9. Socioeconomic Constraints to Legumes Production in Rice-Wheat Cropping Systems of India

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Abstract

Despite lower cost of production and higher output prices of legumes, their profitability has remained too low in comparison with rice and wheat. Even if the existing subsidies on fertilizers and electricity for irrigation are withdrawn, it was shown that the rice-wheat cropping sequence remains most profitable. Inclusion of legumes in the system helped in conserving the natural resource base, particularly soil fertility and groundwater, but at the cost of profit, food grain production, and unemployment of fixed resources. The prime need is to break the existing yield barriers of legumes and design innovative policies on risk and resource management.

Introduction

The rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L.) cropping systems (RWCS) which cover about 10 million ha of the Indo-Gangetic Plain (IGP) of India are showing multiple problems. The two major problems are related with (1) production levels of rice and wheat, and (2) sustainability of soil and water resources. On the production side, the key problem is the stagnating or declining yields of rice and wheat. The traditional sources of growth in food grain production have been exhausted (Joshi et al. 1994). An issue of greater concern is that the total factor productivity of rice and wheat is also showing declining trends (Kumar and Mruthyunjaya 1992; Kumar and Rosegrant 1994; Kumar et al., in this volume). With regard to resource degradation, there is a threat of deteriorating soil nutrient status and groundwater level. The available reports reveal that soils in RWCS have become deficient in some macronutrients (e.g., nitrogen and sulfur) and micronutrients (e.g., zinc, manganese, and iron). Similarly, the water table is fast receding in good quality (saline, alkaline) acquifers (Joshi and Tyagi 1991), while increasing in poor quality acquifers. These problems need to be solved to increase food grain production in a sustainable manner to meet the present and future demands from the most inherently fertile and intensively cropped region in the country.

Crop diversification through legumes can play an important role in addressing many of the problems arising in RWCS. Legumes complement cereals in both production and consumption. In the production process legumes improve soil fertility status, require less water than cereals, and their rotation with cereals helps control diseases and pests. On the consumption side, legumes are the cheapest source of protein in the vegetarian diet and supplement mineral and vitamin requirements. Despite their value in production and consumption, the area under legumes in RWCS has declined after the introduction of improved technologies during the mid-1960s (Joshi 1998). Several reasons for the declining status of legumes have been reported. These include: (1) government focus on support of cereals; (2) lack of superior technology for legumes; (3) biotic constraints related to diseases in legumes; (4) abiotic constraints such as soil salinity, waterlogging, and frost; and (5) socioeconomic constraints. Little has been analytically reported on socioeconomic constraints to legumes production in RWCS. This study is an attempt to address the socioeconomic factors constraining legumes production.

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More specifically, the study empirically examines the socio-economic issues, which may be relevant for researchers and policy makers on legumes production in RWCS. The specific objectives are to:

- Identify the major socioeconomic constraints that affect legumes production.
- Examine alternative options to alleviate the identified socio-economic constraints.
- Identify opportunities for legumes in RWCS.

Methodology

Data and Sample

The analysis is based on both secondary and primary data. The secondary data were collected from published sources on area, production, yield, and prices of legumes, rice, and wheat (Government of India 1995, 1998). To collect primary data, Karnal district in Haryana was purposely selected because of two specific reasons: (1) rice-wheat is the predominant cropping system in Karnal than in other districts of Haryana; and (2) area under legumes in this district has rapidly declined with the advent of the green revolution in the mid-960s. It was envisaged that conclusions derived from this district would be relevant for other regions in Punjab and Uttar Pradesh, which practice intensive RWCS and have similar agroclimatic features.

Seventy farmers were randomly selected by following a systematic sampling scheme. A three-stage sampling procedure was adopted to select blocks, villages, and farmers. At the first stage, a cluster of four blocks, namely Indri, Karnal, Nilokheri, and Nissing, was selected on the basis of largest area under rice and wheat. In the second stage, seven villages were randomly selected. In the third stage farmers were sampled, making a sample size of 70 farmers.

Primary data were collected through personal interview in a specifically designed questionnaire for the year 1996/97. Data on item-wise cost of production of different crops, their yield levels and profitability were collected from sample farmers. Information on irrigation schedule, water charges, and electricity charges were also collected.

Analytical Framework

Economics of crop production was computed for each crop to evaluate the profitability of rice and wheat in comparison with legumes. Profitability of different crop rotations was also compared with the rice-wheat sequence. These comparisons were made with and without irrigation and fertilizer subsidy. The purpose was to examine whether subsidies in irrigation and fertilizer changed the economics of different crops, particularly rice and wheat.

Five indicators were assessed to examine the trade-off between rice-wheat and legumes. These indicators were: (1) profit; (2) food grain production; (3) fixed resources; (4) groundwater; and (5) soil nutrients. The trade-off values for each indicator were computed as follows:

$$TO_i = (C_i - L_i)/L$$

where, TO_i is the trade-off for i^{th} indicator; C. is the value of i^{lh} indicator for cereals (rice or wheat); and L is the value of i^{th} indicator for legumes (pigeonpea (*Cajanus cajan* (L.) Millsp.), chickpea (*Cher arietinum* L.), or berseem clover (*Trifolium alexandrinum* L.; Egyptian clover)].

Legumes in the Existing Cropping System

The cropping pattern followed by the selected sample farmers in 1996/97 indicated that rice and wheat were the major crops of the study area, to the extent of occupying 81 % of the total cropped area (Table 9.1). Legumes (grain, fodder, and summer) covered only 9% of the total cropped area. Important grain legumes were pigeonpea, chickpea, lentil (*Lens culinaris* Medic), mung bean *(Vigna radiata* (L.) Wilczek), and black gram (*Vigna mungo* (L) Hepper) which occupied about 3.4% area. Berseem and lucerne (*Medicago sativa* L.; alfalfa) were the fodder legumes, which covered 3,5% of the total cropped area. During summer, *Sesbania* sp was grown in about 2.2% of the cropped area. Area under oilseeds and other commercial crops [e.g., sugarcane (*Saccharum officinarutn* L)] was negligible. It was noted that farmers were maintaining about 3.5% area under fodder during the rainy season, particularly sorghum (*Sorghum bicolor* (L.) Moench) and maize (*Zea mays* L.), while berseem and lucerne were the main fodder crops during winter. Although legumes area in this dominant RWCS was less than 10%, it was much higher than area of other crops. This indicated that legumes were still preferred besides rice and wheat although the extent was small.

Table 9.1. Cropping pattern in selected villages, of Karnal district in Haryana. India, 1996/97.

Crop group	Crop	Area (%)
Cereals (grain)	Rice	43
	Wheat	38
	Others (maize)	0.2
Cereals (fodder)	Sorghum, maize	3.4
Legumes (grain)	Pigeonpea, chickpea, lentil, mung bean, and black gram	3.4
Legumes (fodder)	Rerseem and lucerne	3.5
Legumes (summer)	*Sesbania* spp	2.2
Oilseeds	Mustard, toria, and sunflower	2.8
Commercial crops	Sugarcane	3.2
Others	Others	0.6

Source: Based on on-farm survey, 1996-97.

Profitability of Legumes vs Rice and Wheat

Profitability is the most important criterion for allocating area to alternative crop choices. Profitability of a crop is largely influenced by cost of production, crop yields, and output prices. Table 9.2 presents the economics of rice, wheat, and important legumes (pigeonpea, chickpea, lentil, and berseem). Despite substantially lower cost of cultivation of legumes when compared with that of rice and wheat, the profitability of different legumes did not consistently match that of rice and wheat. However, berseem clover was more profitable than wheat but it was solely grown for fodder purposes, and its area expansion was restricted by market considerations.

Table 9.2. Cost and net profit of rice, wheat, and legumes in selected villages of Karnal district, in Haryana, India, 1996/97.

Crop	Cost (Rs ha^{-1})	Gross income (Rs ha^{-1})	Net income (Rs ha^{-1})
Rice	13150	30200	17050
Wheat	11825	23725	11900
Pigeonpea	5515	14180	8665
Chickpea	7015	16590	9575
Lentil	6075	13135	7060
Berseem	9180	22800	13620

Source: Based on on-farm survey, 1996-97.

Lower net profit of legumes when compared with that of rice and wheat was mainly due to their poor yield performance. However, output prices of all legumes were much higher than those of rice and wheat. Yields of legumes were so low that higher output prices could not make them more profitable than rice and wheat (Table 9.3). The output prices of pigeonpea were just double those of rice whereas the yield level of rice was four times higher than pigeonpea. Similarly, chickpea prices were almost double those of wheat prices, but wheat yields were 60% higher than chickpea yields.

Analyzing historical trends in the prices of legumes, rice, and wheat, it was noted that the minimum support and procurement prices of all legumes announced by the government were always kept higher than those of rice and wheat (Table 9.4). Historically, yields of legumes were always substantially lower than those of rice and wheat in Haryana, Punjab, and Uttar Pradesh. It was noted that yields of rice and wheat increased much faster than legumes in these states (Table 9.5). The analysis clearly reveals that a yield breakthrough in legumes was not realized as in rice and wheat. Although a number of improved cultivars of various legumes were developed, they were not widely disseminated due to lack of knowledge of the farmers.

Table 9.3. Yield and grain prices of rice, wheat, and important legumes in selected villages of Karnal district in Haryana, India, 1996/97.

Crop	Yield (kg ha^{-1})	Price (Rs kg^{-1})
Rice	4250	6.80
Wheat	4030	5.00
Pigeonpea	1035	13.00
Chickpea	1460	11.00
Lentil	960	13.00

Source: Based on on-farm survey, 1996-97.

Table 9.4. Minimum procurement prices (Rs t^{-1}) of rice, wheat, and important legumes.

Crop year	Rice[1]	Wheat	Chickpea	Pigeonpea
1975/76	740	1050	900	na[2]
1980/81	1050	1170	1750	1900
1985/86	1420	1620	3000	2600
1990/91	2050	2250	4800	4500
1995/96	3600	3800	7000	8000
1996/97	3800	4750	7400	8400

1. Refers to common type of paddy.
2. na = not applicable.
Source: Government of India (1998).

Table 9.5. Average yield (kg ha^{-1}) of rice, wheat, and important legumes in major rice- and wheat-growing states of the Indo-Gangetic Plain in India.

State	Year	Rice	Wheat	Chickpea	Pigeonpea
Harvana	1975/76	2060	1980	820	210
	1980/81	2600	2360	630	1080
	1985/86	2800	3090	820	1070
	1990/91	2770	3480	720	950
	1995/96	2272	3640	1010	790
	1996/97	2964	3880	800	1133
Punjab	1975/76	2550	2370	990	500
	1980/81	2740	2730	580	1000
	1985/86	3180	3530	910	1100
	1990/91	3230	3710	740	820
	1995/96	3050	3827	892	880
	1996/97	3397	4234	920	850
Uttar Pradesh	1975/76	930	1360	720	1470
	1980/81	1050	1650	860	1450
	1985/86	1490	2000	860	1360
	1990/91	1830	2170	880	1230
	1995/96	1889	2423	690	1010
	1996/97	2121	2668	930	1139

Source: Government of India (1995, 1998).

Profitability of Alternative Cropping Sequences

The profitability of the rice-wheat cropping sequence was compared with other alternative cropping sequences. This analysis was done under three alternative options: (1) existing prices of fertilizers and electricity charges paid by the farmers for irrigation; (2) without electricity subsidy for extraction of groundwater for irrigation; and (3) without fertilizer and electricity subsidy for irrigation. Results of this exercise are presented in Table 9.6. It was noted that rice-wheat-black gram was the most profitable crop sequence with the prevailing subsidies in fertilizers and electricity for irrigation. It was followed by rice-berseem and rice-wheat-mung bean sequences. The adoption of these three crop sequences was limited in the study area due to resources and market constraints. Cultivation of black gram and mung bean requires much water after the harvest of wheat, whereas berseem area expansion was restricted due to the limited market determined by livestock population. Profitability of the rice-wheat sequence, the most popular in the study area, was higher than those of rice-chickpea and pigeonpea-wheat. It was noted that even if the existing subsidies on fertilizer and electricity for irrigation were withdrawn, the rice-wheat rotation was still the most profitable crop sequence. The analysis confirmed that from the profitability point of view it was logical for the farmers to allocate area for rice-wheat sequence. Substitution of legumes for rice or wheat means loss in earnings of the farmers. To introduce or substitute legumes in RWCS, profitability of legumes needs to be raised substantially. It would come through a substantial increase in their yield levels, which could be attained through dissemination of appropriate technologies on farmers' fields.

Table 9.6. Profitability ('000 Rs ha^{-1}) of various crop rotations under different scenarios in Karnal district, Haryana, India.

Crop rotation	With subsidy[1]	Without subsidy in fertilizer	Without subsidy in electricity and fertilizer
Rice-wheat-black gram	31.4	30.2	22.5
Rice-berseem	30.6	29.8	20.9
Rice-wheat-mung bean	30.5	29.2	21.5
Rice-wheat	28.9	27.8	20.6
Rice-chickpea	26.6	26.0	20.0
Pigeonpea-wheat	20.5	19.7	18.0

1. Subsidy in fertilizer and electricity for irrigation.
Sourer: Derived from data of on-farm survey, 1996-97.

Trade-off between Legumes and Competing Crops

Rice and wheat arc clearly the most profitable crops. However, in terms of resource degradation, RWCS is threatening the sustainability of the existing production system and the natural resource base. Thus the role of legumes becomes important in improving the sustainability of the natural resource base. An analysis was undertaken to examine the trade-off if rice was substituted by pigeonpea and wheat by chickpea, lentil, or berseem. Five criteria were assessed to examine the trade-off due to inclusion of legumes in the existing production systems. These were: (1) profit; (2) food grain production; (3) fixed assets (farm implements and machinery); (4) groundwater; and (5) soil nutrients (nitrogen). It is obvious that majority of the farmers maximize profit, food grain production, and utilize fixed resources.

The results of this analysis are presented in Table 9.7. Trade-off values were computed as explained in the analytical framework section. The trade-off values for replacing rice by pigeonpea were examined and it was observed that farmers would lose about 49%

Table 9.7. Trade-off (percentage change) in replacing rice or wheat with legumes in Karnal district, Haryana, India, 1996/97'.

Indicator	Pigeonpea	Chickpea	Lentil	Berseem
Profit	-49	-19	-41	+ 2
Food grain	-76	-64	-76	
Fixed resources	-57	-49	-61	-43
Groundwater	+95	+85	+83	-125
Soil nutrients	+65	+73	+75	+56

1. In rice-wheat cropping system, rice was substituted by pigeonpea and wheat by chickpea, lentil, and

2. Herseem is a fodder legume.
Source: Derived from data of on-farm survey, 1996-97

Table 9.8. Marginal value products (Rs) of inputs for rice, wheat, pigeonpea, and chickpea, in Karnal district, Haryana, India, 1996/97[1].

Input	Rice	Pigeonpea	Wheat	Chickpea
Fertilizer	5.2	-4.9	2.2	1.6
Irrigation	-2.8	601.9	7.2	-186.7
Machinery	278.3	na[2]	70.6	624.2

1. Marginal value products were derived from the production functions estimated for each crop by regressing gross value of output with three independent variables. namely fertiliser, irrigation, and machinery. These values indicate additional gain (if positive) or loss (if negative) by subsequent increase in the level of the respective input.
2. na = not applicable as no machinery was used for pigeonpea cultivation.
Source: Derived from data of on-firm survey, 1996-97.

profit. The region would need to sacrifice 76% food grain production and 57% of the fixed resources would remain unutilized. However, on the positive side, the region would save about 95% of the groundwater and 65% of the nitrogenous fertilizer. Assessing trade-off between wheat and chickpea, it was noted that farmers would lose about 19% profit. The region would sacrifice about 64% food grain production, and about 49% fixed resources would not be utilized, which have high opportunity cost. As a gain, chickpea cultivation would save about 85% of groundwater and 73% of nitrogenous fertilizer. Similar trade-offs were observed for wheat and lentil. Interestingly, the trade-off between wheat and berseem (a fodder legume) was different, and there was negligible loss in profit. This was despite the groundwater used for berseem being much more than that used for wheat. Thus substitution of wheat by this fodder legume would mean further over-exploitation of groundwater.

Production functions were also estimated by treating value of outputs of different crops as dependent variables and use of fertilizer, irrigation, and machinery as independent variables. Marginal value products of independent variables for rice, wheat, pigeonpea, and chickpea were computed (Table 9.8). The marginal value products of different factors of rice and pigeonpea indicated that there was over-utilization of irrigation water in rice, and excess use of fertilizer in pigeonpea. In case of chickpea and wheat, the marginal value products of fertilizer for wheat was more than that of chickpea. This suggests that with limited availability of fertilizer, first priority for fertilizer application would go to wheat because of its higher marginal value products. Marginal value products for irrigation water for wheat was positive but negative for chickpea. This is because the chickpea crop is sensitive to excess water.

This analysis suggested that there was a trade-off between different indicators when legumes substituted rice and wheat. Although there was a loss in terms of profit, food grain production, and use of fixed resources, there were substantial gains in conserving groundwater and nitrogenous fertilizers. In view of the trade-off between important indicators, it is necessary to develop an optimum combination of RWCS with inclusion of some legumes in the production system to improve the sustainability of water and soil resources and meet the basic objectives of farmers.

Market and Prices

Another most important constraint to legumes production in RWCS is lack of adequate output markets. Markets for legumes were thin and fragmented in comparison with rice and wheat, which have assured markets (Byerlee and White 1997). It has been observed that government procurement for legumes was not effective as it was for rice and wheat. Farmers on many occasions did not get the minimum prices announced by the government.

The price spread (or the market margin) for legumes was much higher than that of rice and wheat due to higher postharvest costs. The share of farmers' returns in consumers' price was much lower for legumes than for rice and wheat. It was estimated that the price spread for pigeonpea dhal was Rs 15 kg^{-1}, while it was less than Rs 1 kg^{-1} for rice (Joshi and Pande 1996). The price spread for chickpea was Rs 3.20 kg^{-1}, whereas it was only Rs 1.20 kg^{-1} for wheat. The estimates on farmers' share in consumers' rupee in the case of pigeonpea was about 40%, and about 85% for rice. For chickpea it was about 35%, and for wheat it was as high as 91%.

The above results showed that farmers are not really benefited by higher market prices of legumes. To encourage legumes production in RWCS, similar mechanisms of their procurement as for rice and wheat need to be evolved.

Risk

Risk is one of the most important constraints in legumes production. Production of legumes is relatively more risky that that of rice and wheat. The price and yield risks of legumes were much higher than those of rice and wheat (Joshi and Pande 1996). The coefficients of variation in yields of rice, wheat, pigeonpea, and chickpea in the RWCS were computed for all the districts in the Indian states of IGP. It was noted that the coefficients of variation of chickpea and pigeonpea yields were greater than those of wheat and rice in most of the districts. This suggests that legumes were more prone to risk due to crop failure (represented by yields) in comparison with rice and wheat. Similarly, price fluctuations (post- and preharvest) in chickpea and pigeonpea were higher than those in rice and wheat. These findings clearly suggested that yield and price risks were hindering adoption of legumes in the RWCS.

Challenges for Future

The analysis presented above suggested that the major constraints in legumes production in RWCS were their lower profitability when compared with that of rice and wheat. Despite a lower cost of cultivation and higher output prices of legumes than rice and wheat, the low profit was mainly due to their poor yield performance. This was due to lack of any significant technology breakthrough as was witnessed for rice and wheat. There has been a significant change over time in yield levels of legumes. It is estimated that if pigeonpea was to compete with rice, its yields must be increased from the current 1 t ha^{-1} to about 2 t ha^{-1}. Similarly, lentil yields must be raised from < 1 t ha^{-1} to at least 1.4 t ha^{-1} to compete with wheat. Chickpea yields are approaching levels that would allow it to compete with wheat. The estimates suggested that average chickpea yields must be increased from 1.51 ha^{-1} to 1.61 ha^{-1}. Although chickpea is now competitive with wheat with respect to yield, the risk factor due to diseases and insect pests in chickpea remains high and needs due attention.

In the future, legumes research has to better compete with advanced research in rice and wheat. Biotechnology research in rice and wheat has already made headway. With the new technology frontier in rice and wheat, the existing low yield levels of legumes will further displace them from the production system. It is therefore necessary that more resources should be allocated for advanced research in legumes to face the challenge. Efforts should be strengthened to enhance yield potential of extra-short-duration pigeonpea, chickpea, and hybrid pigeonpea (Joshi and Pande 1996).

Production risk is another area which needs more focused attention. More disease resistant varieties with high yield potential should be introduced in the RWCS. Unless more stable and high-yielding varieties of different legumes are introduced, the probability of increased adoption of legumes in RWCS is remote. Another challenge for future policy research is to create assured output markets for legumes. The markets should be such that farmers get at least minimum procurement prices of their produce as they always get for rice and wheat. The second issue concerning markets for legumes is to reduce the postharvest losses as well as costs. High processing costs leads to higher price spread. There is a need for research to develop appropriate technologies which could minimize the processing losses in legumes.

Summary and Conclusion

It is evident that rice and wheat were more profitable than legumes but consumed more groundwater and soil nutrients. Legumes can play an important role in conserving groundwater and soil nutrients, especially nitrogen.

Rice and wheat were more profitable than legumes even without fertilizer and irrigation subsidies. Therefore, merely withdrawing subsidies from fertilizers and electricity for groundwater may not solve the problem of sustainability of natural resources (groundwater and soil nutrients) in RWCS. Crop diversification through introduction of legumes can play an important role in improving the sustainability of the production system. But the challenge is to break legume yield barriers, and design innovative policies on risk and resource management.

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