7. Prospects for Grain Legumes in Asia

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INTRODUCTION

The total production of grain legumes in the world in 1978 was estimated at 161 million mt or 10.2 per cent of the total cereals produced[2] which was grown on 155 million ha or 20.5 per cent of the total area planted to cereals. In the region of particular concern for the APO, i.e., the developing market economies of East Asia,[3] the trend is similar. In the same year a total of 23 million mt of grain legumes or 8.6 per cent of the total quantity of cereals were produced in the region on an area of 38 million ha or 22.9 per cent of the total area planted to cereals.

However, while the world production of grain legumes in 1978 comprised 50 per cent soybeans, and only 38 per cent pulses and 12 per cent groundnuts, in the developing market economies of East Asia soybeans contributed not more than 5 per cent where pulses and groundnuts accounted for 61 per cent and 34 per cent, respectively. Thus, in these East Asian countries as a group, the importance of soybeans is almost negligible at the present time compared with pulses and groundnuts which are dominant. In the absence of yield increases and given a nearly constant area planted to groundnuts and pulses, the relative quantum of grain legumes produced when compared to cereals has decreased continuously over the past decades even as both 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-

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[2] All grain pulses, including soybeans and groundnuts.

[3] According to grouping by FAO Production Yearbook 1978.

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 to cereals, the decreasing trend of grain legume production in relation to cereal production in the East Asian developing countries has been alarming the policy-makers who would like to see levels of food-grain and protein availability from legumes restored to their historically important position.

On the other hand, there are studies which show that for India (major country in the East Asian 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 large total availability of protein as a result of the green revolution in wheat than they would otherwise have (5) (Figure 1). In other words, this study shows that given other choices in non-green revolution schemes and continuation of past trends, the consumers were in fact better off with more cereals of the high-yielding type and less pulses. This is because the additional cereal production provided more additional protein as to substantially increase the trend in total protein availability. Even though this solution may be nutritionally adequate, it does not satisfy the provision of a slightly more luxurious diet. A cereal production of the post-green revolution levels *together* increased pulse availability would be more satisfactory.

It is in view of this desirable alternative that the prospects of grain legume production in Asia are being assessed in relation to (i) the biological nature and related technological limitations in increasing production of grain legumes; and (ii) economic factors and policies.

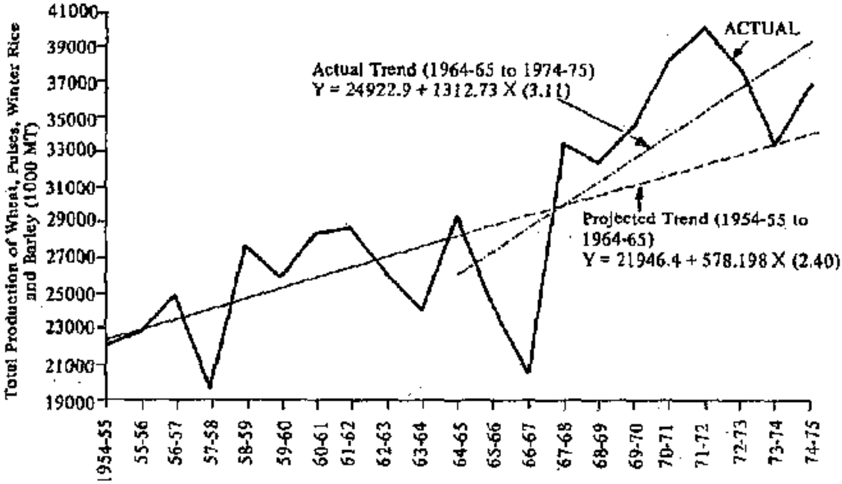
BIOLOGICAL AND TECHNICAL ASPECTS

Yield Increase Prospects in Grain Legumes

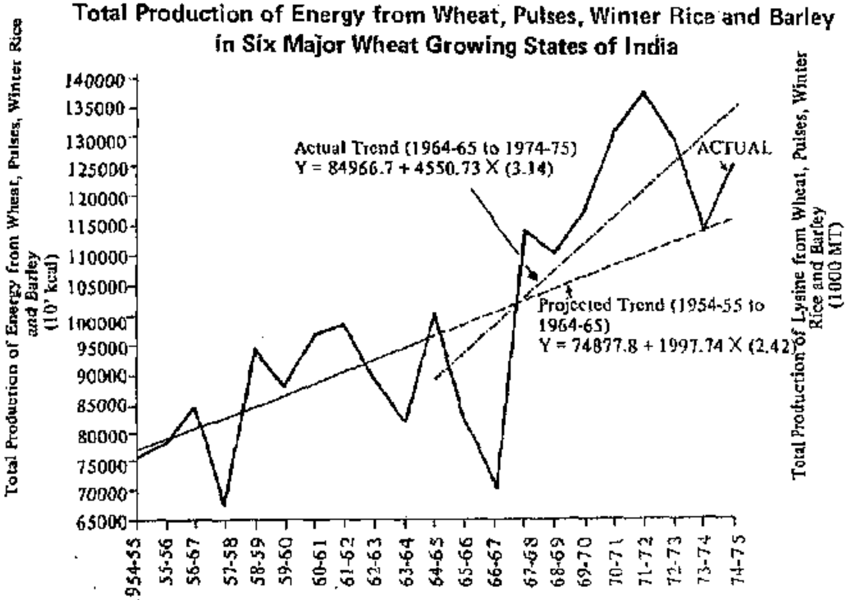
Fundamental differences exist in comparing cereal crops with legumes regarding yield potential and response to plant breeding efforts. As Green (1) puts it, "the consequences pf these differences are illustrated by the progress of the soybean and the maize crops in the U.S.A." He notes that "with a background 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. Soybean yields have increased, but only in a linear fashion, and researchers are still looking for a breakthrough" (Figure 2).

On the one hand, the biological constitution of grain legumes (in

Figure 1. Total Production of Wheat, Pulses, Winter Rice and Barley in Six Major Wheat Growing States of India



Total Production of Energy from Wheat, Pulses, Winter Rice and Barley in Six Major Wheat Growing States of India



Source: Ryan J.G. and M. Asokan (1977).

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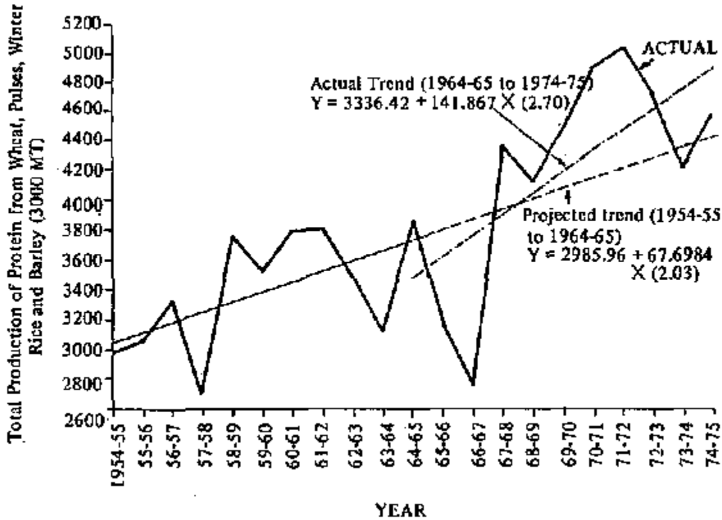
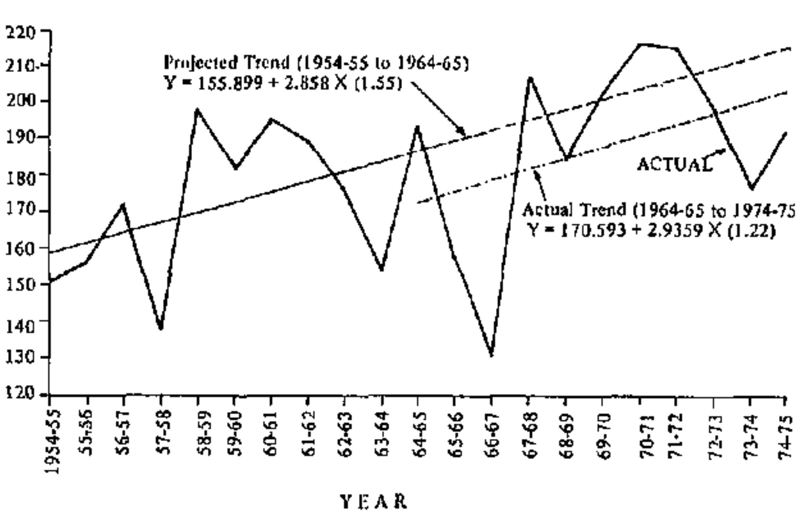
Total Production of Protein from Wheat, Pulses, Winter Rice and Barley in Six Major Wheat Growing States of India



Total Production of Lysine from Wheat, Pulses, Winter Rice and Barley in Six Major Wheat Growing States of India



symbiosis with rhizobium bacteria) enables them to draw nitrogen from the air to produce grains of high protein (and high fat) content. And the other, 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 the cereals in producing food).*

Nevertheless, intensive efforts are underway at international research institutes such as the AVRDC, ICRISAT and national institutes, e.g., the Indian Agricultural Research Institute (IARI) 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 have moved upward. At the AVRDC the breeding work continues on soybeans and mungbeans (6).

ICRISAT breeders are pursuing different breeding 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. For groundnuts, disease resistance more than yield potential, is being emphasized to stabilize production of this crop in the 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 for 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 early-maturing features of the U.S. cultivars with disease resistance of local black-seeded varieties.

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 cannot be expected to come about soon; more likely the gap must be expected to continue or even widen. But new cropping systems may become possible once new early-maturing and/or disease-resistant varieties of these

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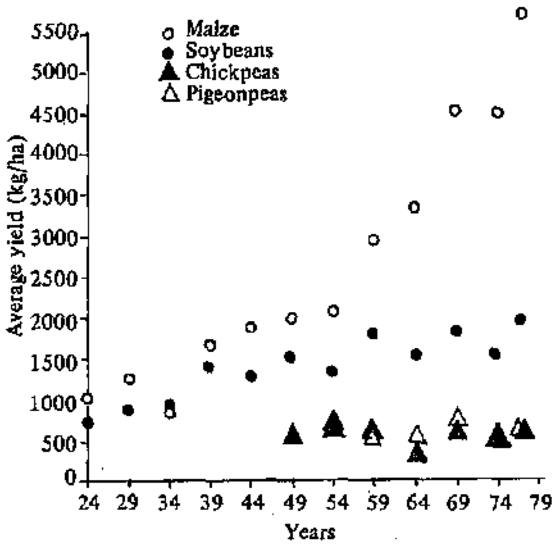
* Personal communication from A.R. Sheldrake.

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



Sources: Maize - U.S. Dept. Comm., 1975; FAO 1978.
Soybeans - Probst and Judd, 1973; FAO 1978.
Chickpeas - Govt, of India.
Pigeonpeas - Govt. of India.

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

legumes are available. This will also increase the farmers' incomes and will likely contribute to the expansion of areas planted to pulses.

Location-Specific Conditions Determining Yields

The complex physiology of grain legumes is probably also responsible for the fact that, generally, in comparison with 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 process and yields; and 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).

It is because of this relatively strong location-dependency of grain legumes that legume breeders place emphasis on environmental insensitivity (2). However, even then particular varieties clearly perform best in particular environments.[1] At the same time, because pulses have relatively high nutritive value, they have a higher unit value which, in turn, at given transport rates per unit of weight, provides this crop with better transportability than cereals. In fact, within India the extent and degree of pulse trade involves considerably more long-distance exchanges than that of comparable cereals (compare Figures 3 and 4).

Consequently, the overall productivity of pulses in any country or state is relatively more dependent upon effective inter-regional 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 legume crops improve soil fertility is well recognized by farmers who practise 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 with crops and soil condition (4). Groundnuts or cowpeas have been reported to leave the equivalent of 60 kg of N/ha in the soil while pigeonpeas leave about 30-40 kg N/ha.[2]

In Asia, as in most countries of the world, until about 1973 the

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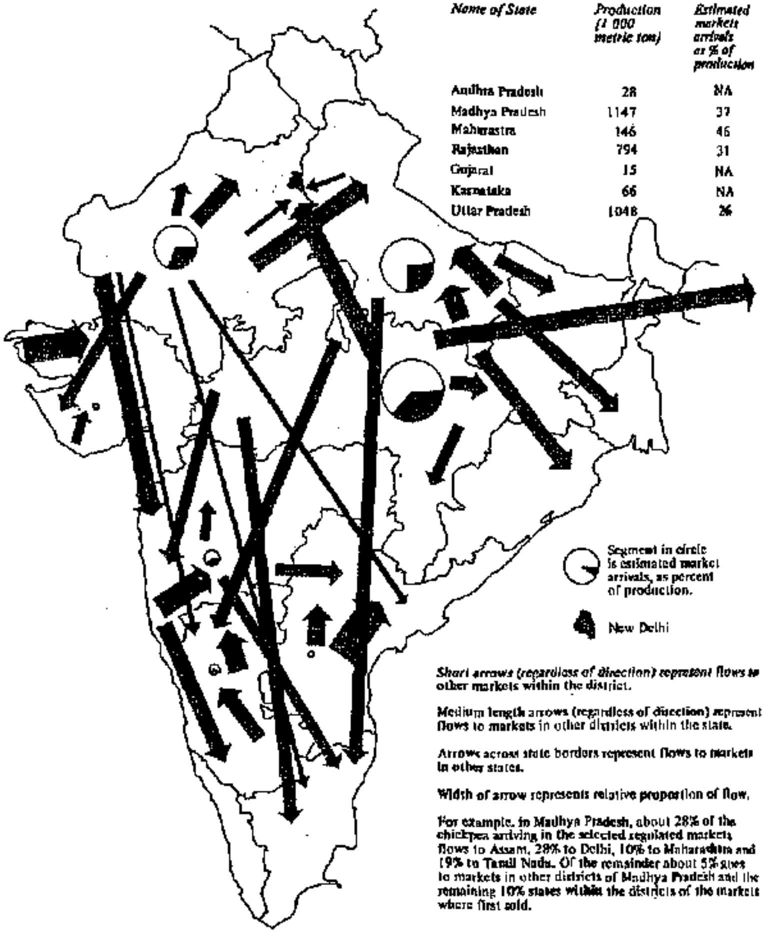
[1] For instance, the International Soybean Program (INTSOY) groups the varieties tested in international trials into about 12 location zones, determined by 4 sets of latitudes of 10° each and 3 altitude levels <500m, 500-1,000m, > 1,000m (9).

2 Personal communication from P.J. Dart.

Figure 3. Production of Chickpea, Market Arrivals as Percent of Production, and Total Flows (as Percent of Market Arrival) from Selected Food Grain Markets in Selected States of India, 1974-1975.

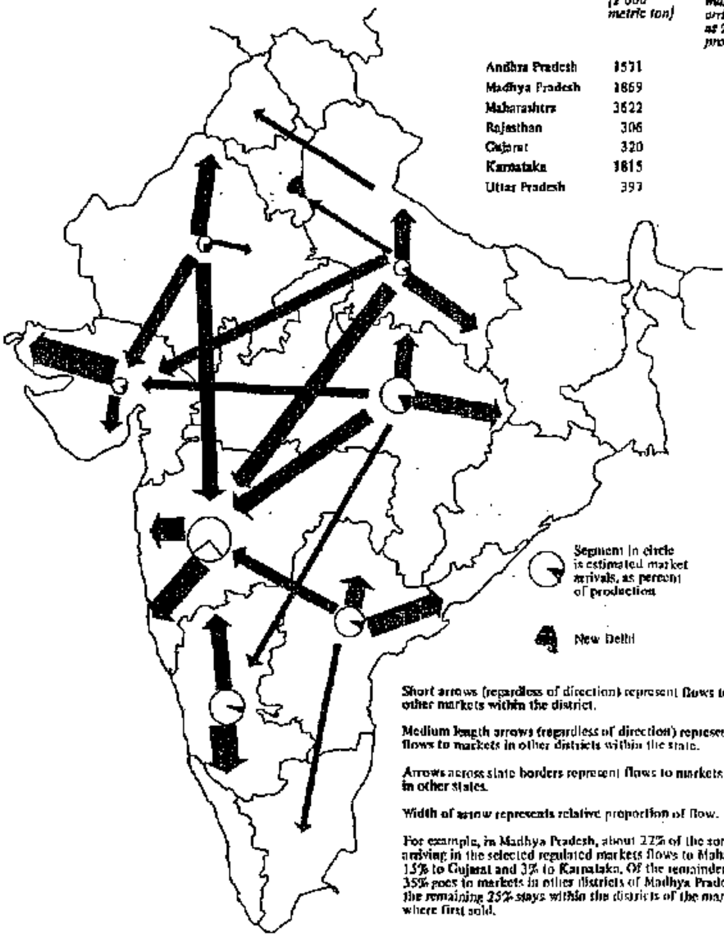


Name of State	*Production (1 000 metric ton)*	*Estimated market arrivals as % of production*
Andhra Pradesh	28	NA
Madhya Pradesh	1147	37
Maharastra	146	46
Rajasthan	794	31
Gujarat	15	NA
Karnataka	66	NA
Uttar Pradesh	1048	26

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 Arrival) from Selected Food-grain Markets in Selected States of India, 1974-1975.

Name of State	*Production (1 000 metric ton)*	*Estimated markets arrivals as % of production*
Andhra Pradesh	1571	8
Madhya Pradesh	1869	18
Maharashtra	3622	NA
Rajasthan	306	31
Gujarat	320	16
Karnataka	1815	5
Uttar Pradesh	397	12



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

prices for nitrogen fertilizers increased at a lower rate than did the prices of agricultural products so that nitrogen fertilizers were continuously becoming cheaper in relation to crop outputs (Figure 5). Wherever farmers in the past grew 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 the 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 increased to Rs. 5/kg of N in urea to avoid further subsidies; prior to 1973 the nitrogen price had been between Rs. 2 and 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 pre-1973 levels.

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

ECONOMIC ASPECTS AND RELATED POLICY ISSUES

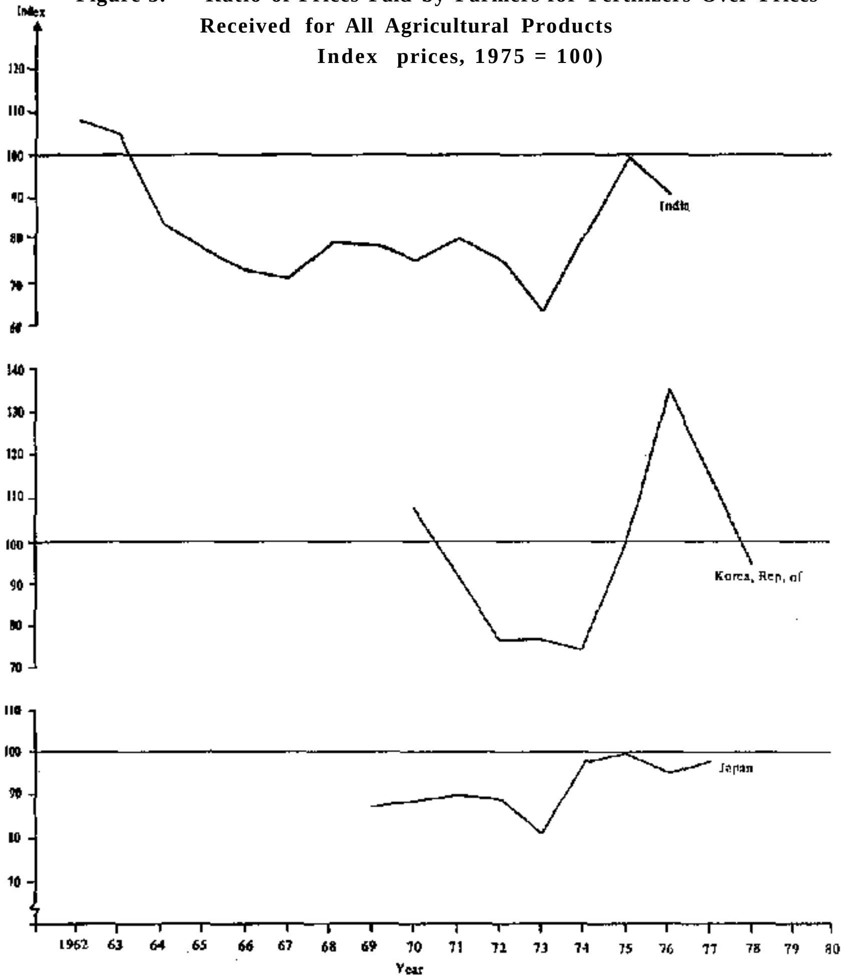
In view of the above biological and technological characteristics, grain legumes play a special role among the foodgrains. Because of their capability to fix nitrogen, the cultivation of grain legume crops is affected by policies for nitrogen fertilizers. Susceptibility to disease and pest attacks places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

Elasticities

In addition to, or rather because of, their technical and biological peculiarities, grain legumes have certain economic characteristics which are reflected in the 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-per cent 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 such also population, income

Figure 5. Ratio of Prices Paid by Farmers for Fertilizers Over Prices Received for All Agricultural Products Index prices, 1975 = 100)



Source: Korea and Japan: FAO Production Yearbook 1978; India: various issues of the Bulletin of Food Statistics.

and other price-cost relationships can be derived from past trends, it is possible to predict the 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 (Tables 1 and 2 and Figure 6).

An income elasticity of +1 implies that a 1-per cent increase in income will bring about a 1-per cent increase in demand for that commodity. Elasticities for both edible oils as well as pulses and other foods are approximately 1 for Indian rural 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-per cent increase in price, demand will fall by 1-per cent assuming that prices of other commodities do not 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 consumers 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 at slightly reduced rates.

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

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 treating 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

Table 1. Income Elasticity of Demand, India

Commodity	Rural Income Groups			Urban Income Groups		
	Low	Middle	High	Low	Middle.	High
Cereals	0.9	0.6	0.3	1.0	0.5	0.1
Edible oils	1.5	1.0	1.0	1.2	1.1	0.4
Pulses and other foods	1.1	1.1	0.7	1.0	1.1	0.8
Milk and milk products	2.0	2.2	0.7	1.7	2.1	0.9

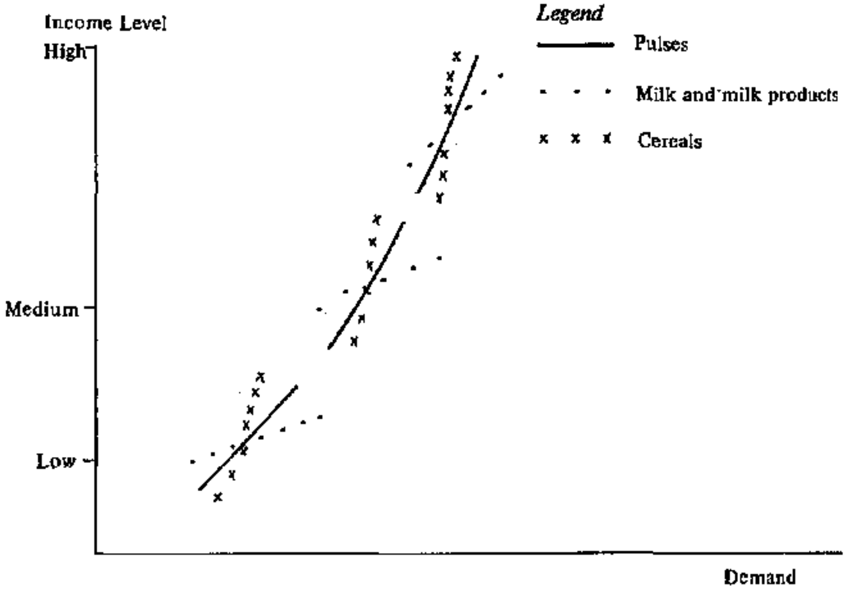
Source: Radhakrishna, R. and K.N. Murty, 1980.

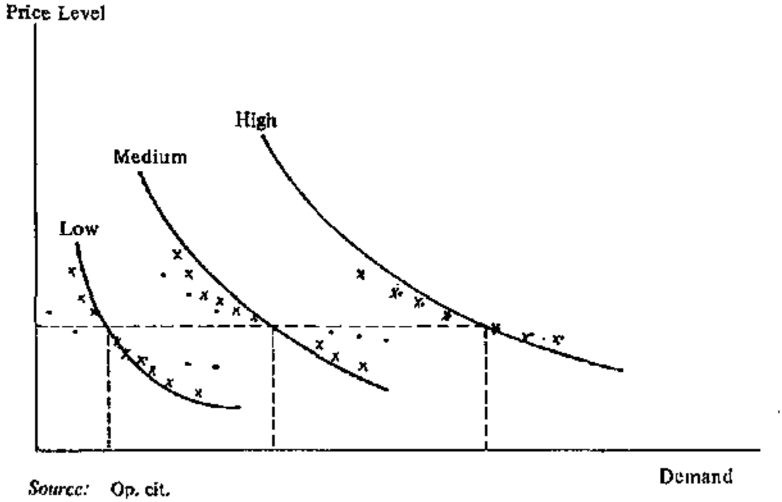
Table 2. Price Elasticity of Demand, India

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 and other foods	_.9	_.7	_.2	-.9	-.6	-.2
Milk and milk products	-1.5	-1.2	-.2	-1.4	-1.0	-.1

Source: Op. cit.

Figure 6. Income and Price Elasticities of Demand for Pulses, Cereals and Milk Products (Schematic)





Source: Op. cit.

there are in the immediate future only limited ways of mobilizing the 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, varieties with resistance to diseases and pests and, generally, less environment-sensitive varieties are found, these will contribute to productivity, while yields also increase.

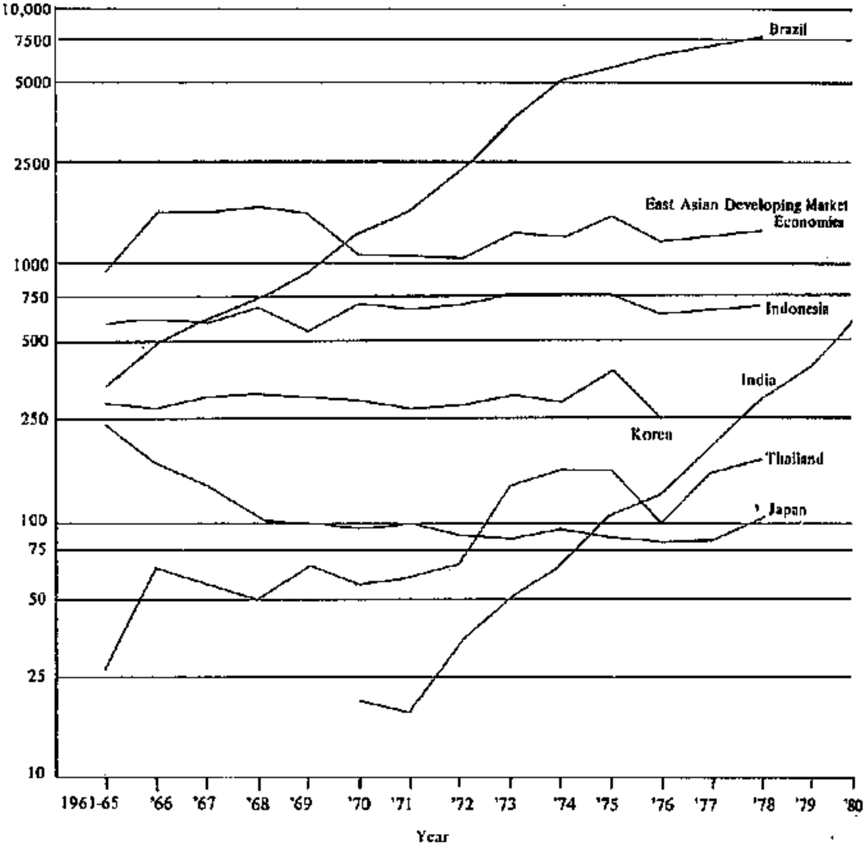
Market Development

The importance of market policies for the successful introduction and expansion of a relativey unknown pulse crop, i.e., soybeans, can be shown for India. Black-seeded soybeans have traditionally been grown in the north central region of India but only on a few thousand ha in remote hilly areas. After some efforts at adaptive research were made, 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 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 planted to yellow soybeans increased 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, the former varieties entered fanners' fields in the plains and passed through the market channels which had been created originally for the yellow varieties (7).

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

Efforts are underway to develop earlier-maturing, high-yielding yellow varieties having good germination and disease-resistant characteristics similar to the black varieties. This would stimulate further the diffusion of soybeans to wast areas presently lying fallow during the rainy season

Figure 7. Expansion of Area Planted to Soybeans in Selected Countries (Semilogarithmic Scale)



in central India. Similar to India, other countries are making efforts at getting the soybean industry off the ground, e.g., Thailand (Figure 7).

Trade and Exchange

The above account of the crucial role of market development for soybean production in India points out a special case of a more general principle in operation, i.e., the principle of comparative advantage that mobilizes 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 to 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.

The results of a modeling exercise compares the effects of inter-regional 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.[1]

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.[2] Transporta-

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

2 Personal communication from S.L. Bapna.

tion costs between regions correspond to official rail freight rates between centrally located places in each of the three states. 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 in the crop year, 1971/72, i.e., 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 per cent 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:[1]

total output of rice remains unchanged;
total output of sorghum decreases by 5 per cent;
total output of chickpea decreases by 13 per cent; and
total output of all foodgrains together decreases by 2 per cent.

Suppose now that new technologies are found and adopted for all three crops in all regions so that yields increase by 50 per cent in the states which have the highest yields and by proportionately less in the states with lower yields.[2] Further, all supply functions shift allowing a productivity growth over initial levels in the same way as yields; at the same time, an increase of 25 per cent in demand in all regions for all crops is assumed. In this case the imposition of trade restrictions causes:

total output of rice to decrease by 1 per cent;
total output of sorghum to decrease by 7 per cent;
total output of chickpea to decrease by 15 per cent; and
total output of all foodgrains to decrease by 4 per cent.

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 in the model is affected considerably more by the imposition

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[1] For more details of the model, see von Oppen. M., ICRISAT Economics Programme discussion paper No. 3, 1978, Table 4.

[2] 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, (8).

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 a fuller 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.* 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.

CONCLUSION

Utilizing the above information on biological potential and economic constraints to grain legume production, the prospects of grain legume production in Asia may be assessed as follows:

1. There appears to be — until now — only limited potential for rapid yield increases of existing pulse varieties. Dramatic developments are not expected, although the search for improved varieties and hybrids continues. Early-maturing varieties and varieties resistant to diseases 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 in initiating wide-spread adoption of new pulses, such as the traditional black-seeded soybean in India (which may sooner or later be

* 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 (sec von Oppen. 1978, Figure 2).

succeeded by an indigenously bred yellow variety).

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, an enhanced inter-country exchange would also help to increase production and avilability.

REFERENCES

1. Green, J.M. 1979. Pulse improvement research technology for the semi-arid tropics. Proceedings, International Symposium on Development and Transfer of Technology for Rainfed Agriculture and the SAT Farmer. ICRISAT, 28 Aug. - 1 Sep. 1979, Hyderabad, India.
2. Rachie, K.O. and Plarre, W.K.F. 1974. Breeding methodology for tropical soybeans. Proceedings, Soybean Production, Protection and Utilization, 14-17 October 1974, Addis Ababa, Ethiopia. Edited by D.K. Whigham, College of Agriculture, University of Illinois at Urbana — Champaign, International Agricultural Publications, INTSOY Series No. 6, March 1975, p. 30.
3. Radhakrishna, R. and Murty, K.N. 1980. Models of complete expenditure systems for India. International Institute for Applied Systems Analysis, A-2361 Laxenburg, Austria. Working paper.
4. Rao, M.R. 1980. Legumes in the traditional and improved cropping systems in India. Presented at the Symposium on Grain Legumes Production, Asian Productivity Organization, 9-15" Nov. 1980, Chiangmai, Thailand.
5. Ryan, J.G. and Asokan, M. 1977. Effect of green revolution in wheat on production of pulses and nutrients in India. Reprinted from Indian Journal of Agricultural Economics 22(3), July—Sept.
6. Shanmugasundaram, S. 1980. Agronomic aspects of soybean and mungbean farming. Presented at the Symposium on Grain Legumes Production, Asian Productivity Organization, 9-15 Nov. 1980, Chiangmai. Thailand.
7. Von Oppen, M. and Scott, J.T. 1976. A spatial equilibrium model for plant location and interregional trade. American Journal of Agricultural Economics 58(3):437-445, Aug.
8. Von Oppen, M. 1978. Agricultural marketing and aggregate productivity: a dimension to be added to agricultural market research. ICRISAT Economics Program discussion as per 3.

9. Whigham, D.K. and Judy, W.H. 1978. International soybean variety experiment, third report of results. College of Agriculture, University of Illinois at Urbana-Champaign, International Agricultural Publications, INTSOY Series No. 15.