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COMPARISONS OF CROP YIELDS FOR DIFFERENT FERTILIZATION LEVELS AND VARIETIES FOR THE CUZCO SIERRA REGION OF PERU

by

Joseph D. Coffey

Raleigh, North Carolina

Lima, Peru

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(Rough draft)
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Note to reader:

These notes were prepared while the author was a visiting professor to the Faculty of Social Sciences at the Universidad Agraria, Lima, Peru. The data presented herein were used to establish yield targets for alternative technological levels which will be used in the author's Ph.D. dissertation to be submitted to the Department of Economics, North Carolina State University, Raleigh. Readers are cautioned that these notes are very tentative and are subject to future revision and modification.

The purpose of reproducing these notes is twofold: (1) They may provide a useful summary of experimental evidence, much of which is not available in published form and (2) they may be useful indicators of the relative magnitude of the changes in yields and yield potentials that could be anticipated for the Sierra region. Since these data were taken from experiments conducted in several Sierra regions, it is felt that they may be applicable to areas other than the Cuzco region. However, no attempt has been made at this.

Introduction 1/

The crop yields given in Table 1 were based upon reported average farm yields and varietal and fertilization experiments for the Sierra region. The yields in Table 1 are classified by four "technological" levels. The technological levels and their characteristics are as follows:

1/All monetary values are expressed in Peruvian soles. One U.S. dollar equals 26.82 Peruvian soles. The metric system is used for all measures. One hectare equals 2.471 acres, and one kilogram equals 2.025 pounds.

Table 1. Estimated low, average, and high yield levels for selected crops by technological level for Cusco Sierra Region[a]

Technology and yield level	Barley	Corn	Broad beans	Potatoes	Quinua	Wheat
			(kilograms/hectare)			
Traditional						
low	600	900	600	3,500	400	600
average	750	1,100[b]	750	5,300[b]	600	800
high	900	1,300	900[b]	6,000	800	1,000
Transitional						
low	1,000	1,200	800	7,000	900[b]	900[b]
average	1,150[b]	1,400	1,000	8,500	1,200	1,050
high	1,300	1,600	1,200	10,000	1,500	1,200
Modern						
low	1,400	1,800	1,100	12,000	1,300	1,200
average	1,700	2,200	1,400	15,000	1,600	1,500
high	2,000	2,600	1,700	18,000	1,900	1,800
Potential						
low	2,000	2,500	1,800	15,000	1,800	2,000
average	2,600	3,000	2,200	20,000	2,200	2,500
high	3,200	3,500	2,600	23,500	2,800	2,900

[a]Based upon experimental and departmental yields given in Appendix Table 5.
[b]Approximate 1963 average yield as given by Convenio de Cooperación Técnica (1964).

(1) Traditional: lowest level of technology where practically no purchased non-farm inputs are used and yields are near or below the present-day averages for the Cuzco department.

(2) Transitional: some off-farm inputs are purchased and selected improved practices are followed. Yields are slightly above the departmental average.

(3) Modern: most of the recognized improved and recommended practices are followed. Yields are significantly above the departmental average. Only the most efficient farmers presently attain this level. The modern level may be considered as a goal to reach within the next fifteen to twenty years.

(4) Potential: the highest attainable level under present-day conditions when the most advanced technologies are used under excellent management. This level characterizes the yields that have been attained in the Sierra region under experimental conditions. The potential level may be used as an attainable goal during the next twenty to thirty years.

These experimental data amply demonstrate that crop yields vary over a wide range due to many uncontrollable factors, such as, climate, pests, location, etc. In an effort to reduce the variation arising from changing climatic conditions, annual averages for several years and locations have been used when the data were available. Experimental data for potatoes are the only data that have been subjected to extensive statistical analyses. The preliminary findings from these data suggest that yield responses to fertilizer in the Sierra region do not differ significantly between locations. At least, locational differences have been less significant than within locationdifferences and since data on soil types and capabilities are very limited, no distinction between land capabilities was made.

Undoubtedly, there are some biases that have not been eliminated. For example, experiments are usually conducted in the most suitable locations and therefore, experimental yields are probably higher than could be expected in other locations in

the same region. Also, there is a definite tendency for the better farmers to have the better land and the poorer ones to have the poorer land. Consequently, some of the yield differences between the better and poor farmers is due to land capability.

In the sections that follow the six major Sierra crops are discussed individually. Since the experimental data in these sections are rather difficult to compare due to the variations in fertilization levels and combinations, the hurried reader may prefer to turn directly to the summary given in Appendix Table 1, which is reproduced from a draft of mimeographed notes by the author entitled "Estimated Costs, Yield, and Resource Requirements for Crops and Livestock for the Cuzco Sierra Region of Peru."

Barley

Barley yields under experimental conditions in the Cuzco Department have been as high as 6,461 kgs./ha. (Table 2), but generally have been in the 1,500 to 3,000 kgs./ha. range (Tables 2 and 3). The varietal experiments generally have higher yields than the fertilization ones. The fertilizer response data in Table 3 are too variable to permit firm conclusions. For all the experiments, there is at least one fertilization level where the returns above fertilizer cost are greater than when no fertilizer is applied. Under most circumstances, it appears that the 40-40-0 level would be most profitable.

High yielding varieties have average yields of about 1,000 kgs./ha. more than the local varieties (Table 2). It appears that yields of over 2,000 kgs./ha. are attainable when improved practices are used.

Table 2. Comparison of yield per hectare in experiments of local and high-yielding varieties of barley for Cusco department for years 1958 to 1963[a]

Crop year	Local varieties	High yielding varieties	Increases over local varieties
	(kgs./ha.)		(%)
1958-59	1,408	1,533	9
1959-60	3,635	6,461	78
1960-61	3,172	3,535	11
1961-62	3,598	4,481	26
1962-63	1,090	1,938	78
Average	2,572	3,590	40
Range	1,545	4,928	69

[a]Variety data for average of 1958 to 1963 experimental yields in Cusco Department from Proyecto Nacional de Cereales (1962, Table XVI) and (1963, Table 30). Fertilizer rate was 40 kgs. N and 40 kgs. P_2O_5.

Table 3. Response of barley to fertiliser for three Sierra Departments for three crop years[a]

Fertilisation level N-P-K[b] (kgs/ha)	Crop year and department 1961-62[c] Junín (kgs/ha)	(Returns[g] per ha.)	1962-63[d] Junín (kgs/ha)	(Returns per ha.)	1963-64[e] Cusco (kgs/ha)	(Returns per ha.)	1963-64[f] Ayacucho (kgs/ha)	(Returns per ha.)
0 - 0 - 0	1,340	2,412	1,285	2,313			1,157	2,083
40 - 0 - 0							1,444	2,159
0 - 40 - 0					1,978	3,260	1,459	2,335
40 - 40 - 0					2,582	3,928	1,672	2,290
40 - 40 - 40	2,090	2,722	2,149	2,828				
80 - 40 - 0					2,865	3,997	1,846	2,163
80 - 40 - 40	1,923	1,961	3,022	3,960				
80 - 80 - 40	2,073	1,971	2,915	3,487				

[a]Adapted from unpublished data provided by Departmento de Suelos y Abonos, SIPA.

[b]Response to K was non-significant in most experiments.

[c]Average of three experiments at Montero, Huancas, and Saños Chico with Chevalier variety.

[d]Average of four experiments at Saños Chico, Instituto Agropecuario Pallán and Sicaya with Chevalier variety.

[e]Average of two experiments at Quispiquilla and Maras with Gupta and Ness-23 varieties.

[f]Average of one experiment at Pampas with Chevalier variety.

[g]Gross returns per hectare less fertilizer costs. Calculated at barley price of S/.1.80/kg. and fertilizer cost of S/.11/kg. N, S/.7/kg. P, and S/.8/kg. K.

Corn

Experimental and survey data indicate that corn yields fluctuate widely between years and locations as well as between modern and traditional systems of production. For example, 1964 corn yields in the Callejon de Huaylas region were less than half those for 1963 (Table 4) Experimental yields in Mantaro Valley are four to seven times higher than those for small and medium farmers in the same region (Tables 5 and 6).

The difference between experimental and farm yields are exaggerated since experimental yields are corrected to a 100% stand and the experiments are usually located in the most favorable corn producing locations/where adequate supplementary irrigation water is available.

Available experimental data for corn response to N-P-K fertilization are not consistent. Usually only one of the elements or its interaction with another will be statistically significant. For the data in Table 6, applications up to 160 kgs./ha. of N would be profitable while for the data in Table 7, only the 50 kgs./ha. would be profitable based upon/the corn price and fertilizer price ranges common to the Sierra.

Average 1963 corn yields for Cusco Department of 1,130 kgs./ha. were about equal to those for the Mantaro Valley for 1961 given in Table 5. Therefore, it appears that yields under farm conditions increase an average of 10 - 20% in traditional systems when some improved practices are used. With more fertilizer and additional practices the yields may reach 1,500 kgs./ha. Yields of around 2,000 to 3,500 kgs./ha. appear to be attainable on the average under the favorable conditions.

Table 4. Comparison of corn yields for five hybrid varieties with local variety of Callejon de Huaylas region of North-central Peru Sierra for 1963 and 1964[a]

Variety	Year	
	1963	1964
	(kilograms/hectare)	
PMC 562	9,678	3,060
PMV 565	8,238	2,679
PMC 561	8,040	2,580
PMV 662	4,896	2,280
PMC 563	6,513	2,861
Local variety	6,522	3,533

[a]Variety data were adapted from unpublished data provided by Programa Cooperativa de Investigaciones en Maiz, Universidad Agraria, LaMolina, Lima, Peru. Data are for irrigated experiments fertilized with approximately 100 kg. N, 80 kg. P and 40 kg. K for Callejon de Huaylas region of Ancash Department for 1963 and 1964.

Table 5. Comparison of corn yields with and without selected cultural practices in Mantaro Valley for 1961[a]

Description of cultural practice	Yield with practice	Yield without practice	Percent change in yield
	(kilograms/ha.)		
Fertilize with manure	1,452	1,191	+22
Fertilize with Guano de Islas	1,316	1,191	+10
Tractor drawn implements	1,120	929	+21
Supplemental irrigation	975	1,155	-16
Crops rotated	1,181	1,105	+ 7

[a]Adapted from Rodriquez, R. and Wong, F. (1962, pp. 97-103). Data based upon survey of 320 small and medium sized farms in 16 zones in the Mantaro Valley. Not all farms were included in each comparison and therefore, the average yields for different practices are not directly comparable.

Table 6. Response of corn hybrid variety PMV-662 with irrigation to alternative levels of fertilization at three locations in Mantaro Valley, 1963a

Level of fertilization N-P-K	Location			Average	Marginal Product
	San Lorenzo	Matahuasi	Campo Concepcion		
	(kilograms per hectare)				
0 - 0 - 0	1,832	2,763	3,838	2,811	
					3,693
80 - 40 - 40	4,677	7,618	7,217	6,504	
					376
120-40 - 40	5,203	7,318	8,120	6,880	
					357
160-40 - 40	5,573	7,430	8,709	7,237	

[a]Adapted from Programa Cooperativo de Investigaciones en Maiz (1963, pp. 100 - 103).

Table 7. Average response of corn to Guano de Islas fertilization for ten experiments in the Sierra[a]

Amount of nitrogen	Yield	Marginal Product
		(kilograms per hectare)
0	2,880	
		550
50	3,430	
		160
100	3,590	
		130
150	3,720	

[a]Fertilizer data were adapted from Calzada and Chavez (1960, pp. 9-10). Average for ten experiments in the Junin, Apurimac, Ayacucho, Cuzco, Huanuco, and Ancash departments for years 1956 to 1958. Approximate analysis of Guano de Islas is N 13%, P_2O_5 10%, and K_2O 2%. All experiments but one were irrigated. Improved or adapted varieties were used.

In the Sierra region of Cuzco, corn is normally grown on the irrigated land. Agricultural technicians indicate that corn is more susceptible to drought than most of the other crops and consequently, the risk of growing corn on non-irrigated land is probably greater than it is for the other crops. Therefore, in the Sierra portion, at least, yield levels must be discounted for this risk.

Broad beans

Broad beans (habas) have not received much attention from the researchers. The result of one experiment in Junin is summarized in Table 8. The difference in yield levels between the two locations in Junin is due primarily to the effects of irrigation in a dry year. The irrigated yield levels are about double the non-irrigated yields. As would be expected, the yield response to fertilizer is greater for the irrigated plots. However, even under the irrigated conditions, the fertilizer response is low.

Comparisons of these experimental yields with the published yields are not very meaningful since the latter is an unknown combination of average yields both for dry and green broad/ beans. The yield range under/ non-experimental conditions is about 600 - 1,200 kgs. per hectare. Since little irrigated land is available in the Sierra of Cuzco, the set of experimental yields for non-irrigated conditions is probably more representative of Cuzco conditions.

Table 8. Response of broad beans to alternative fertilization levels for two experiments in the Mantaro Valley in 1960[a]

Level of[b] fertilization N-P-K	Junin experiment station irrigated		Fundo Mansanares not irrigated	
	Yield	Returns above[c] fert. cost	Yield	Returns above[c] fert. cost
(kgs/ha.)	(kgs/ha.)	(soles/ha.)	(kgs/ha)	(soles/ha.)
0 - 0 - 0	3,497	11,016	1,743	5,490
50 - 0 - 0	3,592	10,765	1,825	5,199
100 - 0 - 0	3,790	10,838	1,921	4,951
100 - 50 - 0	3,580	9,827	2,097	5,156
100 - 0 - 50	4,302	12,051	1,926	4,567
100 - 50 - 50	4,636	12,753	2,186	5,036
150 - 0 - 0	3,556	9,551	1,937	4,452

[a]Adapted from Davila (1961). Yields based on dry broad beans (habas secas). Average of a non-irrigated and irrigated experiment in Junin department for 1960.

[b]Source of nutrients was guano de islas, ammonium sulfate, superphosphate of calcium, and potassium sulfate.

[c]Assumes S/.3.15/kg. for bread bean price and N @ S/.11/kg., P @ S/.7/kg., and K @ S/.8/kg.

Potatoes

The experimental data in Table 9 indicate that high levels of fertilizer are profitable for potatoes under the price conditions that are expected to prevail. For the data in Table 9, which are based upon an extensive fertilizer response study by the Departamento de Suelos y Abonos of SIPA, the marginal cost up to yields of about 27 metric tons per hectare are about S/.0.30 per kg. The estimated potato response function (Footnote a Table 9) yields an optimal fertilizer combination outside the range of the experimental data. Therefore, optimal fertilization levels are not presented.

Table 10 gives an indication of the differential response of improved and traditional potato varieties to fertilizer. The yield of improved varieties without fertilizer surpasses that of the traditional varieties by about 4 metric tons/ha. However, with fertilization this margin is about 10 metric tons--more than two times greater.

Average yields in the Cusco Department have been 5.3 metric tons per hectare. However, yields of the more progressive farmers in the Cusco region are known to surpass 20 metric tons in favorable years. For example, yields reported by the Corporacion de Reconstrucion y Fomento del Cusco (1963) for the small farmers that cooperated in their fertilizer credit program approach or exceed 20 metric tons.

Quinua

Recent experimental data is not available for quinua fertilization and varietal response. The data in Table 11 probably indicate the extremes of quinua response to nitrogen. It appears that it is profitable to apply at least 30 kilograms of nitrogen per hectare. With quinua priced at S/.3.00 per kilo and nitrogen at S/.11.00 per kilo, succesive 30 kilogram additions of nitrogen would be profitable as long as yield increases over 110 kilograms per hectare are obtained.

Table 9. Yield, marginal cost, marginal product and breakeven price for selected levels of fertilizer on potatoes in Canas department[a]

Fertilizer level (N-P-K)	Yield[b] 1962 and 1964	Marginal product of fertilizer	Marginal cost[c] of fertilizer	Price of potatoes at which marginal cost equals value of marginal product
	(kgs/ha)	(soles/ha)	(kgs/ha)	(soles/kg.)
0 - 0 - 0	9,790			
		7,032	2,080	0.30
80 - 80 - 80	16,822			
		5,624	880	0.16
160 - 80 - 80	22,466			
		2,304	560	0.24
160 - 160 - 80	24,750			
		2,176	640	0.29
160 - 160 - 160	26,926			

[a]Based on unpublished data provided by Departmento de Suelos, SIPA. Potato response function used is $Y = 9.79 + 0.0687^{*}N - 0.00011^{*}N^2 + 0.00018^{*}NP + 0.00017^{*}PK$, where Y = metric tons of potatoes per hectare, N = kilograms of nitrogen per hectare, P = kilograms of phosphate per hectare, and K = kilograms of potassium per hectare. Equation is for 1960 to 1964 data. An asterisk (*) indicates significance at .05 level. $R^2 = .44$. Intercept value 9.79 is for 1964 and 1962. Its value for 1961 is 1.88 lower and for 1963 is 2.71 higher.

[b]Yields for 1961 are 1,880 kgs. lower and for 1963 2,710 kgs. higher.

[c]Fertilizer cost used is S/.11/kg. N, S/.7/kg. P, and S/.8/kg. K.

Table 10. Comparison of effects of alternative fertilization levels on traditional and improved potato varieties for three experiments conducted in Cusco Department[a]

Location and date	Fertilization level	Yields compared to base[b]	
		Traditional varieties	Improved varieties
Anta 1961	None	100 (7.5)	194 (14.6)
	Medium (100N - 75P - 75K)	177 (13.3)	274 (20.6)
	High (200N - 150P - 150K)	223 (16.8)	367 (27.6)
Maras 1963	None	100 (4.0)	205 (8.2)
	Medium (80N - 80P - 80K)	230 (9.2)	475 (19.0)
	High (160N - 160P - 160K)	330 (13.2)	695 (27.8)
Cusco 1964	None	100 (8.0)	116 (9.3)
	Medium (80N - 80P - 40K)	166 (13.3)	251 (20.1)
	High (160N - 160P - 80K)	260 (20.8)	328 (26.2)
Average	None	100 (6.5)	165 (10.7)
	Medium	183 (11.9)	306 (19.9)
	High	260 (16.9)	418 (27.2)

[a]Based upon unpublished experimental data provided by Departmento de Suelos y Abonos, Division de Experimentacion, SIPA. Least significance difference between yields is approximately two metric tons per hectare. Not irrigated with average of 33,300 plants per hectare.

[b]Yields in metric tons per hectare in parenthesis.

Based upon interviews of farmers in the Cuzco and Puno Departments, White (1964, p. 4) reports the following quinua yields per hectare:

(1) small farmers (less than six hectares of cultivated land) using traditional techniques--70 - 900 kgs./ha.

(2) large farmers (six hectares or more of cultivated land) using some improved practices--1,200 - 1,500 kgs./ha.

(3) farmers using the best production practices--900 - 2,500 kgs./ha.

The reported average department yields for 1959, 1960, and 1962 have a variation of 385 to 3,063 kgs./ha. (White, 1964, p. 4). Most of these yields, however, are around 800-900 kgs./ha.

Wheat

The experimental results in Tables 12 and 13 indicate that the yield of the higher yielding wheat varieties is almost double that of the local varieties when grown under favorable fertility conditions and that fertilizer increases yields by about 50%. The returns above fertilizer cost in Table 13 suggest that fertilization levels as high as 80 kg. N and 80 kg. P may be profitable. These experimental yields are considerably higher than the 912 kg./ha. average for the Cuzco Department. According to the reports of agricultural technicians, the more progressive Cuzco farmers have been attaining yields of over 1,100 kgs./ha.

Table 11. Response of quinua to alternative fertilizer levels and types in Junin and Puno Departments[a]

Nitrogen[b] Source	Amount of Nitrogen	Junin Department		Puno Department	
		Yield	Marginal Product	Yield	Marginal Product
	(Kilograms per hectare)				
--	0	796		3,836	
			153		576
Manure	30	949		4,412	
			202		-310
Manure	60	1,151		4,102	
			-125		185
Manure	90	1,026		4,287	
--	0	810		4,109	
			335		525
Guano de Islas	30	1,145		4,634	
			37		225
Guano de Islas	60	1,182		4,859	
			390		-199
Guano de Islas	90	1,570		4,660	

[a]Adapted from Gorbitz and Lima de la Fuente (1957, p. 6).
[b]The approximate percentage of N-P-K in manure and Guano de Islas is 1.25 - 1.0 - 0.5 and 13.0 - 10.0 - 2.0, respectively. Only the amount of nitrogen was reported.

Table 12. Comparison of yield per hectare of experiments of local and high-yielding varieties of wheat for Cusco department for years 1959 to 1963[a]

Crop year	Local varieties	High yielding varieties	Increase over local varieties
	(kgs/hectare)		(%)
1959-60	2,074	3,356	62
1960-61	1,875	4,295	129
1961-62	539	2,202	309
1962-63	1,333	1,597	20
Average	1,455	2,863	97
Range	1,535	2,698	209

[a]Adapted from Proyecto Nacional de Cereales (1962) and (1963). The fertilizer application on these variety checks was 40 kgs. nitrogen per hectare, 40 kgs. phosphate/hectare, and zero potassium.

Table 13. Response of wheat to fertilizer for three Sierra locations for crop year 1963-64[a]

Fertilization level N-P-K	Location: Junin Department[b] San Lorenzo		Cuzco Department[c] Quispiquilla		Junin Department[d] Huancas	
	Yield	Returns above fert. cost[e]	Yield	Returns above fert. cost[e]	Yield	Returns above fert. cost[e]
(kgs/ha)	(kg/ha)	(soles/ha)	(kg/ha)	(soles/ha)	(kg/ha)	(soles/ha)
0 - 0 - 0	2,103	5,678	--	--	1,066	2,878
0 - 40 - 0	2,611	6,770	2,239	5,765	--	--
40 - 0 - 0	2,536	6,480	2,632	6,666	--	--
40 - 40 - 0	2,962	7,277	2,953	7,253	1,498	3,325
40 - 80 - 0	2,910	6,857	3,056	7,251	--	--
80 - 40 - 0	2,807	6,419	3,397	8,012	1,868	3,884
80 - 80 - 0	3,361	7,635	--	--	--	--

[a]Based upon unpublished data taken from 1964 Informe Anual of the Departmento de Suelos y Abonos, SIPA.

[b]Average of one experiment. Variety not specified. Two levels of potassium were used but the results were non-significant.

[c]Average of one experiment with Bonza and Mariño varieties.

[d]Average of one experiment. Variety not specified.

[e]Wheat @ S/.2.70/kg., N @ S/.11/kg., P @ S/.7/kg., and K @ S/.8/kg.

LIST OF REFERENCES

Christiansen, J. 1964. Cultivo de la papa, (Growing of the potato), No. 51, Ministerio de Agricultura, Lima, Peru.

Convenio de Cooperacion Tecnica. 1964. Peru 1963--estadistica agraria (Peru 1963--agrarian statistics), Ministerio de Agricultura, Lima, Peru.

Corporacion de Reconstruccion y Fomento del Cusco. 1963. Campana de fertilizantes, (Fertilizer program), Corporacion de Reconstruccion y Fomento del Cuzco, Cuzco, Peru.

Gerbitz, A. and R. F. Luna. 1957. Estudios sobre la quinua en el Peru, (Studies on quinua in Peru), Circular No. 72, Ministerio de Agricultura, Lima, Peru.

Instituto Nacional de Planificacion. 1964. Manual de investigacion agropecuaria--departamento de Puno, (Manual of agricultural investigation--department of Puno), Documento de Trabajo No. 2, Instituto Nacional de Planificacion, Lima, Peru.

Programa Cooperativo de Investigaciones en Maiz. 1963. Informe Anual 1963, (Annual Report 1963), Universidad Agraria, Lima, Peru.

Rodriquez, R. and F. Wong. 1962. Estudio sobre el indice de rendimiento del maiz en el Valle del Mantaro, durante la campaña agricola del año 1960-1961, (A study of corn yields in the Mantaro Valley during the crop year 1960-1961). Unpublished Ingeniero Agronomo thesis, Universidad Agraria, Lima, Peru.

Schenck, F., Paulette, M. y Arca, M. 1963. Cultivo del maiz en la costa, (Cultivation of corn on the coast), Boletin Tecnico No. 37, Ministerio de Agricultura, Lima, Peru.

The Interamerican Cooperative Service of Southern Peru. 1959. Agricultura: su estado actual y sus perspectivas, (Agriculture: Its present status and future prospects), Vol XII (PS/C.26), Peruvian North American Cooperative Education Service, Lima, Peru.1/

The Interamerican Cooperative Service of Southern Peru. 1959. Manual de estadistica regional, (Manual of regional statistics), Vol XXVIII, (PS/G.59), Peruvian North American Cooperative Education Service, Lima, Peru.1/

1/This reference is commonly known as the Plan del Sur (Southern Peru Plan) which was conducted during the 1957-59 period as a result of a severe drought in Southern Peru. The complete study was published (both in English and Spanish) in 30 volumes. Copies of certain volumes can be obtained from the Faculty of Social Science, Universidad Agraria, LaMolina, Lima, Peru.

Proyecto Nacional de Cereales. 1962. Informe anual 1961-62, (Annual report 1961-62), Ministerio de Agricultura, Lima, Peru.

Proyecto Nacional de Cereales. 1963. Informe anual 1962-63, (Annual report 1962-63), Ministerio de Agricultura, Lima, Peru.

White, T. K. and Carlos Luque, Capacity of quinua to compete for consumer expenditures and farm resources, North Carolina Agricultural Mission to Peru and Experiment Station, SIPA, LaMolina, Feb. 1964, (MIMEO).

Appendix Table 1. Crop yields and their percentage changes for varietal and fertilization experiments in the Sierra Region of Peru and for 1951-53 and 1961-63 Cusco Department averages

Characteristic	Barley[a]	Broad Beans[b]	Corn[c]	Potatoes[d]	Quinua[e]	Wheat[f]
	(kilograms per hectare and percent)					
Varieties:						
Traditional varieties	2,572	--	5,027	11,800	--	1,455
Improved varieties	3,590	--	5,083	19,267	2,108	2,863
Percent change	+40	--	+1	+63	--	+97
Fertilization level: (kgs. of N, P_2O_5 +K_2O/ha.)						
None	1,261	2,620	2,880	10,700	2,388	1,584
1 to 80	1,469	2,709	3,430	--	2,802	2,490
Percent change over none	+13	+3	+19	--	+17	+57
81 or more	2,362	2,993	3,655	23,500	2,886	2,900
Percent change over none	+87	+14	+27	+120	+21	+83
Cuzco Department average yields[g]:						
1951-53	1,143	--	1,456	5,165	910	929
1961-63	1,119	--	1,432	5,051	879	912
Percent change	-3	--	-2	-2	-3	-2

[a]Variety data for average of 1958 to 1963 experimental yields in Cusco Department from Proyecto Nacional de Cereales (1962) Table XVI, (1963) Table 30. Fertilizer rate was 40 kgs. N and 40 kgs. P_2O_5. Fertilizer data provided by Departmento de Suelos y Abonos, SIPA, Lima, Peru. Average yields from ten experiments in Junin, Cuzco and Ayacucho Departments during 1961 to 1964.

[b]Adapted from D. Davila (1961). Yields based on dry broad beans (habas secas). Average of a non-irrigated and irrigated experiment in Junin department for 1960.

[c]Variety data were adapted from unpublished data provided by Programa Cooperativa de Investigaciones en Maiz, Universidad Agraria, LaMolina, Lima, Peru. Data are for irrigated experiments fertilized with approximately 100 kg. N, 80 kg. P and 40 kg. K for Callejon de Huaylas Region of Ancash Department for 1963 and 1964. Fertilizer data were adapted from Calzada and Chavez (1960) pp. 9-10. Average for 10 experiments in the Junin, Apurimac, Ayacucho, Cuzco, Huanuco, and Ancash departments for years 1956 to 1958. Approximate analysis of Guano de Islas is N 13%, P_2O_5 10% and K_2O 2%. All experiments but one were irrigated. Improved or adapted varities were used.

Appendix Table 1 (continued)

[d]Variety and fertiliser data are the averages of three experiments in Cusco Department during 1961 to 1964 period and were adapted from unpublished data provided by Departamento de Suelos y Abonos, SIPA, Variety tests were fertilized with approximately 87 kgs. N, 78 kgs. P_2O_5 and 65 kgs. K_2O per hectare.

[e]Variety yield was taken from White (1965, p. 5) and is average experimental yield for a three year period of six different varieties for Puno department. Fertilizer data are from Gorbitz and Luna de la Fuente (1957, p. 8).

[f]Variety data were adapted from Proyecto Nacional de Cereales (1962, Table XIII) and (1963, Table 16) and Informe Anual 1962-63, Cuadro 16, SIPA. The fertilizer application on these variety checks was 40 kgs. N and 40 kgs. P_2O_5 per hectare. They are averages of 1959 to 1963 experimental data for the Cusco Department. Fertilizer data were adapted from the unpublished 1964 annual report of the Departamento de Suelos y Abonos, SIPA, La Molina, Lima, Peru. They are averages of three experiments for 1963 in the Cusco and Junin Departments.

[g]From unpublished data provided by Ministerio de Agricultura, SIPA, Oficina de Estudios Economicos, Lima, Peru.