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Rice-Wheat System in Haryana: Prioritizing Production Constraints and Implication for Future Research

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INTRODUCTION

Rice-wheat crop sequence has emerged in a big way in the state of Haryana during the last two decades. The area under rice and wheat in the state is 0.83 and 1.97 million hectares (m ha) respectively, and as a system, rice-wheat covers more than 0.6 m ha which accounts for 16.73 per cent of the total cropped area. Most of the area under rice-wheat rotation is concentrated in the belt known as Indo-Gangetic plains. Rice-wheat economy of this region is of great importance due to many reasons. Apart from its significant contribution towards national food security and farm employment, this system is crucial for farm export (mainly basmati rice). Also a large number of non-farm families depend directly and indirectly on the rice-wheat economy of this region. Most important is that the growth rate of rice-wheat output in the region is an important determinant of growth of agricultural sector in the state.

The state has achieved impressive growth in agriculture especially in rice and wheat production during the last two decades or so. Concerns are now being raised that the existing high level of rice-wheat productivity is under threat. There is a growing perception among agricultural scientists, officials and farmers that the rice-wheat system brought to the fore many problems that are not faced when rice and wheat are grown in different crop sequence (Hobbs and Morris, 1992; Harrington *et al.*, 1993; Singh and Paroda, 1994; Chand and Haque, 1997; ICAR, 1998). Plateuing of yield, decline in total factor productivity, symptoms of soil–chemicalisation, outbreak of new pests and diseases, strain on water resources and increasing incidence of weed infestation are important among them (Mehla *et al.*, 1998). These issues have far reaching consequences and there is urgent need to address these problems. On the other hand, if experiment station yields or on-farm trials are any indication then available statistics indicate that even in high growth rice-wheat system in Haryana, there is still a vast untapped reservoir existing at current level of technology exploitation, which can help raise productivity. Diagnostic surveys have been conducted (Harrington *et al.*, 1993; Mehla *et al.*, 1998) in this zone and quite a few studies have been undertaken on

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constraint analysis but those studies were focused on single crop and failed to quantify the magnitude of losses arising from this set of constraints. Not much information is available which could form the base to prioritize the production constraints in rice-wheat system. Prioritizing production constraint research in India is primarily confined to rainfed rice system (Ramasamy *et al.*, 1996; Widawsky and O'Toole, 1996) and that too for biotic and abiotic constraints leaving aside socio-economic issues. Earlier studies on constraint analysis also suffered from another limitation that they used the state boundary rather than agro-ecological regions or sub-regions as the target domain. Those studies have seldom identified homogeneous production zones where the constraints were of more or less similar in nature and magnitude and research outputs have homogeneous impacts. But in recent years production system research has come to be seen by many as a useful alternative to commodity-based research.

Efforts have been made in this study to delineate rice-wheat-based production zone in Haryana (RWZH), to identify production constraints that cause significant production losses, and to rank these constraints in terms of their impact on production losses. The study also explores researchable issues on the basis of constraint prioritization in rice-wheat based production system under irrigated agro-ecosystem as defined by National Agricultural Technology Project (NATP).

METHODOLOGY

Study Area

The study covers the areas of Trans-Gangetic plains of Haryana that includes eight districts, viz., Ambala, Jind, Kaithal, Karnal, Kurukshetra, Panipat, Sonepat and Yamunanagar. This is an important agricultural zone where rice-wheat based production system has emerged as the dominant cropping sequence and is considered to be the most profitable one in recent years (Nagarajan, 1998). Major soil types are sandy loams to clay loam. Soils are calcareous but do not have calcium carbonate layer within one metre depth. These soils are low in organic carbon, available nitrogen, and phosphorous and medium to high in potash. Soil pH varies from 7.4 to 9.3. Some parts are salt affected and deficient in zinc. The climate is classified as semi-arid sub-tropical. Normal annual rainfall ranges from 600 to 850 mm. And about 80 per cent of the annual precipitation falls between July and September. Temperature ranges from 4^0 C in the month of January to 44^0 C in May/June with hot winds blowing from west to east. Agricultural infrastructure is well developed in the area. A well organised Department of Agriculture exists in the state up to village level for transfer of technology. Every village of the area is linked with metalled roads and electricity and all the cities and towns have regulated markets and procurement arrangements.

Delineation

To undertake more focused research in the irrigated rice-wheat based production system it is necessary to identify the research domain. For this purpose the latest available data (1995-96) in *Statistical Abstract of Haryana* as well as the district level data (1990-94 series) generated in a project on 'Sustainable Rainfed Agriculture Research and Development' was used (ICRISAT, 1998). Districts falling under this production system were delineated considering the predominance of rice and wheat crop and per cent of net sown area irrigated. The districts with 40 per cent or more of net irrigated area and where rice is the major crop during *kharif* and wheat in *rabi* were selected. For these districts having rice and wheat area each with more than 20 per cent in the gross cropped area were retained to focus on the rice-wheat system. In total, eight districts, as mentioned earlier, were delineated that constitute the boundary of RWZH.

Sampling Design

After delineation, Kaithal and Karnal districts were selected purposively keeping in mind the dominance of rice-wheat crop sequences. Moreover, there are quite a few research stations engaged there in rice-wheat research. These two districts also experienced large-scale cultivation of basmati rice in recent years. In the next stage of sampling one block was selected randomly from each of the two districts. Finally, three villages from each of these two blocks were chosen randomly for conducting rapid rural appraisal.

Identifying Production Constraints

There is no single best method for identifying client constraints and research needs. A review of the annual reports of the research organisations helps to identify some constraints. Many research programmes have already collected a tremendous amount of information on the needs of these clients. Unfortunately, this information is rarely pooled. Even more rarely is it synthesised into a usable form. Therefore, the most important step in identifying client constraints is to review existing sources of information and gather fresh information from the clients as well as concerned researchers working in that region. The most commonly used techniques to obtain additional information on client constraints are rapid rural appraisal (RRA), participatory rural appraisal (PRA) and focused group meeting (FGM). In this study RRA was undertaken in six villages and 15 agro-biological scientists were contacted for detailed discussion already working on various aspects of rice-wheat system. An exhaustive list of constraints in irrigated rice and wheat production with special reference to Indo-Gangetic plains of Haryana was prepared by reviewing the literature and through interactive process with extension workers and scientists. Subsequently, the constraints having economic significance were shortlisted for which information was gathered. The constraints include technical and socio-economic factors that limit rice and wheat yields. We categorised the technical constraints as: (1) diseases, (2) insect and pests, (3) weeds, (4) water related problems, (5) soil related problems and (6) others (physiological/agronomic).

Estimation of Intensity/Severity of Constraints and Calculation of Production Loss

The severity of each constraint was assessed through estimation of yield loss. For each crop the average absolute quantity of yield loss attributed to each constraint was estimated from the response given by the farmers. This information was then cross-checked by the scientists and extension personnel. The farmers were also asked to estimate the proportion of area affected by each constraint to total rice or wheat area in the village and to estimate the long-term probability of occurrence of a particular constraint in that particular village on the basis of their past experiences. Estimates of six different villages were then averaged for each crop and constraint. Total yield loss was calculated from these averages. The average yield loss multiplied by area affected and then by the prices of rice and wheat (recommended by the Commission for Agricultural Costs and Prices) provided the value of production foregone. The procedure for calculating production loss is given as:

$$\Phi = n.p.l.$$

where Φ = average yield loss attributed to each constraint (kg/ha),
n = proportion of area affected (per cent),
p = probability of occurrence of a particular constraint (per cent),
l = absolute yield loss attributed to each constraint (kg/ha).

$$\eta = \Phi \bullet N$$

where η = total production loss (000 tonnes),
Φ = as explained above,
N = area under individual crop in RWZH (million ha).

$$Z = \eta \bullet P$$

where Z = value of production loss (Rs. million).
η = as explained above,
P = price of output (Rs./kg).

An example of a production loss calculation is given in Table 1.

TABLE 1. CALCULATION OF PRODUCTION LOSS

Example: Leaf Blight in Wheat

Data

n = 10 per cent; p = 33 per cent; l = 3000 kg/ha; N = 0.952 million ha; P = Rs.5.50.

Calculation

Φ = n. p. l.	η = $\Phi \bullet$ N	Z = $\eta \bullet$ P
= 0.10 x .33 x 3000	= 99 x 0.952	= 94.248 x 5.50
= 99 kg/ha.	= 94.248 thousand tonnes	= Rs. 518.364 million.

Result: Value of production loss from leaf blight in wheat in RWZH is estimated to be Rs.518.36 million.

Prioritizing socio-economic constraints is more difficult. Cropwise analysis was not possible as the same set of constraints affect the entire region irrespective of crops or crop systems. Therefore, cardinal measurement of their impact on yield gap could not be tried but the farmers were asked to rank the constraints as per their severity. A comprehensive list of socio-economic constraints was given to them and they were asked to assign the value 1 to the most limiting constraint, value 2 to the next important one, and so on. Then the rank values were averaged across the villages and a composite score is obtained on the basis of which top ten socio-economic constraints were prioritized.

Estimates of Yield Gaps

In this study, the central idea of a yield gap is crucial to understand the severity of different constraints that need urgent research attention. Yield gap is defined as the difference between the potential yield and actual yield. The difference is explained by a number of constraints - biological, physical and socio-economic. All these constraints together account for the entire yield gaps. It can be decomposed into two parts, viz., yield gap I and yield gap II. Yield gap I is the difference between an experiment station's average yield and an on-farm experiment's average yield. This yield gap arises from differences in environment that can not be managed in the farmer's field. Yield gap II, which is the primary concern of the present study, is the difference between actual farm yield and the yield attained in on-farm experiments. This gap reflects the effects of various biotic, abiotic and socio-economic constraints.

RESULTS

Yield Gaps in RWZH

The estimates of yield gaps are presented in Table 2. The results of these estimates illustrate considerable yield gaps in both rice and wheat. As expected, yield gap in percentage terms is the smallest in non-basmati rice and wheat where one expects to find modern varieties, high inputs and assured irrigation. The highest yield gap in percentage terms occurs in basmati rice, which is least responsive to high inputs and susceptible to a wide range of pests and diseases. The average yield obtained by the farmers is less than half of experiment station yield. In all the crops yield gap II is very large compared to yield gap I. This suggests that there are barriers to improved management practices, which can be managed in the farmers' fields.

TABLE 2. ESTIMATED YIELDS AND YIELD GAPS IN RICE AND WHEAT

(kg/ha)

Particulars of yields (1)	Rice (non-basmati) (2)	Basmati rice (3)	Wheat (4)
1. Experiment station yield*	8,350	5,750	6,275
2. On-farm experiment yield*	7,025	4,850	5,871
3. Actual farm yield **	5,215	2,785	4,219
4. Yield gaps†			
(a) Yield gap I	1,325	900	404
(b) Yield gap II	1,810	2,065	1,652
(c) Yield gap (I+II)	3,135	2,965	2,056
(d) Yield gap total (per cent)	60.12	106.46	48.73
(e) Yield gap II (per cent)	34.71	74.15	39.16

Source: *Various experimental results from RRS-CCSHAU, Kaul and Uchhani and DWR, CSSRI and RRS-IARI (all Karnal). **Generated by the study. † Self calculated following standardised methodology.

Estimates of Yield Losses

Once the yield gaps are known, the next step is to identify the composition of the gap in terms of technical and socio-economic constraints and measure the contribution of these constraints. Estimates of crop loss by individual constraint provide a quantitative comparison of constraint severity across the zone and the rationale for future research thrust. We have identified a large number of constraints that the farmers are facing in this region. However, this does not mean that all these constraints are major and occur simultaneously. These may occur in the most severe form in any one of the seasons/years in any one of the sub-regions. The farmers were asked to state their total crop yield losses which were then segregated on account of individual constraints. The yield loss indicated by the farmers is when the constraint is occurring beyond the economic threshold level. In this process few minor and/or unknown constraints could have been left out that might have resulted in slightly over-estimated yield losses attributed to major constraints. But this does not affect much the relative ranking of major constraints and thus the list of priority research problems remained unaffected. Only the constraints causing major production losses are discussed below (Table 3).

Non-Basmati Rice

Average yield losses in non-basmati rice due to all the constraints worked out to be 1,810 kg/ha, which is about 35 per cent of the average farm level yield. Therefore, there exists a 35 per cent potential to increase the productivity of non-basmati rice in RWZH through elimination of the losses. Total losses from technical constraints were 1,590 kg/ha, which accounted for about 88 per cent of the estimated yield gap. The bacterial leaf blight tops the list of damages by causing a maximum yield loss of 350 kg/ha. The other diseases, in order, are the grain discolouration, a result of complex multi-fungi infestation, blast, false smut and bakane. Among insect pests, white backed plant hopper is the major problem causing 165 kg/ha yield loss, followed by rice hispa. Barta weed (E. crusagali) is an important constraint contributing about 126 kg/ha to the yield losses. Zinc deficiency is a common adverse soil problem. Water stress and use of brackish water are common water related problems causing considerable yield losses. Of the agronomic constraints, delayed and prolonged transplanting caused significant yield loss.

TABLE 3. ESTIMATED YIELD LOSSES DUE TO MAJOR CONSTRAINTS IN RICE AND WHEAT

(*kg/ha*)

Constraints (1)	Rice (non- basmati) (2)	Basmati rice (3)	Wheat (4)
Diseases			
Leaf blight	350.00	85.00	99.00
Grain discolouration	150.00	-	-
Blast	120.00	350.00	-
False smut	49.50	-	-
Bakane	12.50	67.00	-
Sheath rot	-	12.50	-
Rust	-	-	59.40
Loose smut	-	-	56.25
Insects and pests			
White backed plant hopper	165.00	-	-
Rice hispa	100.50	-	-
Leaf folder	-	160.00	-
Stem borer	-	83.52	-
Aphid	-	-	48.00
Rodent	-	-	89.55
Termite	-	-	50.00
Weeds			
E. crusagali (Barta)	125.63	20.00	-
Cyprus iria (Motha)	60.00	-	-
Phalaris minor	-	-	250.00
Wild oat	-	-	8.25
Water regime			
Water stress	142.50	98.00	-
Brackish water	62.50	25.00	150.00
Waterlogging	-	-	80.00
Soils			
Zinc deficiency	150.00	40.00	75.00
Others			
Late sowing/transplanting	101.84	280.00	350.00
Poor quality seed	-	75.00	33.00
Lodging	-	60.00	-
Low plant population	-	-	90.00
Technical constraints	1,589.97 (87.84)	1,356.02 (65.67)	1,438.45 (87.07)
Socio-economic constraints	220.04	708.98	213.55
Total (all constraints)	1,810.00	2,065.00	1,652.00

Basmati Rice

In basmati rice, average yield losses in RWZH were 2,065 kg/ha that accounted for as high as 74 per cent of farm level yield. Losses due to technical constraints were 1,356 kg/ha, which accounted for 66 per cent of the estimated yield gap. Relative share of socio-economic constraints to total yield loss is highest in this crop. Among diseases, blast causes the greatest damage (350 kg/ha), followed by leaf blight, bakane and sheath rot. Leaf folder and stem borer are two major insect pests causing about 160 and 84 kg/ha yield loss respectively. The problem of weed is not that much severe as in the case of non-basmati rice and wheat. However, water stress and zinc deficiency cause considerable damage to the basmati rice. Among the agronomic and other constraints, delayed transplanting, poor quality seed and lodging contributed 280, 75 and 60 kg/ha of yield losses respectively.

Wheat

Averages yield losses in wheat were 1,652 kg/ha which amounted to 39.16 per cent of farm level yield. Losses from socio-economic constraints were also very low in wheat, as in the case of non-basmati rice. It is not surprising in a situation where this crop does not suffer from any price risk as in the case of basmati rice. Among diseases, leaf blight is the most serious, followed by rust and loose smut. Rodent, termite and aphid are important insect pests. Phalaris minor is an endemic weed in RWZH where rice-wheat rotation is practised over time causing 250 kg/ha yield losses. Use of brackish water as irrigation, waterlogging before sowing and zinc deficiency are important water and soil related problems contributing 150, 80 and 75 kg/ha to the yield loss respectively. Losses due to late sowing in wheat is the highest among the three crops. This suggests that with increasing cropping intensity and the cultivation of basmati rice, the problem of late sowing in wheat is intensified. Low plant population and poor quality seed are also important problems in wheat in RWZH.

Rice-Wheat System

As the yield losses are not comparable among crops, the estimates of total value losses due to various constraints in the rice-wheat system is reported in Table 4. Value losses from major constraints were aggregated across crops to characterise losses for the rice-wheat system. Total losses from technical constraints in the rice-wheat system in RWZH amounted to Rs. 17,795.48 million. This makes up 77 per cent of yield gap II. The results are important for two reasons. First, a very large portion of the yield gap was attributed to technical constraints, demonstrating that solution of these constraints is not trivial. Secondly, loss estimates, when aggregated, are not larger than the yield gap. The latter is a hazard in summing loss estimates for individual constraints (Widawsky and O'Toole, 1996), but not encountered in this study. It is not surprising that a higher proportion of the production losses is attributable to technical constraints in RWZH. This is one of the most favorable rice-wheat growing regions and adoption of modern inputs is widespread. Socio-economic and infrastructural constraints are not as limiting as in the case of rainfed agro-ecoregion. Therefore, technical constraints assume a greater role in limiting yield. But a sizeable amount of value production (23 per cent of total loss) is foregone due to the existence of a number of socio-economic constraints.

TABLE 4. ESTIMATED VALUE OF PRODUCTION LOSSES IN RICE-WHEAT SYSTEM

(Rs. million)

Constraint (1)	Rice (non-basmati) (2)	Basmati rice	Wheat (4)	Rice-wheat system (5)
Late sowing/transplanting	185.96	1,519.84	1,832.60	3,538.40
Blast	219.12	1,899.80	-	2,118.92
Leaf blight	639.10	461.38	518.36	1,618.84
Phalaris minor weed	-	-	1,309.00	1,309.00
Brackish water	114.13	135.70	785.40	1,035.23
Zinc deficiency	273.90	217.12	392.70	883.72
Leaf folder	-	868.48	-	868.48
Water stress	260.21	531.94	-	792.15
Poor quality seed	-	407.10	172.79	579.89
Low plant population	-	-	471.24	471.24
Rodent	-	-	468.88	468.88
Stem borer	-	453.35	-	453.35
Waterlogging	-	-	418.88	418.88
Bakane	22.83	363.68	-	386.50
Barta weed	229.39	108.56	-	337.95
Lodging	-	325.68	-	325.68
Rust	-	-	311.02	311.02
White backed plant hopper	301.29	-	-	301.29
Loose smut	-	-	294.53	294.53
Grain discolouration	273.90	-	-	273.90
Termite	-	-	261.80	261.80
Aphid	-	-	251.33	251.33
Rice hispa	183.51	-	-	183.51
Motha weed	109.56	-	-	109.56
False smut	90.39	-	-	90.39
Sheath rot	-	67.85	-	67.85
Wild oat weed	-	-	43.20	43.20
Technical constraints	2,903.28	7,360.48	7,531.72	17,795.48
	(87.84)	(65.67)	(87.07)	(76.82)
Socio-economic constraints	401.78	3,848.34	1,118.15	5,368.27
Total (all constraints)	3,305.06	11,208.82	8,649.87	23,163.75

Priority Research Problems

The ranking of the top ten research problem areas on the basis of estimated loss of value production can be seen from Tables 5 and 6. Since the ranking of socio-economic constraints is ordinal, it is difficult to compare them with technical constraints. Moreover, relative ranking of technical constraints also changes across crops. Thus the last column in Table 5 indicates the priority research problems for the entire rice-wheat system in RWZH. The aggregate data show which constraints are critical with respect to total losses. The late sowing/transplanting tops the list, indicating the urgency for research intervention to contain the damage. Rice blast is particularly endemic in basmati rice and also ranked seventh in non-basmati rice. The other disease causing large damages to all the three crops is leaf blight. Phalaris minor is a serious problem in wheat while leaf folder in the case of basmati rice. The problems of brackish water (that leads to soil salinity) and zinc deficiency are prevalent in RWZH. The problem of water stress is common in both basmati and non-basmati rice where it ranked fourth and fifth respectively. One may question why there is water stress in an irrigated environment. The reason is that though the entire rice area in RWZH is irrigated, the supply of irrigation water is constrained due to power failure resulting in delayed and inadequate irrigation. However, two of the top ten constraints are related to seed. As regards the socio-economic constraints, the ten topmost damaging problems are irregular power supply, non-availability of labour during peak period, high cost of plant protection chemicals, high wage rate of labour, high cost of chemical fertiliser (mainly P and K fertilisers), non-availability of quality pesticides, timely availability of quality seeds, price risk, non-availability of canal water and low price of farm products.

TABLE 5. RANKING OF CONSTRAINTS BY CROPS IN TERMS OF VALUE OF PRODUCTION LOSSES

Ranks (1)	Rice (non-basmati) (2)	Basmati rice (3)	Wheat (4)	Rice-wheat system (affected crop) (5)
I	Leaf blight	Blast	Late sowing	Late sowing/transplanting (All)
II	WBPH	Late transplanting	Phalaris minor	Blast (NBR+BR)
III	Zinc deficiency	Leaf folder	Brackish water	Leaf blight (All)
IV	Grain discolouration	Water stress	Leaf blight	Phalaris minor (W)
V	Water stress	Leaf blight	Low plant population	Brackish water (NBR+W)
VI	E. crusagali (Barta)	Stem borer	Rodent	Zinc deficiency (All)
VII	Blast	Poor seed quality	Waterlogging	Leaf folder (BR)
VIII	Late transplanting	Bakane	Zinc deficiency	Water stress (NBR+BR)
IX	Hispa	Lodging	Rust	Poor seed quality (BR)
X	Brackish water	Zinc deficiency	Termite	Low plant population (W)

Note: NBR=Non-basmati rice; BR= Basmati rice; W= Wheat.

TABLE 6. IMPORTANT SOCIO-ECONOMIC CONSTRAINTS IN RWZH

Sr. No. (1)	Constraints (2)	Composite score (3)	Rank (4)
1.	Irregular power supply for irrigation	1.33	I
2.	Non-availability of labour during peak periods	1.83	II
3.	High cost of plant protection chemicals	3.17	III
4.	High wage rate of labour	4.33	IV
5.	High cost of chemical fertilisers (mainly P and K fertilisers)	4.83	V
6.	Availability of quality pesticides (adulteration)	5.50	VI
7.	Timely availability of quality seeds	6.67	VII
8.	Price risk (mainly for basmati rice)	7.00	VIII
9.	Non-availability of canal water	7.50	IX
10.	Low price of output	7.83	X

RESEARCH AGENDA

Elimination or partial solution of these priority constraints would have a major impact on rice-wheat system. Based on the magnitudes of crop losses due to major constraints, it is possible to identify a partial research agenda for the rice-wheat system in RWZH. The top ten technical constraints to rice-wheat system cover all the six categories studied. Significant losses from delayed sowing demonstrate the acute need for short duration photo-insensitive varieties. Varietal resistance to diseases, particularly to rice blast and leaf blight, is needed against which there is currently no effective genetic resistance. Chemical and cultural controls need to be maintained, and the search for genetic resistance should be continued. Some mechanism to reduce losses due to weeds, particularly phalaris minor, is clearly necessary. Although many conventional methods are available, they are not successful enough to prevent huge production loss. This weed has developed resistance to available herbicides and become a real threat to wheat production. Integrated weed management techniques will have to be evolved to solve this problem in existing areas and to limit its spread in new areas. Soil salinity due to continuous use of brackish water, and zinc deficiency are major soil related constraints for which there are some conventional solutions, but these methods of soil reclamation are very costly and take many years. Biotechnology embraces a range of technical possibilities, the future potential of which is still being hypothesised. However, basic research on transfer of tolerant genes is a distinct possibility. Tolerance to water stress is crucial since many areas in rice-wheat system experience irregular supply of power and canal water. Significant losses from leaf folder, stem borer and white backed plant hopper demonstrate the acute need for genetic resistance. Genetic resistance to insects has a two-fold advantage: it serves to increase yields and reduces the dependency of the farmers on insecticides, thereby addressing environmental concerns. The yield potential of recent rice and wheat technology in RWZH may have reached a threshold, as judged by the narrowing yield gaps between experiment station yield and on-farm demonstration yield. Thus the potential yield ceiling for both rice and wheat must be raised to meet future demand for foodgrain. Biotechnology or hybrid breeding can be an answer to this. New varieties, responsive to high rates of fertilisers, should incorporate multiple resistance to insect pests and diseases, and must have desirable agronomic traits.

The socio-economic constraints confronting the rice-wheat system in RWZH also need to be addressed through research and policy intervention. The task emanating here is to ensure regular power supply to the farm sector. Contrary to popular belief, ground realities indicate that the farmers are not against payment for the electricity bills, if regular supply is ensured. Rice and wheat both are labour intensive crops and periodic shortage of labour leads to delay in farm operations. Thus development of labour saving implements suitable for rice-wheat farming can fetch a better deal in reducing the labour related problems. At the same time there is a need to popularise the available labour saving devices, like recently developed rice transplanter by the Indian Council of

Agricultural Research (ICAR), in this region. The farmers feel that existing pricing policies deny them a remunerative return. Input prices are increasing at a higher rate than the output prices. Thus a pragmatic shift in terms of trade in favour of agriculture will give a powerful incentive for enhancing rice and wheat production. Similarly, policies toward fertiliser subsidy need to be restructured especially in favour of potassic and phosphatic fertilisers. At the same time policies are also needed to encourage the use of potential biological substitutes to agro-chemicals. Basmati growers are facing high price risk for their produce. Exporters often deny them remunerative price even if export prices soar high. Thus policies should encourage formation of farmers' co-operatives for basmati export. Policies are also needed to develop long-term procedures for conjunctive use of canal and groundwater. Finally, development agencies and private sector should ensure that the critical inputs, like quality seeds of recommended rice and wheat cultivars, pesticides and canal water necessary for productive rice-wheat farming are timely available.

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