FARM PROBLEMS, SOLUTIONS, AND EXTENSION PROGRAMS FOR SMALL FARMERS IN CAÑETE, LIMA, PERU.

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Abstract

This was a study about ways of improving the Cañete small farmer community (4,800 households, 18,080 ha) through agricultural extension.

Several procedures were used to gather data. A *sondeo* (rapid appraisal survey) was conducted to obtain a general understanding of the community. A survey of 60 random household interviews was also conducted to obtain accurate information. Other secondary data sources were also used.

The analyses included production functions, linear programming, and extension programming. Production functions for seven geographical zones were generated based upon multiple regression of cotton yield as a function of fertilization and environmental factors.

Linear programming was used to simulate and better understand the current situation of individual households. Following statistical validation, a projection of future production, income, and consumption was undertaken at the household level. These simulation models are "interactive working models."

Finally, a list of nine priority extension programs for the Cañete farm community was proposed.

Introduction

Farming Systems Research & Extension (FSR&E) represents a unique approach to agricultural research and extension; it was formulated in response to the complex and diverse production methods encountered on small often-mixed farms in the developing world (Zandstra, 1983). Norman (1982) proposed four stages in FSR&E: diagnostic, analysis, testing, and extension. The FSR&E approach is concerned with the need identification of small farmers, by observing first-hand the farmers' situation by multidisciplinary teams of experts (Hildebrand & Waugh, 1986). *Need* can be defined as a deficiency, imbalance, lack of adjustment, or gap between the present situation and a set of societal norms believed to be more desirable (Boone, 1985). Targeting Outcomes of Programs (TOP) developed by Bennett and Rockwell (1995) proposes that program planning targets *SEEC* –social, economic, and environmental conditions- then the *practices* necessary to achieve the targeted conditions, and the *KASA* –knowledge, attitudes, skills, and aspirations- needed to realize adoption of the practices. The program also targets the *reactions* needed to ensure sufficient *participation* in program *activities* that enable learning the intended *KASA*.

Cañete has 4,800 small farmers with 12 ha or less (80% of the 22,600 ha). In general, the environmental conditions in Cañete including soils, climate, and water resources are not agricultural constraints. Compared to other regions of the country, these agro-climatic conditions are perceived as being very favorable. The Cañete Valley is an influential agricultural production area in Peru. Despite these favorable agro-climatic advantages, on average, households (7 members) have an annual income of US$ 1,420, and many Cañete residents live below international standards for nutrition, health, housing, services, and other basic needs (Valle Grande Rural Institute, 1997).

Valle Grande Rural Institute (VGRI) is a NGO development institution that has been in existence for more than 30 years in the Cañete Valley promoting rural improvement through extension and education programs designed for low income farmers. This study contributes to the programming efforts of VGRI by providing small farmers' current situation analyses and proposing ways of improvement through extension programs.

Purpose and Objectives

The overall purpose of this study was to identify farmers' problems and needs and to design extension programs to improve the livelihood of limited resource farmers in the Cañete Valley. The specific objectives of the study were to:

(1) Develop production functions that explain the current cotton production enterprise and use the production functions to predict future yields of small farmers in the Cañete Valley.

(2) Use linear programming to simulate individual household's livelihood systems and to explore production alternatives in different scenarios of the small farmers in the Cañete Valley.

(3) Propose a priority list of future extension programs to meet the needs of small farmers in the Cañete Valley.

Methods and Data Sources

The population and sample differed based upon the multiple data collection methods used by the researcher. In order to develop the cotton production functions, the researcher used a population of small farmers who borrowed money through the Valle Grande Rural Institute during the period 1992 through 1998 (N= 1,860). A purposeful sample (n= 622) consisting of farmers with complete records was used to develop the production functions.

In terms of the linear programming model, the researcher used data from numerous sources including a *sondeo*, survey, and selected secondary data. First, six multidisciplinary professionals conducted a *sondeo* (May 11 to 15, 1998) consisting of a sample of 22 farmers in the area. A *sondeo* is an open-ended, non-structured interview technique (Hildebrand, 1976).

Second, the researcher conducted a survey (May 18 to July 17, 1998) consisting of structured questions developed based upon knowledge of the Cañete Valley, and the *sondeo* results. A questionnaire consisting of 70 items was developed. The instrument contained three sections. The first section had three subsections: (1) household information, (2) agricultural factors, and (3) economic information. The second section consisted of seven open-ended needs assessment questions. The final section included 13 open-ended questions regarding farm problems and concerns. The population for the survey consisted of limited resource farmers in the Cañete Valley (N=4,800). A random sample of 60 farmers was selected for participation in the survey

Ex post facto or secondary data were also gathered. These data came from records maintained by the Valle Grande Rural Institute, from records maintained by the city government, and from records of Peru's Ministry of Agriculture.

The data were analyzed using Microsoft® Access 97 SR-1, Microsoft® Excel 97 SR-1, and Microsoft® Visual Basic.

Results and Discussion

Cotton Production Functions

The purpose of this analysis was to generate production functions based upon multiple regression of cotton yield based upon fertilization and environmental factors.

The dependent variable in all cases was the cotton per ha yield in quintals (100 lb). The independent variables tested were: nitrogen (N), phosphorus (P), and potassium (K) in kilograms, annual environmental index (average production per ha for the specific year) (EI) in quintals, and the interaction between the fertilizers and the annual environmental indexes, EIxN, EIxP, EIxK.

The fertilization rates used by the farmers in the cotton crop were the amounts recommended by Valle Grande Rural Institute. These amounts had little variation within zones (Table 1).

Table 1: Range of fertilization factors by geographic zone, kg/ha

	Cerro Alegre	La Quebrada	San Benito	San Francisco	Santa Bárbara	Palo Isla	Quilmaná
N	170-240	180-230	190-245	200-250	110-229	200-240	200-240
P	46-110	46-120	46-120	30-103	46-100	80-100	80-100
K	40-100	50-100	50-100	40-90	25-95	90-100	90-100

The annual environmental index (EI) is the result of calculating the average of all available production data for each year. As seen in Figure 1, the annual environmental conditions are responsible for drastic changes in the yield variable of the cotton crop. For analyses and recommendation purposes the production years are divided into good (more than 60 qq/ha), fair (more than 45 but less or equal to 60 qq/ha), and poor (less or equal to 45 qq/ha).

The interactions of the environmental index variable (EI) and the macronutrient variables (N, P, and K) were the result of multiplying both values creating the interaction variables (EIxN, EIxP, and EIxK).

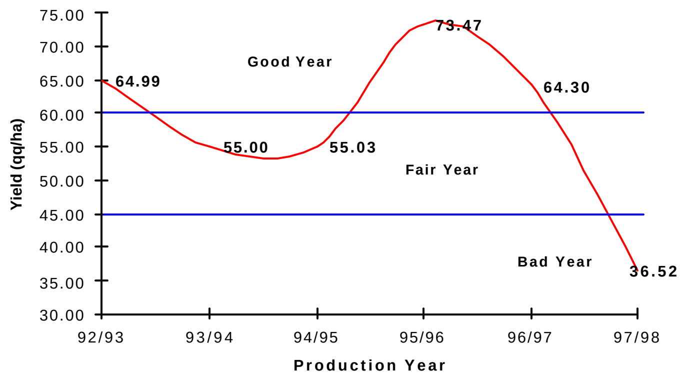

Figure 1: Annual environmental index for cotton yield in Cañete

Seven multiple linear regressions were developed (one for each association or geographic zone) of the following form:

$$Y' = a + b_1X_1 + b_2X_2 + \ldots b_kX_k$$

Where:

Y'	is the estimated value of cotton yield in one zone in quintals (100 lb),
$X_1, X_2, \ldots X_k$	are the independent variables,
a	is the intercept, and
$b_1, b_2, \ldots b_k$	are the partial regression coefficients.

The hypotheses tested in each case ($\alpha = 0.05$) were:

F test for the whole regression equation:

Ho: $R^2 = 0$ in the population.

H1: $R^2 > 0$ in the population, and

t-test for the independent variables:

Ho: $b_k = 0$ in the population

H1: $b_k <> 0$ in the population

The coefficients that were statistically significant at 95% confidence level ($\alpha = 0.05$) are the only independent variables reported in each specific equation because they can be used for prediction purposes (Table 2). Although curvilinear variables (x^2) were included in the regression analyses, none were significant at this level of confidence.

Table 2: Cotton production function coefficients

Zone	Intercept	N	P	K	EI	EIxN	EIxP	EIxK
Cerro Alegre	88.790	--	-4.010	-0.340	-6.160	--	0.071	--
La Quebrada	77.690	--	-0.910	--	--	--	0.014	--
Palo Isla	-81.50	-1.720	--	3.580	--	0.012	--	--
S. Bárbara	119.450	--	--	-1.660	--	--	-0.006	0.020
S. Benito	44.57	-0.870	--	1.580	--	0.016	-0.025	--
S. Francisco	-63.01	0.460	4.900	-5.570	--	--	-0.088	0.103
Quilmaná	52.06	--	--	-0.840	--	--	--	0.010

-- Non-significant.

This analysis of cotton production functions demonstrates enormous variability among geographic zones in relation to yield and its response to fertilizers and environmental factors. This fact pointed out the need to make fertilization recommendations on an individual basis (geographic zone) using the production functions, according to the anticipated environmental factors.

These production functions also demonstrate that, contrary to common belief, higher yields are not necessarily reached with higher amounts of fertilizers. Actual recommended fertilizer amounts might be too high; they are probably based upon trails conducted on the very best soils in good years.

Linear Programming

The purpose of this analysis was to study the various farming systems in the Cañete Valley community in order to evaluate different scenarios. Linear programming was used first to simulate the households' current situation and after statistical validation, predict different farmer's responses to various scenarios.

The simulation of the Cañete community was done using the 60-household survey sample. Independent linear programming models –one for each household- were developed. That fact was critical for analyzing the overall community while maintaining the diversity of the systems. In all cases, there was a one-year model and a six-year model.

Based on the data gathered in the survey, the following activities and constraints summarize the livelihood systems used to construct one-year and six-year linear programming models that maximize discretionary cash at the end of the year after satisfying all basic family needs (Table 3):

1. There are two well-known production seasons in Cañete. The matrix was divided into these: First season, August 15th to April 14th, and second season, April 15th to August 14th.
2. Land is a limited resource in the Cañete Valley. Its use is intensive.
3. Renting land from both the owners' perspective and the renters' perspective is a common practice in the community that was included in the models.
4. Labor is a limited resource. It is determined by the number, age, and gender of the household members.
5. The household has the opportunity to hire people in labor intensive-seasons (labor is available in the community). It is also common that the household members work for others (off-farm labor) to supplement household income.

6. Water is not a limited resource in the first semester, but it is, in some cases, in the second semester. The availability of water is determined by the frequency, time, and flow of water received in each household.
7. Management is an aggregate index computed by summing the total years of education of all members in each particular household.
8. Credit is an available resource for cotton and maize in the first semester and for maize in the second semester (development agencies, industry). The interest is 10% in the first semester and 8% in the second. The farmers may get cash credit (retailer, intermediaries, pesticides shop, etc.), and may be assessed as much as 100% interest for just one season of credit. Credit is also available for activities such as asparagus and grapes in the six-year model.
9. Each household has some cash at the beginning of each season. This money is used for household expenses, livestock, and production activities.
10. The family and livestock consume maize and sweet potato produced on the farm. The family requires a certain amount of livestock produced by the household.
11. The cash, if not used in the first semester, can be transferred to the second semester. If the cash in the second semester is not used, it is transferred to the end of the year cash. The needed cash is transferred to the first semester of the next year, in the six-year model.
12. The cash at the end of the year could be negative in the one-year and in the six-year models. Negative cash at the end of the year indicates a non-sustainable system.

Analyses were conducted from different perspectives. The researcher attempted to explain overall household system dynamics based on individual models of all 60 households. After the aggregation of the sixty model solutions, they were compared with the original data to validate the models. Both an F-test and a t-test were used to test the models.

The F-test compared the data variances in order to determine if both sets of data had equal variances. The t-test compared the means (with equal or unequal variances) in order to determine if significant differences existed between the two sets of data: simulated and survey. Both tests were based on probability level of 0.05. The null hypothesis in each case was that variances and means were not equal.

Table 3: Resources and constraints for linear programming, average household

Resources and Constraints	Sign	Unit	Amount
Land I	<=	ha	4.72
Land II	<=	ha	4.72
Male labor I	<=	days	449.00
Male labor II	<=	days	224.00
Female labor I	<=	days	466.00
Female labor II	<=	days	233.00
Male hired I	<=	days	449.00
Male hired II	<=	days	224.00
Female hired I	<=	days	464.00
Female hired II	<=	days	230.00
Water I	<=	m^3	64,076.88
Water II	<=	m^3	32,038.44
Management I	<=	unit	31.48
Management II	<=	unit	31.48
Credit for cotton and/or maize I	<=	Soles	9,700.58
Credit for maize II	<=	Soles	3152.69
Household cash I	<=	Soles	4,999.99
Household cash II	<=	Soles	3300.00
Livestock consumption I	=	unit	8.00
Livestock consumption II	=	unit	4.00
Maize consumption (house) I	=	Kg	543.11
Maize consumption (house) II	=	Kg	273.46
Maize consumption (livestock) I	=	Kg	960.89
Maize consumption (livestock) II	=	Kg	478.55
Sweet potato consumption (house) I	=	Kg	497.07
Sweet potato consumption (house) II	=	Kg	900.13
Sweet potato consumption (livestock) I	=	Kg	900.13
Sweet potato consumption (livestock) II	=	Kg	600.08

Note: I is first semester: August 15^{th} to April 14^{th}.
II is second semester: April 15^{th} to August 14^{th}.
Average of the 60 sample households.

Table 4 shows this analysis. The null hypothesis for variance is rejected (F = 1.50, p = 0.062) indicating that we can accept that the variances are not different. The t-test, assuming equal variances, leads us to reject the null hypothesis and accept that the sample and the results of the simulated models represent the same population. (t = 0.135, p = 0.893).

Table 4: Total land used (t-test assuming equal variances)

Land used	n	Mean	Variance	t	p
Model simulation	60	3.68	3.71	0.135	0.893
Real data	60	3.73	5.55		

(F = 1.500, p = 0.062)

Based on this validation analysis, we conclude that the linear programming models adequately simulate the population sampled: Cañete's small farmers. In consequence, these models can be used with confidence to project production, income, and consumption in different scenarios for any of Cañete's small farmer households.

The one-year and six-year validated models were run in different scenarios. These different scenarios are examples based on the current Cañete situation. It should be understood that the models could be used with any Cañete household in any scenario according to the situation after inputting the model with appropriate data. The results are always on an individual basis that could be aggregated to better understand the community.

Asparagus and grapes are two introduced crops in the Cañete Valley. They are perceived as complex but profitable. Currently, the development agencies are recommending these crops for the small farmers as alternatives to improve their livelihood. Indeed, development agencies are financing these crops. The six-year model was used to test the viability of these alternatives from the small farmers' perspectives. In the case of the asparagus, the development agency requires that the small farmer be able to plant at least one hectare due to harvesting and marketing concerns.

Without losing the system diversity, there were some naturally occurring household groupings. As suspected, family composition: number of members, ages and gender were critical characteristics as well as the land resource.

No household is financially capable of investing in grape production. However, 46 households would be able to raise some asparagus, twenty-five of which could produce over one hectare (Table 5), the minimum required for commercial production. Those households that could devote a greater amount of land to asparagus production are characterized as having fewer children living at home, and having more available adult labor. In addition, they have larger farms and tend to have more land in the lower to middle valley range (probably the most productive lands in the valley). They are also more highly educated.

Table 5: Asparagus activity and household composition

Grouping	Composition				Land	Management
	1	2	3	4	ha	or Education
No Asparagus 14 out of 60 (13.33%)	0.50	0.79	1.71	1.64	4.35	20.69
< 1 ha Asparagus 21 out of 60 (35.00%)	0.19	0.67	2.24	2.14	4.11	31.90
>=1 ha Asparagus 25 out of 60 (41.67%)	0.08	0.56	2.56	2.60	5.45	38.19
Solution for “Average” Household **0.84 ha Asparagus**	0.21	0.65	2.25	2.22	0.18	31.48

Note: 1, males and females of less than five years.
2, males and females between five and fourteen years of age.
3, males between fourteen and sixty-five years of age.
4, females between fourteen and seventy-five years of age.

Extension Programming

The subsequent programming information is proposed as recommendation for Valle Grande Rural Institute extension work.

Based upon data collected by the researcher (sondeo, survey), supplemental data (Valle Grande Rural Institute records, records maintained by the city government of Cañete, and Peru's Ministry of Agriculture), and the researcher’s knowledge and experience in the region, the following nine major extension programs are proposed:

1. Traditional Crop Management. Pest control, fertilizer application, weed control, and pesticide applications of traditional crops.
2. Adoption of New or Improved Crops. New crops with some economic advantage, when compared to traditional crops.
3. Credit and Land Ownership. Farmers must know how to obtain credit. In addition, they need to understand the relationship between land credit and ownership.
4. Commercial Marketing. Farmers need to analyze marketing elements to make wiser decisions in order to obtain higher incomes.
5. Farm Management. Farmers need to follow a sequential orderly production process based upon decisions made from clear and accurate records. The farmers must generate such data through record keeping and budgeting.
6. Legal Issues. Small farmers need to know about agricultural policies and tax law.
7. Farming Associations. Small farmers need to know how to organize themselves in associations in order to undertake common goals such as the advantage of purchasing products by scale, labor efficiency, diffusion of information and optimization of financial resources. One critical point of the associations should be to decrease crime related to the theft of crops and assets.
8. Healthy Diets. There is a need to modify the diets of small farmers to include more farm-raised products in their diets.
9. Pesticide Use and Environmental Conservation. Farmers need to decrease their dependence upon chemical pesticides and incorporate Integrated Pest Management (IPM) practices.

Conclusions and Implications

The production functions may become predictor tools. For example, a “poor year” anticipated, would be a “good year” for Cerro Alegre and San Francisco if fertilized adequately. This opportunity would be much better with an anticipated better cotton price because of less Cañete total production. These equations may also become risk avoidance tools. For example, in Palo Isla it would not be recommendable to raise cotton in a “poor year” or even in a “fair year” because of the low yields expected. In Quilmaná zone, where the worst results were reported, it is perhaps recommendable not to raise cotton, even in “good years.”

Statistical comparisons of the Cañete linear programming models with the real data allowed validation of these models, indicating that the models adequately simulate the population sampled. This statistical validation process was an innovation used for first time in this investigation to the author’s knowledge. The diversity of the household systems of Cañete community requires individual approaches. Use of an “average household” or a “representative household” is not appropriate in drawing conclusions for the whole community. Based in the linear programming simulations, asparagus, and grapes -highly recommended crops to all small farmers by the development agencies- were analyzed. The simulation of the six-year models found out that while no small farmer would be able to raise grapes, according to scenarios, only a relatively small segment of the population would be able to raise asparagus. The recommendation of this crop should be on an individual basis, after solving the appropriate model in the appropriate scenario.

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