BIBLIOGRAPHIC DATA SHEET	1. CONTROL NUMBER PN-AAJ-573	2. SUBJECT CLASSIFICATION (695) AF00-1400-G570

3. TITLE AND SUBTITLE (240)

Prospects for grain legume production in Asia

4. PERSONAL AUTHORS (100)

von Oppen, M. K.

5. CORPORATE AUTHORS (101)

ICRISAT

6. DOCUMENT DATE (110)	7. NUMBER OF PAGES (120)	8. ARC NUMBER (170)
1981	23p.	FEA633.3.V945

9. REFERENCE ORGANIZATION (130)

ICRISAT

10. SUPPLEMENTARY NOTES (500)

(In Economics Program Progress Report 19)

11. ABSTRACT (950)

12. DESCRIPTORS (920)

Asia
Grain legumes
Productivity
Soybean
Cowpeas
Pigeon peas
Plant breeding
Nitrogen
Economic aspects

13. PROJECT NUMBER (150)

698039330

14. CONTRACT NO.(140)

AID-698-0393-3-T

15. CONTRACT TYPE (140)

16. TYPE OF DOCUMENT (160)

AID 590-7 (10-79)

FEA
633.3
V945

PN-AAJ-573

Economics Program
Progress Report 38

Prospects for Grain Legume Production in Asia

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January 1985

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PROSPECTS FOR GRAIN LEGUME PRODUCTION IN ASIA†

M. von Oppen*

INTRODUCTION

Production of grain legumes[1] in the world in 1978 amounted to 161 million tons or 10.2% of the amount of cereals produced. The world area of grain legumes in 1978 was 155 million hectares or 20.5% of the area under cereals. In the area mainly of concern for the Asian Productivity Organization, i.e. the developing market economies of East Asia,[2] the picture is similar. In 1978 a total of 23 million tons of grain legumes were produced, or 8.6% of the amount of cereals produced in this region: the area was 38 million hectares or 22.9% of the area under cereals.

However, while the world production of grain legumes in 1978 comprised 50% soybeans, and only 38% pulses and 12% groundnuts, in the developing market economies of East Asia soybeans contributed not more than 5%; here pulses accounted for 61% and groundnuts 34%. Thus, in these East Asian countries as a group the importance of soybeans is almost negligible at present while pulses and groundnuts dominate. In the absence of any increase in yields and given a nearly constant area under groundnuts and pulses the relative amount of grain legumes when compared to cereals has decreased continously over the past decades, even though area and yield of soybeans is increasing.

As an important source of protein and fat, pulses, groundnuts and soybeans complement cereals in the diets of people, especially in the low income countries. In addition, grain legumes provide a valuable source of nitrogen to the soil. In view of this importance of the grain legumes as a complement

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† Presented at the Symposium on Grain Legumes Production, Asian Productivity Organization, 9-15 November 1980, Chiangmai, Thailand. ICPISAT Conference Paper No. 30 released for publication on 20 January 1981.

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1. All grain pulses, including soybeans and groundnuts.

2. According to grouping by FAO Production Yearbook 1978.

to cereals, the decreasing trend of grain legume production in relation to cereal production in East Asian developing countries has been alarming policy makers who would like levels of foodgrain availability and protein from legumes to be restored to what they used to be historically.

On the other hand, there are studies which show that for India, which is the major country of the East Asia developing market economies, the decrease in pulse production and availability of pulse protein as a result of the green revolution in wheat and expansion of areas sown to cereals in North India since the mid-1960s, was more than offset by additional protein which came with the additional cereal production. This meant that consumers on average had a larger total availability of protein as a result of the green revolution in wheat than they would have without (Fig 1, Ryan and Asokan 1977). In other words, this study shows that given the other choice of no green revolution and continuation of past trends, consumers were in fact better off with more cereals of the high yielding type and less pulses, because the additional cereal production provided more additional protein such as to substantially increase the trend in total protein availability. Even though this solution may be nutritionally adequate, it does not provide the satisfaction of a slightly more luxurious diet. More satisfactory would be a cereal production at the post green revolution levels <u>together</u> with also increased pulse availability.

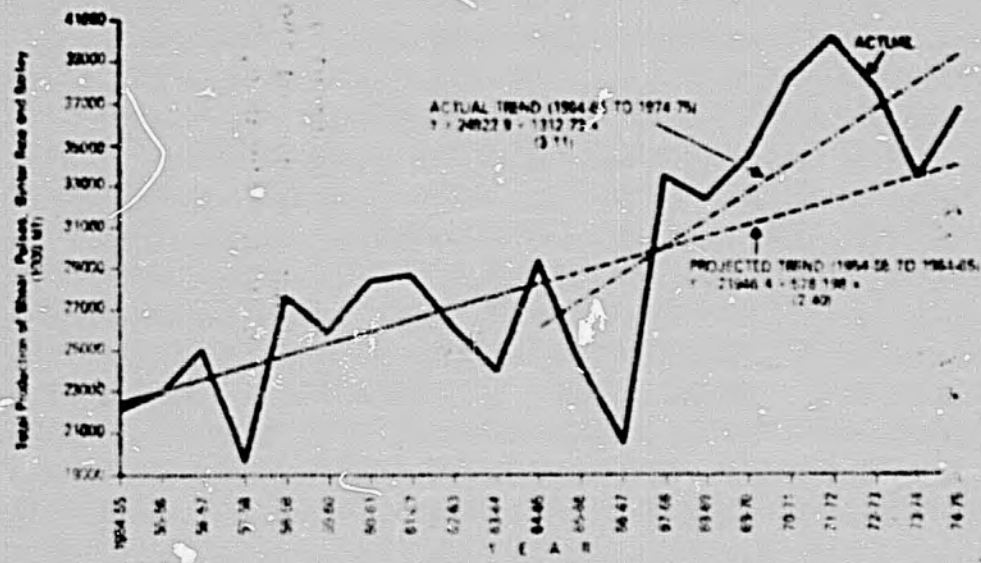
It is in view of this desirable alternative that the prospects of grain legume production in Asia are being assessed. In the following, two points will be discussed in detail: (1) the biological nature and related technological limitations in increasing production of grain legumes and (2) economic factors and policies.

1. BIOLOGICAL AND TECHNICAL ASPECTS

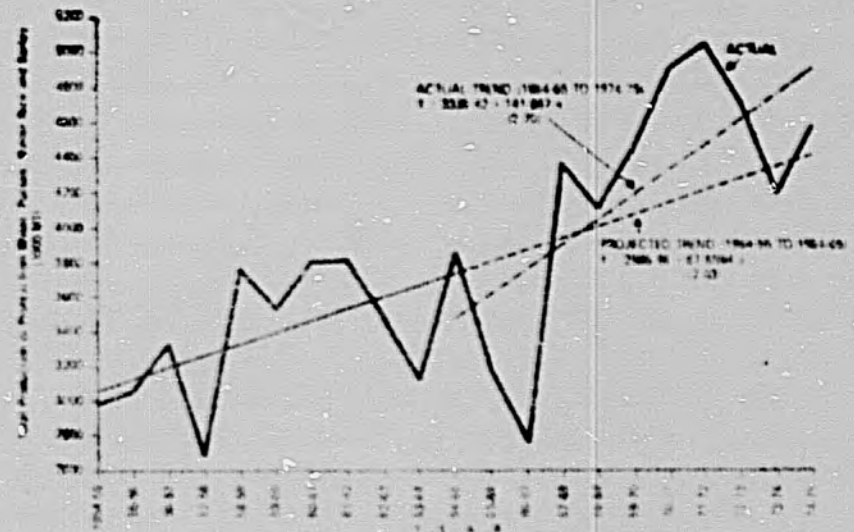
Prospects regarding yield increases in grain legumes

When comparing cereal crops with legumes, regarding yield potential and response to plant breeding efforts, fundamental differences exist. As Green (1979) puts it, the consequences of these differences are illustrated by the progress of the soybean and the maize crops in the U.S.A. Presenting Figure 2, Green notes: with a background of intensive research on maize for many years, and a breakthrough in the teens that started reaching the farmers in the late 1920s and early 1930s, production has increased dramatically.

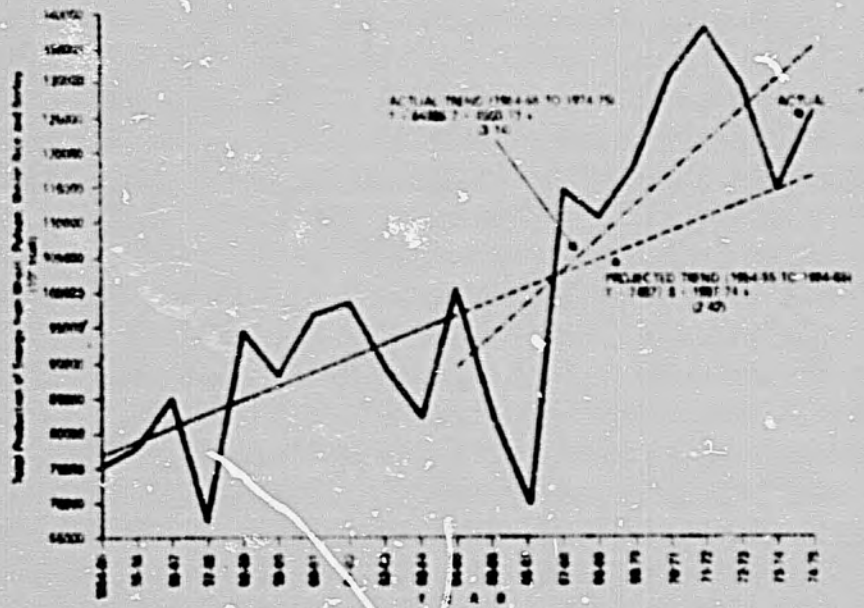
FIGURE 1 TOTAL PRODUCTION OF WHEAT, PULSES, WINTER RICE AND BARLEY IN THE 12 MAJOR WHEAT GROWING STATES OF INDIA



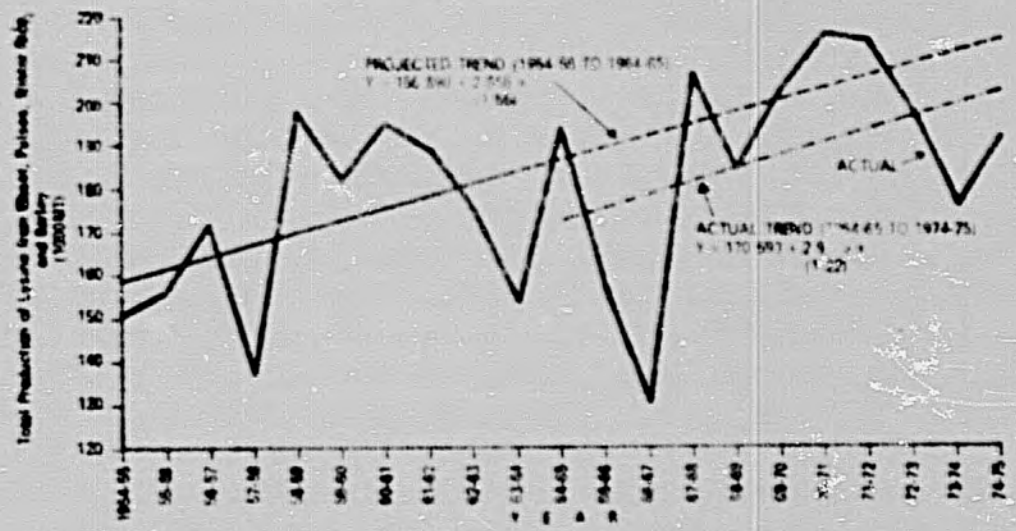
TOTAL PRODUCTION OF PADDY FROM WHEAT, PULSES, WINTER RICE AND BARLEY IN THE 9 MAJOR WHEAT GROWING STATES OF INDIA



TOTAL PRODUCTION OF MAIZE FROM WHEAT, PULSES, WINTER RICE AND BARLEY IN THE 9 MAJOR WHEAT GROWING STATES OF INDIA



TOTAL PRODUCTION OF LYSINE FROM WHEAT, PULSES, WINTER RICE AND BARLEY IN THE 9 MAJOR WHEAT GROWING STATES OF INDIA



Source: Ryan and Asokan (1977).

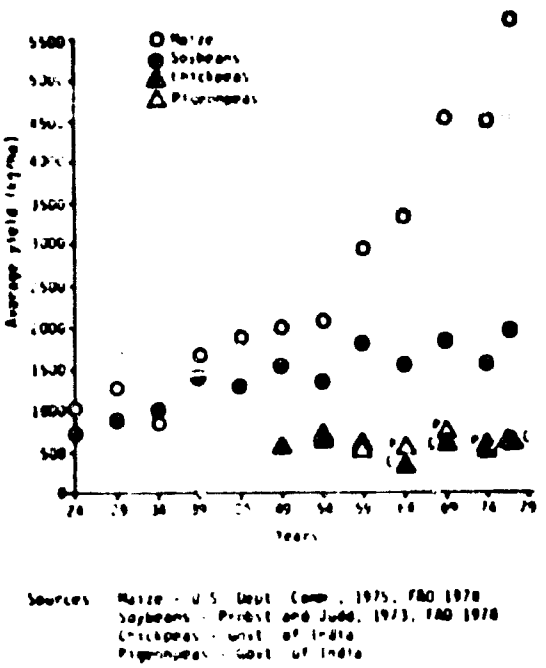


Figure 2. Annual mean yield (kg/ha) at 5-year intervals of maize and soybeans in USA and chickpeas and pigeonpeas in India, 1924-1977

Source: Proceedings, International Symposium on Development and Transfer of Technology for Rainfed Agriculture and the SAT Farmer. ICRISAT, 28 Aug-1 Sep 1979, Hyderabad, India, p. 18.

Soybean yields have increased, but only in a linear fashion, and researchers are still looking for a breakthough" (Green 1979).

On the one hand the biological constitution of grain legumes enables them in symbiosis with rhizobium bacteria to draw nitrogen from the air to produce grains of high protein (and high fat) content. On the other hand, the genetic and physiological complexities involved seem to limit their ability to produce higher yields (even though in energy equivalents the protein-and -fat-rich pulses are as efficient as are cereals in producing food).[3]

Nevertheless, intensive efforts are underway at international research institutes such as AVRDC, ICRISAT and national institutes, such as the Indian Agricultural Research Institute and elsewhere to produce higher yielding legume crops. These efforts began only relatively recently and this delay compared to most cereals in the start of serious breeding efforts is probably another reason why grain legumes have been showing stagnant yields during the past decades, while cereal yields moved upward. At the AVRDC the work continues on soybeans and mungbeans (Sundaram 1980).

At ICRISAT breeders are following different strategies for different crops. In chickpeas, the strategy is to go for taller plant types with more pods, and considerably higher yields for this type are being found already in F_3 generations. Resistance against diseases especially wilt is another breeding objective. In pigeonpeas, hybridization appears to provide a promising avenue for achieving higher yields. Also work on short duration varieties of pigeonpeas is underway, to enable farmers to grow a second crop following the early maturing pigeonpea. In groundnuts not so much yield potential but disease resistance is being emphasized to stabilize production of the crop in the largely largely unprotected environment of most developing countries. Of course, success with this strategy will also increase average yields. The higher yield potential which already exists in some cultivars under disease-protected conditions would then be combined with those varieties for which satisfactory disease resistance has been attained. Similarly, with soybeans the present strategy in India is to combine high yield potential and short duration of the U.S. cultivars with the disease resistance of local black seeded varieties.

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3. Personal communication from A.R. Shelbrake.

However, despite these and other efforts in legume improvement, dramatic increases in yields of grain legumes may not be expected in the immediate future. More promising are the contributions to stability and short duration which these breeding efforts are likely to bring about in a relatively near future. Consequently, a reduction in the relative cost of production due simply to higher yields of pulses as compared to cereals ca not be expected to come about soon; more likely the gap must be expected t continue or even widen. However, new cropping systems may become possible once new varieties of these legumes are available with characteristics suc as early maturity and/or disease resistance and this will also increase farmers' incomes, and is likely to contribute to an expansion of the area under pulses.

Location-specific conditions determining yields

The complex physiology of grain legumes is probably also responsible for th fact that generally in comparison to most cereals, yields and qualities of grain legumes are more dependent on location-specific conditions. For instance, photosensitivity and temperature affect yields of most legumes at different latitudes and locations; rhizobium strains available in the soil affect their nitrogen fixation and yields; the spectrum of damaging pests and diseases is greater in grain legumes than in cereals and losses are higher. Traditionally therefore, certain cultivars are grown in limited areas, e.g. in India different regions grow different types of chickpeas (Kabuli, Gulabi, Desi), pigeonpeas (White, Red, Speckled, Black) or any othe of the numerous pulse crops.

It is because of this relatively strong location-dependency of grain legumes that legume breeders place emphasis on environmental insensitivity.[4] However, even then particular varieties clearly perform best in particular environments.[5] At the same time, pulses because of their relatively high nutritive value, have a higher unit value which in turn at given transport rates per unit of weight, provides the pulses with better transportability

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4. See Rachie and Plarre (1974).

5. For instance, the International Soybean Program (INTSOY) groups the varieties tested in international trials into about 12 location zones, determined by 4 sets of latitudes of 10° each and 3 altitude levels <500m, 500 -1000m, >1000m (Whigham 1978).

than cereals. In fact, within India the extent and degree of pulse trade involves considerably more long distance exchange than that of comparable cereals (compare Fig 3 and Fig 4).

Consequently, overall productivity of pulses in any country or state is relatively more dependent upon effective interregional trade within the country or state than is cereal production. The implications of this will be explained in detail below.

Value of nitrogen fixed by legume crops

The fact that legumes improve soil fertility is well recognized by farmers, who practice crop rotations or crop mixes which contain a certain proportion of legumes; the amount of nitrogen which a legume crop may add to the soil varies across crops and soil conditions.[6] Groundnuts or cowpeas have been reported to leave the equivalent of 60 kg of N/ha in the soil and growing a crop like pigeonpeas is reported to equal about 30-40 kg N/ha.[7]

In Asia, as in most countries of the world, until about 1973 the prices for nitrogen fertilizers increased at a lower rate than did the output prices so that nitrogen fertilizers were continously becoming cheaper in relation to crop outputs (Fig 5). Wherever farmers in the past were growing pulses in order to also make use of their effect on soil fertility, the increasing availability of cheap nitrogen fertilizers removed this limitation and farmers could increasingly expand cereal production, supported by inorganic nitrogen fertilizers at the expense of grain legumes. In world markets since 1974 a drastic increase in nitrogen prices relative to cereal prices occurred. However, many countries have at first attempted to prevent this price rise from affecting farmers. Therefore, massive fertilizer subsidies were initially being paid in countries like India, to maintain a relatively low price of fertilizers in the interest of increasing food production, i.e. cereal production. Recently nitrogen prices in India were increased to Rs. 5/kg of N in urea to avoid further subsidies; prior to 1973 the nitrogen price had been between Rs. 2 to 2.5/kg N. Even though prices of agricultural products are also increasing it is not likely that relative nitrogen prices will in the near future come down to levels prevailing prior to 1973.

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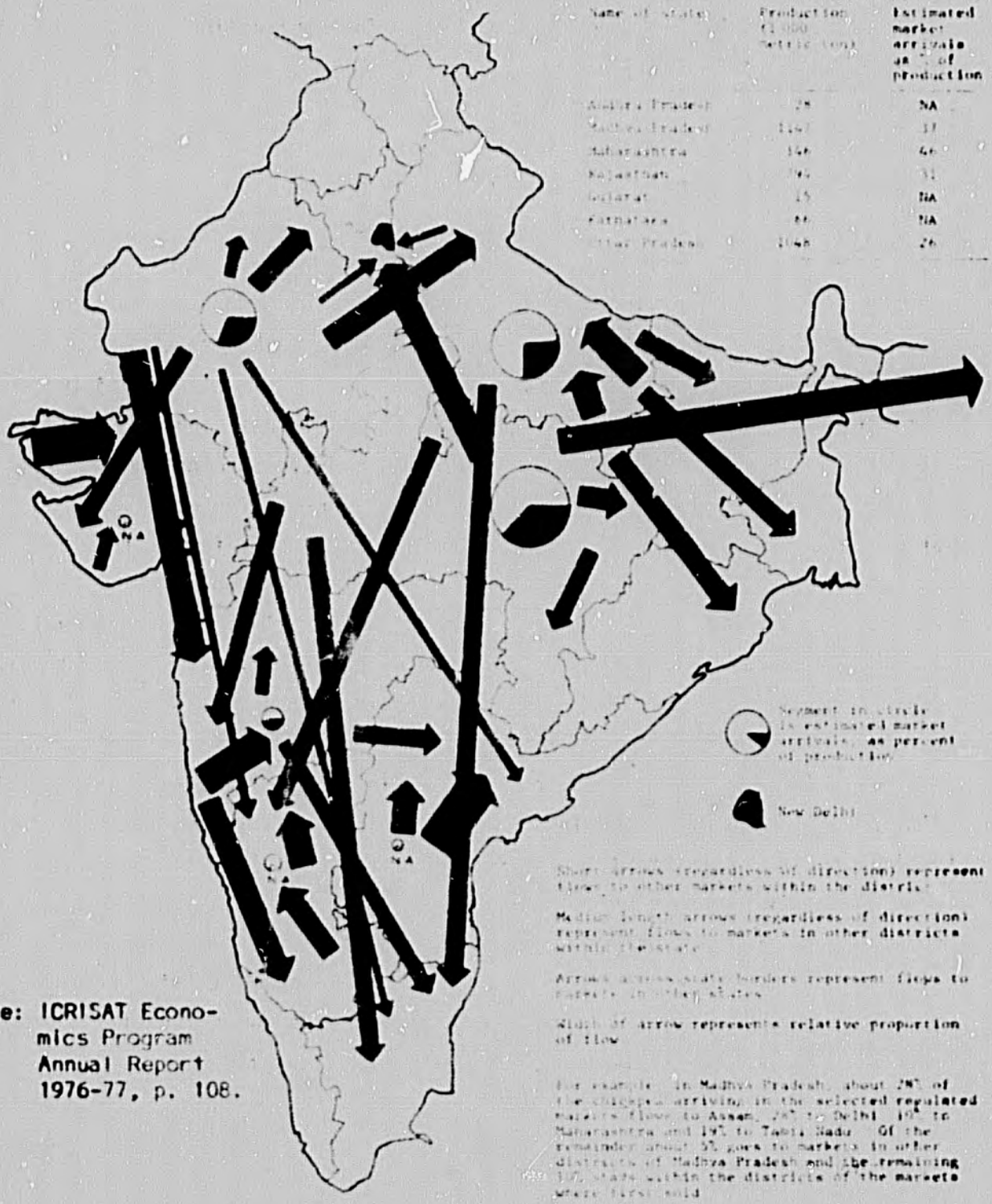
6. See Rao (1980).

7. Personal communication from P.J. Dart.

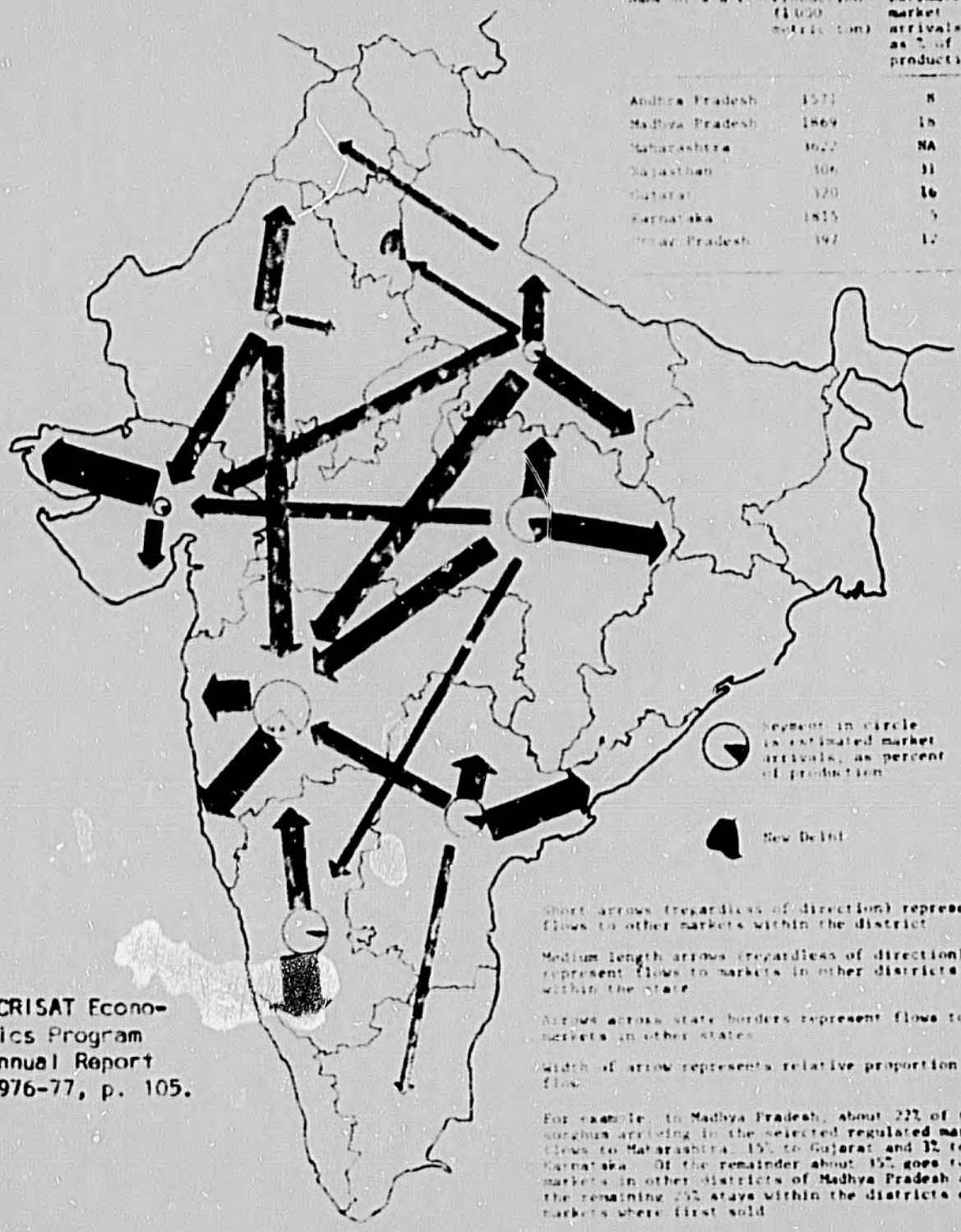
Figure 3. Production of chickpea, market arrivals as percent of production, and total flows (as percent of market arrivals) from selected food-grain markets in selected states of India, 1974-1975.



Source: ICRISAT Economics Program Annual Report 1976-77, p. 108.

Figure 4. Production of sorghum, market arrivals as percent of production, and total flows (as percent of market arrivals) from selected food-grain markets in selected states of India, 1974-1975.

Name of state	Production (1000 metric tons)	Estimated market arrivals as % of production
Andhra Pradesh	1571	8
Madhya Pradesh	1869	18
Maharashtra	3627	NA
Rajasthan	306	31
Gujarat	320	16
Karnataka	1815	5
Uttar Pradesh	197	12



Source: ICRISAT Economics Program Annual Report 1976-77, p. 105.

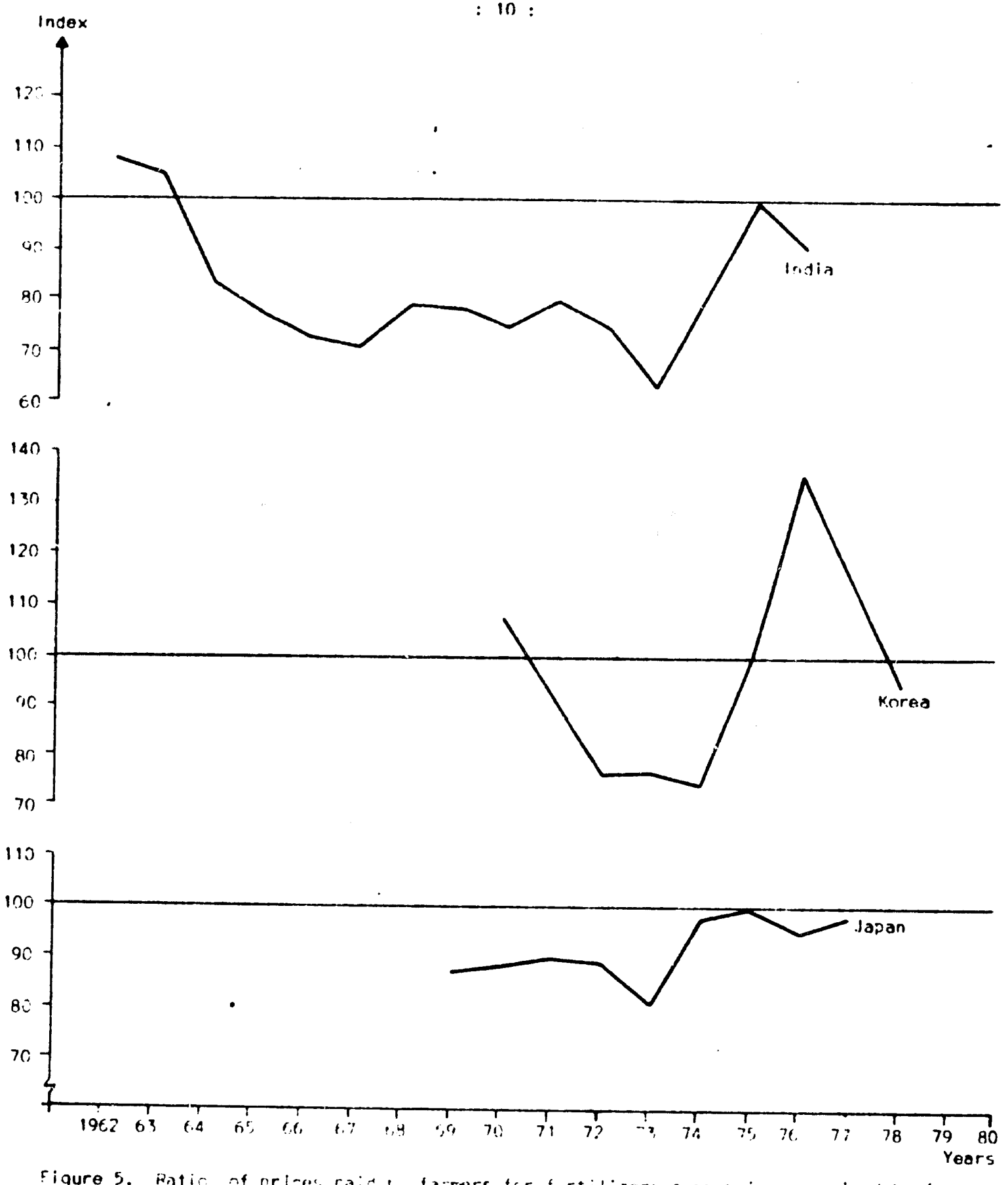


Figure 5. Ratio of prices paid by farmers for fertilizers over prices received by farmers for all agricultural products (Index prices, 1975 = 100)

Source: Korea and Japan: FAO Production YearBook 1978, India: Bulletin of Food Statistics, various issues.

Consequently, production of grain legumes, to the extent it would be practiced for maintenance of soil fertility, is likely to be inhibited by artificially low nitrogen fertilizer prices and availability at the farmers' level; vice versa high prices of nitrogen fertilizers will trigger farmers to make wider use of grain legumes and their residual nitrogen.

2. ECONOMIC ASPECTS AND POLICY RELATED ISSUES

In view of the above biological and technological characteristics, grain legumes play a special role among the foodgrains. Because of their capability of nitrogen fixation cultivation of grain legume crops is affected by policies for nitrogen fertilizers. Susceptibility to disease and pest attacks places importance on policies regarding pesticide availability. Location-specific yield performance and high unit value place emphasis on policies which determine market access.

Elasticities

In addition to, or rather because of, their technical and biological peculiarities, grain legumes have particular economic characteristics. These are reflected in producers' and consumers' decisions in response to changes in prices and incomes. These responses are measurable in the form of elasticities, i.e. the percentage change in quantities supplied or demanded given a 1% change in price or income.

If the income and price elasticities of demand and the price elasticity of supply are known for an economy for which also population, income and other price-cost relationships can be derived from past trends, it is possible to predict production of a particular commodity within the context of changes in prices, costs, and other policy related issues. Unfortunately, these are often not known exactly. However estimates indicating the general order of magnitude are available for India.

Demand elasticities

Pulses and oil producing legumes belong to a group of commodities which generally have income and price elasticities of demand in between those for cereals at the lower end, and for milk and milk products at the higher end (Table 1 and Fig 6).

An income elasticity of +1 implies that a 1% increase in income will cause a 1% increase in demand for the commodity. Elasticities for both edible oils as well as pulses and other foods are around 1. for Indian rural and

Table 1

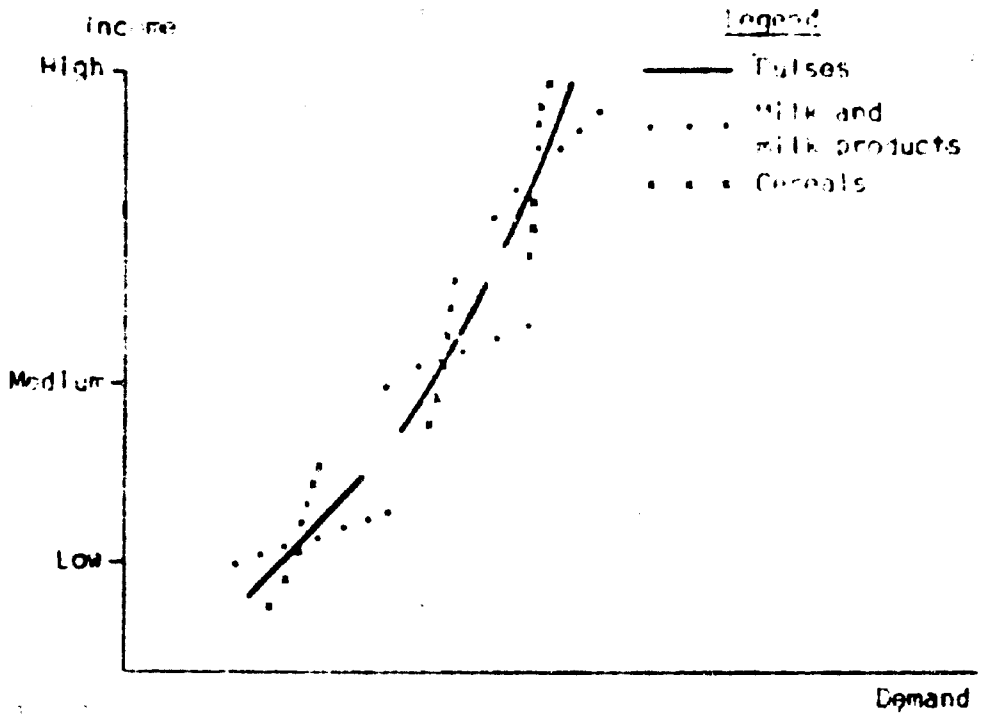
Income elasticity of demand - India

Commodity	Rural income groups			Urban income groups		
	Low	Middle	High	Low	Middle	High
Cereals	.9	.6	.3	1.0	.5	.1
Edible oils	1.5	1.0	1.0	1.2	1.1	.4
Pulses + other foods	1.1	1.1	.7	1.0	1.1	.8
Milk and milk products	2.0	2.2	.7	1.7	2.1	.9

Price elasticity of demand - India

Commodity	Rural income groups			Urban income groups		
	Low	Middle	High	Low	Middle	High
Cereals	-.9	-.5	-.2	-.9	-.3	-.02
Edible oils	-1.1	-.6	-.3	-1.0	-.5	-.03
Pulses + other foods	-.9	-.7	-.2	-.9	-.6	-.2
Milk and milk products	-1.5	-1.2	-.2	-1.4	-1.0	-.1

Source: Radhakrishna and Murty (1989)



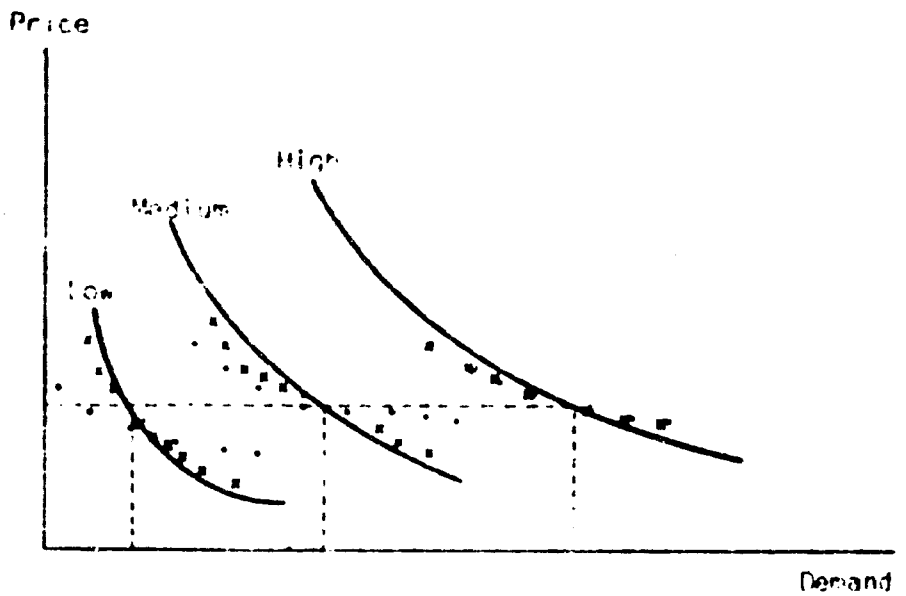


Figure 6. Income and price elasticities of demand for pulses, cereals & milk products (schematic).

Source: Radhakrishna and Murty, (1980).

and urban households, with a slight decrease for higher income groups. Hence it can be expected that the demand pressure for these commodities will continue and even increase, if per capita incomes increase with development.

A price elasticity of -1 implies that with a 1% increase in price, demand will fall by 1% assuming prices of other commodities don't change. For edible oils and pulses, low income groups have price elasticities around -1 and as income increases price elasticities increase to about -.2.

If production of grain legumes remain stagnant as in the past, while population increases and income stays constant, demand will increase and prices will rise which will force persons in the lower income groups to considerably reduce their intake of these commodities, while the higher income groups -- less affected by the price rise in their demand -- will continue to consume oils and pulses, even though at slightly reduced rates.

Supply elasticities

There is evidence from preliminary analysis of district data on production response to changes in relative commodity prices and prices of inputs in India, that the supply elasticities of groundnuts and pulses are near +0.5: a price increase of 1% would be followed by an increase in production of 0.5%.

Supply and demand elasticities

Given the fact that price elasticities of demand are about twice those of supply, we can expect that market prices will have a tendency of stabilizing relatively quickly; any shock from an unexpected low or high production (e.g. due to weather variation) will be absorbed by the relatively more elastic demand without creating strong responses on the supply side.

On the other hand, the relatively inelastic supply response of farmers to price changes shows that with increasing demand (due to income and population growth) a sharp rise in grain legume prices will not be followed by a rapid increase in area planted to pulses. Consequently, as long as there are in the immediate future only limited ways to mobilize genetic potential for low cost/high yield production of grain legumes, all other possible sources for generating conditions leading to higher aggregate production must be tapped. In the long-run, and as soon as varieties of short duration, varities with resistance to diseases and pests and generally less environment-sensitive varieties are found, these will contribute to productivity, while yields also increase.

Market development crucial for expansion of traditional soybeans

The importance of market policies for the successful introduction and expansion of a so far almost unknown pulse crop, i.e. soybeans, can be shown for India. Black seeded soybeans have traditionally been grown in north central India but only on a few thousand hectares in remote hilly areas. After adaptive research yellow varieties from the United States showed potential on the Vertisols of Madhya Pradesh, Maharashtra and Uttar Pradesh. In 1971 on the initiative of the state governments of Madhya Pradesh and of Uttar Pradesh a minimum support price was established for farmers growing and selling this crop in order to encourage the cultivation of yellow soybeans. Aided by considerable extension efforts, the area under yellow soybeans grew to some 20 000 ha by 1973. Most of the expansion occurred in and around the high rainfall black soil areas where fields were traditionally kept fallow in the rainy season. Increasing production facilitated market development, with traders bidding for the crop and mostly small scale industries absorbing the products, the oil for margarine preparation and the meal for fermentation in pharmaceutical production of antibiotics. Unexpectedly, this market development suddenly stimulated a rapid diffusion of the black seeded local varieties into the plains. With better germination and higher disease resistance than the introduced yellow varieties, these black varieties entered farmers fields in the plains and passed through the market channels which had been created originally for the yellow varieties (von Oppen and Scott 1976).

The growing soybean industry increasingly utilized the traditional varieties. By 1979 black seeded varieties accounted for 95% of an estimated 600 000 hectares sown to soybeans. The development of a market channel had played a crucial role in connecting the latent demand for soy oil and soymeal with the dormant potential supply of soybeans.

Presently efforts are underway to develop earlier maturing, high yielding yellow varieties having germination and disease resistance characteristics similar to black varieties. This would stimulate further diffusion of soybeans to vast areas presently lying fallow during the rainy season in central India. Similar to india other countries are making efforts at getting a soybean industry off the ground, e.g. in Thailand (Fig 7).

Trade and exchange to mobilize differences in comparative advantage

The above account of the crucial role of market development for soybean production in India points out a special case of the more general principle in

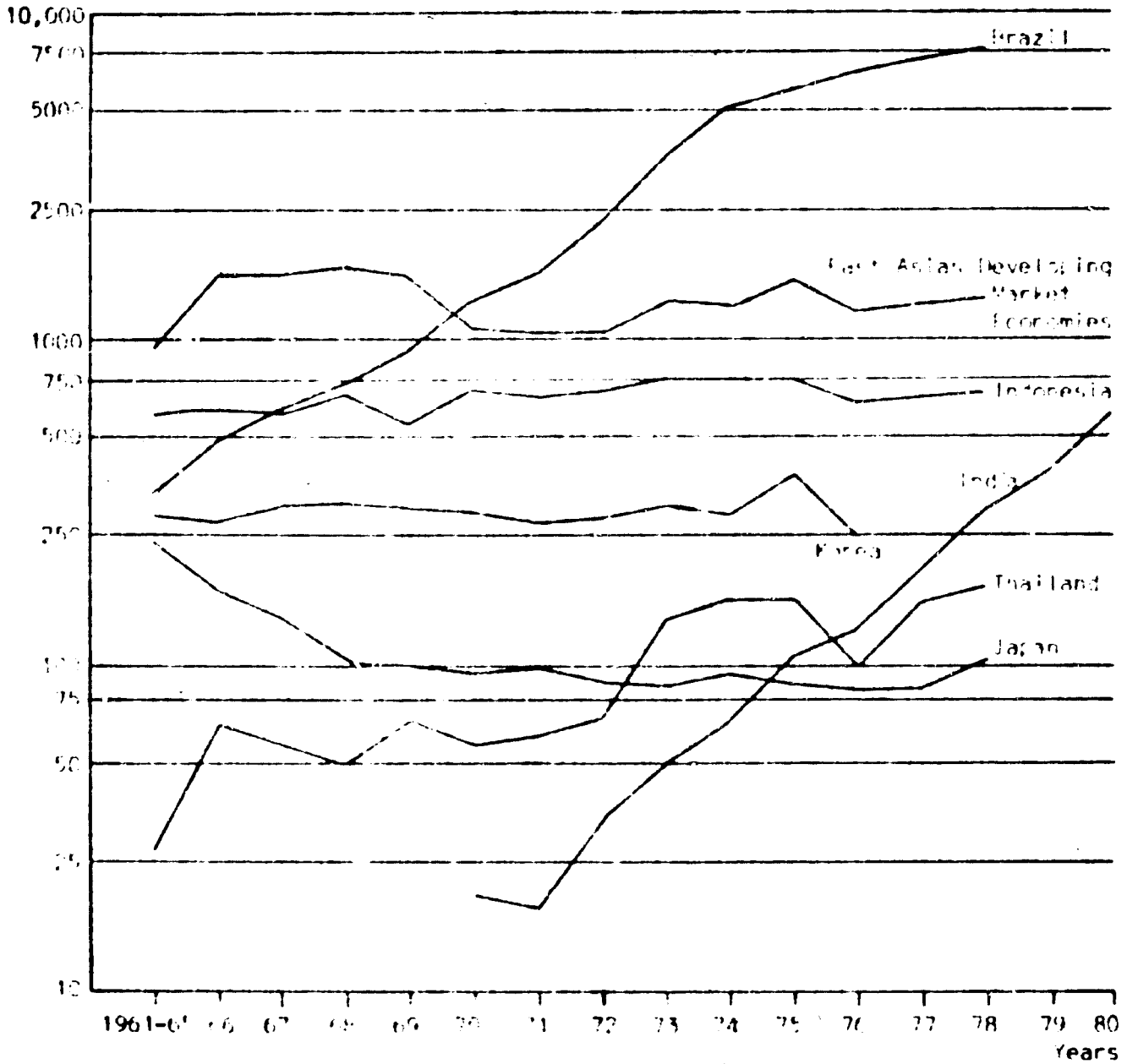


Figure 2. Expansion of area under soybeans in selected countries (semi-logarithmic scale)

operation, i.e. the principle of comparative advantage, mobilizing resources through market exchange.

Following this principle one of the major approaches to increasing the productivity of grain legumes in the short-run might be to take into account the location-specificity of these crops and make better use of differences in comparative advantages of regions which should emphasize the production of the comparatively best suited crops, be they pulses, leguminous oilseeds, cereals or other crops. In other words, by mobilizing trade and exchange systems which permit each region to specialize in the production of the comparatively best suited crop, relatively large gains in aggregate productivity can in fact be expected. This reasoning especially applies to grain legume crops because they are high in value and are easier to transport than cereals.

In the following we shall discuss the results of a modeling exercise in which we compare the effects of interregional trade on production of cereals and pulses in India. Even though this model was run for a different purpose, its results illustrate in a striking way how interregional trade in foodgrains affects the production of pulses considerably more than cereals.

The model is based on data which represent the following hypothetical case: In the three Indian states of Andhra Pradesh, Madhya Pradesh, and Maharashtra, three crops, namely: rice, sorghum and chickpea are grown and all three crops compete for the same locally available resources, in this case represented by land.[8]

Yield per acre is assumed to be restricting the supply, so that the total use of land for all three crops cannot exceed its limits in each state. Supply is further restricted by a linear function of area response to price multiplied by yield. The initial elasticities of supply were derived from available estimates and represent -- as far as they are known -- actual conditions. The model also incorporates demand as a linear function of price using elasticities available or derived from other sources.[9] Transportation costs between regions correspond to official rail freight rates between centrally located places in each of the three states.

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8. Other resources, such as capital and labor which are mobile in the long run, will tend to be allocated, wherever most profitable. Under conditions of restricted interregional commodity exchange these resources would move from surplus regions (because of natural comparative advantages) to deficit regions, where higher prices ensure higher returns.

9. Personal communication from S.L. Dapna.

Given this environment a quadratic programming model allocates crop production in each of the states so that producers' plus consumers' welfare minus total costs for transportation is maximized. Application of this model produces optimal allocation of land to crops, quantities produced as well as commodity flows and accompanying price levels.

The initial data set represented existing conditions (1971-72). In other words, low yields and high costs of production before the introduction of new technology. Suppose now that the governments of the three states decided to impose trade restrictions such that the quantities traded of each crop among all regions was not to exceed 10% of the quantities traded without restrictions. The imposition of the trade restrictions under these conditions changes production of the three foodgrains in all three states as follows:[10]

total output of rice remains unchanged;

total output of sorghum decreases by 5%;

total output of chickpea decreases by 13%; and

total output of all foodgrains together decreases by 2%.

Suppose now that new technologies are found and adopted for all three crops in all regions so that yields increase by 50% in the states which have highest yields and by proportionately less in the states with lower yields.[11] Further, all supply functions shift allowing a productivity growth over initial levels in the same way as yields; at the same time, an increase in demand in all regions for all crops of 25% is assumed. In this case the imposition of trade restrictions causes:

total output of rice to decrease by 1%;

total output of sorghum to decrease by 7%;

total output of chickpea to decrease by 15%; and

total output of all foodgrains to decrease by 4%.

Comparison of the two cases shows the impact of trade restrictions. With the advance of new technologies, which widen regional differences in crop yields, more trade across regions is implied. A pulse crop such as chickpea

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10. For more details of the model, see von Oppen 1978, Table 4.

11. A comparison of wheat yields in eight major wheat growing states in India between the years 1954-55 to 1958-59 and 1970-71 to 1974-75 shows that after the introduction of new wheat technologies, yields had not increased by the same percentage in every state but rather in a proportional fashion, i.e. yield increased the more, the higher the original yield level had been (with the exception of Bihar and Gujarat, where yield increases were higher). See von Oppen 1978, Appendix IV.

in our model is affected considerably more by the imposition of trade restrictions than are any of the commonly grown cereals.

In this model restrictions on commodity trade affect pulse production by almost five times more than cereals. The wider differences in yield levels across regions in the case of the pulse crop (location specificity) and the higher value per unit of weight (transportability), jointly require more interregional trade for full exploitation of its potential.

Restricting this trade, as India has done at times in some states has certainly had a depressing effect on pulse production in the country.[12] Since 1977-78 most of the restrictions on foodgrains have been abolished. However there are some states which still monopolize and restrict the export of some commercial crops into other states, such as Gujarat for groundnuts and Maharashtra for cotton. Nevertheless, the generally open market is expected to affect productivity with a lag of about 2 years, so that by 1980 changes in the cropping patterns in farmers fields should become visible.

3. CONCLUSION

Utilizing the above information on biological potential and economic constraints to grain legume production, we can assess the prospects of grain legume production in Asia as follows:

1. There appears to be -- until now -- only limited potential for rapid yield increases of existing pulses. Dramatic developments are not expected, although the search for improved varieties and hybrids continues. Early maturing varieties and varieties with disease resistance will also make grain legume production more profitable to farmers.

2. Continuing subsidies on nitrogen fertilizer prices will tend to neutralize the advantage pulses have in allowing soil fertility increases by nitrogen fixation. This may however gradually change as energy prices continue to rise.

3. The development of market channels is important to initiate widespread adoption of new pulses, such as the traditional black seeded soybean in India (which may sooner or later be succeeded by an indigenously bred yellow variety).

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12. For instance, between 1966 and 1968 when the Northern Chickpea Zone was established by Punjab and Uttar Pradesh; and from 1967 to 1969 in Karnataka, and from 1966 to 1969 in Bihar where pulses were specifically subjected to export restrictions; other states such as Rajasthan, Maharashtra and Madhya Pradesh are likely to have exercised restrictions on pulse trade between 1966 and 1977 when in these states "all foodgrains" were under more or less strictly enforced control (see von Oppen 1978, Fig 2).

4. Where the adverse effects of restricted trade in foodgrains are recognized and accordingly conditions for interregional trade are improved (instead of limiting trade within a country) there appear to exist good chances for generating considerable increases in the production of pulses.

5. Similar to the importance of trade and market exchange for pulse production within a country, also enhanced inter-country exchange would help to increase production and availability.

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