YIELD GAP AND PRODUCTION CONSTRAINTS IN RICE-WHEAT SYSTEM: SCENARIO FROM EASTERN UTTAR PRADESH

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Abstract

The yield gap and the production constraints in the rice-wheat (R-W) system in eastern Uttar Pradesh were studied. The yield gap II (difference between the yield obtained at nearest demonstration plot and actual yield obtained on farmers' fields in a particular region) has been found 45 percent and 38 percent in rice and wheat crops, respectively, in the irrigated rice-wheat system. The technological and socio-economic constraints have accounted for 54 percent and 46 percent of the yield gap, respectively, in the system. Soil-related constraints rank first, followed by weed-related constraints. Among the individual constraints, zinc deficiency rank first followed by nitrogen deficiency and incidence of *Phalaris minor*. The study has concluded that for the sustainability of the R-W system, priority should be accorded to bridge the existing yield gap through addressing the production constraints.

Keywords: Production constraints, rice-wheat system, yield gap, socio-economic constraints

Introduction

Rice and wheat are two main pillars for the food security in India. These two crops, together account for over 58% of the area and over 77% of the production of food grains in the country (GoI, 2010). The combined share of these two commodities reported over 90% of total quantity consumption of cereals in rural India (CSO, 2010). However, compound growth in the area, production, and yield of these two crops has decelerated in recent past. The growth of wheat area, production, and yield during 1980s was 0.46 %, 3.57%, and 3.10% per annum, which changed to 1.72%, 3.57%, and 1.83% in 1990s and decelerated to 1.21%, 1.89%, and 0.68% during the period of first decade of the twenty first century. In rice, the growth rate of area, production, and yield were 0.41%, 3.62%, and 3.19% per annum, which decelerated to 0.68%, 2.02%, and 1.34% and further decelerated to -0.03%, 1.59%, and 1.61% during corresponding period (GoI, 2010). These scenarios prove that there is no further scope for area expansion and productivity growth in these two crops. It is also documented that yield stagnation and other problems such as depletion in groundwater table, deterioration of soil health for production of rice and wheat occurred in the state of Punjab, Haryana, and Western part of Uttar Pradesh where Green Revolution technologies adopted in early than in eastern India. Hence, to increase the

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production, judicious option is only to bridge the yield gap in eastern India where there are abundant availability of groundwater with suitable agro-climatic condition and huge yield potential in these two crops.

The rice-wheat system is being practised in Uttar Pradesh (UP) since 1872 AD and the area under rice-wheat (R-W) sequence in India was estimated to be nearly 11 million hectares during 1996-98. Nearly half of this area is in UP and within the state, the system is largely concentrated in the eastern region to the extent that about 22 % of the total area under R-W system of the area in the country (Singh, 2001). This region is characterized by inadequate irrigation, low levels of input-use, traditional practices, frequent flooding and other weather-induced risks. It also requires a different technological, infrastructural and policy support from the northern region. While some studies have analysed the performance of R-W system in the northern India (IRRI, 1990; Hobbs *et al*., 1992, Chaudhary and Harrington, 1993; Harrigton *et al*., 1993; Roy and Dutta, 2000), systematic studies focusing on the eastern Uttar Pradesh are relatively few. Therefore, the present study has examined the yield gap and production constraints of R-W system in the eastern UP.

Methodology

Study area and sources of data

Eastern Uttar Pradesh comprises twenty eight districts, which classified into three agroecological zones, namely Eastern Plain Zone, North-Eastern Plain Zone, and Vindhya Zone, and occupies one-third of the net sown area of Uttar Pradesh.

Secondary data collected from 'Uttar Pradesh Ke Krishi Akre' annual publication of Department of Agriculture, Government of Uttar Pradesh and used for categorization of the districts on the basis of yield of rice and wheat. For identification of production constraints, primary as well as secondary data were used. The production constraints were elicited from the scientists, extension personnel, and other government officials. These data were collected from farmers practising the R-W system. For the selection of sample farmers, 15 districts (Azamgarh, Mau, Bahraich, Shrawasti, Basti, Sidharth Nagar, Sant Kabir Nagar, Deoria, Kushi Nagar, Faizabad, Ambedkar Nagar, Gorakhpur, Maharajganj, Gonda and Balrampur) were selected with higher proportion of R-W system. From each district, two blocks and from each block, one village was selected randomly. All the farmers in a village were grouped into three categories on the basis of their size of holdings. A total of 10 farmers from each village were selected. Thus, a total of 140 farmers were selected for the detailed farm survey.

Estimation of yield gap

In this study, the concept of yield gap as suggested by Zandstra *et al.* (1981) was used. This total yield gap can be decomposed into two parts, viz. Yield gap I and Yield gap II. Yield Gap I refers to the difference between research station yield and potential farm yield obtained at demonstration plots, while Yield Gap II, reflecting the effects of biophysical and socio-economic constraints, is the difference between yield obtained at the nearest demonstration plot and actual yield obtained on farmers' fields. This gap was of prime concern in the present study. The yield gaps were estimated as follows:

Yield Gap I= $[(Y_R - Y_D)/Y_R] \times 100$

Yield Gap II= $[(Y_D - Y_F)/Y_D] \times 100$

Where. Y_R is the research station yield, Y_D is the demonstration plot yield, and Y_F is the actual farm yield.

Estimation of production losses due to various constraints

The severity of technological constraints was assessed through estimation of production losses. The proportion of area affected, average yield loss and frequency of occurrence being indicators of severity of a constraint, information on these aspects was collected from the sample farmers based on their experience and perceptions. The estimates were averaged for rice and wheat separately for each constraint. The production losses were calculated on the basis of area affected and yield loss per hectare due to a particular constraint in the region. The production losses were multiplied by the procurement price to get the value of production foregone a constraint. All technological constraints were ranked on the basis of the value of production loss. The socio-economic constraints were ranked on the basis of percentage of sample farmers reporting about a particular constraint.

Results and Discussion

Categorization of the districts on the basis of productivity of rice and wheat in Eastern Uttar Pradesh

The categorization of the districts in eastern Uttar Pradesh on the basis of yield of rice is presented in Table 1. It shows that none of the district occupies the position in the category of High productivity districts (2.5-3.5 t/ha) and all the districts except Ballia and Sonbhadra were concentrated in categories of medium to medium-low productivity districts (1.5 to 2.5 t/ha).

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Table 1. Categorization of the districts on the basis of productivity of rice in eastern Uttar Pradesh, 2007-09.

Category	District
High productivity districts (2.5-3.5 t/ha)	None
Medium productivity districts (2.0-2.5 t/ha)	Ambedkar Nagar, Kushinagar, Maharajganj, Barabanki, Sultanpur, Faizabad, Chandauli, Allhabad
Medium-low productivity districts (1.5-2.0 t/ha)	Pratapgarh, Deoria, Gonda, Balrampur, Ghazipur, Shrawasti, Gorakhpur, Bahraich, Jaunpur, Sant Kabir Nagar, Azamgarh, Mau, Varanasi, Sant Rabidas Nagar, Kaushambhi, Mirzapur, Basti, Sidharth Nagar
Low productivity districts (1.0-1.5 t/ha)	Ballia, Sonbhadra
Very low productivity districts (<1.0 t/ha)	None

Source: Author's calculation with data from Directorate of Agriculture, Government of Uttar Pradesh, Lucknow.

The categorization of the districts on the basis of yield of wheat is presented in Table 2. It shows that all the districts except Sonbhadra are concentrated into categories of high and medium productivity (2.0-3.5 t/ha).

Table 2. Categorization of the districts on the basis of productivity of wheat in eastern Uttar Pradesh, 2007-09.

Category	District
High productivity districts (2.5-3.5 t/ha)	Balrampur, Ambedkar Nagar, Kushinagar, Maharajganj, Barabanki, Sultanpur, Gonda, Faizabad, Deoria, Gorakhpur, Bahraich, Jaunpur, Sant Kabir Nagar, Ballia, Azamgarh, Mau, Varanasi
Medium productivity districts (2.0-2.5 t/ha)	Ghazipur, Basti, Pratapgarh, Shrawasti, Chandauli, Sidharthnagar, Allahabad, Sant Rabidas Nagar, Kaushambhi, Mirzapur
Medium-low productivity districts (1.5-2.0 t/ha)	Sonbhadra
Low productivity districts (1.0-1.5t/ha)	None
Very low productivity districts (< 1.0 t/ha)	None

Source: Author's calculation with data from Directorate of Agriculture, Government of Uttar Pradesh, Lucknow.

Estimation of yield gap in rice and wheat

As seen from Table 3, the estimated yield gap I was 0.174 t/ha (5 %) and yield gap II was 1.45 t/ha (42 %) in the case of rainfed rice. In irrigated rice, yield gap I was 0.631 t/ha (12%), while yield gap II was 2.030 t/ha (45%). In the wheat crop, yield gap I was 1.636 t/ha (29%) and yield gap II was 1.519 t/ha (38 %). It implies that average yield of rice and wheat was much below the potential yield in the region. The yield gap II was 2 t/ha and 1.5 t/ha in rice and wheat respectively, and much scope for yield enhancement in these two crops in the region.

Table 3. Yield gaps in rice-wheat system at Faizabad centre in eastern Uttar Pradesh (t/ha).

Particular	Rice		Wheat
	Rainfed	Irrigated	Irrigated
Average research station yield	3.629	5.141	5.675
Average front line demonstration yield	3.455	4.510	4.039
Average actual farm yield	2.000	2.480	2.520
Yield gap I	0.174	0.631	1.636
	(5)	(12)	(29)
Yield gap II	1.455	2.030	1.519
	(42)	(45)	(38)
Total yield gap	1.629	2.661	3.155
	(47)	(57)	(67)

Source: Experimental and demonstration yield data from coordinated projects and frontline demonstrations.

Estimation of value of yield losses in rice - wheat system in eastern Uttar Pradesh

Considering rice and wheat together for the irrigated rice-wheat system, the shares of technological and socio economic constraints were found as 54 percent and 46 percent, respectively (Table 4). Within the technological constraints, soil related constraints ranks first followed by weeds, diseases, insect pests and climate related constraints in irrigated rice-wheat system in eastern Uttar Pradesh.

Table 4. Estimates of yield losses due to major constraints in irrigated rice-wheat system in eastern Uttar Pradesh.

Constraints	Average estimated yield loss (kg/ha)	Yield gap II (%)	Estimated value of yield lossess (in crore Rs.)
Technological constraints			
Abiotic constraints			
Climate related constraints	136	7.1	164
Soil related constraints	892	46.4	1077
Biotic constraints			
Insect pests	164	8.5	196
Diseases	219	11.4	263
Nematodes	29	1.5	35
Weeds	460	23.9	558
Rodents	7	0.4	85
Wild cow	9	0.5	13
Technological constraints	1916	54	2391
Socio-economic constraints	1633	46	1899
Total	3549	100	4290

Source: Author's calculations with data from selected farmers' and extension personal in the region.

Prioritization of the production constraints in irrigated rice-wheat system

The technological constraints were prioritized on the basis of the value of yield losses in irrigated rice-wheat system (Table 5). Among the individual constraints, zinc deficiency, nitrogen deficiency, and stem borer occupied top ranked in rice crop, while Phalaris minor, nitrogen deficiency, and phosphorus deficiency were important in wheat. It implies that to minimize the yield gap, these important constraints should be given priority in that order in the region.

The socio-economic constraints were ranked on the basis of opinions and perceptions of the respondents (Table 6). Among the socio-economic constraints, lack of knowledge about new technologies ranked first followed by lower share of nutrient supply through FYM and poor extension facilities.

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Tables 5. Priority ranking based on value of production losses in irrigated rice-wheat system in eastern Uttar Pradesh.

Priority ranks	Rice	Wheat	Rice-wheat system
1	Zinc deficiency	Phalaris minor	Zinc deficiency
2	Nitrogen deficiency	Nitrogen deficiency	Nitrogen deficiency
3	Stem borer	Phosphorus deficiency	Phalaris minor
4	Phosphorus deficiency	Avena spp.	Phosphorus deficiency
5	Drought	Chenopodium album	Stem borer
6	Cynodon dactilon	Late season moisture stress	Avena spp.
7	False smut	Hailstorm	Late season moisture stress
8	Waterlogging	Melilotus albs	Potash deficiency
9	Sulphur deficiency	Zinc deficiency	Chenopodium, album
10	Sheath rot	Potash deficiency	Cynodon dactilon
11	Brown spot	Anguina tritici (nematodes)	Drought
12	Flood	Fumeria parvi	Sulphur deficiency
13	Cyprus rotendus	Foliar blight	Hailstorm
14	White-backed planthopper	Cynodon dactilon	False smut
15	Potash deficiency	Loose smut	Stem borer
16	Late season moisture stress	Wild cow	Chenopodium album
17	Sheath blight	Karnal bunt	Waterlogging
18	Selaria glauca	Sulphur deficiency	Sheath rot
19	Leaf folder	Rodents	Melilotus alba

Source: Author's calculations with data from selected farmers' and extension personnal in the region.

Table 6. Ranking of identified socio-economic constraints for the irrigated rice-wheat system in eastern Uttar Pradesh.

Constraints	Frequency of constraints reported by farmers	Rank
Lack of knowledge about Integrated Plant Nutrients Management (IPNM), Integrated Pest Management (IPM), low input cost technologies such as blue green algae, new varieties and improved technologies suitable for stress environment, zero tillage and crop residue management	29	1
Low share of nutrients supply through FYM in total nutrient supply, lion's share of animal dung used as fuel	23	2
Poor reach to extension agencies and lack of demonstration trials	17	3
Low irrigation facilities and erratic supply of electricity	15	4
Low pulses area related to rice-wheat system area and lack of suitable cropping sequence	14	5
Lack of output market infrastructure	11	6
Lack of proper developed road infrastructure	10	7
Small and fragmental holding and limited resource base of farmers	8	8
Lack of improved implements and supply of quality agro-chemicals and seed	7	9
Declining area under common property land	6	10

Source: Author's calculations with data from selected farmers' and extension personnel in the region.

Based on the study, the policy implications for sustainability of the rice-wheat production system are presented in Table7.

Table 7. Policy implications for sustainability of rice-wheat system in eastern Uttar Pradesh.

Constraints	Possible causes	Opportunity	Suggestions	
			Research theme	Policy tools
Soil-related constraints	Un-scientific crop rotation, imbalanced use of fertilizers and steady decline in use of organic manure	Adoption of integrated plant nutrient management and resource conservation technologies, such as zero tillage	Diagnosis of constraints for adoption of integrated plant nutrient management and resource conservation technologies and suitable alternatives for FYM	Suitable policy for encouragement of balanced use of fertilizers, bio-fertilizers, FYM and other organic manures
Weed-related constraints	Continuous R-W crop rotation, spurious supply of weedicides besides decline in efficacy of existing weedicides	Suitable crop rotation, supply of quality weedicides and promotion of integrated weed management	Development of efficient weedicides, crop specific module for weed management	Suitable policy to check supply of quality weedicides and encouragement of integrated weed management
Slow adoption of new technology and poor extension support system	Lack of up-to-date knowledge of new technologies besides steady decline of government support	Suitable policy for technologies transfer from research station to farmers field	Development of location specific technologies and its refinement through farmers' participation	Suitable policy for strengthening of linkages among state agricultural universities, development departments, Krishi Vigyan Kendras and farmers

Conclusions and policy implications

The study has shown that there is a huge potential to increase crop yields at farm level. The main socio-economic constraint reported to lack of knowledge about improved technologies, which could be addressed by strengthening extension services. Suitable policy for gradually encouragement for use of balanced fertilizers along with FYM, supply of quality inputs apart from strengthening of linkage between research institutes and farmers are imperative for sustainability of the system. Concerted efforts are needed to bridge the yield gap through translation of prioritised production constraints into research objectives and allocating resources to research and development. At the same time, development of infrastructure and rural institutions are essential to further accelerate and sustain the productivity growth in the region.

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