CGPRT No. 20

Sensitivity of Soybean Production to Price Changes A Case Study in East Java

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The CGPRT Centre

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Foreword

The study was carried out in 1987/1988 as a supplement to Phase I of the Soybean Yield Gap Analysis Project (SYGAP) of the CGPRT Centre, the main objective of which is to develop suitable technology to increase farmers' soybean yield.

While occupied with the activities of identifying constraints to increased yields and on-farm research, it became apparent that there was a need to investigate just how competitive soybean would be against alternative crops when relative prices change. By knowing this, we would be in a position to judge whether soybean is a persistent and dominant contributor to farmers' income and accordingly, to prove the need for SYGAP and other similar endeavours to increase soybean yield.

The results of the study indicate that, at current relative prices, soybean is more profitable than alternative crops in Indonesia. More specifically, within a possible range of changes in current prices, soybean is in close competition with either rice or peanuts, while it enjoys a stronger competing position relative to maize in Indonesia. The application of improved technology will certainly result in an even better position for soybean.

The study was conducted with assistance from Malang Research Institute for Food Crops (MARIF) staff: Mr. Heriyanto, Ms. Rully Krisdiana and Mr. A Ghozi Manshuri. The co-operation of MARIF Director is herewith acknowledged.

Shiro Okabe
Director
CGPRT Centre

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Summary

In the production area soybean is always part of the local cropping system, combined in some way with other crops, either as a sole crop relay or as an intercrop. Assuming that farmers are sufficiently price-responsive, changes in external factors (i.e. factors which are beyond the farmers' control) such as output and input prices, will not only affect soybean production, but also that of related crops in the cropping system. Thus, the possible effect of those external changes should be analysed within a farming-system framework.

The main objective of the study was to evaluate the possible impact of changes in relative output prices on soybean farm production. Linear programming was used to organize and analyse the data. The necessary input-output coefficients were estimated from data from a farm survey conducted in Pasuruan District for the dry season of 1986 and the rainy season of 1986/87, where soybean is grown on irrigated fields (*sawah*).

This study did not consider risk as a factor that might prevent farmers from achieving an optimum level of production. Interpretation of the results and recommendations from this study should thus be judged within this limitation.

The results showed that, compared with other food crops in the post-rainy and dry seasons in the survey period, soybean was more profitable. More specifically, with current price ratios, the planting of soybean as a monocrop was more profitable than an intercrop of corn and soybean, or any other crop. There would be no serious problem in recommending the soybean monocrop in place of soybean intercrops, as the latter were practised by only 20% of farmers in the survey area. The intercrops may persist as long as these farmers consider the risk in growing a soybean monocrop is greater than the increased income derived from it.

Peanut and rice were crops competitive with soybean, within the range of their current feasible price changes. By setting the price of soybean at Rp 650/kg, for example, while increasing the price of peanut to Rp 1575/kg, and the price of rice to more than Rp 160/kg, farmers would reduce the area of soybean crop and substitute it with peanut and rice, respectively. Shifts in cropping areas will result if farmers are profit-oriented. Within the limit of feasible price changes in 1987, and assuming soybean to be planted in all fields the critical price of soybean (lower price limit) should have been around Rp 915/kg. Atlower prices, substitution with peanut and rice crops for some of the soybean area became attractive.

At the 1987 price ratios and production technologies, corn did not seem to be very competitive with soybean. Only when soybean prices were very low (i.e. less than Rp 650/kg), did it become economically feasible for corn to enter the local cropping pattern. At soybean prices around Rp 483/kg, half of the crop area would have been occupied by corn during the dry season.

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1

Introduction

Background

Two distinct strategies may be followed to help farmers increase production. The first is to develop new technologies that farmers are willing to adopt, given their current economic circumstances. The second strategy is to encourage policy-makers to modify relevant economic circumstances, so that they can adopt the otherwise less profitable new technologies.

Soybean plays a very important role in the diet of many Indonesians, as an inexpensive source of protein and fat. As the food balance sheet indicates most of the protein intake by people in Indonesia is from vegetable sources (e.g. *tempe, tahu*, *kecap*).

In East Java, there are two types of farming system used to grow soybean : 1) lowland-based farming (*sawah*), where soybean is grown during the dry season, and 2) upland-based farming, in which soybean is planted in the wet season. Pasuruan District is one of the important centres for soybean production in East Java Province, where most of the farmers plant soybean after rice in the post-rainy or dry season in the irrigated lowland areas.

In the production area soybean is always a part of the local cropping system, combined in some way with other crops, either as a sole crop relay or as an intercrop. Assuming that farmers are sufficiently price-responsive, changes in external factors, like input and output prices, will not only affect soybean production, but also that of related crops in the cropping system. Thus, it is clear that the possible effects of such external changes should be analysed within a farming-system framework. Through the sensitivity analysis of some typical farm models, some ideas on the quantitative aspects and direction of changes in soybean farming systems and operations, due to changes in the relevant prices, may be investigated in advance. Such information, when made available, is valuable to government decision-makers and planners in predicting the consequences of policy changes which involve the alteration of existing price ratios.

Objectives of the study

The main objective of the study is to evaluate the possible impact on soybean production of changes in relative prices which result from anticipated policy changes.

In order to achieve this, the following sub-objectives were pursued :

1. The identification and formulation of relevant soybean farming models, based on certain specified characteristics, which may reasonably represent the actual farming systems in the production area. The estimation of present levels of inputs used, yields and incomes of the farm models.

2. The estimation of the optimal use of resources in these farm models under the present price regime and the recommendation of feasible changes necessary to bring about optimal levels of operation.

3. The carrying out of sensitivity analyses of the impact of possible changes in crop prices on the optimal farming system.

4. Based on the above analyses, the recommendation of practical ways to increase soybean production, with a view to achieving self-sufficiency in the domestic supply.

Methodology

The survey was carried out in Pasuruan District, Province of East Java, where soybean is grown on irrigated lowlands (*sawah*). This district was selected because it has the largest soybean cropping area in the province, and is also the site of the SYGAP[1] experiments. Interviews were conducted with the sample farmers in order to collect data on input-output relationships of last year's crops. The actual data collection took place in June 1987. Fragmented data on soybean farming in this area, were made available from previous surveys by MARIF and SYGAP studies, and were used to supplement the present survey data.

Village and farmer sample selection

From this study area, the three largest soybean-producing sub-districts (*kecamatan*) were chosen which also included the sites of earlier SYGAP experiments. The second step included the selection of two villages in each of the selected sub-districts, using the same criteria as in the first.

The third step was to randomly choose 10 soybean farmers in each selected village, thus making a total of 60 farmers who were interviewed for the study. These selected sub-districts and villages are presented in Table 1.1.

Table 1.1 Subdistricts and villages selected for the study, 1987.

Sub-District	Village
Wonorejo	1. Cobanblimbing 2. Pakijangan
Kejayan	1. Wrati 2. Kademungan
Sukorejo	1. Kalirejo 2. Lemahbang

Method of data analysis

[1] SYGAP, (Soybean Yield Gap Analysis Project) is a CGPRT Centre Project, under which the present economic study is conducted as a follow-up.

Linear programming was used to organize and analyse the data. Linear programming analysis is known to produce useful information on : 1) functional linkages and comparative cost advantages in production, 2) optimal levels of farm production, and 3) the impact of feasible policy changes.

Two alternative soybean farm models were formulated, which reflected the existing differences in farming systems and operations in the study area. The models, which were based on the dominant cropping patterns, were subjected to an optimization process by linear programming, to analyse whether the existing farms were efficient or in need of some adjustments.

In order to evaluate the possible impact of policy changes, the effects of which are inevitably manifested in changes in output and/or input price, a sensitivity analysis was conducted using the same models.

It should be noted that this study did not take into account the risk factor involved in the farm production of soybean and related crops. The results and recommendations derived from the study should be interpreted within this limitation.

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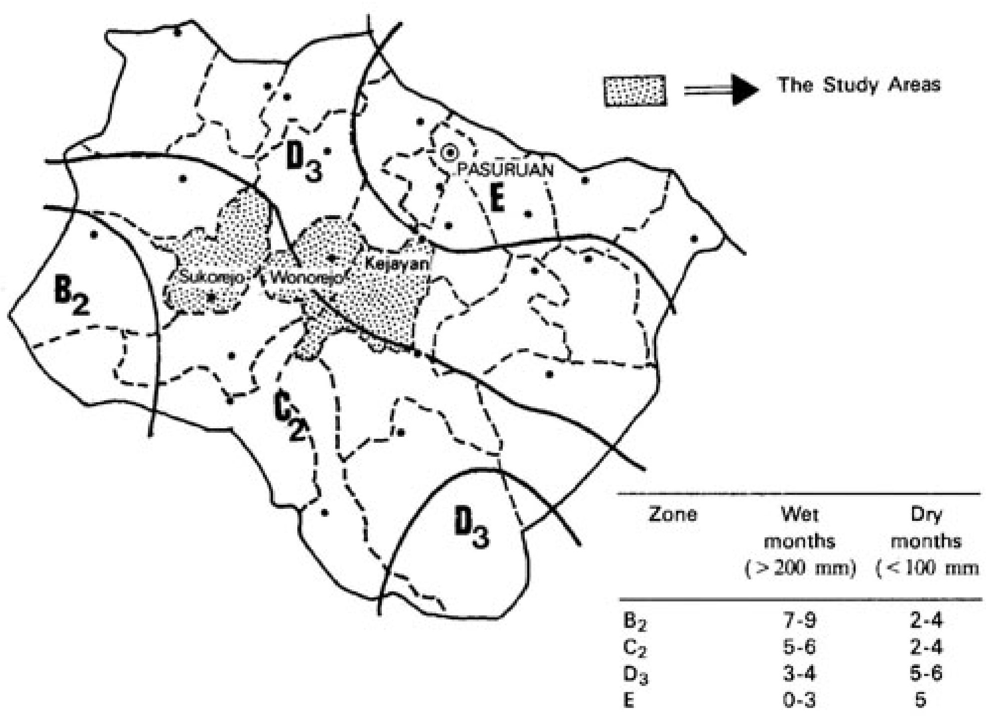
Soybean Farming Systems of in an Irrigated Area

Description of the study area

Pasuruan District is one of the important production centres of soybean in East Java. In this area, since 1986, SYGAP on-farm testing of a number of agronomic hypotheses has been conducted in co-operation with Malang Research Institute for Food Crops (MARIF) and Bogor Research Institute for Food Crops (BORIF).

Figure 2.1 shows the map of Pasuruan District, including Wonorejo, Kejayan and Sukorejo Sub-Districts, which were the areas selected for this sensitivity analysis study. As a whole, the *kecamatans* consist of irrigated areas (65%), drylands or uplands (24%), and home gardens (11%).



Zone	Wet months (> 200 mm)	Dry months (< 100 mm
B_2	7-9	2-4
C_2	5-6	2-4
D_3	3-4	5-6
E	0-3	5

Figure 2.1 Climatological map of Pasuruan District and the *kecamatans* surveyed.

The altitude is around 70 m above sea level, with soil acidity (pH) varying between 6.5 and 7.0. The main soil type occurring in the study area (Wonorejo, Kejayan and Sukorejo Sub-Districts) is regosols, with only a few stretches of latosols or mediterranean soils.

The total area of soybean harvested in 1986 in Pasuruan District was estimated to be 30,972 ha, of which the Sub-Districts of Kejayan, Wonorejo and Sukorejo contributed some 13,052 ha (41%). According to Oldeman (1976), the area is in the D3 and C2 agro-climatic zones (see Figure 2.1). The D3 zone is characterized by 3-4 months with more than 200 mm rainfall per month and 5-6 months with less than 100 mm/mo. The C2 zone has 5-6 months with more than 200 mm/mo and 2-4 months with less than 100 mm/mo. Generally, the rainy season begins in January-February, whereas the dry season starts around August.

The soybean farming system

Data from sample farmers in the study area indicate that they operate an average of 0.78 ha irrigated land, 0.40 ha dryland and 0.08 ha home garden. Farmers crop three times in the irrigated areas: 1) in the rainy season (December-March), 2) in the post-rainy season (April-July), and 3) in the dry season (August-November). Soybean may be planted twice on irrigated land, i.e. in the post-rainy season after rice and in the dry season. On the other hand, soybean is grown in the wet season on upland, to supply seed for the soybean crop after rice in irrigated areas.

Rainfall distribution and the general cropping patterns of soybean in irrigated areas are shown in Figure 2.2.

Sample data indicate that out of the total irrigated lands managed by an average farmer, he operates only 0.63 ha of soybean crop in the post-rainy season and 0.43 ha of the same in the dry season.

Compared with other crops, soybean has occupied a relatively large area probably because: 1) it is the traditional crop, 2) the cost of soybean production is lower than other crops, and 3) there are no serious marketing problems. This means that soybean is an important crop in the study area. After soybean is harvested and the grain is dried, a large portion of the product is sold in the market, at prices around Rp 550 - 650/kg.

In the study area, the total production of soybean has tended to increase from year to year. This has been caused by increases in both the area harvested and the yield. The development of soybean production from 1974 to 1986 in Pasuruan District may be observed in Figure 2.3.

Farmers' practices

Land preparation

Since the soil is still wet just after the rice harvest, farmers grow soybean without land preparation in the post-rainy season. Seeds are either dibbled or sown on the field. In order to reduce the water level, they dig drainage ditches around the bunds and shallower ones across the middle of the fields. On many occasions when the rain is very heavy, the drainage is not effective enough to reduce water-logging. In the dry season, farmers usually do not prepare the land very intensively, and ploughing twice and harrowing once are considered sufficient.

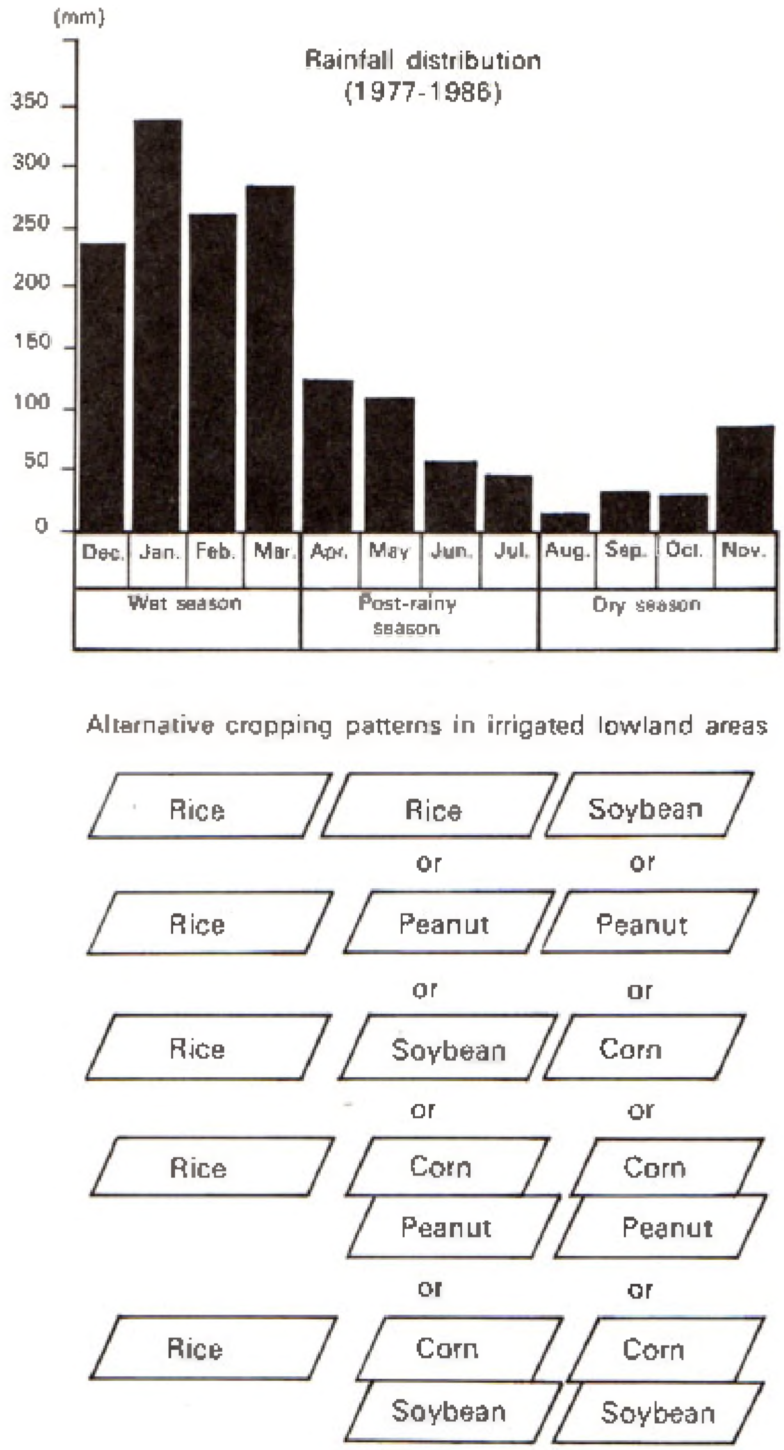


Figure 2.2 Soybean farming system on the irrigated lowlands of Pasuruan District, 1986

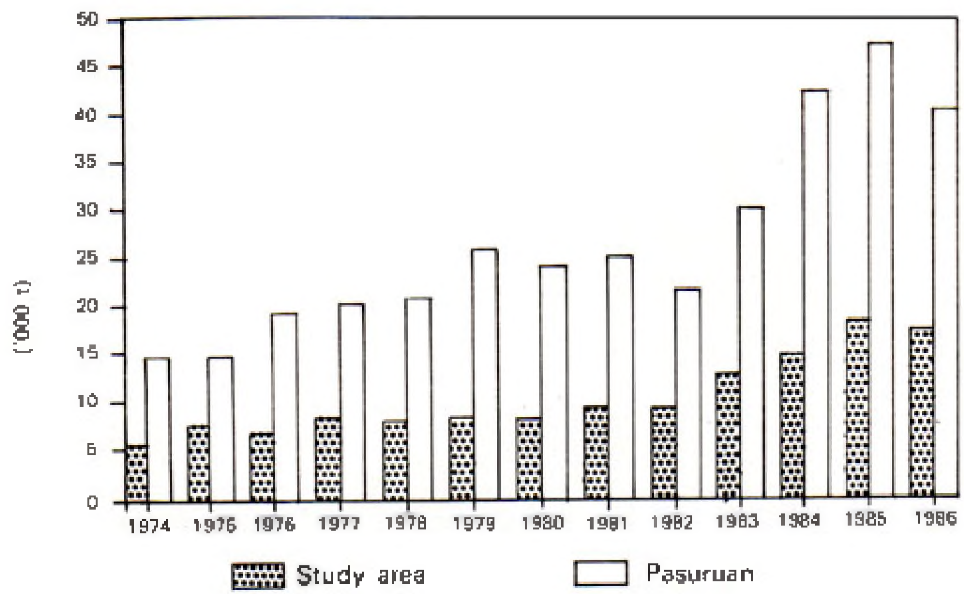


Figure 2.3 Soybean production in Pasuruan District and the study area

Planting

Following traditional practices, the planting density is about 1,500,000 plants per ha in the post-rainy season and around 700,000 plants per ha in the dry season. In the post-rainy season most farmers plant soybean by using one of two methods:

1. Broadcasting the seed and then covering the field with straw.

2. Covering the field with straw first and then broadcasting the seed.

Sometimes when there is not much rain they burn the straw on the field. In this case dibbling is prepared for the soybean grain, and the plant holes are then covered with ash.

In the dry season, preparation of plant holes ("dibbling") is a common practice. However, only a few (23%) of the farmers dibble at regular plant distances, while the majority practice random dibbling. The average seed rate is about 55 kg/ha in the study area. Most farmers use improved soybean varieties, (i.e. Wilis, No. 29, etc.)

Fertilizer application

Only a limited number of farmers (10%) apply fertilizers to their soybean crop in the post-rainy season, i.e. soybean after rice, and only nitrogenous fertilizers and some micronutrients (with the trade mark, *Gandasil*) are used. Some of the reasons for not applying fertilizers are as follows:

1. They believe that the residual effect of fertilizers applied to the previous rice crop is still enough for the soybean crop.

2. Water-logged conditions caused by heavy rains, make it difficult to apply fertilizers.

3. The broadcasting of seeds, resulting in irregular plant densities, contributes to the difficulties in the application of fertilizers.

In the dry season almost half (45%) of the farmers applied fertilizers, with elemental doses of around 20 kg Nitrogen, 17 - 33 kg Phosphate and 0.20 kg micro-nutrients per hectare. The time of application starts from 15 to 45 days after seed planting. With fertilizer application, it was reported that yields in the post-rainy season were 44% higher, while those in the dry season were 14% higher, when compared with soybean crops without fertilizer application (Yogiarti et al. 1986)

Crop Protection

Controlling insect pests of soybean is one of the important keys to preventing yield losses. Common insects are *Agromyza* spp., *Spodoptera* spp. and *haedonia inclusa*. Generally, farmers use insecticides only after the insects have actually attacked the plants. They do not apply insecticides earlier, because of 1) unavailability of insecticides in the village, and 2) lack of information on the appropriate application time of insecticides. Most farmers use Thiodan or Diazinon for all insect problems, spraying 2-3 times per season.

Weeding

In the post-rainy season more weed problems may be expected than in the dry season. This is a result of the planting time and methods being followed. Due to labour competition with other enterprises rather belated weeding, if any, is done 30-45 days after germination. The broadcast seed with straw coverage in the post-rainy season also makes weeding difficult. It appears that during the vegetative stage, the soybean crop has to face strong competition with weeds.

Irrigation

Water is sufficiently available in the post-rainy season, but not so in the dry season. The lack of water for irrigation during the dry season frequently results in watering the field too late.

Harvesting

The time of harvesting is about 90 - 114 days after planting. The average yield of soybean as a monoculture is around 0.7 - 0.9 t dry grain/ha in both seasons. In the case of soybean intercropped with corn, the soybean yield is around 0.5-0.7 t dry grain/ha and the corn yield is 0.2-0.5 t dry grain/ha.

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Farming System Model of Soybean

Model formulation

As was stated earlier, the linear programming technique was used in the analysis. This selects the best programme (course of action) from a set of feasible alternatives. The formulation of a linear programming model of soybean farming systems and their relevant operations should include identification of the following.

Decision variable

As a dependent variable, the decision variable should first be identified to solve the linear programming problem. For this study, the decision variables in the model comprised :

1. Production activities. These are alternative crops the farmers may consider growing on their irrigated lowlands in both post-rainy and dry seasons. Rice, peanut, soybean, soybean intercropped with corn, and peanut intercropped with corn are the possible crops grown in the post-rainy season. In the dry season the possible alternatives are corn, soybean, peanut, soybean intercropped with corn, and peanut intercropped with corn.

2. Labour-hiring activities. These provide farmers with alternatives of hiring certain labour when the supply of family labour is not enough for specified activities. The time-specific activities include those of pre-harvest, harvest and post-harvest for crops in both seasons.

3. Input-buying activities. These are alternative materials purchased by farmers for use on their farms, namely: seed and fertilizer in both seasons.

4. Capital-borrowing activities. These guarantee farmers secure funds to buy insecticides needed in both seasons if their own capital is not enough.

5. Output-selling activities. Farmers are assumed to sell all of their outputs produced by the various farm enterprises.

Constraints

Constraints in a linear programming analysis are characterized by many kinds of relationships between the decision variables themselves, and between the decision variables and any performance targets or goals of farming. A number of constraints are considered in this model, namely: land, material inputs (seed and fertilizer), family labour use in various cropping activities, and working-capital in both seasons.

Objective function

The objective of the soybean farming system and operation is to maximize profit or income. This is considered a reasonable assumption in the survey area since the larger portion of the crop produce is sold in the market.

Considering the existing soybean farming system and its related operation mentioned above, a general mathematical linear programming model may be constructed as follows:

$$\text{Maximize } Z = C_1 X_1 + C_2 X_2 + \ldots + C_n X_n$$

$$\text{Subject to} \quad a_{11} X_1 + a_{12} X_2 + \ldots + a_{1n} X_n \leq b_1$$

$$a_{21} X_1 + a_{22} X_2 + \ldots + a_{2n} X_n \leq b_2$$

$$- \quad - \quad - \quad -$$

$$- \quad - \quad - \quad -$$

$$a_{m1} X_1 + a_{m2} X_2 + \ldots + a_{mn} X_n \leq b_m$$

Where Cj , b_i and a_{ij} (i=1,2,...m; j=1,2,...n) refer to the constants to be determined from the application of existing technology on the soybean farm in question; X_j is the relevant decision variable. The definitions of the parameters are as follows:

a_{ij} is the amount of resource i that must be allocated to each unit of activity j,
b_i is the available fixed amount of resource i,
C_j is the value (Rp) per unit of activity j.

Two types of soybean farming systems are represented mathematically in this model and analysed accordingly. It appears from the sample that some 80% of the farmers grow soybean as a monocrop, while 20% are practising intercropping. Thus, the soybean farming system of Category I is defined as a monocropped soybean enterprise in relay cropping with other crops. The soybean farming system of Category II, on the other hand, is that in which soybean is intercropped with corn. These categories also vary in terms of the amounts of resources available.

The input-output matrix of the generalized model is presented in Table 3.1. The input-output coefficients which are used in the programming model may be found in Appendices 10 and 11.

Assumptions of the model

The basic assumptions underlying the soybean farming systems and operations model are as follows :

1. Additivity of resources and activities.
   The property of additivity means that the sum of resources used by the different activities must equal the total quantity of resources available for each activity for all resources, individually and collectively.

2. Linearity of the objective function.
   This means if a farmer obtained C_j rupiah from one ha of farm enterprise U_j, then from X_j ha he could get C_jX_j rupiah.

3. Divisibility of activities and resources.
   This assumption implies continuity in the value of resources and output. For example, we may use inputs in fractional quantities such as 0.65 ha of land, or 8.50 hours of labour, etc.

4. Non-negativity of the decision variables.

5. Proportionality of activity levels of resource use.
   Proportionality assumption implies linear relationships between activities and resources. Also this assumption implies constant resource productivity and constant returns to scale.

6. Single-valued expectations.
   This means that resource supplies, input-output coefficients, prices of resources and activities, are known with certainty. This also assumes that uncertainties and/or risks do not exist.

Table 3.1 Input-output matrix of the model of soybean farming systems and operations in Pasuruan District, 1987.

Activities / Constraints	Production activities x1.......xk	Hired Labour activities xk+1.......xm	Buying input activities xm+1.......xn	Borrowing capital activities xn+1.......xp	Selling output activities xp+1.......xq	R H S
Post-rainy season						
Land	1					$= b_{11}$
Seeds (4)	a_{21}		-1			$\leq b_{12}$
Fertilizer (4)	a_{31}		-1			$\leq b_{31}$
Labour (17)	a_{41}	-1				$\leq b_{41}$
Capital	a_{51}			-1		$\leq b_{51}$
Land	1					$= b_{61}$
Seeds (3)	a_{71}		-1			$\leq b_{71}$
Fertilizer (3)	a_{81}		-1			$\leq b_{81}$
Labour (17)	a_{91}	-1				$\leq b_{91}$
Capital	a_{101}			-1		$\leq b_{101}$
Yields transfer (4)	$-y_{111}$				1	$= b_{111}$
Objective function	$-c_{1i}$	$-c_{2i}$	$-c_{3i}$	$-c_{4i}$	$-c_{5i}$ Max	

Sensitivity analysis

Sensitivity analysis enables the linear programmer to answer various questions related to the impact of changes in the value of some coefficients, without altering the other parameters in the original linear programming model. In this case, the set of basic variables in the optimal solution is unchanged, although their values may change.

For this purpose, only changes in the objective function are planned for the sensitivity model. Changes in the coefficients of the objective function are made based on the results of the optimal solution from the first model. Mathematically this problem is presented as follows :

Maximize $Z = (C_j + d_j) X_j$

Subject to $a_{ij} X_j < b_i$

$X_j > 0$

$_i = 1, ..., n$

$_j = 1, ..., m$

d_j = a constant

λ = coefficient of change

The value of λ depends on the range of feasible values in the optimal solution of the first model.

4.

Optimum Farm Production of Soybean

Farm resource utilization

Based on the results of data analysis of the five alternative crop enterprises in the post-rainy and dry seasons, the optimal solution was that of soybean as a monocrop. The decision of farmers of Category I to plant soybean as a monocrop appears to be the best possible choice. If farmers of Category II want to maximize profit, they have to change the cropping from soybean intercropped with corn to that of soybean as a monocrop.

Land

The land area of Category I farmers was limiting in both seasons, with the respective shadow prices of Rp 406,140/ha in the post-rainy season and Rp 494,110/ha in the dry season, (Appendix 1). The same situation applied for Category II farmers, where the respective shadow prices were Rp 433,500/ha in the post-rainy season and Rp 521,813/ha in the dry season, (Appendix 2).

The range of optimal land area under soybean was from 0.547 to 0.625 ha in the post-rainy season and 0.625 ha in the dry season for Category I farmers, while that of Category II farmers was from 0 to 0.556 ha in the post-rainy season and from 0.379 to 0.570 ha in the dry season.

The effect on income reduction when other activities were introduced into the optimal farm plan, are presented in Appendices 3 and 4. For example, the reduction in income when an intercrop of soybean and corn was introduced was Rp 120,920. This means that if farmers reduced the area under soybean as a monocrop from the optimal level to a lower level, and replaced it with an intercrop of soybean and corn, they would lose as much as Rp 120,920 profit for each hectare changed. The maximum permissible change was, however, limited to only 0.0781 ha in the post-rainy season for Category I farmers, and was only 0.1226 ha in the dry season with reduction in income amounting to Rp 100,073/ha.

Labour

The supply of family labour for the various farm operations involved in producing soybean in irrigated lowlands was not always limiting. The estimated optimal labour use and the available supply are found in Appendices 5 and 6. For Category I farmers in the post-rainy season, only family labour for drainage preparation, weeding and harvesting activities was constraining. In the dry season, family labour for cleaning the field, planting, weeding and harvesting was limiting. As shown in Appendices 1 and 2, the shadow price for male labour was Rp 650/day, while that of a woman was Rp 500/day. The use of animal labour, coming from the draft animals owned by the farm family, was still below capacity. If hired, the cost was Rp 1750 per five hours of work.

The lower and upper limits of labour use were different for each season and each activity. For example, in the dry season, the availability of female family labour for each specified activity was 7.50 days for Category I farmers. The feasible lower limit was 7.50 days and that of the upper limit was 17.50 days, for labour used to plant soybean (see Appendix 1). This means that, when the need was at a maximum, only 7.50 days of female family labour could be engaged in the activity, and the farmer still had to add another 10 days of hired labour (see Appendix 5). The distribution of optimal labour use for growing soybean as a monocrop in both seasons is presented in Appendix 5.

It may be observed that farmers of Category I in the post-rainy season needed to hire one man-day of labour for drainage making, one woman-day for weeding and 9.4 woman-days for harvesting. Similarly, in the dry season they needed to hire one additional man-day to clean the field and 2.60 man-days for planting, while 10, 19.1 and 9.30 woman-days were needed for planting, weeding and harvesting, respectively.

As can be seen from Appendix 6, farmers of Category II had only a few constraints on family labour use. In fact, during the post-rainy season, the supply of family labour was sufficient and no hired labour was needed. In the dry season, however, additional male labour was hired for planting, while female labour was also hired to supplement work for planting and weeding.

Capital

By definition, capital is the funds made available by farmers tobuy pesticides for protection of the soybean crop. From Appendix 1, it can be seen that capital was a constraint on Category I farmers in both seasons with a shadow price of 115%. This means that if a farmer were investing Rp 100 to buy pesticides in this activity, he would get a return of Rp 115 or a net profit of Rp 15. The range of capital expenditure was from Rp 4500 to Rp 5063 in the post-rainy season and from Rp 6500 to Rp 6970 in the dry season. To overcome the possible shortage, the farmer should borrow from other sources.

Farmers of Category II did not face any constraint on capital for their soybean production in either season. The supply of their own capital was more than enough to purchase the needed pesticides for the crop.

The significance of the very limited range of capital used for pesticide purchase indicates the importance of this type of expenditure in the stability of the optimal farm plan.

Optimum farm income

In general, farmers not only looked for the yield they would obtain, but were more interested in the return they could get from the various resources they had allocated. Table 4.1 presents comparisons of costs and returns of the soybean activities from both the current (farmers' plan) and the optimal plan for farmers of Category I. Table 4.2 gives details on that of Category II farmers.

Data from Table 4.1 indicate that costs and returns of soybean crop activities in both plans (farmers' and optimal plans) were not very different. Based on the cost point of view, the labour cost was very high relative to the other costs in the post-rainy season as well as in the dry season. The cost for buying seeds seemed to be high too. More than 65% of the total cost was needed for labour. The optimal plan could reduce the total production cost by only 3.4% (5.5% in the post-rainy season and 2.1% in the dry season).

Table 4.1 Costs and returns of soybean monocrops in Category I farming systems.Pasuruan District, Java, 1987.

	Farmers' plan[a]	Optimal plan	Difference	
	(Rp)	(Rp)	(Rp)	(%)
Post-rainy season				
1. Seed	22,275	22,275	0	0.0
2. Fertilizer	8,576	8,576	0	0.0
3. Pesticide	5,063	5,063	0	0.0
4. Labour	55,760	50,690	-5,070	-9.1
Sub-total	91,674	86,604	-5,070	-5.5
Dry season				
5. Seed	24,150	24,150	0	0.0
6. Fertilizer	7,576	7,576	0	0.0
7. Pesticide	6,970	6,970	0	0.0
8. Labour	106,965	103,965	-3,000	-2.8
Sub-total	145,661	142,661	-3,000	-2.1
Total cost	237,335	229,265	-8,070	-3.4
Production value	692,640	692,640	0	0.0
Net profit	455,305	463,375	+8,070	+1.8
Net B/C ratio[b]	1.92	2.02	+0.10	
Return to labour[c]	3.80	4.00	+0.20	
Return to inputs[d]	7.10	7.20	+0.10	

[a] Optimal size of soybean crop = 0.625 ha. Hence, to make a comparable estimate, average size of the soybean crop is made equal to the optimal size.

[b] Net B/C ratio = (Net profit)/(Total cost)

[c] Return to labour = $\frac{\text{(Production value-Input cost)}}{\text{(Labour cost)}}$

[d] Return to inputs = $\frac{\text{(Production value-Labour cost)}}{\text{(Input cost)}}$

Profit difference between the farmers' and the optimal plan operation was also not so large. Operating in the optimal plan, the farmer would get a net profit of Rp 463,375, which was increased only by 1.8% compared with that of the farmer's plan. It appears that Category I farmers have been managing their soybean crops rationally.
This information is important to government policy makers who are aiming to crease soybean production to the level of self-sufficiency.

Data from Table 4.2 show that soybean planted in an optimal plan (soybean nocrop) was much more profitable than that in the farmers' plan (intercrop of soybean and corn). This implies that Category II farmers in this area should change their intercrop system into a soybean monocrop system, in order to increase their income. However, in the real world, some farmers may consider the value of risk involved in growing a soybean monocrop to be larger than the difference between the actual income from the intercrop and that of the monocropped soybean.

The total cost of production would decrease by around 18.2% (24.6% in the post-rainy season and 13.5% in the dry season) if farmers grew soybean as a monocrop, and their net income would be Rp 414,862 (an increase of 97.1% compared with the intercrop system). The net cost-benefit (B/C) ratio, return tolabour and return to inputs for the optimal plan were larger than those of the farmers' plan. They indicate that the optimal plan was a lot more efficient in the allocation of farm resources.

From the above discussion, it can be concluded that a soybean monocrop is more profitable than an intercrop system. This explains why only 20% of farmers grow soybean as an intercrop. For policy- makers, the important point is that most farmers have been cultivating soybean in a rational manner. It is expected that few problems will be encountered in the introduction of improved appropriate technology to soybean cultivation.

Table 4.2 Costs and returns of soybean intercropped with corn in Category II farming systems, Pasuruan District, 1987.

	Farmers' plan[a] (Intercropped soybean)	Optimal plan (Monocropped soybean)	Difference	
	(Rp)	(Rp)	(Rp)	(%)
Post-rainy season				
1. Seed	18,686	19,575	+889	+5
2. Fertilizer	3,995	7,688	+3,693	+92.4
3. Pesticide	3,548	4,455	+903	+25.6
4. Labour	74,188	44,045	-30,143	-40.6
Sub-total	100,417	75,763	-24,654	-24.6
Dry Season				
5. Seed	21,244	21,225	-19	-0.1
6. Fertilizer	7,040	7,526	+486	+7.0
7. Pesticide	2,448	6,132	+3,684	+150.5
8. Labour	106,744	84,030	-22,714	-21.3
Sub-total	137,476	118,913	-18,563	-13.5
Total cost	237,893	194,676	-43,217	-18.2
Production value	448,388	609,538	+161,150	+36.0
Net profit	210,495	414,862	+204,367	+97.1
Net B/C ratio	0.90	2.13	+1.23	
Return to labour	2.16	4.24	+2.08	
Return to inputs	4.70	7.23	+2.53	

[a]Input and output data are for both soybean and corn crops.

5

Effect of Crop Price Changes on Optimum Production

Change in the crop area

A number of socio-economic circumstances or variables influence farmers' decision-making in soybean crop production. Examples of economic variables include input market prices, the price of the soybean commodity itself and prices of competing commodities. These are external factors to be considered in farm decision-making. Farmers have no control over them but must adjust the use of farm resources and crop combination to whatever changes in these factors.

In this study, only the prices of soybean and its competing crops were altered in order to evaluate the corresponding adjustments the farmer needs to make to the relevant crop areas. This information is useful for policy-makers to consider modifying the relevant economic circumstances, to encouraging farmers to increase the production of soybean.

Possible changes in the output prices may be indicated by a range of values around the prices used in the optimal solution and by the likelihood of future commodity prices in the market. The necessary adjustments were then indicated by the optimization process, using the new price regimes. The resulting effect of the suggested farm-level price changes on the crop areas is discussed in the following.

Firstly, the effect of changes in peanut price concomitant with a specified range of changing soybean prices, is discussed in the context of both the post-rainy and dry seasons. The relevant data are shown in Table 5.1. If the soybean price is Rp 485/kg and the peanut price is increased from Rp 750 to Rp 1025/kg, farmers will reduce the area of soybean cropped by about 30% and start growing peanut in the post-rainy season, while in the dry season they will substitute soybean completely for peanut. At these same prices of peanut, if the price of soybean is increased to Rp 650/kg, the soybean crop becomes more competitive with peanut so that production of soybean will expand to the maximum size in both seasons. Then, if peanut price is increased to Rp 1575/kg and the price of soybean is maintained at Rp 650/kg, soybean will disappear in both seasons. But if soybean price increases to more than Rp 915, the soybean crop can always be maintained in both seasons. This would mean that, for any feasible price change of peanut, soybean could be made competitive with peanut if the soybean price is more than Rp 915/kg. Below this price, increasing peanut price may weaken the position of the soybean crop.

The effect of changes in the price of rice conjoined with a specified range of changing soybean prices, as indicated by the corresponding changes in the respective crop areas, is shown in Table 5.2. These effects could only be obtained during the post-rainy season, since farmers generally do not plant rice in the dry season. If the price of rice is increased from Rp 110 to Rp 160/kg, while the price of soybean is fixed at Rp 650/kg, the soybean crop area would be reduced by 26% and be replaced by the rice

Table 5.1 Effect of price changes of peanut and soybean on the size of enterprise in the soybean monocropped farming system of the irrigated lowlands, Pasuruan District, 1987.

Peanut price[a]	Price of soybean (Rp/kg)				
	485	650	915	1180	1445
	..................(ha)..................				
1. Rp 750/kg					
Post-rainy season					
soybean			0.550to		
	0.625	0.625	0.625	0.625	0.625
peanut	0	0	0	0	0
Dry season soybean	0.560to				
	0.625	0.625	0.625	0.625	0.625
peanut	0	0	0	0	0
2. Rp 1025/kg					
Post-rainy season					
soybean	0.325to			0.550to	0.550to
	0.444	0.625	0.625	0.625	0.625
peanut	0.185to				
	0.330	0	0	0	0
Dry season					
soybean		0.500to		0.583to	0.583to
	0	0.625	0.625	0.625	0.625
peanut	0.489to				
	0.625	0	0	0	0
3. Rp 1300/kg					
Post-rainy season					
soybean	0.592to				
	0	0.625	0.625	0.625	0.625
peanut	0.625	0	0	0	0
Dry season					
soybean	0	0	0.560to	0.583to	0.583to
			0.625	0.625	0.625
peanut	0.427to	0.427to			
	0.625	0.625	0	0	0
4. Rp 1575/kg					
Post-rainy season					
soybean	0	0	0.592to	0.592to	
	0.625	0.625	0.625		
peanut	0.625	0.625	0	0	0
Dry season					
soybean	0	0	0	0.560to	
	0.625	0.625			
peanut	0.427to	0.427to			
	0.625	0.625	0.625	0	0

[a] Shelled peanut.

crop. With the price of rice increasing still more to Rp 210/kg, farmers would completely change the area of soybean into rice crop. But if the price of soybean increased at the same time to Rp 915 or higher, the soybean crop area could always be profitably maintained. Thus, the critical value of soybean price is around Rp 915/kg, where increasing the rice price to Rp 210/kg would still make it infeasible to substitute rice for soybean.

Table 5.2 Effect of price changes of rice and soybean on the size of enterprise in the soybean monocropped farming system of the irrigated lowlands, Pasuruan District, 1987.

Peanut price[a]	Price of soybean (Rp/kg)				
	485	650	915	1180	1445
	..................(ha).................				
1. Rp 110/kg					
Post-rainy season					
rice	0	0	0	0	0
soybean	0.625	0.550to 0.625	0.550to 0.625	0.625	0.550to 0.625
2. Rp 160/kg					
Post-rainy season					
rice	0.500to 0.625	0.048to 0.167	0	0	0
soybean	0	0.458to 0.577	0.625	0.625	0.547to 0.625
3. Rp 210/kg					
Post-rainy season					
rice	0.500to 0.625	0.500to 0.625	0	0	0
soybean	0	0	.625	0.625	0.625

[a]Milling-dry, unhusked rice (*gabah kering giling*).

The remaining discussion deals with the effect of changes in corn price concomitant with a specified range of changing soybean prices, as indicated by the corresponding changes in the respective crop areas. The relevant data are presented in Table 5.3. As corn is only grown in the dry season, area substitution with soybean can only occur in that season. If soybean price is Rp 485/kg or lower, while the price of corn is Rp 300/kg or higher, the farmer will substitute corn for the soybean crop area. But if the price of soybean is higher than Rp 650/kg, it is more profitable to grow soybean crop in this area.. This means that corn is not very competitive with soybean.

Normative supply curve of soybean

The normative soybean supply curve is derived from the relationship between the set of prices received and the related optimal outputs produced by the average (model) farmer in both seasons, which also takes into account the current price of another

Table 5.3 Effect of price changes of corn and soybean on the size of enterprise in the soybean monocropped farming system of the irrigated lowlands, Pasuruan District, 1987.

Peanut price[a]		Price of soybean (Rp/kg)				
		485	650	915	1180	1445
		..................(ha)..................				
1. Rp 150/kg						
Dry season						
	corn	0	0	0	0	0
	soybean	0.560to 0.625	0.625	0.625	0.625	0.625
2. Rp 225/kg						
Dry season						
	corn	0	0	0	0	0
	soybean	0.560to 0.625	0.625	0.583to 0.625	0.625	0.625
3. Rp 300/kg						
Dry season						
	corn	0.625	0	0	0	0
	soybean	0	0.576to 0.625	0.583to 0.625	.583to 0.625	0.583to 0.625
4. Rp 375/kg						
Dry season						
	corn	0.625	0.000to 0.250	0	0	0
	soybean	0	0.375to 0.625	0.583to 0.625	0.583to 0.625	0.583to 0.625

[a] Shelled grain.

closely-related crop. As discussed earlier, changes in the price of peanut, rice and corn may change the farmer's decision on the size of crop activities, as reflected in the changes in crop areas. Thus, by implication, they affect also the production of soybean in both seasons at the farm level. The estimates of production of soybean, as price of soybean and other related crops change, may be observed in Appendices 7, 8 and 9. The detailed accounts of their cross-elasticities at certain levels of soybean prices are presented in Table 5.4. Estimates of own-price elasticities of soybean at certain prices of other related crops are found in Table 5.5.

Specifically, Figure 5.1 illustrates the effect of changes in the prices of rice and soybean on the optimum farm supply of soybean. The normative supply curve of soybean when the price of rice is Rp 110/kg, other things being constant, is the vertical curve S_0S_0. If the price of rice is increased to Rp 160, and the prices of soybean are at Rp 485 and Rp 650, respectively, the normative supply curve of soybean will be the S_1S_1 curves, with the cross elasticities changing respectively from -1.64 to -1.53 and from -0.46 to -0.09 (see Table 5.4). If the price of soybean is Rp 915 and higher, the supply curve will be vertical again.

The case is similar if the price of rice is increased from Rp 160 to Rp 210, while also increasing the price of soybean from Rp 485 to Rp 650. The normative supply curve of soybean will shift to the S_2S_2 curves, and it will also be strictly vertical for the price of soybean at Rp 915 and higher. This indicates that except for the rice price of Rp 110/kg, within reasonable changes of price, the irrigated rice crop is competitive with soybean.

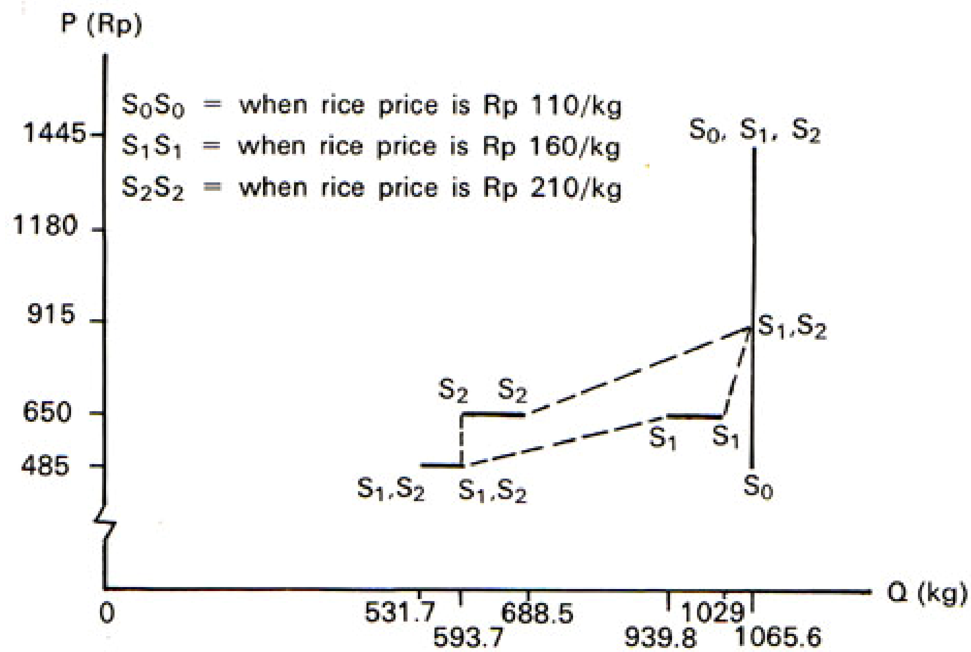

Figure 5.1 Effect of rice price changes on the normative supply curve of soybean in the irrigated lowlands of Pasuruan District, 1987.

The effect of changes in peanut price on the normative supply curve of soybean are shown in Figure 5.2. For a peanut price of Rp 750, it can be shown that the normative supply curve of soybean is strictly vertical (S_0S_0). If the price of peanut is increased to Rp 1025, it will shift to S_1S_1, where if the prices of soybean are increased to above Rp 650 the curve will be vertical again.

The curve will shift to S_2S_2, when the price of peanut increases from Rp 1025 to Rp 1300, where the cross-elasticity is about -8.46 at the price of soybean of Rp 485(see Table 5.4). At the price of soybean of Rp 650, the quantity of soybean has led to an absolute decrease in the cross-elasticity of -3.24 to -2.11. Further, if the price of soybean is above Rp 915, the normative supply curve (S_2S_2) will also be vertical. With the price of peanut increasing to Rp 1575, the normative supply curve of soybean will take the form of S_3S_3, which will be vertical again if the price of soybean increases above Rp 1180. The cross-elasticity is around -4.11 to -4.04, when the price of soybean is Rp 915. Thus, it may be concluded that peanut is very competitive with soybean.

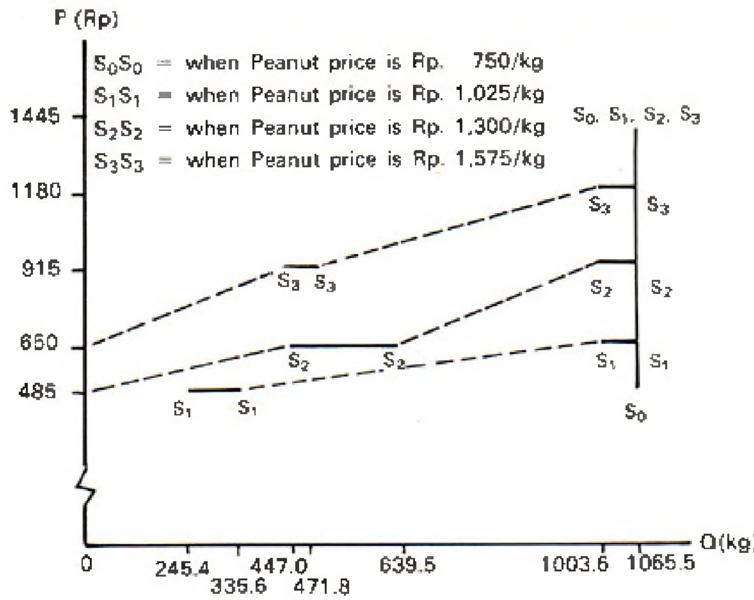

Figure 5.2 Effect of peanut price changes on the normative supply curve of soybean in the irrigated lowlands, Pasuruan District, 1987.

Figure 5.3 presents the effect of corn price changes on the normative supply of soybean on the model farm in the irrigated lowlands of Pasuruan District. Details of the relevant cross-elasticity data are found in Table 5.4.

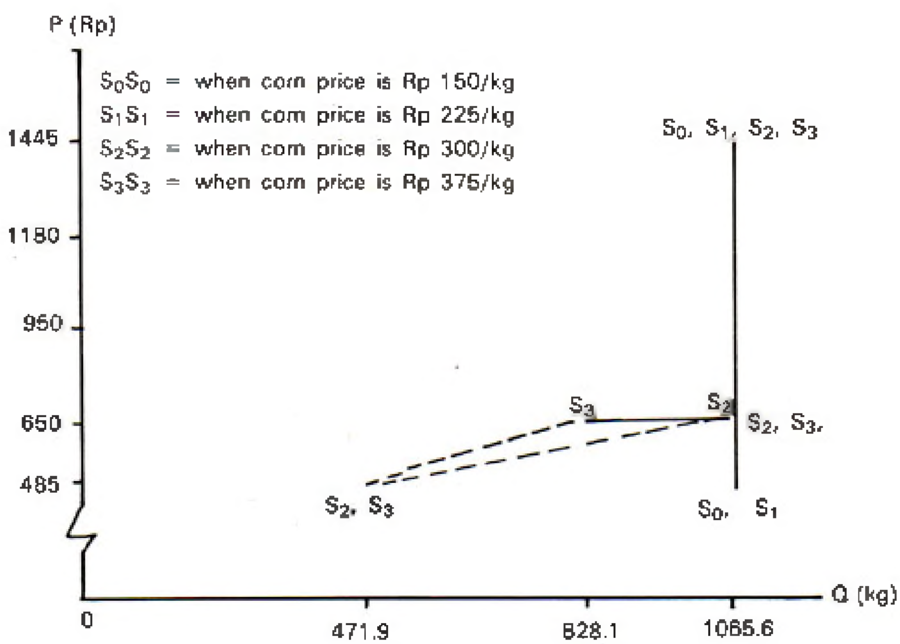

Figure 5.3 Effect of corn price changes on the normative supply curve of soybean in the irrigated lowlands of Pasuruan District, 1987.

At corn prices from Rp 150 to Rp 225 per kg, the respective normative supply curves of soybean S_0S_0 and S_1S_1 were found to be more or less vertical, as can be seen from Figure 5.3, which is based on data in Appendix 9. At the corn price of Rp 300/kg, the normative supply of soybean is as low as 472 kg when the soybean price is Rp 485/kg. It increases to around 1066 kg for the soybean price of Rp 650. For all soybean prices above Rp 650, the supply will be the same (i.e. constant at 1.066 kg), thus making the supply curve (S_2S_2) from that point on vertical.

When the corn price reaches Rp 375/kg and the soybean price is as low as Rp 485, the supply is also only 472 kg. It increases from 828 to 1066 kg when the soybean price increases to Rp 650, and stays at 1066 kg for all prices of soybean higher than Rp 650. These responses to price changes indicate that there is no change in the normative supply of soybean when its price moves higher than Rp 650, even if corn prices have also changed within a reasonable range. Under such conditions, unlike rice and peanut, corn does not seem to be competitive with soybean.

Table 5.4 Cross-elasticities of soybean produced with respect to rice, peanut and corn prices in the irrigated lowlands of Pasuruan District, 1987.

Price changes of related commodities	Level of soybean (Rp/kg)				
	485	650	915	1180	1445
1. Rice(Rp/kg)					
110 to 160	-1.65to -1.53	-0.46to -0.09	0	0	0
160 to 210	-0.07to Inf	-0.03	0	0	0
2. Peanut(Rp/kg)					
750 to 1025	-3.92to -3.36	0	0	0	0
1025 to 1300	-8.46	-3.24to -2.11	0	0	0
1300 to 1575	Inf	-10.45	-4.11to -4.04	0	0
3. Corn(Rp/kg)					
150 to 225	0	0	0	0	0
225 to 300	-2.70to -2.52	0	0	0	0
300 to 375	0	0	0	0	0

Table 5.5 Own-price elasticities of soybean farm supply/production at certain levels of related crop prices in the irrigated lowlands, Pasuruan District, 1987.

	Range of changes in soybean price (Rp/kg)			
	485 to 650	650 to 915	915 to 1180	1180 to 1445
1. At the rice price of				
Rp 110	0	0	0	0
Rp 160	1.85to 1.91	0.10to 0.37	0	0
Rp 210	0.38to	1.27to	0	0
2. At the peanut price of				
Rp 750	0	0	0	0
Rp 1025	3.49to 4.18	0	0	0
Rp 1300	0.68	1.48to 2.27	0	0
Rp 1575	0	0	3.05to 3.36	0
3. At the corn price of				
Rp 150	0	0	0	0
Rp 225	0	0	0	0
Rp 300	2.53to 2.66	0	0	0
Rp 375	1.89to 2.66	0	0	0

6

Conclusions

1. Compared with other food crops in the post-rainy and dry seasons in the survey period, soybean is more profitable. More specifically, with current price ratios, the planting of soybean as a monocrop is more profitable than an intercrop of corn and soybean or any other crop. If farmers actually grow soybean as an intercrop, this means that they consider the risk involved in growing a monocrop to be greater than the difference in income they would have received by raising a soybean monocrop.

2. Peanut and rice are competitive crops with soybean, within the range of their current feasible price changes. By setting the price of soybean at Rp 650/kg, for example, while increasing the price of peanut to Rp 1575/kg or the price of rice to more than Rp 160/kg, farmers would reduce the area of soybean crop and substitute it with peanut or rice, respectively. Shifts in cropping areas result if farmers are profit-oriented. Within the limit of reasonable price changes, the critical price of soybean is around Rp 915/kg. At lower prices, substitution with peanut and rice crops for some of the soybean area becomes feasible.

3. At the current price ratio and production technologies, corn does not seem to be very competitive with soybean. Only when soybean prices are very low (i.e. less than Rp 650/kg), does corn become economically feasible to enter the local cropping pattern. At soybean prices around Rp 483/kg, half of the crop area would be occupied by corn during the dry season.

4. The production of soybean at the farm level depends on technology application, in addition to the area cropped. Current soybean farm technology has resulted in low farm yields compared to the experimental plots. This implies that the cost per unit of production at the farm level could be reduced by using the improved technology. This would result in greater competitiveness of soybean relative to other crops.

In order to achieve self-sufficiency in soybean production, the government of Indonesia should not only consider the application of improved and appropriate technologies, but also a suitable price policy which may be imposed upon soybean and the competing crops. The latter is especially true, if self-sufficiency in more than one crop production is being considered, and where an optimal reallocation of farm resources is needed. To solve these problems, linear programming techniques may also be used in planning appropriate policy changes.

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Appendices

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Appendix 1 Shadow prices of the limited farm resources in the optimal soybean cropping on irrigated lowland, Category I farmers, Pasuruan District, 1987.

Farm resources	Availability	Permissible range of use		Shadow prices
		Lower	Upper	**(Rp)**
Post-rainy season				
Farm land (ha)	0.625	0.547	0.625	406,140
Labour (days)				
Men for drainage	4.5	1.9	inf	650
Women for weeding	7.5	4.5	7.7	500
Women for harvesting	7.5	7.5	7.5	500
Capital for pesticides (Rp)	4500	4500	5063	5150
Dry season				
Farm land (ha)	0.625	0.625	0.625	494,110
Labour (days)				
Men for cleaning the field	5.5	5.5	6.5	650
Men for planting	6.5	6.5	9.1	650
Women for planting	7.5	7.5	17.5	500
Women for weeding	7.5	7.5	26.6	500
Women for harvesting	7.5	7.5	16.8	500
Capital for pesticides (Rp)	6500	6500	6970	1150

[a] Shadow price of capital is about Rp 1150 for each Rp 1000 invested.

Appendix 2 Shadow prices of the limited farm resources in the optimal soybean cropping on irrigated lowland, Category II farmers, Pasuruan District, 1987.

Farm resources	Availability	Permissible range of use		Shadow prices
		Lower	Upper	(Rp)
Post-rainy season	0.550	0.000	0.550	433,500
Farm land (ha)				
Dry season				
Farm land (ha)	0.550	0.379	0.550	521,813
Labour (days)				
Men for planting	5.5	0.0	7.0	650
Women for planting	15.0	0.0	15.4	500
Women for weeding	15.0	0.0	23.4	500

Appendix 3 Income reduction if other activities are to enter into the optimal farm plan of Category I farmers, Pasuruan District, 1987.

Cropping activities	Range of activity (ha)		Income reduction per ha **(Rp)**
	Lower	Upper	
Post-rainy season			
1. Rice	0	0.0000	143,049
2. Peanut	0	0.0339	220,865
3. Intercrop soybean and corn	0	0.0781	120,920
4. Intercrop peanut and corn	0	0.1035	282,080
Dry season			
5. Corn	0	0.0000	133,511
6. Intercrop soybean and corn	0	0.1264	100,073
7. Intercrop peanut and corn	0	0.0100	28,256

Appendix 4 Income reduction if other activities are to enter into the optimal farm plan of Category II farmers, Pasuruan District, 1987.

Cropping activities	Range of activity (ha)		Income reduction per ha (Rp)
	Lower	Upper	
Post-rainy season			
1. Rice	0	0.000	120,545
2. Peanut	0	0.218	216,000
3. Intercrop soybean and corn	0	0.000	85,323
4. Intercrop peanut and corn	0	0.000	27,344
Dry season			
5. Peanut	0	0.000	44,138
6. Corn	0	0.000	248,578
7. Intercrop soybean and corn	0	0.000	139,923
8. Intercrop peanut and corn	0	0.038	136,661

Appendix 5 Optimal labour utilization in soybean cropping by Category I farmers on irrigated lowland, Pasuruan District, 1987.

Cultivation practices	Supply of family labour	Use of		Total
		Family labour	Hired labour	
Post-rainy season				
	.... (man-days)		....	
Drainage	4.5	4.5	1.0	5.5
Planting	6.5	3.4	0.0	3.4
Fertilizing	10.0	4.1	0.0	4.1
Irrigating	7.5	2.0	0.0	2.0
Weeding	7.5	3.4	0.0	3.4
Plant protection	7.5	5.1	0.0	5.1
Harvesting	12.5	9.5	0.0	9.5
Drying	10.0	9.7	0.0	9.7
Processing	8.5	6.9	0.0	6.7
	....(woman-days)		....	
Weeding	7.5	7.5	1.0	8.5
Harvesting	7.5	7.5	9.4	14.9
Processing	15.0	11.5	0.0	11.5
Dry season				
	.... (man-days)		....	
Cleaning the field of straw	5.5	5.5	1.0	6.5
Ploughing	10.0	7.8	0.0	7.8
Harrowing	10.0	3.4	0.0	3.4
Planting	6.5	6.5	2.6	9.1
Fertilizing	10.0	3.9	0.0	3.9
Irrigating	7.5	7.3	0.0	7.3
Weeding	7.5	6.6	0.0	6.6
Plant protection	7.5	5.1	0.0	5.1
Harvesting	12.5	9.5	0.0	9.5
Drying	10.0	8.0	0.0	8.0
Processing	8.5	6.9	0.0	6.9
	....(woman-days)		....	
Planting	7.5	7.5	10.0	17.5
Weeding	7.5	7.5	19.1	26.6
Harvesting	7.5	7.5	9.3	16.8
Processing	15.0	11.5	0.0	11.5
	.... (animal-days)		....	
Ploughing	10.0	7.8	0.0	7.8
Harrowing	10.0	3.4	0.0	3.4

Appendix 6 Optimal labour utilization in soybean cropping by Category II farmers on irrigated lowland, Pasuruan District, 1987.

Cultivation Practice	Supply of family labour	Use of		Total
		Family labour	Hired labour	
Post-rainy season				
	.... (man-days)			
Drainage	6.5	4.3	0.0	4.3
Planting	6.5	3.1	0.0	3.1
Fertilizing	7.0	3.6	0.0	3.6
Irrigating	6.5	1.7	0.0	1.7
Weeding	6.5	3.1	0.0	3.1
Plant protection	8.5	4.5	0.0	4.5
Harvesting	10.5	8.4	0.0	8.4
Drying	15.5	8.5	0.0	8.5
Processing	10.5	6.1	0.0	6.1
	.... (woman-days)			
Weeding	15.0	6.8	0.0	6.8
Harvesting	15.0	14.9	0.0	14.9
Processing	15.0	10.1	0.0	10.1
Dry season				
	....(man-days)			
Cleaning the field of straw	6.0	5.5	0.0	5.5
Ploughing	7.4	6.9	0.0	6.9
Harrowing	7.4	3.1	0.0	3.1
Planting	5.5	5.5	2.5	8.0
Fertilizing	7.0	3.4	0.0	3.4
Irrigating	6.5	6.4	0.0	6.4
Weeding	6.5	5.8	0.0	5.8
Plant protection	8.5	4.5	0.0	4.5
Harvesting	10.5	8.4	0.0	8.4
Drying	15.5	7.1	0.0	7.1
Processing	10.5	6.1	0.0	6.1
	.... (woman-days)			
Planting	4.5	4.5	11.0	15.5
Weeding	15.0	15.0	8.4	23.4
Harvesting	15.0	14.8	0.0	14.8
Processing	17.5	10.1	0.0	10.1
	.... (animal-days)			
Ploughing	7.4	10.1	0.0	10.1
Harrowing	7.4	3.1	0.0	3.1

Appendix 7. Effect of price changes on soybean and peanut farm production on irrigated lowland, Pasuruan District, 1987.

Peanut price[a]	Price of soybean (Rp/kg)				
	485	650	950	1180	1445
	........(kg)........				
1. Rp 750/kg					
Soybean	1003.56 to 1065.63	1065.63	1065.63	1065.63	1065.63
Peanut	0	0	0	0	0
2. Rp 1025/kg					
Soybean	245.40 to 335.60	1003.56 to 1065.63	1003.56 to 1065.63	1003.56 to 1065.63	1003.56 to 1065.63
Peanut	440.00to 488.75	0	0	0	0
3. Rp 1300/kg					
Soybean	0 639.52	447.05 to 1065.63	1003.56 to 1065.63	1003.56 to 1065.63	1003.56 to
Peanut	618.75	381.91	0	0	0
4. Rp 1575/kg					
Soybean	0 471.86	0 1065.63	447.04 to	1003.56 to	1065.63
Peanut	590.34 to 618.75	618.75 381.91	368.75 to	0	0

[a]Shelled peanut.

Appendix 8. Effect of price changes on soybean and rice farm production on irrigated lowland, Pasuruan District, 1987.

Rice price[a]	Price of soybean (Rp/kg)				
	485	650	950	1180	1445
	............(kg)............				
1. Rp 110/kg					
Rice	0	0	0	0	0
Soybean	1003.60 to 1065.65	1065.63	1003.60	1065.63	1003.60 to
2. Rp 160/kg					
Rice	1575.00 to 1968.75	151.44 to 525.00	0	0	0
Soybean	531.70 to 593.75	1065.63 1029.32	1065.63	1065.63	1065.63
3. Rp 210/kg					
Rice	1575.00 to	1575.00 to	0	0	0
Soybean	531.70 to 593.75	539.75 to 688.15	1065.63	1065.63	1065.63

[a]Milling-dry unhusked rice (*gabah kering giling*)

Appendix 7. Effect of price changes on soybean and corn farm production on irrigated lowland, Pasuruan District, 1987.

Corn price[a]	Price of soybean (Rp/kg)				
	485	650	950	1180	1445
	..........(kg)..........				
1. Rp 150/kg					
Corn	0	0	0	0	0
Soybean	1003.56 to 1065.65	1065.63	1065.63	1065.63	1065.65
2. Rp 225/kg					
Corn	0	0	0	0	0
Soybean	1003.56 to 1065.63	1065.63 to 1065.63	1065.65 to 1065.63	1065.63	1065.65
3. Rp 300/kg					
Corn	937.50 to 948.45	0	0	0	0
Soybean	471.88	1019.50 to 1065.63	1019.50 to 1065.63	1019.50 to 1065.63	1019.50 to 1065.63
4. Rp 375/kg					
Corn	937.50 to 948.45	72.90 to 375.00	0	0	0
Soybean	471.88	828.13 to 1065.63	1019.50 to 1065.63	1019.50 to 1065.63	1019.50 to 1065.63

[a]Shelled grain.

Appendix 10 Input-output coefficients of the existing farming system models in the post-rainy season on irrigated lowland, Pasuruan District, 1987.

Input and output	Rice monocropping	Soybean monocropping
1. Seed (kg/ha)		
1.1 Rice	30	-
1.2 Soybean	-	47.5
1.3 Corn	-	-
1.4 Peanut	-	-
2. Fertilizer (kg/ha)		
2.1 Urea	90	60
2.2 TSP	60	35
2.3 ZA	30	
2.4 KO	20	
2.5 Gandasil (pack of 150 g)		3
3. Capital for pesticides (Rp/ha)	7295	8100
4. Labour		
4.1 Draft animal (animal-days)		
4.1.1 Ploughing	20	
4.1.2 Harrowing	9.5	
4.2 Male labour (man-days)		
4.2.1 Cleaning the field of straw	-	
4.2.2 Ploughing	20	
4.2.3 Harrowing	9.5	
4.2.4 Drainage		7.8
4.2.5 Planting	4	5.5
4.2.6 Fertilizing	7.4	6.5
4.2.7 Irrigating	20	3
4.2.8 Weeding		5.5
4.2.9 Plant protection	7	8.1
4.2.10 Harvesting	37.5	15.2
4.2.11 Drying	5.2	11
4.2.12 Processing	7	15.1
4.3 Female labour (woman-days)	45	-
4.3.1 Planting	55	12.3
4.3.2 Weeding	63.	27
4.3.3 Harvesting	15	18.4
4.3.4 Processing	45	-
5. Yield (kg/ha)		
5.1 Rice (milling dry unhusked)	3150	-
5.2 Soybean (farm dry grain)	-	755
5.3 Corn (farm dry grain)	-	-
5.4 Peanut (farm dry grain)	-	-

Appendix 10 Continued.

Input and output	Peanut mono-cropping	Soybean and corn inter-cropping	Peanut and corn inter-cropping
1. Seed (kg/ha)	-		
1.1 Rice	-	-	-
1.2 Soybean	42	-	-
1.3 Corn		5.5	7.5
1.4 Peanut	80	-	80
2. Fertilizer (kg/ha)	-		
2.1 Urea	20	40	-
2.2 TSP	22.5	20	-
2.3 ZA	-	-	-
2.4 KCl		3	-
3. Capital for pesticides (Rp/ha)	2500	6450	2700
4. Labour			
4.1 Draft animal (animal-days)			
4.1.1 Ploughing	15	-	-
4.1.2 Harrowing	-	-	-
4.2 Male labour (man-days)			
4.2.1 Cleaning the field of straw	6.3	19	10.5
4.2.2 Ploughing	15	-	-
4.2.3 Harrowing	-	-	-
4.2.4 Drainage	5	3	9.4
4.2.5 Planting	15	6.4	8.5
4.2.6 Fertilizing	-	3	3
4.2.7 Irrigating	25	9	5.4
4.2.8 Weeding	-	40	20.5
4.2.9 Plant protection	12.5	3	-
4.2.10 Harvesting	12.5	12.5	8.4
4.2.11 Drying	25	13.5	6.7
4.2.12 Processing	20	20.5	26.7
4.3 Female labour (woman-days)	25	12.5	10
4.3.1 Planting	50	36	35.6
4.3.2 Weeding	26	26.5	21.8
4.3.3 Harvesting	25	18.5	32.5
5. Yield (kg/ha)			
5.1 Rice (milling dry, unhusked)	-	-	-
5.2 Soybean (farm dry grain)	-	527	-
5.3 Corn (farm dry grain)	-	140	165
5.4 Peanut (farm dry grain)	400	-	295

Appendix 11 Input-output coefficients of the existing farming system models in the dry season on irrigated lowland, Pasuruan District, 1987.

Input and output	Soybean monocropping	Peanut monocropping
1. Seed (kg/ha)		
1.1 Soybean	51.5	-
1.2 Peanut	-	80
1.3 Corn	-	-
2. Fertilizer (kg/ha)		
2.1 Urea	45	-
2.2 ZA	10	-
2.3 TSP	33.5	15
2.4 Gandasil	4	-
3. Capital for pesticides (Rp/ha)	11.150	3975
4. Labour		
4.1 Draft animal (animal-days)		
4.1.1 Ploughing	12.5	20.5
4.1.2 Harrowing	5.5	6.5
4.2 Male labour (man-days)		
4.2.1 Cleaning the field of straw	10	-
4.2.2 Ploughing	12.5	20.5
4.2.3 Harrowing	5.5	6.5
4.2.4 Drainage	-	-
4.2.5 Planting	14.5	12
4.2.6 Fertilizing	6.2	3.6
4.2.7 Irrigating	11.6	13.5
4.2.8 Weeding	10.5	-
4.2.9 Plant protection	8.1	4
4.2.10 Harvesting	15.2	23.5
4.2.11 Drying	12.8	13
4.2.12 Processing	11	30
4.3 Female labour (woman-days)		
4.3.1 Planting	28	21
4.3.2 Weeding	42.5	-
4.3.3 Harvesting	26.5	28.5
4.3.4 Processing	18.4	
5. Yield (kg/ha)		
5.1 Corn (farm dry grain)	-	-
5.2 Soybean (farm dry grain)	950	-
5.4 Peanut (farm dry grain)	-	590

Appendix 11 Continued.

Input and output	Corn mono-cropping	Soybean and corn inter-cropping	Peanut and corn inter-cropping
1. Seed (kg/ha)			
1.1 Soybean	-	48.5	-
1.2 Peanut	-	-	80
1.3 Corn	35	5	7.5
2. Fertilizer (kg/ha)			
2.1 Urea	50	42	40
2.2 ZA	-	-	-
2.3 TSP	-	37	20
2.4 Gandasil	-	4.5	-
3. Capital for pesticides (Rp/ha)	1500	4450	6367
4. Labour			
4.1 Draft animal (animal-days)	-	-	-
4.1.1 Ploughing	16	18.5	10.5
4.1.2 Harrowing	8	6.5	5.3
4.2 Male labour (man-days)			
4.2.1 Cleaning the field of straw	12	-	-
4.2.2 Ploughing	16	18.5	10.5
4.2.3 Harrowing	8	6.5	5.3
4.2.4 Drainage	5.7	-	3
4.2.5 Planting	15.5	17.8	20.5
4.2.6 Fertilizing	4.5	5.5	3.5
4.2.7 Irrigating	12.6	11.5	10.6
4.2.8 Weeding	12.5	10.2	10.6
4.2.9 Plant protection	4.7	7.1	4.5
4.2.10 Harvesting	13.4	12.5	21.7
4.2.11 Drying	14	15.1	10
4.2.12 Processing	10	24.5	18.2
4.3 Female labour (woman-days)	15.5	34.2	20.5
4.3.1 Planti	25	41	37.8
4.3.2 Weeding	28.7	24.8	35.2
4.3.3 Harvesting	26.5	31.4	30.5
5. Yield (kg/ha)			
5.1 Corn (farm dry grain)	1500	95	360
5.2 Soybean (farm dry grain)	-	673	-
5.4 Peanut (farm dry grain)	-	-	595

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