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Seeds, Water, and Markets to Increase Wheat Productivity in Bihar, India

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The Cereal Systems Initiative for South Asia (CSISA) is a regional initiative to sustainably increase the productivity of cereal-based cropping systems, thus improving food security and farmers' livelihoods in Bangladesh, India and Nepal. CSISA works with public and private partners to support the widespread adoption of resource-conserving and climate-resilient farming technologies and practices. The initiative is led by the International Maize and Wheat Improvement Center (CIMMYT), implemented jointly with the International Food Policy Research Institute (IFPRI), the International Rice Research Institute (IRRI), and the International Water Management Institute (IWMO) and is funded by the US Agency for International Development (USAID) and the Bill & Melinda Gates Foundation.

Introduction

Low and variable yields of wheat in the rice--wheat cropping systems of lower Indo-Gangetic Plains (IGP) of South Asia, covering Bihar and Eastern Uttar Pradesh (EUP) in India and the Terai region of Nepal, are a matter of significant concern for this densely populated region (Chatrath et al., 2007). Increasing the productivity and profitability of wheat is important for Bihar and E U P both for the income security of farmers and the food security of households (Keil et al., 2015). It is the second-largest crop in the region after rice in terms of area, production, and output value. Farmers in Bihar cultivate wheat on more than 2 million ha of land and produce 5--6 million tonnes of it every year. Wheat occupies 28% of the gross cropped area of Bihar and 70% of the sown area in the Rabi season. Despite its importance to the state's agrarian economy and food security, wheat yields and the gross value of output per hectare are the lowest in Bihar among all major wheat-producing states of India while the cost of production (INR/tonne) is high (INR 10,630/tonne vs. INR 9,600/tonne for India); the net profit (INR per hectare) from wheat cultivation is also the lowest (Commission for Agricultural Costs and Prices (CACP), 2020). In this brief, we analyze the four major factors that contribute to low wheat yields in Bihar.

Research question

We focus on four major reasons for low productivity:

1. Irrigation is expensive in Bihar because it is dependent primarily on diesel pumps. Farmers wait for rains to transplant paddy rather than using irrigation. This waiting leads to the late transplantation and harvest of paddy, which delays sowing of wheat, exposing it to terminal heat during flowering and grain-filling stages.
2. Farmers also under-irrigate wheat (i.e., water application is less than the reference evapotranspiration, resulting in water stress) because irrigation is expensive, thereby resulting in yield losses.
3. A large number of wheat growers in Bihar continue to use very old varieties of seeds with low yield potential.
4. Finally, these farmers do not get remunerative prices for wheat. Low and uncertain output prices reduce farmers' incentives for input intensification.

In this note, we discuss the impact of the high cost of diesel–powered irrigation and under-application of irrigation on delays in the sowing of wheat, persistent use of old varieties, and its correlation with lower yields. We also discuss the role of poor price realization of wheat in resulting in lower wheat yields in Bihar to argue for improving procurement prices in the region. In the next section, we describe the data, methods and additional statistics.

Landscape Diagnostic Survey

We rely mainly on the Landscape Diagnostic Survey (LDS) data in this paper which were collected as part of this project. The LDS of wheat production practices and yield collected primary data from a representative sample of randomly selected 7,648 wheat growers from 1,766 villages spread across 40 districts of Bihar and EUP in 2018-19 (Table 1) (Ajay et al., 2020) to understand the dynamics of cropping systems and constraints faced in meeting yield potential at the farm level. More details on the methodology of data collection and sampling strategy of LDS can be found in (Singh et al., 2020). For the largest plot on which the farmer cultivated wheat, the LDS collected data on input use (seeds, fertilizers, water), cultivation practices (method of land preparation, timing, and method of sowing the seeds, frequency of irrigations, weed control, etc.), sales of produce, and the output market price realized. The LDS also has data on soil quality and the location of the largest plot of land. Farmer-reported wheat yields were validated by conducting crop-cutting experiments on more than 300 plots.

Table 1. The LDS Sample in Bihar and EUP

Sampling Units	Bihar	EUP
Number of farmers	5,793	1,855
Villages	1,304	462
Blocks	314	101
Districts	31	9

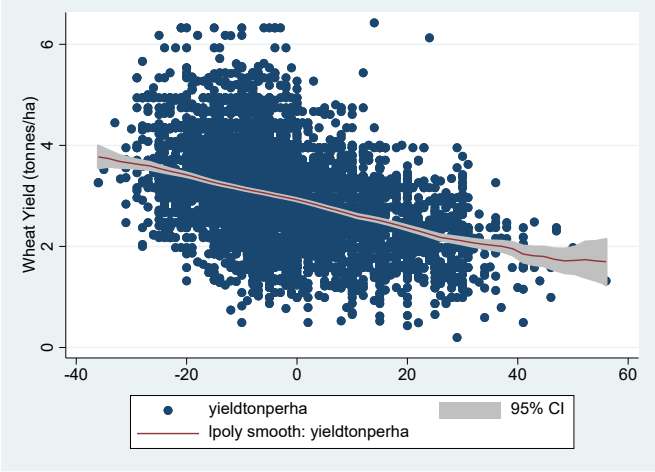
Source: Ajay.et.al., 2020

Reasons for low yields of wheat

i. Late sowing of wheat

Figure 1 below shows a scatterplot of wheat yields against the date of sowing and smoothed values of a kernel-weighted local polynomial regression between the two variables. The X-axis in the figure shows the time of sowing as the number of days from 30th November. Negative values on the X-axis mean that the sowing occurred before 30th November. Both the scatterplot and the fitted non-parametric line show that late sowing of wheat is associated with a significant decline in its yields; this is primarily due to reported heat stress in the latter part of the season. In wheat, a rise in maximum temperature shortens the duration of the grain-filling period which results in reduced grain yield. Earlier in the growing season, heat stress during flowering can cause anther and pollen sterility that limits embryo development thereby creating sink limitations and low harvest indices (Al-Khatib & Paulsen, 1984). Ortiz et al., (2008) found yield losses of 0.7% daily if wheat is sown past an optimum time window based on the cultivars' maturity rating. Thus, solutions to terminal heat stress largely come from earlier sowing (Lobell et al., 2012).

Figure 1: Relationship between wheat yields and date of sowing



Source: Author's calculations using LDS data

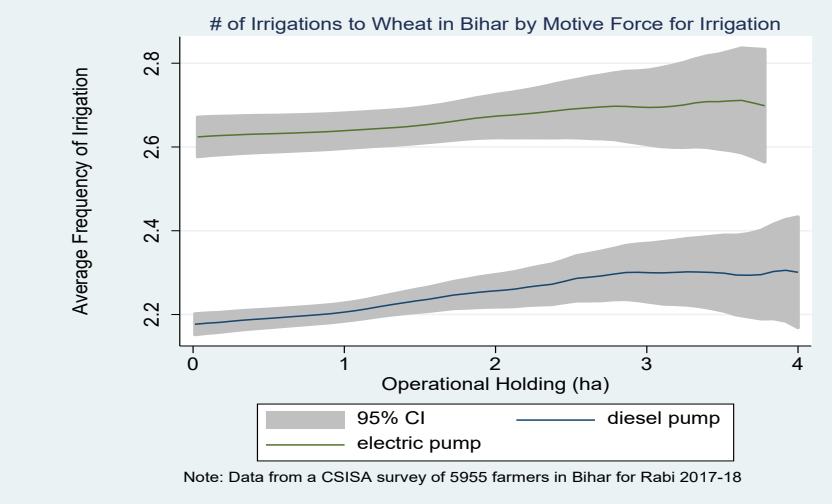
ii. High cost of irrigation is a major reason for delays in rice-wheat cropping system in Bihar

Irrigation is expensive in Bihar because it is almost entirely dependent on diesel pumps. The cost of irrigation per hour for paddy cultivation in Bihar is approximately INR 82 (USD 1.1), whereas it is approximately INR 47 (USD 0.6) in the rest of the country. The number of farmers in Bihar who irrigate paddy and the total hours of irrigation per ha of the crop have increased over the years. Still, under-irrigation persists, resulting in late transplantation of paddy and its low and unstable yields. Late transplantation of paddy also delays its harvest and the sowing of wheat that follows the paddy. Ninety-three-percent of farmers in Bihar who grow wheat in the Rabi season cultivate paddy before it (NCAER, 2015). Therefore, late transplantation and harvest of paddy affect almost the entire wheat area of the state.

iii. The high cost of irrigation also leads to deficit irrigation of wheat

LDS collected data on the frequency of irrigation application to wheat. Sixty-five percent -of all farmers in Bihar irrigated wheat only once or twice, and only 5% of them provided four or more irrigations to their largest wheat plot. Farmers with access to electric pumps apply a significantly higher number of irrigations to their wheat across all landholding sizes.

Figure 2: Number of irrigations to wheat by motive force for irrigation



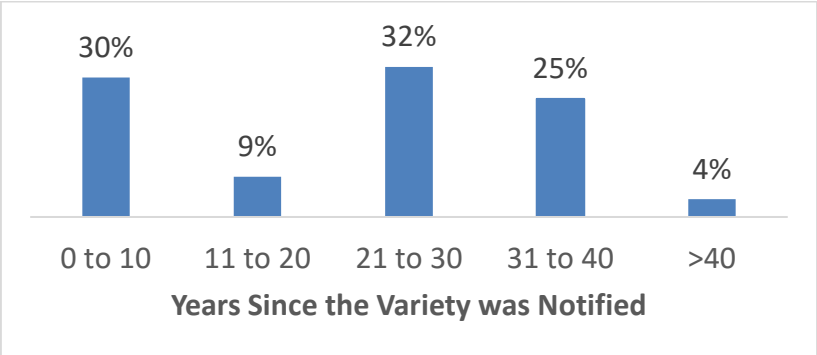
Source: Author's calculations using LDS data

Figure 2 also shows that for both diesel and electric pump users, the irrigation frequency increases very modestly with the increase in holding size. The Minor Irrigation (MI) Census data shows that the average pump size or the hourly discharge rate of wells is not higher in Bihar compared to the rest of India. Therefore, the lower hours of irrigation per ha of wheat in Bihar is a sign of lower water application rates. Furthermore, like most other parts of India, there is very little rain during the Rabi season in Bihar (Zakwan & Ara, 2019). Under-application of water, therefore, leads to moisture stress and yield loss.

iv. Use of old varieties of seeds

Despite the rapid development of new varieties and incentives by state governments to accelerate their adoption, old (>10 years) and very old (> 15 years) varieties continue to dominate the cropped area in Bihar and EUP. Seventy percent of farmers in our sample used varieties that were older than ten years, and more than 60% of farmers used varieties that were developed before the year 2000, as can be seen in Figure 3. From our statistical analysis, we find that use of newer varieties is not influenced by landholding size, and proximity to markets also does not significantly affect the choice of varieties. Farmers who rely on diesel pumps for irrigating wheat are considerably less likely to use newer varieties.

Figure 3: Distribution of respondents by age of seed variety

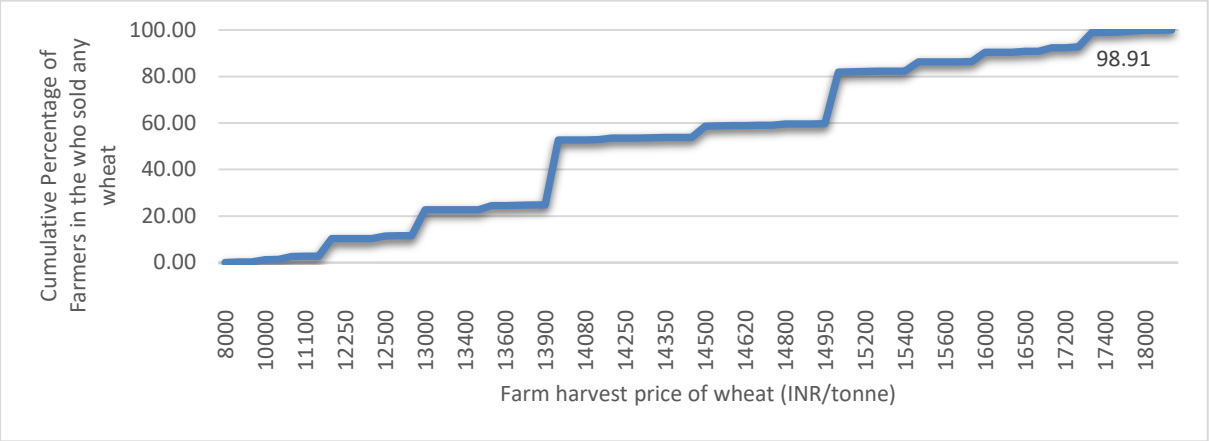


Source: Author's calculations using LDS data

Poor price realization dampens incentives for input intensification

Farmers in Bihar and EUP get low prices for their wheat crops. In 2017-18, the median farmer in the LDS sample got only INR 1400 (USD 19) per tonne of wheat in Bihar and INR 1500 (USD 21) per tonne in EUP at the time of harvest—19% and 13% below the Minimum Support Price (MSP) of INR 17,350 (USD 237) per tonne announced for that year, respectively. If we look at the complete distribution of the farm harvest prices, we find that more than 90% of the farmers in our sample sold wheat at prices below the MSP (Figure 4). There is very little public procurement of wheat at MSP from the region. For example, less than 10,000 tonnes of the 6.1 million tonnes of wheat produced in Bihar in 2017-18 was procured at MSP (Commission for Agricultural Costs and Prices (CACP), 2020). Procurement was low in EUP, as is evident from average price realizations in the LDS sample, but sub-state level data is unavailable to validate this information.

Figure 4. The cumulative distribution of farm-harvest prices (FHP) of wheat (INR/tonne) in 2017-18



Source: Authors' calculation using LDS data. Note: 182 farmers (2.4% of the sample) did not sell any wheat. 98.91% of farmers who sold wheat received prices at or below the minimum support price announced by the Government of India.

Poor price realization diminishes farmers' incentives for input intensification. Farmers would irrigate more and will be willing to spend more on other yield-enhancing inputs if they get better prices for their produce. Increasing the public procurement of wheat is a strategy that states like Haryana, Madhya Pradesh, and Punjab use to guarantee a higher price of wheat for their farmers. Higher and more predictable output prices encourage input intensification by farmers and result in higher crop yields (Hazrana et al., 2020).

Policy strategies to promote sustainable intensification of rice-wheat cropping system in Bihar

Given our findings, we recommend a three-pronged action by the Government of Bihar to increase the productivity and profitability of the rice-wheat cropping system in the state.

i. Ensure affordable access to irrigation for everyone

However, multiple primary surveys, show that access to irrigation is present in almost all villages of Bihar and EUP. Irrigated agriculture in Bihar relies predominantly on groundwater. Ninety-three percent (of 5,669 respondents) of farmers in the LDS used groundwater for irrigation. Electrification of irrigation wells can help reduce the cost of pumping groundwater. The recent improvements in rural electrification and power supply conditions in the state offer an opportunity for rapid electrification of irrigation. The number of electric pump-sets in the state has increased from 48,500 in 2013-14 to 253,000 in 2019-20. The most recent MI census counted 640,000 mechanized wells in Bihar in 2013-14. If we assume that the total number of mechanized wells has not increased, then more than one-third of all irrigation wells are now connected to the electricity grid. However, North Bihar (part of Bihar north of the Ganga river), lags the southern part of the state in the electrification of irrigation wells. The lower operating cost of electric pumps will reduce irrigation costs for farmers in Bihar if the power supply is reliable and of good quality. Separate feeders and investment in new supply lines will help improve the quality and reliability of power supply, reduce technical losses, and allow more reliable accounting of energy consumption by farmers.

ii. Accelerate the adoption of improved varieties

Many wheat growers in Bihar also grow maize in the winter season. Interestingly, the same farmer uses single-cross hybrid seeds of maize and old wheat varieties on adjacent plots. The dominance of private companies in the maize market is one reason for the rapid penetration of new hybrid seeds in the state. IARI-PUSA has tried collaborations with small and medium seed companies and start-up

firms to accelerate the adoption of new rice and wheat varieties developed by the institute with remarkable success (Kishore et al., 2020). We recommend the government of Bihar initiates the public-private participation (PPP) model for the dissemination of improved varieties. Instead of charging royalties or license fees from private partners, the state government may even use seed subsidies to pay cash rewards to companies that reach more farmers to accelerate the adoption of newer seed varieties. In addition, the government should target the promotion of early sowing of paddy to villages with higher levels of electrification of irrigation wells. Farmers with electric pumps are more likely to adopt early transplantation and switch to newer varieties.

iii. Ensure better price realization of crops for farmers in Bihar and EUP

Programs to improve farmers' access to inputs like electrification of irrigation and PPP to accelerate varietal turnover should be combined efforts to increase farmers' price realization for wheat (and paddy). Recent studies also note that a farmer who sells twice as much receives a 2.4–2.5% higher price on an average in Bihar. Therefore, initiatives for the aggregation of small and marginal farmers' produce by forming farmers' groups or producer companies will help. Increasing the public procurement of wheat (and rice) is another option to ensure that farmers get remunerative prices and do not face price uncertainty. Higher and assured prices will increase farmers' incentives to intensify wheat cultivation, resulting in higher productivity and profits (Hazrana et al., 2020; Mythili, 2008). However, a public procurement-led strategy can create excessive dependence on subsidies and delink production from demand resulting in an excess production of wheat that does not have a market. Creating more competitive agricultural wholesale markets and linking farmers or farmer groups directly to these markets may be a more sustainable way to increase farmgate prices of wheat (and other food grains).

Conclusion

Our analysis shows that increasing wheat productivity in Bihar, and EUP and Nepal's Terai requires looking at the rice-wheat cropping system together. A concerted approach that includes a) public investments in the electrification of irrigation and rationalization of irrigation subsidies to ensure widespread access to affordable irrigation, b) incentives to promote private sector participation in input markets to accelerate the adoption of improved varieties, c) scaling up of institutional innovations (like FPOs) to aggregate marketable surpluses of smallholder farmers, and d) the creation of competitive agricultural markets to ensure better price realization is required to increase wheat yields and farmers' incomes from wheat production.

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