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COMMERCIAL PRODUCTION OF SOYBEANS IN COSTA RICA

An Agro-economic Feasibility Study

Conducted for CARE/USAID OPG 515-0127

by

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SUMMARY

Stimulated by a guaranteed (though small) national market there has been renewed interest toward introducing soybeans into Costa Rica at a commercial level. The Ministry of Health nutrition program, and complementary processing plant, will provide sufficient demand to utilize soybean production from 800-1,000 hectares. Concrete support has been offered by the government with regard to production credit, crop insurance, and marketing. It has agreed to finance and insure up to 500 hectares in 1979, and will perform all marketing services.

Based upon the sparse information that exists and the opinions of technicians who have experience with soybeans in Costa Rica there are strong indications that the crop is agronomically feasible. Comparative farm budget studies indicate that soybeans could compete with alternative crops, even at fairly modest yields (25 qq/ha).

The principal region selected for the 1979 planting is Guanacaste. Introducing soybeans in this zone has the following advantages:

a. experience exists with varieties and planting dates,

b. climatic conditions are favorable,

c. they complement existing cropping pattern,

d. there is existing farm level infrastructure,

e. adequate marketing facilities for cleaning, drying, and storage are available, and

f. it is a priority area for crop diversification as determined by government planning.

In order that this first attempt to introduce the crop on a significant level have the greatest possible chance of success planning and coordination are key elements. Due to its vested interest in the project, and the availability of time and resources, CARE will perform important functions during the 1979 planting season:

a. coordinate the inputs of the participating institutions,
b. monitor crop progress,
c. provide technical assistance to farmers,
d. provide seed and innoculant, and
e. guarantee the market for all production.

INTRODUCTION

During the last two decades CARE and USAID have stimulated nutrition feeding programs in Costa Rica through the donation of U.S. Public Law 480 Title II Commodities. Beginning in 1974 discussions were held between the Government of Costa Rica, USAID and CARE to plan for the eventual phase-out of these donated commodities. The objective of these discussions was to establish a systematic program for the continuation of the nutrition feeding programs utilizing indigenous commodities. In order to do this it was felt necessary to create an infrastructure base for which the commodities could be produced, processed and distributed in Costa Rica. On September 29, 1976 USAID and CARE signed an Operational Program Grant (OPG-515-0127) for a project having the dual purpose of soybean production and a low cost processing

plant whereby the soybeans produced along with other indigenous commodities could be processed into nutritious food products for the feeding programs in Costa Rica.

The purpose of the grant now in its third year is to: 1) establish, equip and staff a manufacturing facility to produce inexpensive nutritious blended foods and protein supplements; and 2) demonstrate the economic feasibility of producing soybeans in Costa Rica for use as a raw material for the production of nutritious blended foods and protein supplements for low income groups.

The accomplishment of the project to date for the soybean production aspect of this project has been limited to experimentation and demonstration production due to the fact that no market has existed on a commercial scale for the soybeans. The project is now at a critical juncture given the fact that the low cost extrusion cooking plant has been constructed, equipped and a management service contract is about to be signed for the operation and management of the plant. The Ministry of Health (MOH/CARE) plant will thereby provide a guaranteed market of a minimum of 1,500,000 lbs. (680 M.T.) of soybeans per year. This should serve to encourage and stimulate the soybean production. It is therefore felt to be a critical time to take a look at where the project has been and its future potential for realizing the objectives of the project.

METHODOLOGY

This study presents an economic analysis of soybean production in Costa Rica, and in part looks to principles of production economics and profit motivation as factors which influence the farmers decision making process and selection of farm enterprise activities. The decision to produce a specific crop mix on available land is influenced by the (a) cost and availability of factors of production; (b) ecological conditions, (c) expected price of the agricultural commodities; and (d) production and marketing uncertainties.

In order to determine the technical and economic feasibility of introducing soybeans into Costa Rica as a competitive commercial crop alternative, the following procedure was used:

1. Select the most appropriate geographical region for soybean production;
2. Estimate the technical coefficients for producing soybeans in the selected area;
3. Transform the technical coefficients into cost estimates;
4. Calculate the net return to land from soybeans; and
5. Compare the net return to land from soybeans with that for alternative crops.

In addition to considering the technical and economic aspects of soybean production at the farm level, the study discusses the institutional support necessary for a national program in soybeans.

Information for this study was derived from two sources: (a) interviews with officials representing research, extension, education, banking, insurance and agricultural policy institutions (Appendix I), and (b) reports provided by the Central Bank of Costa Rica, CARE, USAID/CR, the Ministry of Agriculture, INTSOY, and the University of Costa Rica. The study was conducted during the period January 29 to February 9, 1979.

LOCATION OF SOYBEAN PRODUCTION

Three factors are examined with regard to selecting the initial site(s) in which to introduce soybeans as a commercial crop:

-- Agronomic and ecological conditions.

-- Land use and infrastructure characteristics.

-- Public policy.

As indicated in Figure 1, Costa Rica is divided into five agricultural administrative regions: the Central Valley, the Altantic Zone, the Northern Zone, the South Pacific Zone and the Dry Pacific Zone.

In the Central Valley most agricultural land is dedicated to high valued horticultural and permanent export crops, shown in Table 1. Soybeans cannot compete with the income producing capability of coffee, tomatoes, onions and potatoes in this region, nor are the topography and elevation of the area suitable for soybean cultivation. At the higher elevations (and lower temperatures) of this zone soybean yields

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SECO
ZONA
NORTE
OCEANO ATLANTICO
ZONA
ATLANTICA
VALLE
CENTRAL
PACIFICO
SUR
OCEANO PACIFICO
PANAMA

FIGURE 1

TABLE 1. CROP AND LIVESTOCK CONTRIBUTION TO FARM VALUE OF PRODUCTION BY REGION

Agricultural Region and Farm Size	Percent Contribution to Total Value of Farm Production		
	Annual Crops	Perennial Crops	Livestock Products
Central Valley			
2 to 3 Ha.	10	51	39
5 to 10 Ha.	7	60	33
10 to 20 Ha.	6	60	34
North Zone			
2 to 3 Ha.	13	42	45
5 to 10 Ha.	13	44	43
10 to 20 Ha.	23	70	7
Dry Pacific			
2 to 3 Ha.	20	5	75
5 to 10 Ha.	15	7	78
10 to 20 Ha.	13	6	81
South Pacific			
2 to 3 Ha.	15	44	41
5 to 10 Ha.	13	43	44
10 to 20 Ha.	16	43	41
Atlantic Zone			
2 to 3 Ha.	8	31	61
5 to 10 Ha.	10	47	43
10 to 20 Ha.	12	45	43

SOURCES: From Daines, Representative Small Farm Analysis, Table 22.

are relatively low. In addition, topography is normally too steep for mechanized production techniques. As indicated in Table 2 over 70 percent of the total area is classified as steep.

In the Atlantic Zone there is also strong competition from high valued perennial crops. Approximately 44% of the value of agricultural production is from banana, plantain and cacao. Also, major problems for soybean production in this area would be encountered due to excessive rainfall throughout the year. The total zone is characterized as humid (Table 2) making weed and disease control, and mechanical operation during the crop cycle more difficult and costly. Also, a high moisture content at harvest time greatly increases problems of harvesting, handling and storage.

In the Northern Zone, the cropping patterns are essentially the same as those in the Atlantic Zone (Table 1), having the large majority of agricultural land in coffee and livestock operations. High humidity conditions during much of the year will be accompanied by problems in mechanical planting and harvesting, and weed control. There are areas within this region (Upala, for example) which are suitable for soybean production which are dedicated to bean production, which is possibly of higher value and certainly of higher national priority at present.

The South Pacific Zone has agronomic characteristics which make it suitable for soybean production. However, on the flatter land soybeans would have to compete with corn and rice, and the rainfall patterns favor rice and corn production. This region, however, is likely

TABLE 2. LAND CLASS CHARACTERISTICS BY PHYSICAL ZONE IN COSTA RICA

	ZONES			
	Pacific Litoral	Central Northern	Central East	Atlantic Litoral
SOIL TYPE 1/		%		
Class I	19	28	12	30
II	32	53	15	10
IV	12	6	9	15
Forest	37	13	64	45
TOPOGRAPHY				
Level	34	34	14	80
Steep	66	66	86	20
TEMPERATURE				
Warm	90	80	8	91
Temperate	9	17	82	9
Cold	1	3	10	-
RAINFALL				
Dry	68	12	45	0
Humid	32	88	55	100

PACIFIC: Guanacaste, Puntarenas
CENTRAL NORTHERN: Alajuela, Heredia
EAST CENTRAL: San José, Cartago
ATLANTIC: Limón

1/ Class I Soils suitable for intensive cropping (e.g. annuals).
Class II Soils generally in permanent crops or pasture.
Class IV Soils suitable for pasture.

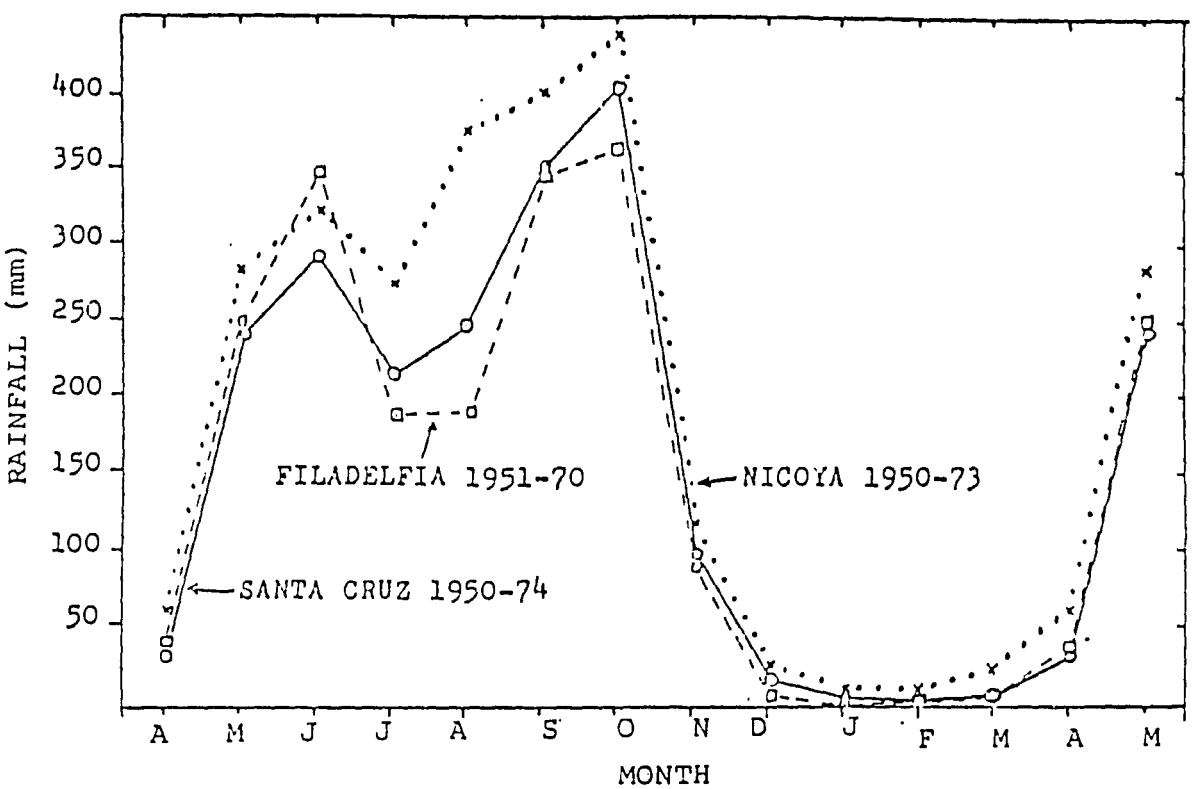
to be the second area into which soybean production moves, very possibly as a rotation crop on smaller farms.

The Dry Pacific Zone offers adequate ecological conditions for soybean production. There is little competition with the higher valued perennials which contribute only 6 percent of the zone's agricultural total value product. The Guanacaste area of the Dry Pacific has a short dry period (canícula) during the rainy season that is prejudicial to rice and corn production.

The rainy season extends from May to November in the Guanacaste retion, however, during the last two months there is high annual variability of rainfall. Soybeans which are more resistent to low moisture and have a shorter crop cycle than either rice or corn, are more likely to produce a commercial crop under adverse conditions. Soybeans planted in the second half of the rainy season (e.g. as a rotation crop) will have a good probability of reaching physiological maturity before the water supply is exhausted. Harvesting in early December, well into the dry season (see Figure 2), would guarantee low moisture content of the grain.

The introduction of commercial soybean production into Costa Rica is feasible in the Dry Pacific (Guanacaste) region of the country. The area is flat, possesses the required ecological conditions support development in large areas of the zone, and has been identified by the

FIGURE 2. ANNUAL RAINFALL DISTRIBUTION IN THE GUANACASTE REGION



100 mm. = 4 inches.

Presently large areas of Guanacaste are planted in rice and the yields in this zone are substantially below those in other zones (e.g. South Pacific). In addition, as indicated earlier, the irregularity of rainfall during the latter part of the dry season has a negative effect on the region's yearly production average. The Costa Rican Government's planning for agricultural development contemplates that 20,000 hectares will be taken out of rice production in the Dry Pacific Zone over the next few years. To date, sorghum and cotton have been identified as alternative crops to replace rice, and short cycle oil crops are being named as a new activity to aid in filling the void as rice areas are decreased. Soybeans, one of the important oil crops, have been identified as a promising activity because of several attributes:

-- lower moisture requirement than rice;

-- shorter cycle permits double cropping (especially rotation with corn);

-- high protein content for human and animal consumption;

-- high quality oil content;

-- infrastructure and technology existing in the area can be used in soybean production and handling.

The market offered by MOH/CARE, although limited, bridges an important gap often encountered when attempting to introduce a new commercial crop.

The policy declarations by the government in support of soybeans have been backed by an offer to finance and insure, through public

institutions, up to 500 hectares of plantings in 1979. Guanacaste has been identified as the primary site for crop introduction, and these monetary policy instruments are being used to guide the development of soybeans into this zone.

In order to reach a threshold level of production within a relatively short period, and to economize on production costs, the introduction of soybeans will focus on medium to large farm units where mechanization can be used. A further reason for choosing the Dry Pacific (and secondarily the South Pacific) zone as the principal target area is the mechanization capability which already exists. It is generally believed that a national soybean program must rely in part on large scale mechanized production (perhaps Paraguay provides a notable exception), and Guanacaste provides a functioning mechanized production capacity. Using mechanical harvesters as an indicator of machinery sophistication in production, Table 3 indicates the advantage that Guanacaste presently has. Considering that much of this machinery is now used in rice production, it is seen that it could become available to soybeans (and sorghum) as rice areas are diminished.

TABLE 3. NUMBER OF MECHANIZED HARVESTERS IN COSTA RICA, BY AGRICULTURAL ZONE

Zone	Number of Harvesters
Central Valley	43
Atlantic	6
Northern	14
South Pacific	369
Dry Pacific	609

SOURCE: 1973 Agricultural Census.

PRODUCING SOYBEANS IN COSTA RICA: RESEARCH AND FARM EXPERIENCE

Soybean research and supervised field trials have been conducted during the past 10-15 years by the University of Costa Rica, Ministry of Agriculture, and CARE-Costa Rica. In spite of this rather long acquaintance with soybeans in Costa Rica, little is available on which to base a national program. Field work has been sporadic and soybean research has not been given the same priority as accorded other basic foods. The major research that has been concentrated in Guanacaste and focused on the identification of appropriate varieties and cropping calendar. Little has been done in the areas of fertilizer use, cultivation techniques, weed control, or disease and pest control. Existing information is presented in the following tables and discussion, as well as in a descriptive bulletin (published by the CARE/USAID OPG) which summarizes the University of Costa Rica's experience to date (Appendix III).

Tables 4-6 indicate yields which have been obtained in trials with different varieties, locations and planting dates. These dates indicate generally the influence that timing may have on yields. The wide fluctuations experienced, however, make it difficult to specify the most favorable month for planting, and that these experiments were conducted in different years makes it impossible to separate the annual effect from the monthly effect. Further, information on yields obtained in field trails does not enlighten us as to problems in harvesting due to wet conditions (a high risk with May/June plantings), nor grain quality. However, it must be noted that this is the only information available

TABLE 4. AVERAGE SOYBEAN YIELDS FOR DIFFERENT PLANTING PERIODS IN GUANACASTE, 1968 (EXPERIMENT STATION RESULTS)

Month of Planting	Average Yield qq/ha.
June	46.2
July	42.1
August	34.1
September	23.1

Variety: Improved Pelican

Source : Rolando Gutiérrez V.,"Investigaciones Sobre el Frijol de Soya" MAG Bulletin, 1968 (Table 2, pg. 16).

TABLE 5. AVERAGE SOYBEAN YIELDS FOR DIFFERENT PLANTING PERIODS IN GUANACASTE, COSTA RICA 1973-76 (EXPERIMENT STATION RESULTS)

Month of Planting	Average Yield qq/ha.
May	59.4
August	46.2
September	39.6
October	35.2
November	30.8

Varieties: Williams (III), Calland (III), Clark-63 (IV), Davis (VI), Improved Pelican (VIII), Hampton (VIII), Jupiter (IX), Semmes (VIII).

Source : Rodrigo Alfaro M., "Pruebas Comparativas de Cultivares de Soya en Cinco Epocas de Siembra en Guanacaste", Agron. Costar., 1(2): 129-141, 1977.

TABLE 6. EXPERIMENT STATION RESULTS WITH DIFFERENT SOYBEAN VARIETIES IN GUANACASTE, COSTA RICA

Variety	Planting Date	Yields qq/ha.	
Improved			
Pelican	18/8/76	45.4	
	3/9/75	39.8	
	6/10/75	31.1	
Average: Improved Pelican			38.8
Jupiter	18/8/76	41.7	
	3/9/75	41.7	
	6/10/75	46.5	
Average: Jupiter			43.3
VFV-1	18/8/76	55.5	
Average: VFV-1			53.5
Clark-63	18/8/76	55.6	
	3/7/75	36.7	
	6/10/75	30.0	
Average: Clark-63			40.8

Source: Rodrigo Alfaro M. "Pruebas Comparativas de Cultivares de Soya en Cinco Epocas de Siembra en Guanacaste", Agron. Cost. 1(2) 129-141-1977.

and that the results are very positive with respect to yields. This level of production obtained during experimental work is in agreement with the observations and conclusions expressed by various technicians of INTSOY, among whom the consensus is that there are significant areas in Costa Rica in which yields of two metric tons (44 qq) are commercially feasible (trip reports by Minor, 1977 and Sager, 1978).

The largest recent effort to bring soybeans into Guanacaste was in 1977 and was done under the direction of CARE-Costa Rica. Due to the wide variation in yields, small areas planted, possibly late planting date, and lack of diagnostic information attempting to explain the overall poor results obtained, little benefit is gained from the experience. Again, one can be encouraged by the high yields obtained by a few farmers, but there were over 50% of the farm trials which yielded less than 8 qq per hectare.

SOYBEAN PRODUCTION: COSTS AND RETURNS

In order that production costs calculated for this study have a wide range of application, farm budgets for soybeans were estimated for two levels of production technology: mechanized and semi-mechanized. These budgets (Tables 7 and 8) represent a composite drawn from information prepared by the Central Bank, for credit purposes; the Insurance Institute, to determine levels of coverage; CARE, based on their experiences in 1977; and the results indicated by experimental

data. Technical coefficients and prices were adjusted to reflect present conditions and prices. Average yields indicated for the two systems of production reflect a consensus of persons with experience in soybean production, as well as estimates used in the several budget calculations mentioned earlier.

Costs

Average per hectare costs were calculated for the mechanized and semi-mechanized systems. For the former, the cost associated with a yield of 25 qq. was ₵2,883.00 per hectare; changes in yields will affect costs according to associated harvest and handling expenses. The semi-mechanized technology cost rose to ₵3,935.60 per hectare for an average yield of 25 qq., principally as a result of a more intensive use of labor in weed control and harvesting.

These high costs associated with the semi-mechanized system, however, are subject to modifications, and will decrease as increased mechanization is employed. The cost estimates presented here represent the upper extreme for a semi-mechanical operation.

Yields

In calculating the farm budgets an average yield of 25 qq. per hectare was used. It is to be expected that as experience is gained with soybeans the potential commercial yield will increase, and a higher proportion of farmers will attain acceptable levels of production.

TABLE 8. ESTIMATED FARM LEVEL BUDGET FOR GROWING SOYBEANS IN GUANACASTE, COSTA RICA - (SEMI-MECHANIZED FARM)

	Explanation	Unit	Per Hectare Cost ¢
	Labor and Machinery Cost		
1.	Land preparation	5.65 m.hr.	621.50
2.	Hand planting with fertilizer	40.0 p.hr.	160.00
3.	Spray applications	18.0 p.hr.	72.00
4.	Weeding (2 times)	160.0 p.hr.	640.00
5.	Harvesting (hand pulling)	160.0 p.hr.	640.00
6.	Threshing	25 qq	500.00
7.	Transport	25 qq	50.00
8.	Subtotal		2,603.50
	Materials		
9.	Seed and inoculant	1.50 qq	450.00
10.	Fertilizer 10-30-10	150 kgs	300.00
11.	Soil insecticide	20 kgs	248.00
12.	Insecticide	1 lt.	90.00
13.	Subtotal		1,088.00
	Other Costs		
14.	Use of sacks	25 sacks	50.00
15.	Social charges		44.10
16.	Interest (12% per annum-6 Mos.)*		150.00
17.	Subtotal		244.10
	Total Cost per Hectare (8+13+17)		3,935.60

* Interest cost estimate is based on the sum of 1, 2, 3, 4, 9, 10, 11 and 12.

m.hr. = machinery-hour
p.hr. = person-hour

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Price [1/]

MOH/CARE will pay ₡160/qq for the 1979 harvest, subject, of course, to the standard adjustments made for moisture and impurity levels. This price was established at its present level in order to provide an incentive for producers to enter into a new activity, in the face of its inherent risks and uncertainties regarding costs and yields. The price is somewhat above world market levels (approximately ₡110/qq) to provide the farmer a competitive return vis-a-vis alternative crops.

1/ US$1.00 = ₡8.54

Returns to Land

Net return to land from soybeans is that money which remains after all other production and marketing costs excluding land have been paid. Tables 9 and 10 show the expected return to land at various levels of yield and price. The potential net return situation under the mechanized system of production is, at first glance, much more favorable than that using semi-mechanized technology. However, in the final analysis, one must estimate the portion of total labor payments which accrues to family labor. This figure must then be added to the net return, as calculated above, to determine the total income derived from soybean production. This consideration will obviously have serious application only in the case of small farm production where a significant portion of labor input is provided by the family.

Soybeans as an Alternative Crop in Guanacaste

In the previous section, it was demonstrated that there exists a

TABLE 9. NET RETURN* TO ONE HECTARE OF LAND IN SOYBEAN PRODUCTION IN GUANACASTE, COSTA RICA - (MECHANIZED FARM)

Prices ₡/qq	Yields - qq/ha. 20	25	30	35
130	-163.00	367.00	897.00	1,427.00
140	37.00	617.00	1,197.00	1,777.00
150	237.00	867.00	1,497.00	2,127.00
160	437.00	1,117.00	1,797.00	2,477.00
170	637.00	1,367.00	2,097.00	2,827.00

* Based on an estimated cost of ₡2,283.00 per hectare pre-harvest costs. Total costs include this amount plus ₡120.00 for each 5 qq. of production which represent harvest and post-harvest handling costs.

TABLE 10. NET RETURN* TO ONE HECTARE OF LAND IN SOYBEAN PRODUCTION IN GUANACASTE, COSTA RICA - (SEMI-MECHANIZED FARM)

Prices ¢/qq	Yields - qq/ha. 20	25	30	35
130	-1,087.60	-685.60	-283.60	118.40
140	- 887.60	-435.60	16.40	468.40
150	- 687.60	-185.60	316.40	818.40
160	- 487.60	64.40	616.40	1,168.40
170	- 287.60	314.40	916.40	1,518.40

* Based on an estimated cost of ¢2,695.60 per hectare pre-harvest costs. Total costs include this amount plus ¢248 for each 5 qq. of production which represent harvest and post-harvest handling costs.

range of price-yield combinations which result in positive net returns to land in soybean production. This, however, does not become relevant unless compared to the net returns to alternative crops. In the Guanacaste area these crops are corn, rice, sorghum and cotton. Net returns were estimated for these crops when yields are varied and prices are held constant at the official rates.

In the case of corn, for example, one hectare of land will yield ₡92.30 at 40 qq/ha. and ₡2,552.35 at 70 qq/ha. (Table 11). If soybeans are to compete with corn, at the given product price/input cost relationships, soybean yields must average about 50 percent of corn yields. At a price relationship between soybeans to corn of ₡160:₡82, 27 qq/ha. of soybeans would complete with 55 qq/ha. of corn on the mechanized farm. However, much uncertainty exists regarding the yields which would be obtained for corn in Guanacaste. The 1973 Agricultural Census indicates that average per hectare yield for farms over 50 hectares during the second planting season was only 25 quintales. This is the season appropriate for soybeans, and perhaps the estimated yields of 55 quintales per hectare used by the Insurance Institute are overly optimistic, and that, in fact, soybeans are highly competitive.

Table 12 reports the net return to land in rice production. As indicated, positive returns are obtained at the 30 qq/ha. level. In 1973, the agricultural census reported an average rice yield in the Dry Pacific of about 35 quintales per hectare. At this level of rice productivity, soybeans would be able to compete if yields averaged 25 quintales, and price per quintal were ₡160.

TABLE 11. NET RETURN TO LAND IN CORN PRODUCTION IN GUANACASTE GIVEN FLUCTUATIONS IN YIELD (PRICE = ₡82/qq.)

Yield (qq/ha)	Return/Hectare* (₡)
25	-1,137.70
30	- 727.70
35	- 317.70
40	92.30
45	502.30
50	912.30
55	1,322.30
60	1,732.30
65	2,142.30
70	2,552.30

* Based on cost estimate of ₡3,187.70

TABLE 12. NET RETURN TO LAND IN RICE PRODUCTION IN GUANACASTE GIVEN FLUCTUATION IN YIELDS (PRICE = ₡132.10)

Yield (qq/ha)	Return/Hectare* (₡)
25	- 208.55
30	451.95
35	1,112.45
40	1,772.95
45	2,433.45
50	3,093.95
55	3,754.45
60	4,414.95
65	5,075.45
70	5,735.95

* Based on an estimated cost per ha. of ₡3,511.05

Similarly, in Table 13 it can be seen that sorghum (which is the most competitive crop with soybeans from agronomic and marketing aspects, as well as being a high priority crop for Guanacaste) will closely approximate soybean returns with yields over 50 quintales per hectare. In the 1973 Agricultural Census the average yield was 51 quintales. Given the additional experience since that time, and the emphasis it will receive as a rice substitute, it can be expected that present sorghum yields are significantly higher than 1973 levels.

Finally, Table 14 shows cotton to be a lucrative crop when yields of greater than 13 qq/ha. of fiber are obtained (approximately 37 qq/ha. seed cotton). What is not shown in the table is the high risk factor associated with cotton production; a factor which keeps most farmers out of this activity, and all but eliminates strong competition between cotton and soybeans, under present conditions.

Tables 15 and 16 summarize the competitive positions between soybeans and alternative crops in the Guanacaste region. The values shown should be taken more in the sense of indicators of tendencies and relative magnitudes rather than single value references for comparisons. Yield and cost uncertainty dictates that several factors be weighed regarding the selection of one alternative over another.

Institutional Position

The evaluation of the institutional position regarding soybean introduction into Costa Rica is based upon interviews and complementary

TABLE 13. NET RETURN TO LAND IN SORGHUM PRODUCTION IN GUANACASTE (PRICE = ₡65)

Yield (qq/ha)	Return/Hectare* (₡)
30	- 651.90
40	- 1.90
50	648.10
60	1,248.10
70	1,948.10

* Based on an estimated cost per hectare of ₡2,601.90.

TABLE 14. NET RETURN TO LAND IN COTTON PRODUCTION IN GUANACASTE (PRICE = ₡520.90)

Yield 1/	Return/Hectare* (₡)
10	490.59
11	30.31
12	551.21
13	1,072.11
14	1,593.01
15	2,113.91
16	2,654.81

* Based on an estimated cost per hectare of ₡5,699.59

1/ Quintals of fiber per hectare.

TABLE 15. MINIMUM YIELDS NEEDED TO COVER PRODUCTION COSTS IN GUANACASTE AT OFFICIAL PRICES

Product	Mimimum Yield/Ha. (qq)	Average Farm Yield/Ha. (qq)
Corn	38.8	55.0 1/
Rice	26.5	36.5
Sorghum	40.0	50.0
Cotton	10.9	13.0

1/ Probably over estimated. 35-40 qq/ha. would more likely be a closer estimate for overall commercial corn production.

TABLE 16 POINT ESTIMATES OF TOTAL REVENUE, COST RETURNS TO ONE HECTARE OF LAND PLANTED IN SOYBEANS OR ALTERNATIVE CROPS IN GUANACASTE, COSTA RICA

Crop	Price	Yield	Total Revenue	Total Costs	Net Return to Land	Net Return % of Total Costs
	(¢)	(qq)	(¢)	(¢)	(¢)	(%)
Soybeans						
Mechanized Farm	160.00	25	4,000	2,283	1,717	75.2
Mechanized Farm	160.00	30	4,800	3,003	1,797	59.8
Semi-Mechanized Farm	160.00	30	4,800	4,184	616	14.7
Corn	82.00	55	4,510	3,188	1,322	41.4
Rice	132.10	36.5*	4,823	3,511	1,312	37.4
Sorghum	65.00	50	3,250	2,602	649	24.9
Cotton	520.90	13.1	6,813	5,700	1,113	19.5

* 1973 Agricultural Census date for second cycle (i.e., planting in months August-November).

date obtained from planning documents. Information gained from the former source is particularly difficult to reproduce in that there are many intangibles that one carries away from interviews and group exchanges. In an attempt to faithfully relay the total institutional position, the discussion will be divided among:

-- general impressions;

-- tentative plans;

-- concrete offers.

The overriding feeling that has pervaded all interviews has been one of enthusiasm and optimism toward developing commercial soybean production. The opportunity offered by CARE/USAID project (although on a limited scale) for technical and financial support in production and marketing activities seems to have provided a catalyst to solidify and coordinate already existing ideas regarding soybeans. There appears to be a concordance within the institutions that they display a certain flexibility in the face of the uncertainties associated with this new enterprise. Although past experience has been limited and widely varied, it is believed that soybeans could offer a crop alternative which responds to several current needs in the agricultural sector.

Soybean research which is being conducted by both the Ministry of Agriculture (MAG) and the University of Costa Rica will, at minimum, continue at its present level. The University is working principally in variety introductions and testing, and responses to

different planting dates. One of the primary goals in this testing and observing is to identify those plant characteristics in tropical varieties which are associated with high yields, which would enable the researcher to concentrate his selection and breeding on those factors.

Research activities in MAG also have focused on the behavior of different varieties during different planting cycles. It, however would like to expand its program to encompass production technology and practices, including planting densities, fertilization, and weed, pest and disease control. There is interest in elevating research in short cycle oil crops (including soybeans) to a separate activity, rather than a secondary area of study within other crop programs.

Operational support for the 1979 planting has been offered by the Banco Central (BC) and Banco Nacional (BN) (credit), Instituto Nacional de Seguros (INS) (insurance), and the Consejo Nacional de Producción (CNP) (marketing). The BC/BN has agreed to provide financing for up to 500 hectares principally, or entirely, in the Guanacaste region. To facilitate coordination between the BC/BN and other participating entities, exercise supervision over production activities, and allow greater flexibility for responding to changing financial needs, the BN will be the only channel through which soybean production credit will be offered. The initial per hectare financing level will be determined in joint discussions by appropriate institutions, and the interest rate will vary between 8-10% in accordance with BN policy.

The Instituto Nacional de Seguros (INS) has also agreed to allow up to 500 hectares in its program. Initially, the insurance limit is 60% of the estimated value of production per hectare. INS considers 30 qq/ha. as a realistic obtainable yield, and at ₡160/qq. the average value will be ₡4,800. Insurance covering 60% of this calculated value would pay a maximum of ₡2,880 in the case of complete loss. The premium to be charged for this coverage is computed at 6% of the maximum insured value, and is ₡172 per hectare.

Marketing will be through the various offices of the Consejo Nacional de Producción (CNP) (Figure 3) and the farmer will receive ₡160/qq., less adjustments for humidity, impurities and damage which will be established according to accepted criteria. The CNP will perform all drying, cleaning, handling, storage and transport needed to deliver an acceptable product to CARE/San José, and the price received will reflect the costs for these services.

The Role of CARE

During this first year of commercial soybean production, CARE will provide various goods and services:

-- Coordination

-- Supplier of seed and innoculant

-- Technical assistance

-- Market

COSTA RICA: Agencias de Compra del CNP.

FIGURE 3

The several functions of the institutions indicated earlier are to be performed in the service of an extremely small group of farms, which represent an insignificant part of the national agricultural sector. It would be impossible and irresponsible for these institutions to dedicate disproportionate resources to this activity in light of other demands and priorities. Yet, if the soybean program is to be successful in 1979, and grow in the manner desired, an intensive coordination effort must be provided. The principal functions as coordinator will be in the areas of farmer identification; information transfer regarding designated producers to the BN, INS, MAG and CNP; facilitating the flow of information between farmers and participating institutions; guaranteeing the timely acquisition of inputs; and the smooth functioning of the marketing mechanism.

The inputs for which CARE will be directly responsible are seed and innoculant. It will have to program the opportune transfer of acceptable quality seed from foreign source to the individual farmer. In addition, local availability of appropriate chemical products (including fertilizers, herbicides, and insecticides) must be assured.

The extension service of MAG does not have experience in soybean production. Technical assistance to farmers, and status reports to the BN for credit disbursement, must be performed by CARE agronomists. It would be highly recommendable that these agronomists present general concepts regarding soybean production to extension agents in the areas so that maximum benefit and experience will be gained during the crop cycle.

Finally, CARE is commited to the purchase of all production from farmers on the pre-planting register which CARE will develop. Market stability is a critical element and precedent in this first year of production.

CONCLUSIONS

1. Commercial production of soybeans in Costa Rica is both technically and economically feasible.

2. The principal region for introduction of soybeans should be Guanacaste (Pacífico Seco) where:

   a. There is experience with varieties and planting dates;

   b. The climatic conditions are favorable;

   c. It would complement present cropping patterns;

   d. There exists the farm level infrastructure;

   e. The government desires greater crop diversification;

   f. There are adequate market facilities for cleaning, drying and storage.

3. CARE must perform an important role in coordination, technical assistance, and marketing during the first year. MOH/CARE has a vested interest in soybeans as an intermediate goal in its established nutrition program. Up to this time USAID/CARE and the GOCR have committed sufficient resources to the soybean project,

the use of which are completely in perspective when considered in the context of the overall program and the investment made to date. However, the OPG is presently scheduled for termination at the end of September 1979, though CARE is presently preparing a proposal for its extension. The continued support of this project warrants careful and positive consideration.

4. There have been firm offers of institutional cooperation to support at least 500 hectares during this first year, and strong assurances of continued and increased government participation in the future.

RECOMMENDATIONS

To establish an order of priority and immediacy, recommendations are presented in terms of short run (1979) activities and longer range planning.

I. 1979 Soybean Planting

A. CARE

1. CARE contract a second agronomist who has experience in soybean production (preferably in Costa Rica) and with Spanish fluency.

2. Both agronomists be located in the major production area during the crop cycle.

3. CARE agronomists act in the capacity of agents of the Banco Nacional for crop inspection prior to each credit dispersal.

4. CARE agronomists organize a short training session for MAG extension agents and Banco Nacional inspectors in order to acquaint them with the basics of soybean production. This should be done no later than July 15.

5. CARE organize and finance a trip to Ecuador and Perú for the purpose of observing the institutional and technical aspects of soybean production. A suggested composition of this group is:

   a. One of two CARE agronomists;
   b. Representative of the banking institutions (either Central or Nacional);
   c. Representative of MAG research department (strongly suggest Ing. Eladio Carmona);
   d. Representative of agricultural planning institution.

   With the exception of the researcher, participants need only visit Ecuador; the research representative would benefit from a short stay in Perú to

familiarize himself with varieties which are not in Ecuador. See Appendix II for a more detailed trip plan. (NOTE: Ecuador is suggested because of its many similarities to the Costa Rican situation and a fairly long (10-15 years) history of soybean research and commercial production. If, however, it is not possible to arrange this trip, other areas would be satisfactory.) Due to the complexity of international exchanges, organization must be begun immediately, in case this recommendation is accepted.

B. The Consejo Nacional de Producción (CNP) establish a table of standards for soybeans, indicating the base levels of humidity, impurities, broken beans (if applicable), size, color, etc. Price penalties should also be indicated. It should be kept in mind that the standards set at this time should contemplate future uses of soybeans (oil extraction, etc.) so that they will not have to be modified as the amplitude of the national market increases.

C. Ministry of Agriculture (MAG) research department should collaborate closely with farmers and establish test, demonstration, and experimental plots and areas in the production zone. This will give MAG additional experience while its research program is being planned and initiated.

It would be very beneficial if University of Costa Rica cooperation and participation were obtained for these on farm activities.

D. There should be a meeting of all participating institutions during April to plan the role and responsibilities of each.

II. Future Activities

It is somewhat premature to make detailed recommendations for the future without seeing the direction that the initial effort will take. Broadly, however, two eventualities must be considered:

-- the 1979 program is not as successful as expected
-- the 1979 program is successful.

(NOTE: The order in which these are presented does not reflect pessimism; it is only because the first possibility presents much simplier planning alternatives and actiivties.)

A. Limited Success of 1979 Program

In the case that results of the 1979 season do not reach expectations, a careful diagnostic must be made in an attempt to explain this failure. Subsequent actions will

depend upon the findings of the analysis. MOH/CARE must also consider alternatives for obtaining raw materials for its 1980 and future nutrition programs. If production in 1979 by some farmers, and/or in some areas, is acceptable, MOH/CARE may want to contract with individual producers for its needs, while the national soybean program adopts another strategy (e.g. further research period).

B. Successful 1979 Program

1. Production

With a successful 1979 season it is probable that commercial interest in soybeans will be greatly stimulated. Important considerations regarding future production will be with respect to price; use of credit and crop insurance to establish preferencial production zones; extension of production to smaller farmers for whom soybeans would represent a profitable alternative or complementary crop; integration of the soybean program into the overall agricultural sector, strategy and development plan; and expand the research program to include all phases of soybean production.

2. Marketing

The CARE demand for soybeans in limited when viewed

in terms of national supply capability. New markets must be developed for increases in production past the modest 800-1,000 hectares comtemplated to meet MCH/CARE demand. Processing facilities will have to be developed which will entail cooperative planning between public and private sectors and coordinating national production with imported oil and oil-seed meal policy.

APPENDIX I

Interviews, meetings and discussions were held with the following persons:

A. Ministry of Agriculture

1. Dr. Hernán Fonseca - Minister
2. Ing. Willy Loría - Vice Minister
3. Ing. Eladio Carmona - Director of Agricultural Research
4. Ing. Gilberto Campos - Director of Extension
5. Ing. Luis Bolaños - Assistant Director of Extension

B. Instituto Nacional de Seguros

1. Lic. Verny Viales - Chief of the Agriculture Division

C. Banco Central de Costa Rica

1. Ing. Oscar Chacón - Chief of the Agro-Technical Division

D. Banco Nacional de Costa Rica

1. Ing. Fernando Mata - Chief of the Program Department

E. Consejo Nacional de Producción

1. Ing. Guillermo Herrera - Chief of the Purchasing Department
2. Ing. Manuel Jiménez - Commercial Department

F. University of Costa Rica

1. Dr. Ronald Echandi - Director of CIGRAS

G. CARE-Costa Rica

1. Mr. Justin Jackson - Director
2. Ing. Manuel Enrique Fernández - Agronomist

APPENDIX II (very tentative - as a guide)

General itinerary for Proposed Soybean Observation Trip to Ecuador (Perú):

A. CARE Agronomists

1. Visit INTAP experiment stations - Pichilingue, Boliche and Portoviejo

2. Visit different sized farms, including large mechanized, small, cooperatives, etc. (if possible include that of Sr. Francois Durín, in Quevedo).

3. Visit MAG personnel involved in extension.
4. Talk with Banco de Fomento credit supervisors concerning inspection and credit disbursement.

5. Meet with association of soy producers.
6. Talk to Eloy Salazar, Daniel Navas, and José Villacis (in private sector) regarding weed and pest control.

7. MAG - Jorge Gutiérrez for overview-program level.
8. MAG - Francisco Cevallos - overview-ministry/national level.

B. Research

Ecuador

1. INIAP Experiment Stations, Pichilingue, Boliche and Portoviejo - regarding all short cycle oil crops.

2. Ing. Jorge Matamoros, Sub-Director of INIAP in Guayaquil.
3. Visit large and small farms (include Durín farm in Quevedo).
4. Talk to and visit MAG research personnel and research/demonstration plots.

5. MAG - Jorge Gutiérrez for overview-program level.
6. MAG - Francisco Cevallos for overview-ministry (National level).

7. INIAP - Dr. Enrique Ampuero - Director

Perú

1. Research facilities.
2. Farms.

C. Bank Representatives

1. Banco Central concerning Fondo Financieros operation.
2. Banco de Fomento regarding crop financing-Guayaquil.
3. MAG Francisco Cevallos - overview - national level.
4. Banco de Fomento - Quevedo.
5. Experiment station-Quevedo? Boliche?
6. Farm - esp. Durín
7. Marco Peñaherrera - Sub-Secretary MAG.
8. Processing industry
   a. Oil
   b. Animal fe

D. Planning Representative

1. National Planning Board - concerning role of short cycle oil crops.
2. MAG planning.
3. Experiment Station - Quevedo? Boliche?
4. Farm - Durín
5. Jorge Matamoros - INIAP Sub-Director
6. Francisco Cevallos - MAG.
7. Jorge Gutiérrez - MAG.
8. Processing industry
   a. Oil
   b. Animal feed

9. Ministry of Health - if applicable, regarding human consumption of soy products.

10. Marco Peñaherrera - Sub-Secretary MAG

11. Superintendencia de Precios

ATTACHMENT II

OPG EVALUATION TEAM RECOMMENDATIONS

Extend the processing portion of the OPG for a period of two years to:

a. establish operational feasibility of processing plant.

b. develop a plan for the institutionalization of the plant within one year from the date of this evaluation.

c. identify applications for Full Fat Soy Flour and other low cost nutritious food products which could be manufactured with the plant facilities by providing approx. $25,00(

d. undertake a study to determine the need for additional storage facilities.

e. bring plant on stream by providing a contingency fund of a least $7,500 (approx. 5% of equipment costs), provided for capital expenditures.

The responsibility for quality control monitoring should be transferred from CITA to an appropriate Ministry of Health entity/dependancy.

The draft AID/Audit Report be shared with USDA, CSU and CARE and that their comments be considered prior to completion and issuance of the final audit report.

Continue efforts to assure good communications between USAID, CARE and CSU.

CULTIVO Y PRODUCCION DE SOYA (Glycine max (L.) Merrill) EN COSTA RICA

Ronald Echeandi E.
Enrique Chaverri

Cultivo y Produccion de Soya (Glycine max (L) Merrill) en Costa Rica

Ronald Echandi Z.

Enrique Villalobos R.

CENTRO PARA INVESTIGACIONES EN
GRANOS Y SEMILLAS, FACULTAD DE AGRONOMIA
UNIVERSIDAD DE COSTA RICA

Edición

Cooperativa Americana de Remesas
al Exterior (CARE)

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AGRADECIMIENTO

Los autores desean dejar constancia de su agradecimiento a todos y cada uno de los agricultores que han colaborado durante varios años en los programas de evaluación y reproducción de soya, poniendo a la disposición sus tierras e insumos. En especial deseamos agradecer a los propietarios de la Hacienda Tempisque, la familia Gillen-Clachar, la colaboración brindada a la mayoría de los programas de soya.

También deseamos hacer nuestro agradecimiento extensivo a los profesores de la Facultad de Agronomía de la Universidad de Costa Rica, Ingenieros Agrónomos Primo Luis Chavarría y Gilbert Fuentes por haber tenido la gentileza de revisar los aspectos relativos a control de hierbas y control de insectos respectivamente.

El apoyo de la Cooperativa Americana de Remesas al Exterior (CARE), y la agencia para El Desarrollo Internacional (AID), que han hecho posible la difusión del cultivo de soya en el país así como la preparación de este manual también es altamente agradecida.

INTRODUCCION

A pesar de que la soya como cultivo fue introducida al Continente Americano hace aproximadamente un siglo, problemas asociados a su cultivo han impedido una mayor difusión de esa importante fuente de alimento en las regiones tropicales.

Al preparar el presente manual la intensión de los autores ha sido la de ofrecer al cultivador de soya la experiencia acumulada en los pocos años de existencia del programa de introducción, evaluación y mejoramiento genético de la soya, iniciado en el año 1970, y que opera en el Centro para Investigaciones en Granos y Semillas (CIGRAS) de la Facultad de Agronomía de la Universidad de Costa Rica.

¿QUE ES LA SOYA?

La Soya es un cultivo muy apreciado porque las semillas, que son muy parecidas a los frijoles comunes, contienen bastante aceite (18–22%); la soya puede ser hasta dos veces más nutritiva que la carne de res y ofrece la posibilidad de preparar con ella platos y bebidas muy diversas. Muchos pueblos orientales, en especial los chinos, han vivido por siglos con una dieta casi exclusivamente a base de soya y arroz.

Descripción de la planta:

Como se dijo anteriormente, la soya en su cultivo es muy semejante al frijol común, las plantas de uno y otro son muy parecidas sin embargo la planta de soya presenta vellocidades que cubren las hojas, el tallo y las vainas que contienen únicamente dos o tres semillas.

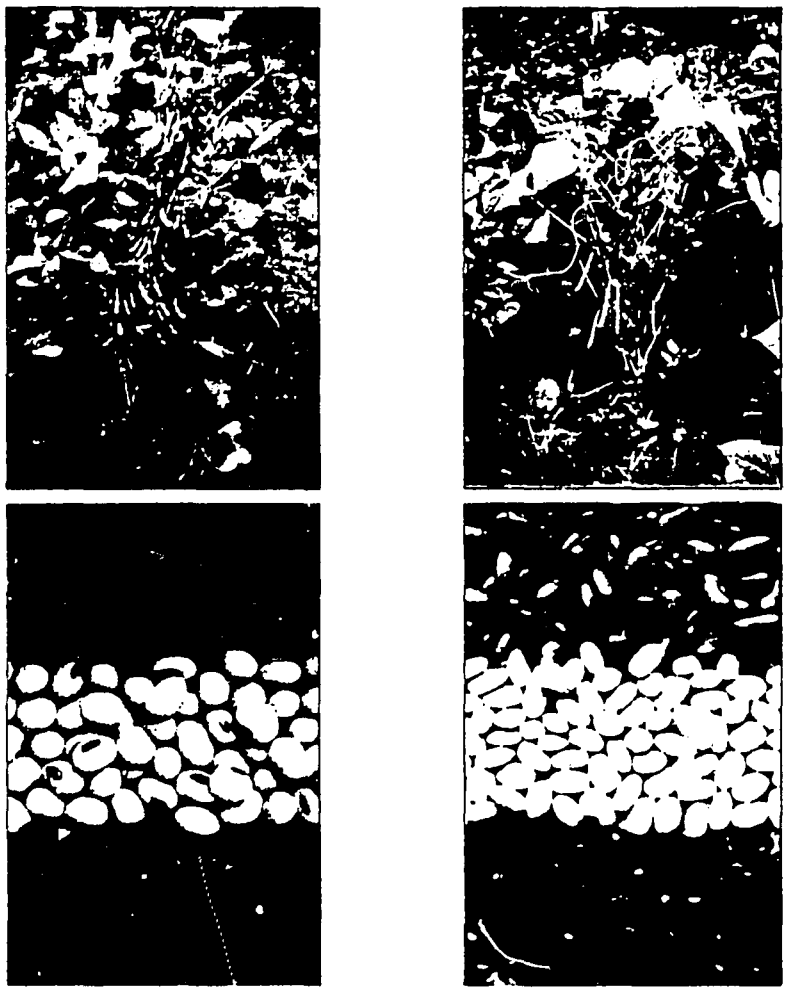

FIGURA 1: Plantas y granos de soya y de frijol común, note las similaridades y las diferencias entre ambos cultivos. A-Planta Soya B-Planta Frijol Común C-Grano Soya D-Grano Frijol Común.

El mejor rendimiento de la soya con relación al frijol común se debe principalmente a que la planta de soya produce muchas vainas, generalmente más de 90 por planta, mientras que el frijol produce entre 10 y 30 únicamente.

II

VARIEDADES

En la soya al igual que en frijol comun existen variedades que son diferentes en el color de la semilla: las hay negras y de tamaño pequeño, muy parecidas al frijol, así como también café, verdes y crema, que son las preferidas para la industria.

Existen pocas variedades de soya que muestran buena adaptación a las condiciones de clima de Costa Rica, ya que las variedades que se cultivan en las zonas templadas no producen bien bajo nuestras condiciones.

Variedades de Soya adaptadas a las condiciones de Costa Rica.

Nombre de la variedad	Color de la Semilla	Ciclo Vegetativo en días a partir de la siembra	
		1ra. Siembra Mayo	2da. Siembra Agosto
Júpiter	Crema	115-120	95-100
Pelícano mejorado	Crema	115-120	95-100
Brasil L. 652	Crema	100-105	85-90
FAO 27381	Crema	115-120	95-100
SIATSA - 194	Crema	107	95-100
SIATSA - 31	Crema	107	90-95
Negra I SPS - 25	Negro	105-115	90-95
CIGRAS - 69202	Café	100-105	85-90

III

ZONAS DEL PAIS APTAS PARA EL CULTIVO DE SOYA

Los mejores rendimientos se han obtenido en siembras en la región del Pacífico seco: cantones de Filadelfia y Santa Cruz de la Provincia de Guanacaste y en el Pacífico húmedo en los cantones de Aguirre, Parrita y Palmar.

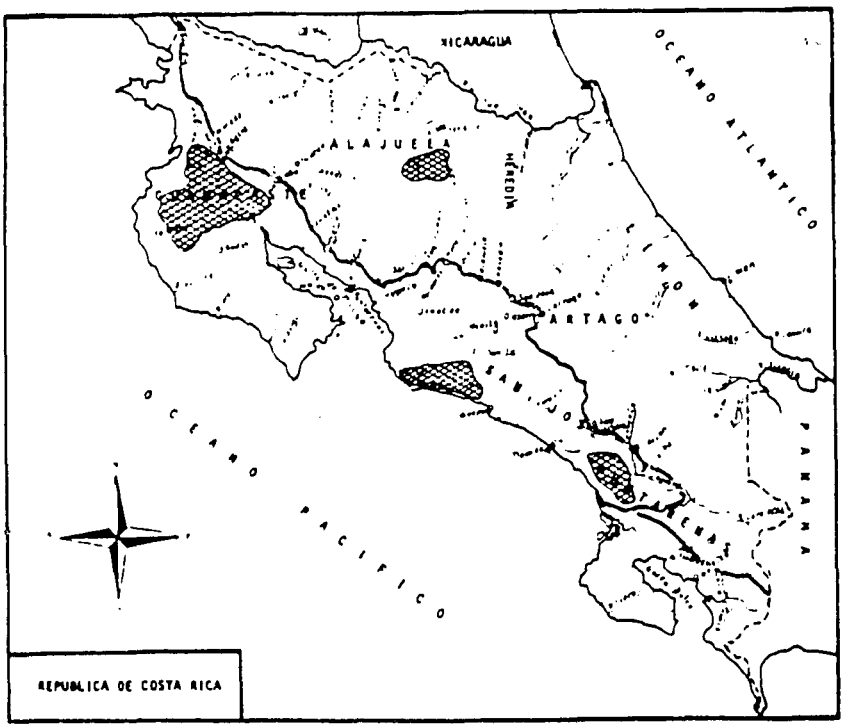

FIGURA 2: Es posible cultivar soya con mayor éxito en las áreas comprendidas dentro de las zonas demarcadas en el mapa.

IV

EPOCAS DE SIEMBRA

La soya puede sembrarse en primera durante el mes de mayo o en postera antes de la segunda quincena de agosto. Las plantaciones sembradas en primera se muestran muy vigorosas y las plantas son de buen tamaño: sin embargo, la cosecha coincide con una época muy lluviosa para la mayoría de las variedades adaptadas a las condiciones de Costa Rica, lo cual resulta en un grano de pobre calidad comercial debido a los daños que ocasiona el exceso de humedad durante el mes de agosto. Por las razones anteriores se recomienda la siembra en segunda siempre y cuando se haga antes de la segunda quincena de agosto: siembras posteriores a la época recomendada resultarán en rendimientos bajos.

V

SUELOS Y SU PREPARACION PARA LA SIEMBRA

Los suelos adecuados para el cultivo de soya son en general los mismos recomendados para la siembra de maíz. El pH no debe ser inferior a 5.5, de textura preferiblemente liviana a fin de que el agua no se encharque.

Una buena preparación del suelo es determinante en la producción de soya. El terreno se ara y rastrea de manera que la superficie quede libre de terrones que luego afectan tanto la labor de siembra como la germinación.

VI

PREPARACION DE LA SEMILLA PARA LA SIEMBRA

La soya, al igual que otras leguminosas, puede tomar nitrógeno directamente del aire a través de microorganismos, bacterias fijadoras de nitrógeno, que se localizan en las raíces de la planta, lo que resulta beneficioso porque permite reducir la cantidad de nitrógeno que se debe agregar en el fertilizante y baja así los costos.

La presencia de las bacterias fijadoras de nitrógeno en las raíces se nota por los pequeños nódulos o abultamientos en las mismas, los cuales cuando están activos al apretarlos entre los dedos aparecen de color rojizo pálido.

FIGURA 3: El inoculante (bacterias, fijadoras de nitrógeno) puede ser agregado en la tolva de la sembradora conjuntamente con la semilla. Cuando la inoculación resulta efectiva en las raíces de las plantas de soya se observan en las raíces nódulos como los de la fotografía.

VII

SIEMBRA Y FERTILIZACION

Densidad de Siembra

En la mayoría de los cultivos al hablar sobre densidad de siembra se hace en peso o volumen de semilla por área, sin embargo por la gran diferencia que existe entre las variedades en tamaño de semillas, se recomienda para soya hacer cálculo basándose en el número de plantas por manzana (o hectárea) y no únicamente en la cantidad de semilla a sembrar.

Una distancia de siembra que se ha encontrado adecuada para las condiciones de Costa Rica es de 5 cm. entre plantas y 50 a 60 cm. entre surcos, lo que significa que deben quedar aproximadamente 20 semillas por metro de surco para lo cual serán necesarias 100 a 125 libras de semilla por manzana (130 a 162.5 libras por hectárea); la densidad entonces será de 280.000 plantas por manzana.

Distancia entre surcos 50 cm. Distancia entre plantas 5 cm.

Las recomendaciones anteriores son de tipo general, en algunos casos será necesario variar la densidad de acuerdo a la época de siembra, la fertilidad del suelo y el hábito de crecimiento. Así variedades propensas a volcarse y que ramifican mucho darán mejor resultado a menor densidad; en tanto que variedades con poca tendencia a volcarse o que ramifican poco podrán sembrarse a mayores densidades, ya que la mayor densidad contribuye al aumento en la altura de las plantas lo que influye en que el material se vuelque con facilidad.

Profundidad de siembra

La profundidad de siembra influye mucho en la uniformidad con que aparecen las plantas sobre el suelo. Se recomienda sembrar a una profundidad no mayor de 4–5 cm. para la mayoría de los suelos de Costa Rica.

Fertilización

No existen aún suficientes datos sobre fertilización de la soya en Costa Rica pero en general se pueden describir las necesidades de fertilización de la soya así:

1– La soya requiere nitrógeno, el cual puede ser suplido por lo menos en una gran parte de las bacterias fijadoras de nitrógeno una vez que éstas se encuentren establecidas en el suelo (2 3 años de agregar inóculo a la siembra).

2– El elemento determinante en la producción de soya es el fósforo; aunque la planta requiere fósforo durante todo su ciclo, el período de mayor demanda se extiende desde el momento de formación de vainas hasta poco antes de la madurez.

3– Aunque existen gran cantidad de informes que indican que el potasio es un elemento importante para el desarrollo y producción en la soya, el hecho de que en la mayoría de los suelos de Costa Rica existen naturalmente cantidades adecuadas de potasio le restan importancia a la necesidad de aplicar dicho elemento.

Con base en lo anterior es posible en términos generales recomendar la utilización a la siembra ya sea de una fórmula completa como 10-30-10 o 12-24-12; en una cantidad de aproximadamente 3 a 4 quintales por manzana variándose según el suelo y aplicando el fertilizante en bandas al lado de la semilla teniendo el cuidado de que no queden en contacto directo.

VIII

DESARROLLO DEL CULTIVO, CONTROL DE MALAS HIERBAS

Las plantitas de soya aparecen entre los 5 y 7 días después de la siembra si la semilla está en buen estado; de no ser así, consulte el cuadro al final de este folleto.

Una vez germinada la nueva planta de soya crece rápidamente por espacio de 5 ó 6 semanas antes de que comiencen a notarse las primeras flores. La producción depende en gran parte del aspecto y condición de las plantas al momento de florecer. En general la mayoría de las variedades de soya crecen muy poco después de la floración.

En una misma planta de soya es posible encontrar tanto flores como vainas a la vez, pues la floración no es muy uniforme y se prolonga por espacio de tres semanas. Las primeras vainas se observan unos 10 días después de aparecer las primeras flores y el período de llenado de vainas se extiende por espacio de 4 a 6 semanas. El período de llenado de vainas es el más importante en relación al rendimiento, cualquier factor que afecte la planta, como la falta de humedad, daños por insectos en el follaje y otras partes de la planta, afectará mucho el rendimiento.

FIGURA 4: El período de llenado de las vainas es muy crítico y deben realizarse las labores necesarias y tomar precauciones para evitar problemas durante ese período del cultivo.

La planta de soya habrá llegado a la madurez cuando las hojas tomen un color amarillo y la mitad de éstas, aproximadamente, se hayan caído. Las variedades difieren, pero es común en la soya que si el cultivo se mantiene en el campo por mucho tiempo después de que la planta ha llegado a la madurez, las vainas se abren y el grano caiga al suelo con la consiguiente pérdida. A fin de evitar pérdidas por caída del grano al suelo es necesario al aproximarse el estado de madurez, diariamente y en especial a la hora más calurosa del día, observar si las vainas comienzan a abrirse y proceder de inmediato a la cosecha.

Control de Malas Hierbas.

Posiblemente uno de los factores más importantes en el control de hierbas es el uso de semilla de buena calidad a la densidad recomendada y plantada en un suelo bien preparado a la profundidad adecuada.

El control de hierbas puede efectuarse en forma manual, mecánica o mediante el uso de erbicidas. Existen un gran número de erbicidas que pueden ser usados en soya; su uso dependerá de una serie de factores entre los cuales están: disponibilidad, costo, hierbas a controlar, estado del cultivo, etc.

Cuando no se logra un control completo de malas hierbas con la aplicación de erbicidas es necesario hacer una deshierba manual o mecánica antes de que el cultivo se desarrolle lo suficiente para "ahogar" por sí mismo la maleza. La aplicación de erbicidas cuando el cultivo está grande no da buen resultado y se corre el riesgo de dañar las plantas.

HERBICIDAS RECOMENDABLES PARA EL CONTROL DE MALEZAS EN SOYA

NOMBRE COMERCIAL	APLICACION	CANTIDAD POR MANZANA
Sencor + Lasso	Preemergencia	3/4 a 1 1/4 libras 1 1/2 a 3 litros
Lasso + Lorox	Preemergencia	2 1/2 a 3 1/2 litros + 1 1/2 a 3 libras
Sencor + Treflan	Preemergente Antes de sembrar (incorporado)	3/4 a 1 1/4 libras + 1 a 2 litros

Las mezclas de erbicidas en soya dan un mejor control de malas hierbas, sin embargo, esta es una operación que requiere cuidado, especialmente cuando se usa Sencor que causa daños a la soya si se sobrepasa la dosis apropiada.

En suelos livianos (arenosos) las dosis necesariamente deben ser menores que las recomendadas, pero si los suelos son pesados, se puede aumentar un poco más la cantidad de erbicida. Cuando tenga duda. Consulte con el agente de extensión de su localidad o con los técnicos de la compañía que distribuye el producto, antes de hacer las aplicaciones.

Daños causados por erbicidas en soya.

En ciertos casos, los daños causados con erbicidas pueden confundirse con algunas enfermedades, por lo que se presenta información que puede ayudar a reconocer el daño:

HERBICIDA	DAÑO
Lorox	Plantas amarillentas con la raíz deformada y el cuello dañado; los extremos de las hojas quemados.
Treflan	Hojas pequeñas y arrugadas, raicillas ausentes o escasas; plantas enanas.
Sencor	Raíces deformadas y el cuello de las plantas pequeñas dañado. Hojas con quemaduras y partes amarillentas.
Lasso	Hojas arrugadas y arrolladas en forma de cuchara, extremos de las hojas con arrugas que le dan a la hoja forma de corazón.

También pueden presentarse daños causados por efecto de los residuos de erbicida usados en otros cultivos en la misma área, en la cosecha anterior.

Gesaprim	Amarillamiento de las hojas con partes muertas.
2, 4, 5 - T	Hojas nuevas alargadas, muy arrugadas y duras al tocarlas.

IX
INSECTOS DE LA SOYA Y CONTROL

En toda siembra de soya se encontrarán insectos, algunos que potencialmente pueden llegar a ser problemáticos si la población crece en forma desmesurada, en cuyo caso será necesario el control.

Existen insectos que se alimentan del follaje o de otra parte de la planta únicamente, en tanto que otros dañan varias partes de la misma.

Algunos de los que hasta el momento causan daño en plantaciones de soya en Costa Rica se describen a continuación.

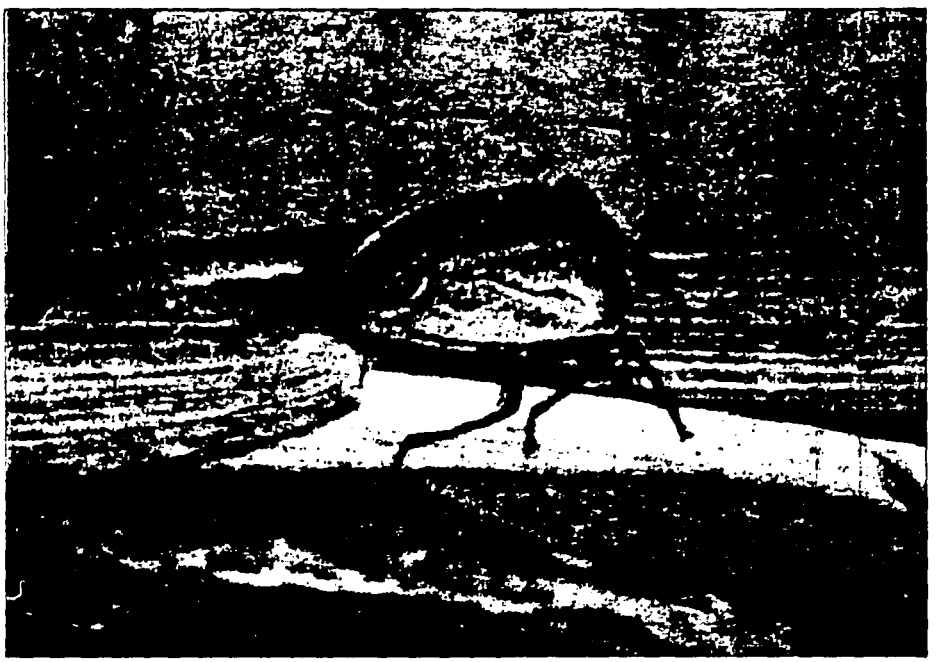

FIGURA 5: El "Chinche hediondo" (Nezara víridula) puede causar reducción en el rendimiento y dañar el grano.

Insectos que causan daño en plantaciones de soya.

Nombre Común	Nombre Científico	Descripción	Daño
Chinche Hediondo	Nezara viridula	Adulto de color verde, de 1.5 cm. longitud que despiden un mal olor. (Figura No. 5)	Pican las vainas tiernas y extraen los jugos dañando los granos y reduciendo así el rendimiento.
Vaquita	Diabrotica spp.	Adulto de color verde claro con 4 pares de franjas amarillos. Aprox. 5mm. de longitud.	Perforan el follaje y los tallos; cuando muy numerosos pueden causar bajas en el rendimiento.
Gusano de maíz	Heliothis zea	Larvas (gusanos) de color café claro con la cabeza anaranjada y de unos 3 cm. de lontitud.	Perforan el follaje y también las vainas y pueden causar severas pérdidas en rendimiento.
Vaquita	Cerotoma ruticornis	Adulto de color negro con 6 pares de manchas amarillas. Aprox. 3mm. longitud.	Perforan las hojas tiernas y dañan las vainas.
Gusanos cortadores	Feltia, Agrotis, etc.	Larvas de hábitos nocturnos que viven en el día en el suelo.	Cortan los tallos de las plántulas y se alimentan del follaje.

CONTROL DE INSECTOS

NOMBRE	RECOMENDACION
Chinche hediondo (Nezara viridula)	Metil Parathion (Folidol) 1 lba. i a/manzana.
	Lannate 1/2 a 1 lba. i a/manzana.
	Sevin 1 1/2 lbas. i a/manzana.

Se recomienda realizar el control del chinche hediondo, cuando se encuentra 1 chinche por metro lineal, lo cual se puede conocer usando una red o sa-

cudiendo las plantas en una manta.

Insectos del follaje	Sevin 1 1/2 lbas. i a/manzana.
	Lannate 1.2 a 1 lba. i a/manzana.
	Metil Parathion (Folidol) 1 lba. i a/manzana.
Gusanos cortadores	Mezcla de afrecho con Dipterez 1 oz/lba. de afrecho aplicado en forma húmeda por la tarde.

X

ENFERMEDADES DE LA SOYA

Es posible que en una siembra de soya se presenten daños causados por microorganismos y la severidad de esos daños dependerá de una serie de factores entre los que están:

1 - Susceptibilidad del material al ataque.

2 - Condiciones ambientales.

3 - Presencia de microorganismos dañinos.

Frecuentemente algunos patógenos que atacan la soya se encuentran directamente en la semilla, en tanto que otros provienen del suelo o de otros campos de soya en los cuales se encuentran presente.

Los microorganismos que causan enfermedades en la soya pertenecen a los tres grupos: a Hongos b. Bacterias y c. Virus.

Aunque la soya es un cultivo de reciente introducción, ya existen problemas causados por enfermedades y se han observado en el campo otras que pueden llegar, con el tiempo, a constituir problema por su naturaleza.

Algunas enfermedades comunes de la soya en Costa Rica.

Nombre común de la enfermedad	Microorganismo causal	Daño o síntomas
Pústula bacterial	Xanthomnas phaseoli. var sojensis.	Manchas en las hojas de tamaño variado de color café rojizo a café oscuro que tienden a unirse y romperse.
Mancha púrpura de la semilla	Cercospora kikuchii	Mancha púrpura en la superficie de los granos. No afecta el rendimiento aunque las semillas afectadas muestran

		baja germinación. Es un factor de apariencia principalmente.
Mosaico común	(Virus SMV)	Plantas afectadas muy temprano; se quedan pequeñas y faltas de desarrollo; las hojas se arrollan hacia abajo arrugándose. En algunos casos las semillas muestran manchas uniformes de color negro.
Marchitez de las plántulas	Pythum spp.	Pudrición de la base del tallo.

Los patogenos causantes de las cuatro enfermedades mencionadas son transportados en las semillas, de manera entonces que la mejor medida de control es el uso de semilla sana y procurar el uso de variedades menos susceptibles.

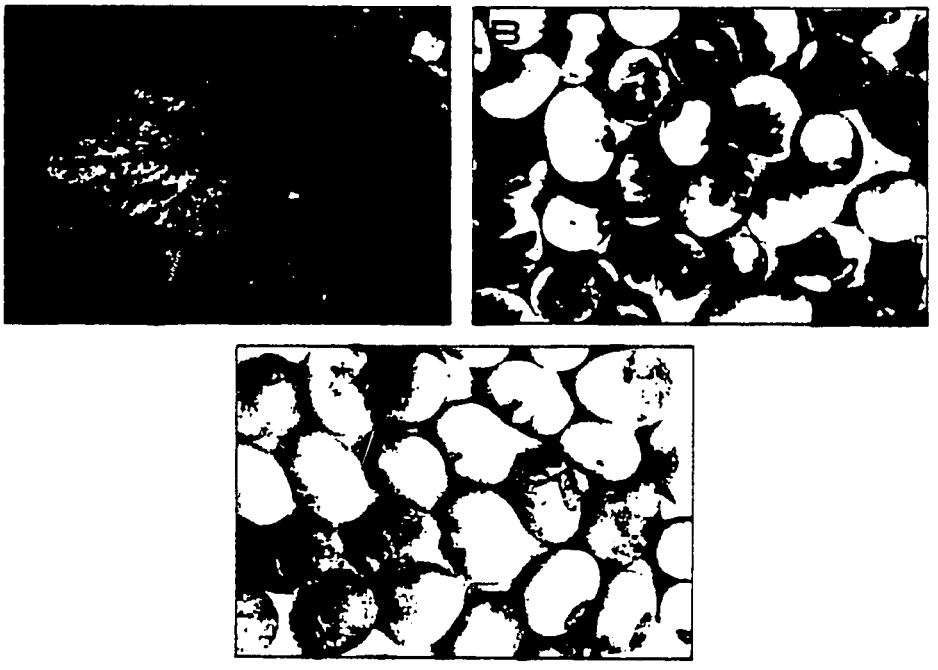

FIGURA 6: Las tres enfermedades más comunes en plantaciones de soya en Costa Rica son: Pústula bacterial (A), Virus del mosaico común que se manifiesta en la semilla (B), y la Mancha púrpura del grano que también se manifiesta en la semilla (C).

XI

USO DE DEFOLIANTES ANTES DE LA COSECHA

Aunque la soya al completar su ciclo de vida suelta las hojas, en ciertos casos en que se requiere uniformar y preparar la plantación para la cosecha es recomendable aplicar defoliante. El Gramoxone a razón de 1 litro por manzana da buenos resultados.

XII

COSECHA

Al momento en que el follaje se torna de color amarillo y las hojas comienzan a desprenderse se puede proceder a la cosecha siempre y cuando el contenido de humedad del grano lo permita, pues de otra forma las vainas tienden a abrirse y expulsar los granos. Cuando el contenido de humedad del grano sea superior a 12% se deberá secar hasta llevarlo a ese valor antes de almacenarla.

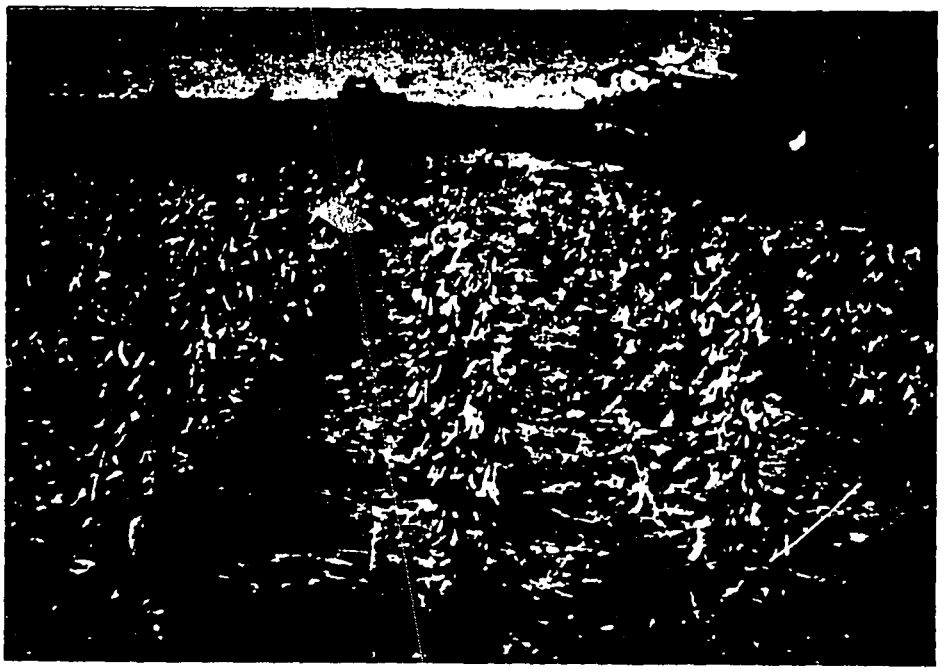

FIGURA 7: Es importante proceder con la cosecha al momento que las plantas aparezcan con el follaje amarillento y gran parte de las hojas desprendidas. Como las vainas en muchas variedades tienden a abrir y expulsar las semillas no debe esperarse para cosechar hasta el momento que el campo luzca como en la fotografía.

El grano de soya tiene la tendencia a cubrirse de polvo por el aceite que contiene; en ningún caso se debe lavar o exponer a la lluvia tratando de mejorar la apariencia del grano.

La cosecha puede realizarse en forma manual para trillar mecánicamente o mediante una cosechadora (combinada) del tipo que se usa para arroz.

En el caso de usar una cosechadora será necesario reducir la velocidad del cilindro a 500 rpm y ajustar las cribas y el molinete para la mínima pérdida.

XIII

PRODUCCION DE SEMILLA DE SOYA

La producción de semilla de soya requiere de una serie de cuidados adicionales respecto a la producción de grano comercial. Uno de los factores más importantes en la producción de semilla de soya es la sanidad del cultivo, pues como se dijo anteriormente al hablar sobre enfermedades, muchas de las que pueden llegar a producir pérdidas económicas grandes son transmitidas por medio de la semilla.

Para asegurar una plantación de soya sana es absolutamente indispensable sembrar semilla sana, con buena germinación y vigor: a fin de lograr lo anterior se recomienda que con suficiente anticipación a la siembra localizar la semilla y comprobar la calidad y condición sanitaria de la misma enviando una muestra representativa para que sea analizada en el laboratorio oficial para el análisis de semillas localizado en la Universidad de Costa Rica en San Pedro de Montes de Oca.

Características de una buena semilla de soya.

Una semilla de soya de buena calidad deberá tener las siguientes características:

Germinación	85%	o mayor
Materia inerte (basura y granos inmaduros)	0.5%	o menor
Semilla de otros cultivos	0.0%	
Semilla de malas hierbas	0.1%	o menor
Plantas enfermas	1.0%	o menor

Atención a la parcela para la producción de semilla de soya:

Para la producción de semilla de soya se deben escoger los suelos de mayor fertilidad y con buen drenaje. Aunque en general para la producción de semilla de soya las operaciones de inoculación, siembra, fertilización, control de malas hierbas e insectos son las mismas recomendadas para la producción de grano comercial, se requiere además especial cuidado de que el terreno no haya sido cultivado de soya durante por lo menos un año.

La producción de semilla demanda una vigilancia constante para eliminar o controlar a tiempo los ataques de enfermedades e insectos. Una práctica recomendable a fin de lograr un grado adecuado de sanidad de la semilla es la aplicación del fungicida "Benlate" al momento de la floración y de nuevo durante el período de llenado de vainas a razón de 1 lba. 1 manzana en ambas épocas.

Conservación de la semilla de soya:

Para conservar la semilla de soya con un buen grado de calidad es necesario almacenarla a baja temperatura (+ 5 C) y humedad ambiente (50% humedad relativa).

Se recomienda a los agricultores NO tratar de guardar su semilla de un año para otro pues inevitablemente se deteriorará y en el cultivo de soya la calidad de la semilla influye mucho en la producción.

XIV

CUADRO PARA EL DIAGNOSTICO DE PROBLEMAS EN PLANTACIONES DE SOYA

1 Etapa. SIEMBRA A 15 DIAS POSTERIORES A LA MISMA.	
SINTOMA	CAUSAS
Espacios en el surco en que no han aparecido plantas.	Distribución de la semilla poco uniforme, problemas de sequía o baja germinación.
Semilla podrida o plantitas marchitas	Ataque de hongos causantes de la marchitez.
Plantitas deformes.	Daño de erbicida.
Tallos de las plantitas cortados o comidos en la base.	Daños por insectos cortadores.
Sistema radical de color café oscuro y hojuelas y partes de las plantitas quemadas.	Daño por contacto directo con el fertilizante.

II Etapa. ESTADO DE PLANTULA A LA FLORACION.	
SINTOMA	CAUSAS
Plantas marchitas o muertas en sectores (parches).	Hongos que atacan el sistema radical.
Plantas enanas y con el follaje de color verde pálido amarillento.	Deficiencia de nutrientes. Daños por herbicida.
Hojas con manchas irregulares pequeñas de color café.	Pústula bacterial.
Follaje agujereado.	Daño de Insectos.
Plantas enanas mostrando floración antes de los 40 días posteriores a la siembra.	Variedad y época de siembra inadecuada.

III Etapa. DE LA FLORACION A LA COSECHA.	
SINTOMA	CAUSAS
Hojas con manchas irregulares de color café.	Pústula bacterial.
Vainas no llenan en forma normal y se secan.	Chinche verde.
Follaje agujereado, en casos severos solamente quedan las nervaduras de las hojas.	Insectos del follaje.
Llenado de vainas lento y semilla muy pequeña.	Deficiencia de agua y época de siembra inadecuada.
Semillas con manchas regulares de color negro sobre el fondo crema.	Virus de mosaico de la soya.
Semilla con manchas de color morado sobre el fondo crema.	Hongo Cercospora kikuchii.
Semilla con arrugas y de color verde pálido.	Grano cosechado con alto contenido de humedad, inmaduro.

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XV

CALIBRACION DE EQUIPOS PARA FUMIGACION

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La calibración adecuada de los equipos empleados en la aplicación de herbicidas y otros productos químicos de uso agrícola es fundamental.

Con la idea de suministrar un método simple para la calibración de equipos de fumigación, se hizo una adaptación al Sistema Internacional del Procedimiento recomendado por el Servicio de Extensión Agrícola de la Universidad de Illinois, considerando que éste puede ser de gran utilidad para estudiantes de agronomía, extensionistas agrícolas o agricultores que de una u otra forma están relacionados con el uso adecuado de los equipos de fumigación.

El procedimiento que se presenta es útil para cualquier tipo de aspersión que se emplee y puede ser usado fácil y rápidamente, una vez que se ha definido la forma en que se aplicará el producto.

Procedimiento.

Paso 1: Seleccione y determine una velocidad de operación apropiada. Mida una distancia de 50 metros bajo condiciones de campo existentes (condiciones en que se va a operar) y tome el tiempo que tarda el tractor en recorrer los 50 metros.

$$\text{Velocidad (KPH)} = \frac{180}{\text{tiempo (segundos) para recorrer 50 m.}} \quad \text{(Ec. 1)}$$

Ejemplo: si el tractor tarde 22.5 segundos en recorrer los 50m., la velocidad de campo será de 8 km/h. (8KPH).

Paso 2: Determine el volúmen de aplicación sugerido para el producto en cuestión, en lt/ha. Nota: Volúmen de aplicación se considera los litros de agua más el producto químico por hectárea tratada.

Paso 3: Utilice la siguiente fórmula para determinar el flujo requerido. (lt/min).

$$\text{Lt/min} = \frac{\text{lt/ha} \times \text{KPH} \times \text{W}}{60.000} \quad \text{(Ec.2)}$$

Lt/ha = litros por hectárea (paso 2).

Lt/min = litros por minuto, en la salida de la boquilla.

KPH = velocidad en kilómetros por hora (paso 1)

W = ancho de patrón de boquilla (cm.):
Método de traslape ("boom"): W = espacio entre orificios

Método de banda: W = ancho de la banda.

Médoto de goteo: W = ancho rociado por boquilla.

Ejemplo: Para aplicar 185 Lt/ha a una velocidad de 8 km/h, con un espaciamiento entre orificios de 50 cm, en un sistema de fumigación tipo "boom" se requerirá un flujo de 1.233 lt/min.

$$\text{lt/min} = \frac{185 \times 50}{60.000} = 1.233 \text{ lt/min.}$$

Ejemplo: para aplicar herbicida en una banda de 35 cm., a una velocidad de 8 km/h., empleando un volumen de aplicación de 37 Lt. por hectárea, se requiere un flojo de 0.1726 Lt/min.

$$\text{Lt/min} = \frac{37 \times 8 \times 35}{60.000} = 0.1726 \text{ (lt/min)}$$

Paso 4: Seleccione e instale la boquilla apropiada que entregue dos litros/ha determinados (paso3), cuando se opera dentro del rango de presión recomendado.

Paso 5: Llene parcialmente el tanque con agua y haga operar la aspersión dentro del ámbito de presión determinado. Coloque un recipiente en la salida de cada boquilla y controle si todas las boquillas entregan el mismo volúmen de agua. Reemplace todas las boquillas que varían más de un 5% del flujo promedio para el tamaño de boquilla usada.

Paso 6: Determine el flujo de agua por boquilla, colectando el agua de una de las boquillas. Compare la cantidad colectada con la que se determinó en el paso 3.

Paso 7: Ajuste la válvula de presión y repita el paso 6 hasta que la cantidad de agua liberada sea la misma a la requerida en el paso 3. Si la presión requerida no está dentro del ámbito recomendado, se debe recalibrar seleccionando un volúmen diferente de aplicación (pasos 2 y 3) variando la velocidad de operación (paso 1) o cambiando el tamaño de las boquillas (paso 4). Es muy importante que la presión final se mantenga dentro del ámbito de presión recomendado.

Paso 8: Llene el tanque con agua hasta la mitad. Adicione la cantidad de herbicida requerido y termine de llenar el tanque con agua. Nunca coloque el herbicida concentrado en un tanque vacío.

Paso 9: Haga poner el equipo de aspersión a la velocidad determinada en el paso 1 y la presión determinada en el paso 7. Después de atomizar una cierta cantidad de hectáreas, verifique si la aplicación apropiada se mantiene.

Paso 10: Después de un cierto tiempo es recomendable recalibrar el equipo de aspersión repitiendo los pasos 6 y 7. Si el flujo del líquido ha cambiado en un 10% es apropiado cambiar las boquillas.

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XVI

TABLA PARA CONVERSIONES

Interconversión de algunas unidades del sistema inglés y del sistema internacional importantes en la aplicación de productos químicos.

PARA CONVERTIR	MULTIPLIQUE POR	PARA OBTENER
Hectáreas	1.4314	manzana
manzanas	0.6986	hectáreas
acres	0.4047	hectáreas
hectáreas	2.4710	acres
acres	0.5793	manzanas
manzanas	1.7262	acres
galones	3.7850	litros
litros	0.2642	galones
botellas	0.6700	litros
litros	1.4925	botellas
botellas	0.1770	galones
galones	5.6457	botellas
cuarto (USA)	0.9460	litros
pinta (USA)	0.4700	litros
kilogramos	2.2045	libras
libras (USA)	0.4536	kilogramos
onzas	28.7500	gramos
gramos	0.0347	onzas
onzas fluidas	29.5700	cm.cúbicos