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Economic returns to cowpea research, extension, and input distribution in Senegal

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ABSTRACT

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This paper calculates the rate of return to a set of cowpea research, extension and distribution projects in Senegal to be between 31% and 92%. The results show that a modestly funded program on a secondary crop can be successful. They also indicate that programs may increase their effectiveness by addressing specific household needs – in this case, by focusing on short-cycle varieties that provide food during the hunger season prior to the traditional harvest.

INTRODUCTION

Since Schultz (1953) and Griliches (1958) first estimated rates of return (ROR) to agricultural research, the literature has blossomed with over 200 published studies (Echeverria, 1990; Evenson et al., 1979). The bulk of these studies focus on Latin America, Asia and the developed countries. For example, in a recent summary of ROR studies, Daniels et al. (1990) find less than ten studies of returns to African agricultural research; this finding is consistent with Echeverria and Evenson et al. (1979). Daniels et al. argue that more ROR studies are needed to understand the causes of success or failure in African agricultural research.

This paper analyzes the returns to investment in agricultural research, extension and input distribution activities designed to increase cowpea

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production in Senegal. The activity examined includes the 1985–86 'Operation Cowpea' (see Bingen et al., 1988), which introduced and distributed to farmers high-yielding, short-cycle cultivars (CB-5 and 58–57), modern inputs such as insecticides and sprayers, and improved cropping practices. It also includes the underlying research efforts that enabled this distribution program. By calculating an ROR to the cowpea research and input distribution activities in Senegal, this paper helps to fill the gap in current knowledge about returns in African agricultural research.

The paper proceeds with a background discussion of cowpeas and cowpea research in Senegal, followed by an economic valuation of the benefits and costs of the research, extension and distribution activities. A rate of return to these activities is calculated and interpreted. The final section provides conclusions.

COWPEAS AND COWPEA RESEARCH IN SENEGAL

Cowpeas most likely originated in Africa, and varieties have spread throughout the world. Cowpeas yield greenpods, 'grain' (peas or dry seed), and fodder. Greenpods, also known as southern peas, are immature grain and can be consumed as such. The main reason for growing cowpeas is to produce grain, which is eaten as peas or prepared as meal or flour. In Senegal, the plant material remaining after harvest is sold or stored as fodder to feed livestock during the dry season.

Cowpeas have a diversity of characteristics, including days from planting to harvest (cycle), which range from 53 to 200 (Singh and Rachie, 1985). Traditional varieties have 80- to 100-day cycles and low yields of dry seed (250–500 kg/ha) compared to yields in Asia and Latin America (400–500 kg/ha) and the U.S.A. (600–800 kg/ha). The low yields in West Africa are attributed to pest damage, disease, rain shortage, poor cropping techniques and poor plant types (Coulibaly, 1987).

Senegalese research on cowpeas and on the establishment and maintenance of cowpea germplasm was carried out in the 1950's and 60's at the Federal West African Agricultural Research Station at Bambey, Senegal. This station became the National Agronomic Research Center in 1960 and the headquarters for the Senegalese Institute for Agricultural Research (ISRA) in 1974. Djibril Sene, a Senegalese scientist, conducted invaluable work on the collection and maintenance of germplasm from the 1940's through the early years of ISRA, traveling as far east as Niger to acquire strains (Sene, 1985).

In 1981, ISRA and the University of California, Riverside (UCR) began working together under the auspices of the Bean and Cowpea Collaborative Research Support Project (CRSP), with the objective "to increase production and yield stability of cowpeas grown in hot semi-arid zones by subsistence farmers" (CRSP, 1988b, p. 117). Breeding efforts to improve plant types focus on the characteristics necessary to raise yields, such as resistance to pests, diseases, drought and heat. Complementary work identifies optimal cropping techniques, such as seeding rates, spacing, varietal intercropping, crop management, storage, and seed production.

In the late 1970's and early 1980's, below-average rainfall in northern Senegal led to low production of all crops, food shortages, and migration out of the Louga region. Particularly severe drought from 1982 to 1984 caused crop failures. In 1984, production of peanuts, the main crop in the area, was poor and only 140 000 t were sold through official marketing channels. This meant that the government was unable to distribute sufficient quantities of peanut seed to farmers in 1985. Consequently, spurred by the Minister of Rural Development, the European Economic Community Delegation, and USAID, the Government of Senegal sponsored a one million dollar project to increase cowpea production in Senegal. This project, called Operation Cowpea, was coordinated by the Ministry of Rural Development and implemented by the Senegalese extension service, SODEVA, in cooperation with ISRA. It focused on Louga, Diorbel, and the Senegal River Valley (Bingen et al., 1988).

ISRA and the Bean and Cowpea CRSP provided technical assistance and scientific information to help implement the operation. The CRSP identified a California, 60-day cowpea variety (CB-5) that could be grown in Senegal and for which adequate seed supplies were available in the U.S. In 1985, 650 t were imported. Along with 200 t of local varieties produced or collected by the EC and FAO, the CB-5 was distributed to farmers in northern Senegal with in-kind credit: for every 1.0 kg of seed received by a farmer, the farmer was obligated to return 1.5 kg at harvest. Fertilizer, insecticide and sprayers were distributed to producer groups at low or no cost. SODEVA provided extension information on the use of insecticides and other farming practices (Bingen et al., 1988).

The area sown to cowpeas more than doubled from the 1980–84 annual average of 52 700 ha to 121 000 ha in 1985 (Table 1). Grain yields increased from 293 kg/ha in 1980–84 to 545 kg/ha in 1985, and grain production increased from the previous 5-year average of 18 568 to 66 000 t/year. [1]

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t, metric tonne = 1000 kg.

[1] 66 000 t is the CRSP estimate, which does not include greenpod production. The EC estimated aggregated greenpod and grain production to be 80 000 t.

TABLE 1

Cowpea area, yield and production: Senegal, 1970–86

Year	Area	Yield	Grain production	Estimated greenpod production [a]
1970–79 [b]	63300	293 [c]	18600	N.A.
1980–84 [b]	52700	328 [c]	15500	N.A.
1985	121000	545	66000	14000
1986	117600	466	54800	11500

[a] Data on greenpod production before 1985 are not available. However, traditional varieties are medium or long cycle, so there is little advantage to harvesting the pods before they fully develop.

[b] Annual average.

[c] For 1970–79 and 1980–84, calculated as average production divided by average area.

Sources: Area planted, grain yield and grain production are from CRSP (1988a). Greenpod production is calculated as follows. The Bean and Cowpea CRSP estimated 1985 cowpea 'grain' production at 66000 t for all Senegal. The EC estimated 1985 production of grain and greenpods to be 80000 t; the difference between the two estimates can be taken to represent greenpod production (CRSP, 1988a). This results in a greenpod:grain ratio of 0.21. It is assumed that this ratio also holds in 1986, and greenpod production is calculated accordingly.

Cowpeas were given a higher priority in the national agricultural agenda and farmers gained confidence in cowpeas as an alternative crop to peanuts (Bunting, 1987).

In 1986, Operation Cowpea continued at a reduced funding level of $600,000. As in 1985, this money was spent on the distribution of improved variety seed, this time primarily the variety 58–57, complementary inputs and extension of farming practices. In 1986, the distribution and extension efforts were often late (after planting time) and seed was often of poor quality. Yields fell to 466 kg/ha and area planted fell to 117707 ha, causing grain production to decrease to 54863 t. In 1987, the program was discontinued due to lack of donor support.

ECONOMIC VALUATION OF BENEFITS AND COSTS [2]

Methodology

The calculation of benefits and costs follows the procedure used by Griliches (1958). Data are insufficient for the use of more sophisticated

[2] Much of the computational detail is omitted due to length considerations.

techniques. In the Griliches procedure, the benefits of the research and distribution program are approximated by the increase in the net value of production (net of production costs) from before the program to after the program. This implicitly uses the pre-program value of production as an approximation to the value that would have been produced during the program years if the program had not been in place.

The approximation of net benefits by increased production value has a potential disadvantage: it is not always easy to determine the effect of the research, extension and distribution program on yields or area, because changes in other factors such as rainfall or price policy could also affect yields or area. For Operation Cowpea this does not appear to be a problem. The rapid implementation and short duration of the program mean that long-term factors such as the human capital of farmers will not change much. Rainfall in 1985 and 1986 was poor, and near the average rainfall from 1980–84. The cowpea price policy did change, with the government establishing a support price for cowpeas of 100 CFA/kg concurrently with the implementation of the operation. However, an examination of market price data indicates that the government price support program was ineffective. [3] Hence, it appears reasonable to attribute the shift in cowpea yields and area from 1980–84 to 1985–86 to the research and distribution program.

Prices

The quality of available data on producer prices for cowpeas prior to 1986 is poor, although the available data indicate that consumer prices appear to be stable during the 1980–86 period. Consequently, 1986 producer prices are used to value production in all years. There is some evidence that 1986 producer prices were lower than 1985 producer prices; to the extent that the actual price in 1985 is underestimated, [4] so are the benefits of the program, which will impart a downward bias to the estimated ROR.

[3] The support price was not binding, and the government purchased only 5000 t in 1985 – less than 10% of production. In 1986 "the government lowered the floor price for cowpeas by almost 10%, and after a strong market in August and September was unable to guarantee the official price" (Bingen et al., 1988, p. 860).

[4] The returns to research literature is often criticized as presenting upwardly biased ROR figures, so whenever approximations are necessary, approximations that impart a downward bias will be chosen.

ISRA has reliable data on producer prices starting in February 1986 for several locations in northern Senegal. During the planting season, prices ranged from 115 CFA/kg in Kebeme to 175 CFA/kg in Gandia with a simple average of 140 CFA/kg. Prior to the main agricultural harvest, the average price rose to 150 CFA/kg, and then fell to 55 CFA/kg at the main harvest but recovered to 70 CFA/kg within a month. Based on these prices, greenpod production is valued at 150 CFA/kg and grain production at 70 CFA/kg.

Increases in production value

The value of cowpea grain production increased from an annual average of 1050×10^6 CFA from 1980–84 to 4620×10^6 CFA in 1985, then decreased to 3840×10^6 CFA in 1986. The estimated value of greenpod production was 2100×10^6 CFA and 1725×10^6 CFA in 1985 and 1986, respectively, leading to total production value of 6720×10^6 CFA and 5568×10^6 CFA for these 2 years.

The increase in production value is the difference in production value from before the program to after the program. However, the program was designed to promote cowpea production in a peanut-growing region. At a value of 90 CFA/kg, the value of displaced peanut production is 1540×10^6 CFA in 1985 and 1460×10^6 CFA in 1986.

Finally, it is assumed that the quality and quantity of fodder produced by traditional and improved variety cowpeas and peanuts are approximately the same. [5]

Increases in production costs

The improved varieties CB-5 and 58–57 require greater input use than do the traditional varieties, including a greater quantity of seed, insecticides, and labor. Figures on costs are available for seeds and insecticides.

[5] The quality assumption is satisfactory since the nutritional value per kg of cowpea fodder is roughly equivalent to that of peanut fodder (Cullison and Lowrey, 1987). The quantity assumption is not generically true. In average to above-average rainfall years with long growing seasons, peanuts and the bushier, traditional varieties of cowpeas produce more plant material than do improved variety cowpeas. However, in northern Senegal during 1980–86 rainfall was 200 mm or less in some years. Under these conditions, the fodder production of short-cycle, drought-resistant cowpeas equals and may surpass that of longer-cycle traditional variety cowpeas and peanuts. Thus it is reasonable to assume that the cowpea program had little effect on fodder production.

Senegalese cowpea data on labor use or costs are not available. The increase in labor requirements used in this paper is taken from Coulibaly's study (1987) of cowpeas in Mali, and an approximation of the shadow price of farm labor is taken from Martin's analysis (1988) of several crops in Senegal. On that land where the increased cowpea area displaced peanuts, Martin's crop budgets for peanuts are used.

Subtracting the increased production costs from the increased production value gives the net change in production value attributed to the program. Using the value of increased grain production as the change in total production value leads to estimated increases in net production value of 1430×10^6 CFA in 1985 and 1103×10^6 CFA in 1986. These figures do not include the value of any increase in greenpod production, resulting in a conservative estimate of benefits attributed to the program.

Program costs

Operation Cowpea was funded by a consortium of international donors working through FAO, at US\$1 000 000 in 1985 and US\$600 000 in 1986. This operation built on previous work of the CRSP, including research on cowpeas and cowpea production, and training of Senegalese scientists, which eventually made it easier to implement the operation. Total program costs include the recurrent costs of the CRSP research program estimated at US\$160 000 per year; costs of U.S. education and training of Senegalese scientists, which vary from year to year; and the Operation Cowpea costs of US\$1 000 000 in 1985 and US\$600 000 in 1986.

RESULTS

The ROR is that value of the variable r which solves:

$$\sum_{t=0}^{\bar{t}} \left[\frac{1}{1+r}\right]^t (B_t - C_t) = 0$$

where the starting date of the program is defined to be time 0, and $\bar{t}$ is the final period in which there are non-zero program benefits or costs. B_t and C_t are the benefits and costs of the program at time t.

The nominal rate of return is estimated to be 31% (Table 2, scenario 1). [6] This number is nominal in the sense that neither the annual benefits nor the annual costs are adjusted for inflation, so that the real rate of

[6] Benefits were converted to US\$ at the exchange rates of 449 CFA/US\$ and 346 CFA/US\$ in 1985 and 1986, respectively.

TABLE 2

Program benefits, costs and rates of return

Year	Benefits	Benefits	Costs
	Current CFA × 10^6	Current US$	Current US$
Scenario 1: Grain-displaced peanuts			
1981	0	0	350000
1982	0	0	360000
1983	0	0	395000
1984	0	0	390000
1985	1537	3423000	1325000
1986	713	2061000	866000
Rate of return = 31%			
Scenario 2: Grain and green podisplaced peanuts			
1981	0	0	350000
1982	0	0	360000
1983	0	0	395000
1984	0	0	390000
1985	3602	8022272	1325000
1986	2199	6355491	866000
Rate of return = 92%			

return is approximately equal to the nominal rate of return less the nominal cost of capital. In the U.S., where much of the program funding originated, nominal capital costs exceeded 15% for some years in the 1981–86 period, so that the 31% ROR indicates a moderately successful program. Also, the conservative assumptions used may impart a downward bias to the estimated ROR, so that the actual returns to research may be somewhat higher.

For example, if the increased cowpea area did not displace peanut area (that is, if the increased land planted to cowpeas had zero value in alternative production), then the benefits from the cowpea program are estimated to be US$5101 × 10^3 in 1985 and US$4726 × 10^3 in 1986.[7]

[7] For the 52700 ha planted to traditional varieties in 1980–84, benefits remain the same as in the base scenario value of 1985 or 1986 grain production less from improved varieties less the value of 1980–84 average grain production from traditional varieties less increased production costs. For the remaining acres, benefits are calculated to be value of grain production plus value of fodder production less production costs of improved varieties.

Under this scenario, the estimated ROR is 66%. The increase in the ROR can be interpreted to represent the returns to having a short-cycle, drought-resistant variety available to plant in low-rainfall years, when late rainfall shortens the growing season or when inadequate quantities of rain prevent a peanut crop.

As a second example, the 38% ROR does not include the value of greenpod production as a benefit because this value is hard to determine precisely. Including the estimated value of greenpod production at pre-harvest prices raises the estimated ROR to 92%, which is an excellent return on investment (Table 2, scenario 2). The difference between the estimated RORS with and without including greenpod production highlights the value of increasing food production during the hunger season immediately preceding the traditional harvest.

CONCLUSIONS

The results of this paper indicate that the cowpea research, extension and distribution program in Senegal has been successful. This success depended on the ability of collaborative research to breed and maintain potentially successful cowpea varieties and to identify these varieties and complementary farming practices for this particular application, the ability of the extension service to disseminate these practices among the farm community, and the subsidized distribution of seed and complementary inputs.

These results are consistent with the congruence rule, which states that the optimal level of research investment should be proportional to the relative value of the agricultural commodity under consideration (Norton and Davis, 1981). The basis of this rule is the observation that research that generates benefits equal to a fixed proportion of the value of production will generate greater benefits when directed towards a commodity with a higher value of production (Griliches, 1958; Bredahl and Peterson, 1976). Current results indicate that research with a modest budget can be effective even if applied to a crop of secondary importance.

The effectiveness of the program in 1985 and 1986 indicates that, in a drought year when peanuts cannot be grown, replication of the distribution and extension program would be successful, even if annual costs were to exceed US$1 million. Identifying which years will be drought years is problematical. Implementing an emergency program once it has been determined that drought conditions are present may substantially raise costs and lower benefits. Nonetheless, this policy option deserves further investigation.

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