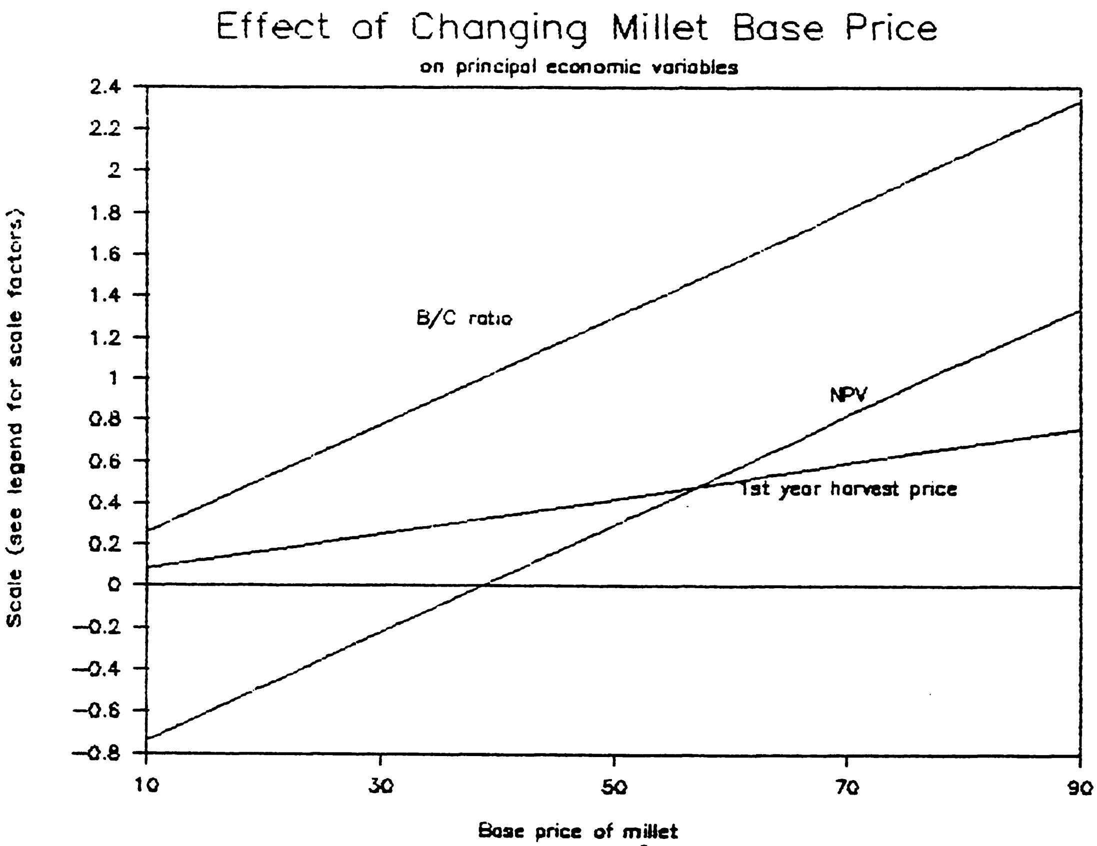
[19] OPVN Monthly Price Reports, November 1985 to August 1986. The estimated producer price of 28 FCFA/kg during this period was substantiated by field observations.

Graph F



Legend

Indicator	Units scale
Net present value	1,000,000,000 FCFA
Benefit/Cost ratio	1/2
Millet price	100 FCFA/kg

1986 in the Sahel. Nonetheless, these prices could persist or even fall further as a result of additional years of good rainfall, a reduction in losses due to crop pests and/or an expansion in the area planted to millet.

Since millet is traded actively between countries throughout the Sahel, production levels outside Niger, including Burkina Faso, Mali, Benin, and Nigeria will also play an important role in the determination of millet prices. This international market can serve to buffer the inelastic demand response to increasing production in Niger. A further factor in determining the future price of millet will be the degree to which it can be substituted for other products in human consumption and in such activities as livestock fattening.

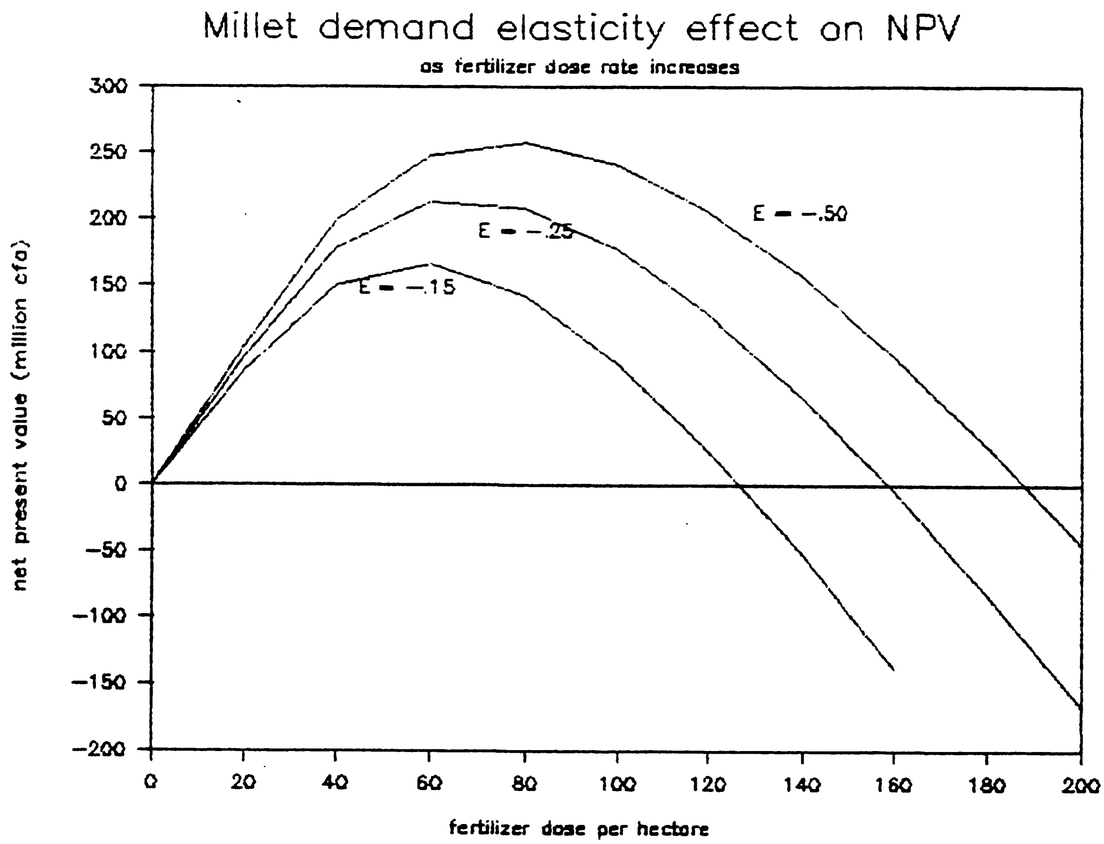
Lastly, the price elasticity of demand coefficient of -0.5 used in the analysis gives only a rough estimate of the expected price effect due to a shift in production. Due to the relatively small area affected by the scheme considered here, (10% of the total) the elasticity effect on prices is minor in the base case. However it becomes increasingly important as the size of the scheme, the millet response rate, or the fertilizer dosage rate increase, since each of these factors raise production and therefore lower the price of millet. Alternatively, assumptions of a more inelastic demand for millet also show the limitations of increasing millet production. Graph G plots the net present value of the scheme with increasing fertilizer dosages for different assumptions of millet demand elasticity to price. The graph shows that for more inelastic demand assumptions, yield improvements represented by increasing fertilizer dosage are economically attractive in a diminishing range. Moreover, the optimal dosage per hectare falls (where each net present value curve peaks). This exercise points out the importance of assumptions concerning the ability of the market to absorb increases in millet production on any scheme to raise production.

D. Scenario IV: Rising Fertilizer Costs

This scenario examines two cases under which fertilizer costs would rise, first, if local fertilizer production were not developed and the country had to depend on imports, and second, if local production were developed, but production costs were to double.

Scenario IV.A, assumes the importation of SSP at a price of 86 FCFA/Kg, representing a 34% rise over the estimated price of local production. This price is derived from the world price of SSP projected by the World Bank for 1990 (in 1987 FCFA), at CIF Niamey prices. The results suggests that even if local production is not developed, the scheme would be feasible in some arrondissements with

Graph G



Legend

Indicator	Units scale
E	the price elasticity of demand for millet

imported phosphate fertilizers. Though the net present value of the scheme would decrease to 114 million FCFA, the benefit/cost ratio would remain positive (1.17) for the department as a whole. The scheme would not be viable in Filingue and Ouallam arrondissements, and borderline in Tera Arrondissement (see Annex A.1 Table 7).

The availability of phosphates from Togo and the possibility that phosphates might be developed in Burkina Faso may further reduce the costs of importation, and possibly make this alternative even more attractive than the development of local production. This issue is not examined further here, but should be the subject of a more in-depth analysis.

Scenario IV.B examines the case in which local production of phosphate fertilizer is developed but costs of production rise. Implicit in this scenario is the assumption that the government would protect local production from import competition if costs rose above the import price. The evaluation shows that doubling production costs would result in a negative net present value and a benefit/cost ratio of 0.83. This attests to the potential non-viability of a local production facility in a closed economy. The possibility that international prices might become competitive with local production may also call into question the merit of building a local transformation facility.

It has been suggested that the Parc-W phosphate plant might be nonviable due to a lack of sufficient local demand (estimated at 30,000 tons/year).[20] Assuming the phosphate dose of 80 kg/ha suggested by the analysis, and a coverage of 10% of the total area planted to millet, a basal dressing scheme carried out on a national scale every third year would generate about 8,000 tons of demand annually. Thus assuming the scheme is economic and production costs have not been grossly underestimated, the analysis suggests that on a national basis a scheme covering one tenth of the land area could assure about 1/4 of the demand necessary to make the phosphate plant a viable venture. However if coverage is expanded to about 35% of total millet area, the demand requirement would be met. Alternatively, higher basal dose, the use of phosphate for annual dressings or for other crops, and/or the export of some production to other countries could produce the complement of demand required to make the phosphate plant viable.

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[20] "Retrospective Study of Fertilizer Supply and Demand in Niger," Ministry of Agriculture/DEPSA, August 1986.

E. Scenario V: Rising Fertilizer Transport Costs

This scenario examines the effect of an increase in the transport costs of the fertilizer from the factory to the village cooperative. These transport costs do not represent all distribution costs since storage, handling losses and on farm costs are not adjusted in this scenario.

In Table 2, the results of a doubling of the transport costs suggest that the scheme is not highly sensitive to these costs, since net benefits decline by only 22% and the Benefit Cost ratio remains strongly positive at 1.34. A sensitivity analysis suggests that transport costs could rise by 375% (from 28 FCFA/tn-km to 150 FCFA/tn-km) before the base case scheme becomes unattractive for the department as a whole. This finding suggests that the scheme will also be viable in most of the rest of the country, since the primary additional cost to extending the scheme to other departments will be the costs of transport.

As has been mentioned above, the logistical requirements posed by the base case scheme far outstrip the current demonstrated capacity of the Centrale d'Approvisionnement. A number of alternatives have been suggested to overcome this obvious constraint. First, reliance on private sector trucking could go far in providing the necessary equipment to handle the transportation. Second, the experience of the army in managing the movement and distribution of food assistance during the previous drought might be put to use in this effort. A third idea is to use airplanes to distribute the fertilizer. This method has purportedly been used successfully for similar schemes in the developed countries, and has been suggested by scientists at ICRISAT as a potentially feasible alternative, though the authors have no information on the costs or capabilities of such a scheme.[21]

Any of these ideas for overcoming the logistical problems posed by the scheme will necessarily require a stronger managerial and organizational capacity than is currently available at the CA. The costs of developing this capacity have not been included in these preliminary analyses, but are a necessary aspect of a complete evaluation of the scheme. Whatever type of distribution system is conceived, this scenario suggests that the costs of distribution should not exceed a cost per tn-km of 150 FCFA for Niamey Department. Alternatively, the net present value of the base

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[21] Crude estimates of the operating costs alone for air transport suggest a cost of about 275 CFA/kg of phosphate delivered. At this cost the scheme is clearly unattractive.

case (about 250 million FCFA) represents an upper limit to the additional costs to the project logistics which the scheme could bear before becoming unprofitable.

F. Scenario VI: The Valuation of Crop By-products

This scenario places a nominal value of 1 FCFA/kg on the production of additional crop by-products produced as a result of the phosphate basal dressing. The purpose of the scenario is to show an additional benefit which could accrue to the scheme. This benefit has not been evaluated in the base case because of lack of evidence of the value of crop by-products. However, it is well known that they do already have a variety of uses in the traditional economy as dry-season feed for animals, as building material, as a soil mulch and as a protection against soil erosion.

IFDC/ICRISAT researchers have also demonstrated the agronomic value of crop by-products. Trials which have left by-products on the field have shown yield effects of the same magnitude as those resulting from the addition of fertilizer.[22] Moreover, the two effects appear to be essentially additive if by-products and fertilizer are used in combination. This finding implies that additional by-products not harvested from fields can have a significant value as green manure. However, these results must be replicated in on-farm situations to ascertain whether traditional soil preparation and planting techniques can immediately accommodate more crop by-products, or whether they must be adapted to benefit from this effect.

The IFDC/ICRISAT yield response curves suggest that an additional 875 kg of by-products per hectare will be generated due to the scheme over the course the three years of measured effects. As a result, as Scenario VII demonstrates, even a small by-product value per kilogram has a significant positive effect on the overall benefits of the scheme (an additional 150 million FCFA in net benefits). These conclusions suggest that as part of a basal dressing scheme, more research is needed on the current role of crop by-products and the potential for expanding their productive uses.

G. Scenario VII: The Impact of a Drought

The Base Case assumes adequate rainfall throughout the three year response period. However, millet response rates to fertilizer are known to be highly sensitive

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[22] Bationo, 1987.

to rainfall. To simulate the case of a 3 year drought in the model, Scenario VI makes the assumption that the A/E ratio is dropped from 0.5 to 0.2 representing a 60% fall in response during a three year drought pulse. This implies a first year response on-farm of only 61 kg (15%), a second year response of 25 kg (6%), and a third year response of 8 kg (2%).

These estimates appear reasonable, when compared to results obtained by ICRISAT in on-farm trials in 1984, a drought year. In the case of PAPR-50%, an average millet yield increase of 60 kg (46% above control) was obtained at a phosphate dose of 12 kg/ha P_2O_5 (75% of the dose assumed in the base case) in Gobere where rainfall was about 70% of the long run average.[23] However in Fabidiji, where rainfall was about 60% of average, no difference in yields was found for the same dose, though at a higher dose (20 kg/ha P_2O_5), a yield increase of 80 kg/ha (a 57% increase over the control) was obtained.

In addition to the lower response rate, the drought scenario includes an increase in the base price of millet from 50 FCFA/kg to 80 FCFA/kg, reflecting the rise in prices nationally due to falling production. Lastly, a value of 1 FCFA/kg is assumed for crop by-products, since in drought years these by-products become highly valuable as animal feed.

The drought Scenario shows that the much reduced yield effect is offset in large part by the increase in millet and by-product price, and as a result the scheme remains robust in drought conditions with a Benefit/Cost ratio of 1.26. However, the scheme is no longer profitable in Ouallam and Filingue arrondissements.

V. Conclusions

The preceding analysis has examined the technical feasibility of a phosphate basal dressing scheme for millet production in the Niamey Department. Overall, the evaluation suggests that the proposed scheme (Base Case Scenario) is attractive economically and holds the potential for raising cereal production in Niger dramatically. The results of the base case show that the scheme could have a benefit cost ratio of 1.5 and a net present value of nearly 260 million FCFA for the Niamey Department.

Several specific findings of the analysis are:

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[23] These results were not significant at a probability level of 0.05 using a two-tailed test. Annual Report, 1984 ICRISAT Sahelian Center, Niamey , Niger, p. 61.

1) The cereal yield response to phosphate is a crucial variable. In the analysis, this response has been derived from highly experimental data. Very little on-farm data exists with which to make a more realistic evaluation. Still, the analysis suggests that the scheme will remain viable even if farmer-managed responses achieved are only 30% of results which have been obtained in experimental trials.

2) The scheme is most sensitive to the assumed price of millet. This price is known to be highly variable, making it difficult to predict the net value of the additional production which the scheme will produce. Nonetheless the scheme remains attractive with a fall in millet price to two thirds of the assumed base price (from 50 to 34 FCFA/kg).

3) The scheme remains robust even for increases in fertilizer production costs of 60% and for a 375% increase in the transport component of distribution costs. However, the volume of fertilizer required by the scheme will far outstrip current delivery capacity and managerial resources through existing channels.

4) The scheme also appears to remain attractive in a drought year because of the anticipated rise in prices despite assumed lower yield response rates.

In light of these encouraging results, one might ask why Niger's dryland farmers do not already use phosphates as the analysis suggests. One possible reason is that phosphates are not easily available to farmers. Evidence suggests that phosphates from Nigeria are available only sporadically, and that the quantity of phosphates supplied through the Central d'Approvisionnement is already insufficient to meet just cooperative demand. A second reason for the minimal use of phosphates may be a lack of knowledge among dryland farmers of the benefits of phosphates. Though phosphate trials have been conducted in Niger for over 40 years, they have not been widespread; only with the initiation of a series of "projets productivités" in the mid-1970s have fertilizer extension efforts been undertaken in a large way. Moreover, most of these efforts promoted annual applications of fertilizer premixes rather than phosphate alone applied as a basal dressing. Differences in input cost, agronomic performance and economic return between the classic fertilizer combinations and the low dosage phosphate basal dressing evaluated above may have been significant enough to have discouraged farmers in the past. A final reason that might explain the insufficient use of phosphates in Niger may be simply that the benefits are still not sufficiently high to initiate use. The extreme risks associated with dryland agriculture, the high cost of credit required to purchase fertilizers and the variability of product prices may necessitate even greater additional benefits than are projected in the analysis above to prompt phosphate fertilizer use.

Still, on the strength of the results in the analysis above, the authors recommend that the idea of a phosphate basal dressing be further promoted. However, they strongly recommend that such a scheme be subject first to more in-depth study of several areas with which this preliminary evaluation has not dealt. In particular, the study should include:

1) A reevaluation of the technical potential of the scheme in light of actual farmer experience with a phosphate basal dressing. Data currently being processed for 1986 and 1987 IFDC/ICRISAT on-farm trials should provide a good beginning for this analysis. To further it, we recommend that national organizations and projects with research-extension capabilities expand their efforts to measure the effects of a phosphate basal dressing scheme under farmer-managed on-farm conditions.
2) An assessment of the scheme's effect on the farmer's enterprise and on his welfare. The analysis above has not examined the additional costs and constraints imposed on the farmer by the scheme, nor the incentives to him to participate in it. However, the attractiveness of the scheme to the farmer will be essential to its success. Thus a more careful evaluation of the farm-level effects of the scheme is necessary.
3) An analysis of the market for the additional production generated by the scheme. The importance of price assumptions in determining the value of the scheme to the farmer and to the society as a whole warrant a more careful examination of the effects of the scheme on product prices.
4) A refinement of the scope of the scheme. The analysis has assumed a random coverage of one tenth of all millet producers by the scheme. A more feasible and effective scheme might be developed to target phosphates to those areas (e.g. soil types, crops, crop varieties and cultivation techniques) for which the economic returns are highest. For example, results of INRAN and IFDC/ICRISAT trials have showed significant responses for sorghum and cowpeas. The potential of these and other promising crops should also be evaluated, and incorporated into a more comprehensive proposal for the use of phosphates in the agricultural sector.
5) A careful analysis and costing of the logistical, administrative and management requirements of the scheme and the potential of the government to meet them. In light of the obvious fertilizer distribution problems posed by the scheme, a

more thorough examination of the logistics of such an operation is needed. Also, the viability of the agricultural cooperative system as a mechanism for the distribution of fertilizer has been assumed. The strength of this assumption should be explored and modified to reflect the actual capabilities of the cooperative structure.

6) An evaluation of the policy dimension of the scheme. The proposed scheme makes no mention of how it will be financed. A complete government subsidy of fertilizer production and distribution obviously contradicts current policy to reduce production subsidies. However, if financed as a one-time effort to demonstrate the feasibility of phosphate fertilizer to farmers, it may be justifiable. Other issues for analysis include the burden placed on public finances, the probable effects on consumer and producer welfare, and the broader implications of the scheme for the development of the agricultural sector.

Annex

A.1 Benefit/Cost Calculations for Scenarios II - VII

A.2 Results of the Sensitivity Analyses

CALCULATION OF COSTS AND BENEFITS BY ARRONDISSEMENT
Scenario IIA: Actual/Experimental response ratio = 100%

ARROND.	AREA TREATED (hectares)	BENEFITS (million CFA): PRESENT VALUE OF EXTRA PRODUCTION (million FCFA) 1st YEAR	2nd YEAR	3rd YEAR	TOTAL BENEFITS	COSTS (million CFA): FERTILIZER QUANTITY (mt)	FERTILIZER COST	DISTANCE (KM)	TRANSPORT COSTS	USRC, COOPERATIVE COSTS	FARM COSTS	TOTAL COSTS	NET BENEFIT: NET BENEFIT	BENEFIT COST RATIO
Filingué	22096	233	86	30	349	1,768	113	366	18	8	13	152	198	2.30
Kollo	14609	231	85	30	346	1,169	75	60	2	5	8	90	256	3.83
Ouallam	12994	114	42	15	170	1,040	67	194	6	5	8	84	86	2.02
Say	6287	117	43	15	175	503	32	110	2	2	4	40	135	4.42
Téra	16621	194	72	25	290	1,330	85	352	13	6	10	114	176	2.55
Tillabéry	8179	102	38	13	153	654	42	228	4	3	5	54	99	2.85
TOTAL DEPT	80,786	991	366	127	1,483	6,463	414		45	29	47	533	950	2.78

CALCULATION OF COSTS AND BENEFITS BY ARRONDISSEMENT
Scenario IIB: Actual/Experimental response ratio = 35%

ARROND.	AREA TREATED (hectares)	BENEFITS (million CFA): PRESENT VALUE OF EXTRA PRODUCTION (million FCFA) 1st YEAR	2nd YEAR	3rd YEAR	TOTAL BENEFITS	COSTS (million CFA): FERTILIZER QUANTITY (mt)	FERTILIZER COST	DISTANCE (KM)	TRANSPORT COSTS	USRC, COOPERATIVE COSTS	FARM COSTS	TOTAL COSTS	NET BENEFIT: NET BENEFIT	BENEFIT COST RATIO
Filingué	22096	91	31	11	133	1,768	113	366	18	8	13	152	(19)	0.88
Kollo	14609	90	31	10	132	1,169	75	60	2	5	8	90	41	1.46
Ouallam	12994	44	15	5	65	1,040	67	194	6	5	8	84	(20)	0.77
Say	6287	46	16	5	67	503	32	110	2	2	4	40	27	1.68
Téra	16621	75	26	9	110	1,330	85	352	13	6	10	114	(3)	0.97
Tillabéry	8179	40	14	5	58	654	42	228	4	3	5	54	5	1.08
TOTAL DEPT	80,786	386	133	45	564	6,463	414		45	29	47	533	31	1.06

CALCULATION OF COSTS AND BENEFITS BY ARRONDISSEMENT

Scenario IIC: Actual/Experimental response ratio = 20%

ARROND.	AREA TREATED (hectares)	BENEFITS (million CFA): PRESENT VALUE OF EXTRA PRODUCTION (million FCFA) 1st YEAR	2nd YEAR	3rd YEAR	TOTAL BENEFITS	COSTS (million CFA): FERTILIZER QUANTITY (mt)	FERTILIZER COST	DISTANCE (KM)	TRANSPORT COSTS	USRC. COOPERATIVE COSTS	FARM COSTS	TOTAL COSTS	NET BENEFIT: NET BENEFIT	BENEFIT COST RATIO
Filingué	22096	53	18	6	77	1,768	113	366	18	8	13	152	(74)	0.51
Kollo	14609	53	18	6	77	1,169	75	60	2	5	8	90	(14)	0.85
Ouallam	12994	26	9	3	38	1,040	67	194	6	5	8	84	(47)	0.45
Say	6287	27	9	3	39	503	32	110	2	2	4	40	(1)	0.98
Téra	16621	44	15	5	64	1,330	85	352	13	6	10	114	(50)	0.56
Tillabéry	8179	23	8	3	34	654	42	228	4	3	5	54	(20)	0.63
TOTAL DEPT	80,786	226	77	26	328	6,463	414		45	29	47	533	(205)	0.62

CALCULATION OF COSTS AND BENEFITS BY ARRONDISSEMENT

Scenario IID: Base yield used to calculate response rate is lowered by 25%

ARROND.	AREA TREATED (hectares)	BENEFITS (million CFA): PRESENT VALUE OF EXTRA PRODUCTION (million FCFA) 1st YEAR	2nd YEAR	3rd YEAR	TOTAL BENEFITS	COSTS (million CFA): FERTILIZER QUANTITY (mt)	FERTILIZER COST	DISTANCE (KM)	TRANSPORT COSTS	USRC. COOPERATIVE COSTS	FARM COSTS	TOTAL COSTS	NET BENEFIT: NET BENEFIT	BENEFIT COST RATIO
Filingué	22096	158	77	36	271	1,768	113	366	18	8	13	152	120	1.79
Kollo	14609	157	76	36	269	1,169	75	60	2	5	8	90	178	2.97
Ouallam	12994	77	37	18	132	1,040	67	194	6	5	8	84	48	1.57
Say	6287	79	38	18	136	503	32	110	2	2	4	40	96	3.43
Téra	16621	131	64	30	225	1,330	85	352	13	6	10	114	111	1.98
Tillabéry	8179	69	34	16	119	654	42	228	4	3	5	54	65	2.21
TOTAL DEPT	80,786	673	325	154	1,152	6,463	414		45	29	47	533	618	2.16

CALCULATION OF COSTS AND BENEFITS BY ARRONDISSEMENT
Scenario IIIA: Base millet price reduced by 25 %

ARROND.	AREA TREATED (hectares)	BENEFITS (million CFA) — PRESENT VALUE OF EXTRA PRODUCTION (million FCFA) 1st YEAR	2nd YEAR	3rd YEAR	TOTAL BENEFITS	COSTS (million CFA) — FERTILIZER QUANTITY (mt)	FERTILIZER COST	DISTANCE (KM)	TRANSPORT COSTS	USRC, COOPERATIVE COSTS	FARM COSTS	TOTAL COSTS	NET BENEFIT — NET BENEFIT	BENEFIT COST RATIO
Filingué	22096	95	33	11	140	1,768	113	366	18	8	13	152	(12)	0.92
Kollo	14609	94	33	11	138	1,169	75	60	2	5	8	90	48	1.53
Ouallam	12994	46	16	6	68	1,040	67	194	6	5	8	84	(16)	0.81
Say	6287	48	17	6	70	503	32	110	2	2	4	40	30	1.77
Téra	16621	79	28	9	116	1,330	85	352	13	6	10	114	2	1.02
Tillabéry	8179	42	15	5	61	654	42	228	4	3	5	54	8	1.14
TOTAL DEPT	80,786	404	141	48	594	6,463	414		45	29	47	533	60	1.11

CALCULATION OF COSTS AND BENEFITS BY ARRONDISSEMENT
Scenario IIIA: Base millet price reduced by 50 %

ARROND.	AREA TREATED (hectares)	BENEFITS (million CFA) — PRESENT VALUE OF EXTRA PRODUCTION (million FCFA) 1st YEAR	2nd YEAR	3rd YEAR	TOTAL BENEFITS	COSTS (million CFA) — FERTILIZER QUANTITY (mt)	FERTILIZER COST	DISTANCE (KM)	TRANSPORT COSTS	USRC, COOPERATIVE COSTS	FARM COSTS	TOTAL COSTS	NET BENEFIT — NET BENEFIT	BENEFIT COST RATIO
Filingué	22096	63	22	8	93	1,768	113	366	18	8	13	152	(59)	0.61
Kollo	14609	63	22	7	92	1,169	75	60	2	5	8	90	2	1.02
Ouallam	12994	31	11	4	45	1,040	67	194	6	5	8	84	(39)	0.54
Say	6287	32	11	4	47	503	32	110	2	2	4	40	7	1.18
Téra	16621	53	18	6	77	1,330	85	352	13	6	10	114	(36)	0.68
Tillabéry	8179	28	10	3	41	654	42	228	4	3	5	54	(13)	0.76
TOTAL DEPT	80,786	269	94	32	396	6,463	414		45	29	47	533	(138)	0.74

CALCULATION OF COSTS AND BENEFITS BY ARRONDISSEMENT
Scenario IVA: Use Imported Fertilizer

ARROND.	AREA TREATED (hectares)	BENEFITS (million CFA): PRESENT VALUE OF EXTRA PRODUCTION (million FCFA) 1st YEAR	2nd YEAR	3rd YEAR	TOTAL BENEFITS	COSTS (million CFA): FERTILIZER QUANTITY (mt)	FERTILIZER COST	DISTANCE (KM)	TRANSPORT COSTS	USRC, COOPERATIVE COSTS	FARM COSTS	TOTAL COSTS	NET BENEFIT: NET BENEFIT	BENEFIT COST RATIO
Filingué	22096	127	44	15	186	1,768	152	366	18	8	13	191	(5)	0.98
Kollo	14609	126	44	15	185	1,169	101	60	2	5	9	116	68	1.59
Ouallam	12994	62	22	7	91	1,040	89	194	6	5	8	107	(17)	0.85
Say	6287	64	22	8	93	503	43	110	2	2	4	51	43	1.84
Téra	16621	105	37	12	155	1,330	114	352	13	6	10	143	11	1.08
Tillabéry	8179	56	19	7	82	654	56	228	4	3	5	68	13	1.20
TOTAL DEPT	80,786	539	189	64	791	6,463	556		45	29	47	677	114	1.17

CALCULATION OF COSTS AND BENEFITS BY ARRONDISSEMENT
Scenario IVB: Double cost of local fertilizer production

ARROND.	AREA TREATED (hectares)	BENEFITS (million CFA): PRESENT VALUE OF EXTRA PRODUCTION (million FCFA) 1st YEAR	2nd YEAR	3rd YEAR	TOTAL BENEFITS	COSTS (million CFA): FERTILIZER QUANTITY (mt)	FERTILIZER COST	DISTANCE (KM)	TRANSPORT COSTS	USRC, COOPERATIVE COSTS	FARM COSTS	TOTAL COSTS	NET BENEFIT: NET BENEFIT	BENEFIT COST RATIO
Filingué	22096	127	44	15	186	1,768	226	366	18	8	13	266	(80)	0.70
Kollo	14609	126	44	15	185	1,169	150	60	2	6	9	166	19	1.11
Ouallam	12994	62	22	7	91	1,040	133	194	6	5	8	151	(61)	0.60
Say	6287	64	22	8	93	503	64	110	2	2	4	72	21	1.29
Téra	16621	105	37	12	155	1,330	170	352	13	6	10	200	(45)	0.77
Tillabéry	8179	56	19	7	82	654	84	228	4	3	5	96	(14)	0.85
TOTAL DEPT	80,786	539	189	64	791	6,463	827		45	31	49	951	(160)	0.83

CALCULATION OF COSTS AND BENEFITS BY ARRONDISSEMENT
Scenario V: Double Fertilizer Transport Costs to the Cooperative level

ARROND.	AREA TREATED (hectares)	BENEFITS (million CFA) — PRESENT VALUE OF EXTRA PRODUCTION (million FCFA) 1st YEAR	2nd YEAR	3rd YEAR	TOTAL BENEFITS	COSTS (million CFA) — FERTILIZER QUANTITY (mt)	FERTILIZER COST	DISTANCE (KM)	TRANSPORT COSTS	USRC, COOPERATIVE COSTS	FARM COSTS	TOTAL COSTS	NET BENEFIT — NET BENEFIT	BENEFIT COST RATIO
Filingué	22096	127	44	15	186	1,768	113	366	36	12	13	174	13	1.07
Kollo	14609	126	44	15	185	1,169	75	60	4	8	8	95	90	1.95
Ouallam	12994	62	22	7	91	1,040	67	194	11	7	8	92	(1)	0.99
Say	6287	64	22	8	93	503	32	110	3	3	4	42	51	2.21
Téra	16621	105	37	12	155	1,330	85	352	26	9	10	130	25	1.19
Tillabéry	8179	56	19	7	82	654	42	228	8	4	5	59	22	1.38
TOTAL DEPT	80,786	539	189	64	791	6,463	414		89	42	47	592	200	1.34

CALCULATION OF COSTS AND BENEFITS BY ARRONDISSEMENT
Scenario VI: Include the value of additional crop byproducts

ARROND.	AREA TREATED (hectares)	BENEFITS (million CFA) — PRESENT VALUE OF EXTRA PRODUCTION (million FCFA) 1st YEAR	2nd YEAR	3rd YEAR	TOTAL BENEFITS	COSTS (million CFA) — FERTILIZER QUANTITY (mt)	FERTILIZER COST	DISTANCE (KM)	TRANSPORT COSTS	USRC, COOPERATIVE COSTS	FARM COSTS	TOTAL COSTS	NET BENEFIT — NET BENEFIT	BENEFIT COST RATIO
Filingué	22096	153	55	19	227	1,768	113	366	18	8	13	152	75	1.49
Kollo	14609	143	51	18	211	1,169	75	60	2	5	8	90	121	2.34
Ouallam	12994	77	28	10	114	1,040	67	194	6	5	8	84	30	1.36
Say	6287	71	25	9	105	503	32	110	2	2	4	40	65	2.65
Téra	16621	125	45	16	185	1,330	85	352	13	6	10	114	71	1.63
Tillabéry	8179	65	23	8	97	654	42	228	4	3	5	54	43	1.80
TOTAL DEPT	80,786	634	226	79	939	6,463	414		45	29	47	533	406	1.76

CALCULATION OF COSTS AND BENEFITS BY ARRONDISSEMENT
Scenario VII: Three year drought pulse simulation

ARROND.	AREA TREATED (hectares)	BENEFITS (million CFA): PRESENT VALUE OF EXTRA PRODUCTION (million FCFA) 1st YEAR	2nd YEAR	3rd YEAR	TOTAL BENEFITS	COSTS (million CFA): FERTILIZER QUANTITY (mt)	FERTILIZER COST	DISTANCE (KM)	TRANSPORT COSTS	USRC, COOPERATIVE COSTS	FARM COSTS	TOTAL COSTS	NET BENEFIT: NET BENEFIT	BENEFIT COST RATIO
Filingué	22096	111	39	14	164	1,768	113	366	18	8	13	152	12	1.08
Kollo	14609	102	35	12	149	1,169	75	60	2	5	8	90	59	1.65
Ouallam	12994	57	20	7	84	1,040	67	194	6	5	8	84	(0)	1.00
Say	6287	50	17	6	73	503	32	110	2	2	4	40	34	1.86
Téra	16621	90	32	11	133	1,330	85	352	13	6	10	114	19	1.17
Tillabéry	8179	47	16	6	69	654	42	228	4	3	5	54	15	1.29
TOTAL DEPT	80,786	457	160	56	673	6,463	414		45	29	47	533	140	1.26

A.2 Sensitivity analyses

Increasing fertilizer quantity per hectare

PRINCIPAL ASSUMPTIONS											
Quantity of fertilizer		20	40	60	80	100	120	140	160	180	200
Expected yield	1st yr	16%	25%	32%	37%	42%	45%	49%	51%	54%	56%
increase:	2nd yr	0%	6%	11%	14%	17%	20%	22%	24%	26%	28%
	3rd yr	0%	1%	3%	5%	7%	9%	10%	11%	13%	14%
Actual/Experimental Respons		50%	50%	50%	50%	50%	50%	50%	50%	50%	50%
Base Millet Price		50	50	50	50	50	50	50	50	50	50
1st harvest price		48	47	47	46	46	45	45	45	45	44
2st harvest price		50	49	49	49	48	48	48	48	47	47
3st harvest price		50	50	50	49	49	49	49	49	49	49
Phospate price		64	64	64	64	64	64	64	64	64	64
Transport costs		28	28	28	28	28	28	28	28	28	28
SUMMARY STATISTICS											
.d74**		1616	3231	4847	6463	8079	9694	11310	12926	14541	16157
Additional production		4930	10064	14367	17821	20692	23144	25284	27180	28883	30428
Net Present Value		105	199	248	258	241	206	157	98	30	-44
Benefit/Cost ratio		1.79	1.75	1.62	1.48	1.36	1.26	1.17	1.09	1.03	0.97

Adjustment of the Actual/Experimental response ratio

PRINCIPAL ASSUMPTIONS									
Quantity of fertilizer		80	60	60	60	60	60	60	80
Expected yield	1st yr	4%	64%	64%	64%	64%	64%	64%	160%
increase:	2nd yr	1%	21%	21%	21%	21%	21%	21%	62%
	3rd yr	1%	14%	14%	14%	14%	14%	14%	24%
Actual/Experimental Response		5%	35%	65%	95%	125%	155%	185%	215%
Base Millet Price		50	50	50	50	50	50	50	50
1st harvest price		50	47	45	43	41	38	36	34
2st harvest price		50	49	48	47	46	46	45	44
3st harvest price		50	50	49	49	49	48	48	48
Phospate price		64	64	64	64	64	64	64	64
Transport costs		28	28	28	28	28	28	28	28
SUMMARY STATISTICS									
		6463	6463	6463	6463	6463	6463	6463	6463
Additional production		1782	12475	23167	33860	44552	55245	65937	76629
Net Present Value		-450	31	476	885	1258	1596	1898	2164
Benefit/Cost ratio		0.16	1.06	1.89	2.66	3.36	3.99	4.56	5.06

Changing base millet price

PRINCIPAL ASSUMPTIONS					
Quantity of fertilizer	80	80	80	80	80
Expected yield 1st yr	37%	37%	37%	37%	37%
increase: 2nd yr	14%	14%	14%	14%	14%
3rd yr	5%	5%	5%	5%	5%
Actual/Experimental Response	50%	50%	50%	50%	50%
Base Millet Price	10	30	50	70	90
1st harvest price	9	28	46	65	83
2st harvest price	10	29	49	68	87
3st harvest price	10	30	49	69	89
Phospate price	64.0	64.0	64.0	64.0	64.0
Transport costs	28	28	28	28	28
SUMMARY STATISTICS					
	6463	6463	6463	6463	6463
Additional production	17821	17821	17821	17821	17821
Net Present Value	-375	-59	258	574	891
Benefit/Cost ratio	0.30	0.89	1.48	2.08	2.67

The University of Michigan

Center for Research on Economic Development

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February 1991

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5. Barlow, Robin. Le Modèle IS - LM: Versions Pays-riche et Pays-pauvre. March 1987.

This paper is designed as a teaching tool for French-language courses in the macroeconomics of development. It shows how the IS-LM model conventionally used for high-income countries can be modified to suit the structure of low-income countries. Both algebraic and geometrical versions of the model are used, and suggestions for classroom exercises are included. The paper is an adaptation of an article by Richard Porter and Susan Ranney which appeared in World Development (1982).

4. Knieriemen, Marily. A Manual for Administration of Research and Development Projects. October 1987.

This manual was written during CRED's field research in Burkina Faso. It contains many suggestions for improving the administration of field research projects, particularly in the context of Francophone West Africa.

Ralandia Case Studies. These case studies are designed to promote class discussion on economic policy in developing countries. They are problem-solving cases, self-contained, and will not require any additional data. The set is available in either English (SP No. 2) or French (SP No. 3).

3. La République Démocratique Populaire de Ralandie: Deux Etudes de Cas. Jacqueline R. Sherman et David F. Gordon. November 1986. 68 p. $5.00.

2. The People's Democratic Republic of Ralandia: Two Case Studies. Jacqueline R. Sherman and David F. Gordon. October 1986. 60 p. $5.00.

1. Barlow, Robin (editor). Case Studies in the Demographic Impact of Asian Development Projects. (Contributors: J. Anderson, H. Barnum, J. Bauer, P. Gosling, A. Jain, H. Mohtadi, and E. Mueller.) 1982. 204 p. $10.00.

This collection is also appropriate for use in the classroom.

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52. Atelier sur la Réforme Economique en Afrique. 1989. 138 p. $10.00. (French report on the workshop held in Nairobi, Kenya in July 1989).

51. Workshop on Economic Reform in Africa. 1989. 118 p. $10.00. (English report on the workshop held in Nairobi, Kenya in July 1989).

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49. Economic Reform in Africa: Lessons from Current Experience. 1988. 132 p. $10.00. (Report on the workshop held in Nairobi, Kenya in September 1988).

48. Saul, Mahir and Green, Ira. La Dynamique de la Commercialisation des Céréales au Burkina Faso, Tome IV: Documents de Travail 5-6. 1987. 290 p. $25.00. (Price for 4-volume French set consisting of PR Nos. 43, 44, 46, & 48 is $90.00 instead of $100.00.)

47. Saul, Mahir and Green, Ira. The Dynamics of Grain Marketing in Burkina Faso, Volume IV: Research Reports 5-6. 1987. 264 p. $25.00. (Price for 4-volume English set consisting of PR Nos. 42, 44 [in French], 45 & 47 is $90.00 instead of $100.00.)

46. McCorkle, Constance M.; May, Charles A.; Szarletta, Ellen Jean; and Pardy, Christopher R. La Dynamique de la Commercialisation des Céréales au Burkina Faso, Tome III: Documents de Travail 1-4. 1987. 400 p. $25.00.

45. McCorkle, Constance M.; May, Charles A.; Szarletta, Ellen Jean; and Pardy, Christopher R. The Dynamics of Grain Marketing in Burkina Faso, Volume III: Research Reports 1-4. 1987. 364 p. $25.00.

44. Dejou, Chantal. La Dynamique de la Commercialisation des Céréales au Burkina Faso, Tome II: Rapports Régionaux. 1987. 768 p. (Part 1 - 412 p.; Part 2 - 356 p.) $45.00. [available only in French.]

43. Sherman, Jacqueline R.; Shapiro, Kenneth H.; and Gilbert, Elon. La Dynamique de la Commercialisation des Céréales au Burkina Faso, Tome I: Analyse Economique de la Commercialisation des Cereales. 1987. 596 p. $30.00.

42. Sherman, Jacqueline R.; Shapiro, Kenneth H.; and Gilbert, Elon. The Dynamics of Grain Marketing in Burkina Faso, Volume I: An Economic Analysis of Grain Marketing. 1987. 576 p. $30.00.

41. Mathes, J.C. and Elon Gilbert. Gestion des ressources en eau et mise en valeur du Bassin du Fleuve Gambie. 1985. 291 p. $20.00.

40. Ames, Peter. Ecologie terrestre et mise en valeur du Bassin du Fleuve Gambie. 1985. 382 p. $20.00.

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34. Derman, William et al. Rural Development in the Gambia River Basin (Gambia River Basin Studies). 1985. 330 p. $20.00.

33. Moll, Russell and Dorr, John. Aquatic Ecology and Gambia River Basin Development (Gambia River Basin Studies). 1985. 244 p. $20.00.

32. Schneider, Curt R. Water-Associated Diseases and Gambia River Basin Development (Gambia River Basin Studies). 1985. 346 p. $20.00.

31. Josserand, Henri et al. Projet Elevage Département de Bakel (Sénégal): Rapport Final d'Evaluation (Partie I, Synthèse; Partie II, Gestion des Pâturages; Partie III, Pédologie et Hydrologie; Partie IV, Etude Socio-économique). 1985. 530 p. $25.00.

30. Josserand, Henri et al. Eastern Senegal Range and Livestock Project: Final Monitoring and Evaluation Report (Part I, Synthesis; Part II, Range Management; Part III, Soils and Water Engineering; Part IV, Socioeconomic Study). 1985. 454 p. $25.00.

29. Sherman, Jacqueline R. Grain Markets and the Marketing Behavior of Farmers: A Case Study of Manga, Upper Volta. 1984. 317 p. $20.00.

28. Shapiro, Kenneth H., et al. Agroforestry in Developing Countries. 1984. 195 p. $12.00.

27. Ariza-Nino, Edgar J., et al. Effets Nutritifs de Politiques Agricoles: Cameroun et Sénégal - Partie I: Rapports de Pays. 1982. 369 p. $8.00. Partie II: Méthodologies d'Analyse et Modalités d'Enquête. 1982. 284 p. $7.00.

26. Ariza-Nino, Edgar J., et al. Consumption Effects of Agricultural Policies: Cameroon and Senegal - Part I: Country Reports; Part II: Methodology. 1982. 465 p. $15.00.

25. See 'Special Publications' section: Case Studies in the Demographic Impact of Asian Development Projects has become Special Publications (SP) No. 1.

24. Makinen, Marty et Ariza-Nino, Edgar J. La Marché Offert au Bétail dans la Zone Nigérienne Centrale (Le Projet de Gestion des Paturages et de l'Elevage). 1982. 63 p. $7.50.

23. Makinen, Marty and Ariza-Nino, Edgar J. The Market for Livestock from the Central Niger Zone (Niger Range and Livestock Project). 1982. 55 p. $7.50.

22. Ariza-Nino, Edgar J. et Griffith, J.L.P. Les Fournisseurs - Argentine, Australie, Nouvelle-Zélande; et Ariza-Nino, Edgar J.; Manly, D.W. et Shapiro, Kenneth H. L'Economie Mondiale de la Viande: Autres Pays - Fournisseurs et Consommateurs (Tome IV/V, La Commercialisation du Bétail et de la Viande en Afrique de l'Ouest). 1981. 476 p. $15.00.

21. Delgado, Christopher L., et Staatz, John M. Côte d'Ivoire et Mali (Tome III, La Commercialisation du Bétail et de la Viande en Afrique de l'Ouest). 1981. 567 p. [Out of Print.]

20. Josserand, Henri P., et Sullivan, Gregory. Bénin, Ghana, Libéria, Togo (Tome II, La Commercialisation du Bétail et de la Viande en Afrique de l'Ouest). 1980. 441 p. $15.00.

19. Ariza-Nino, Edgar J.; Herman, Larry A.; Makinen, Marty; et Steedman, Charles. Rapport de Synthèse; Haute Volta (Tome I, La Commercialisation du Bétail et de la Viande en Afrique de l'Ouest). 1981. 258 p. $15.00.

18. Ariza-Nino, Edgar J.; Manly, D.W.; and Shapiro, Kenneth. The World Meat Economy: Other Supplier and Consumer Countries (Volume V, Livestock and Meat Marketing in West Africa Project). 1980. 183 p. $15.00.

17. Ariza-Nino, Edgar J., and Griffith, J.L.P. Suppliers: Argentina, Australia and New Zealand (Volume IV, Livestock and Meat Marketing in West Africa Project). 1979. 239 p. [Out of Print.]

16. Delgado, Christopher L., and Staatz, John M. Ivory Coast and Mali (Volume III, Livestock and Meat Marketing in West Africa Project). 1980. 439 p. $15.00.

15. Josserand, Henri P. and Sullivan, Gregory. Benin, Ghana, Liberia, Togo (Volume II, Livestock and Meat Marketing in West Africa Project). 1980. 446 p. $15.00.

14. Ariza-Nino, Edgar J.; Herman, Larry A.; Makinen, Marty; & Steedman, Charles. Synthesis: Upper Volta (Volume I, Livestock and Meat Marketing in West Africa Project). 1980. 204 p. $15.00.

13. Eddy, Edward D. L'Utilisation de la Terre et de la Main d'Oeuvre à l'Interieur des Exploitations Agricoles Intégrées de la Zone Pastorale Nigérienne (Monographie III, La Production et la Commercialisation du Bétail dans les Pays du Conseil de l'Entente). 1980. 406 p. [Out of Print.]

12. Staatz, John M. L'Economique de la Commercialisation du Bétail et la Viande en Côte d'Ivoire (Monographie II, La Production et la Commercialisation du Bétail dans les Pays du Conseil de l'Entente). 1980. 536 p. $15.00.

11. Delgado, Christopher K. L'Elevage par Rapport à l'Agriculture au Sud-Est de la Haute-Volta: Analyse de l'Allocation des Ressources au Niveau de l'Exploitation (Monographie I, La Production et la Commercialisation du Bétail dans les Pays du Conseil de l'Entente). 1980. 405 p. [Out of Print.]

10. Shapiro, Kenneth H. La Production et la Commercialisation du Bétail dans les Pays du Conseil de l'Entente: Rapport de Synthèse. 1980. 445 p. $15.00.

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