Bringing Green Revolution to Eastern India: Experiences and Expectations in Bihar

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Summary

Eastern region is rich in natural resources conducive to higher productivity. However its potential could not be exploited for improving agricultural productivity, poverty alleviation and livelihood improvement. The BGREI Program came into inception to address the constraints limiting the productivity of "rice-based cropping system" in Eastern India comprising seven states which includes Bihar. The major focus is on the promotion of improved crop production technologies, water harvesting measures and efficient management of natural resources for overall agriculture development. Major interventions under BGREI are system of rice intensification, direct seeded rice by zero tillage/seed drill/drum seeder, cropping system-based demonstration, stress tolerant varieties, zero tillage wheat, distribution of seeds (HYVs and Hybrids), asset building and site-specific activities (includes assistance for farm machineries & implements). Since the inception of the BGREI Program in Bihar state about 15.7 per cent of the total cultivated area has been covered under different demonstrations using various interventions. Rice yield with different interventions increased as compared to the conventional practice. Rice area in the state didn't change much during the BGREI Program years; however, there is wide variation in the production, which ranged from 3.11 Mt in 2010-11 to 8.24 Mt in 2016-17. As there was less variation in the area, higher production is mainly attributed to the increase in the productivity.

1. State background

Bihar with a geographical area of about 94,200 km^2 is divided by the river Ganges into two parts, the north Bihar with an area of 53,300 km^2 and the south Bihar having an area of 40,900 km^2. Based on soil characterization, rainfall, temperature and terrain, four main agro-climatic zones in Bihar have been identified i.e., Zone-I: North Alluvial Plain; Zone-II: North East Alluvial Plain; Zone-III A: South East Alluvial Plain and Zone-III B: South West Alluvial Plain (Fig. 1). Zone I and II are flood prone whereas Zone III is drought prone. All these three zones have vast untapped potential for increasing the productivity of crops. The details of the agro-climatic zones are given in Table 1.

Fig. 1. Agroclimatic zone map of Bihar (Source: www.krishi.bih.nic.in).

Table 1. Name of the districts under each agro-climatic zone and important physiographic features.

Agro-climatic zones	Districts	Soil	pH	Total rainfall (mm)	Temperature (°C) Max.	Min.
Agro-climatic zone I (Northern West)	West Champaran, East Champaran, Siwan, Saran, Sitarnarhi, Sheohar, Muzaffarpur, Vaishali, Madhubani, Darbhanga, Samastipur, Gopalganj and Begusarai	Sandy loam, Loam	6.5-8.4	1040-1450 (1245)	36.6	7.7
Agro-climatic Zone II (Northern East)	Purnea, Katihar, Saharsa, Supaul, Madhepura, Khagaria, Araria and Kishanganj	Sandy loam, clay loam	6.5-7.8	1200-1700 (1450)	33.8	8.8
Agro-climatic Zone III A (Southern East)	Sheikhpura, Munger, Jamui, Lakhisarai, Bhagalpur and Banka	Sandy loam, clay loam	6.8-8.0	990-1240 (1115)	37.1	7.8
Agro-climatic Zone III B (Southern West)	Rohtas, Bhojpur, Buxar, Bhabhua, Arwal, Patna, Nalanda, Nawada, Jehanabad, Aurangabad and Gaya	Sandy loam, clay loam	6.8-8.0	990-1240 (1115)	37.1	7.8

Rainfall varies from 990 to 1700 mm in the state. Most of the rain is received during the month of July to September. There are three crop seasons: Kharif, Rabi and Zaid. Rice, wheat and pulses are grown in all the districts. Bihar has three types of soil i.e., montane, alluvium and marshy/ swampy soil of Tarai. Soil texture varies from sandy loam to heavy clay. However, the majority type belongs to loam category which is good for crop. Soil pH varies from 6.5 to 8.4. Being located between 25 to 27° North latitude, the climate of Bihar is of mostly sub-tropical. Nevertheless region close to Tropic of Cancer experiences tropical climate during summer. Bihar reels under hot summer season during months of March to June with average temperature are 35-40° C. April to June is the hottest months of the year. December to January is the winter season in Bihar. The winter in Bihar is mild with average temperature 5 to 10°C. Bihar gets its maximum rainfall during South-West monsoon season which prevails from June to September. Average rainfall of Bihar is around 1200 mm.

Bihar is endowed with rich natural resources: fertile soil, adequate water, both surface as well as ground, and favourable climatic conditions which offer opportunities for growing, variety of crops viz. grains, fruits, vegetables etc. These factors are also crucial higher productivity. In spite of these endowments; Bihar also suffers from certain problems- high population density, small farm holdings, poor input and output marketing infrastructure, poor access to new technologies and frequent climatic aberrations (flood & drought). Small farm holding sizes, increasing energy & input prices and shortage of labours force farmers to

adopt sub-optimal and inadequate management practices which end up with lower efficiency of resource use, low productivity and profitability. This contradiction accounts for the low productivity of agriculture.

Bihar accounts for 8.6% of India's population while its share of geographical area is meagre 2.85% of the country putting a stress on natural resources. The share of agriculture and animal husbandry sector to the state GSDP is 18.3%. About 97% of holdings fall under small and marginal categories with average holding size of 0.39 ha. This type of holding pattern does not incentivize farmers to make investments and to adopt modern crop production technology. Poor credit base of farmers further worsens the situation. Poor adoption of modern crop production technology coupled with weather aberrations leaves a wide gap between potential and actual productivity of crops.

Agriculture is the mainstay of economy of Bihar as more than 70% of the population derives their livelihood out of it. The agricultural economy of Bihar is skewed in favour of subsistence sector, since the acreage under food grains, even after a decrease in recent years, is more than 90%. Post bifurcation, Bihar is left with meagre mineral resources and poor industrialization. For a state like Bihar, where over 85% people live in villages and one way or other depend on agriculture and allied activities, the development of agriculture is not only desirable but also inevitable. Without increasing the output in agriculture, growth benefit may not reach the vast majority. The state government appreciates the fact that rural prosperity shall remain a distant dream until agriculture and allied sector is imparted a growth impetus.

Eastern region is rich in natural resources conducive to higher productivity. However, its potential could not be exploited for improving agricultural productivity, poverty alleviation and livelihood improvement. Government of India realised the importance of hidden opportunities got the impression if second green revolution has to come, it has to come from eastern states wherein lay a vast gap between potential and actual productivity.

The BGREI Program came into inception to address the constraints limiting the productivity of "rice-based cropping system" in Eastern India comprising seven states which includes Bihar. The major focus is on the promotion of improved crop production technologies, water harvesting measures and efficient management of natural resources for overall agriculture development.

2. Major interventions with BGREI

2.1.1. Custer demonstrations

a) System of rice intensification: System of Rice Intensification (SRI) was found a significantly superior crop establishment method for irrigated well-drained land. This is a technique for transplanting 10 days old rice seedling with single seedling per hill in wider spacing (25 x 25 cm) having specific nutrient, water and weed management.

b) Direct-seeded rice by zero tillage/seed drill/drum seeder: The yield potential of direct seeded rice (DSR) is high due to wider spacing and increased activity of soil biota. The technology is found feasible and economically viable. It requires less labour and there is no need to prepare nursery. The crop matures 7 to 10 days earlier facilitating timely

sowing of wheat. It requires less water, makes better use of resources and is cost effective. It allows line sowing and facilitates weed control between rows. DSR ensures better crop establishment resulting into higher yield. It is a climate resilient technology.

c) Cropping system-based demonstration: Demonstration on rice transplanting by transplanter in kharif followed by zero tillage wheat sowing in rabi is being taken up. Rice transplanter helped in timely transplanting of rice with its harvest on time. This facilitated timely sowing of wheat, which helped to utilize residual moisture for wheat sowing. This increased the agricultural output and better utilization of land, which used to be fallow in rabi.

d) Stress tolerant varieties (STV): Bihar has twin problems of flood and drought. Stress tolerant varieties like Swarna sub-1 and Sahbhagi Dhan have been a great help to farmers in such areas and farmers have been able to raise good paddy crop. Other interventions like seed distribution, distribution of seed based input have popularized the use of micro nutrient, bio-fertilizers, plant protection mean uses and raise the varietal replacement rate.

e) Zero tillage wheat: In Bihar paddy grown in lowland is harvested late which delays the sowing of wheat till end of December and in some cases till first week of January. Late sown wheat suffers from terminal heat during grain-filling phase, which results in shriveled grains and low yield. Zero tillage ensures timely sowing of wheat because time for field preparation is saved. Zero tillage makes effective use of receding moisture, facilitates time sowing and better management of crop with less cost and efficient and sustainable use of natural resources. This saves wheat from impact of terminal heat and gives higher yield. Cost of cultivation is less, which gives higher income to farmers.

f) Distribution of seeds (HYVs and Hybrids): The distribution of seeds of the high yielding varieties and hybrids have also included in the BGREI program for their popularization and higher yield.

2.1.2 Asset building and site-specific activities

The asset building intervention includes assistance for farm machineries & implements like manual/power sprayer, drum seeder, seed drill/zero-till seed drill, power weeder, self-propelled paddy transplanter, rotavator, multi crop thresher irrigation pipes and pump set. The component of site-specific activities has been provided to induce flexibility in the program to take up the activities not covered under other components of the program which contribute in productivity of rice and wheat. Assistance for activities that would help in enhanced procurement, creation of storage facility, marketing and value addition is also included. These activities will include promotion/creation of primary processing facilities (drying, grading, par-boiling of paddy and bagging, etc.) including farm level storage, institution building, linkage for procurement operations/ marketing.

3. Areas of demonstrations

The BGREI Program was started in the year 2010-11 and over the years about 15.7% of the cultivated area of the state has been covered under the cluster demonstration activity.

Table 2. Rice area of Bihar State vis-à-vis area covered in the BGREI.

Rice area (lakh ha)	Area covered under BGREI demonstration (lakh ha)							Cumulative BGREI demonstration area (lakh ha)	Area covered under BGREI demonstration (%)
	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18		
32.33	0.36	0.78	1.02	0.82	1.01	0.70	0.39	5.08	15.7

4. Trends area, productivity, production of rice and wheat since 2009-10

The trends of rice area and production are described in (Fig. 2). The rice area in Bihar state varied in the range of 2.84 to 3.34 Mha for the period 2009-10 to 2017-18. However, there is wide variation in the production, which ranged from 3.11 Mt in 2010-11 to 8.24 Mt in 2016-17. As there is less variation in the area, higher production is mainly due to the increase in the productivity, which ranged from 1.07 t ha^{-1} in 2010-11 to 2.47 t ha^{-1} in 2016-17.

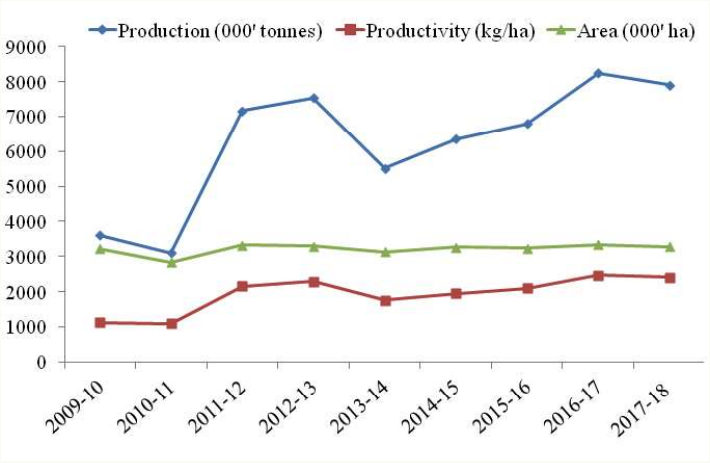

Fig. 2. Trend in area, production and productivity of rice from 2009-10 to 2017-18.

5. Effects of interventions of BGREI

To assess the effects of the technologies on the yield of the rice crop, crop cuttings are done in the demonstration plots along with the conventional practice under different interventions during 2017-18. Based on the cropping cutting data, it is observed that under SRI demonstration highest increase in yield is there i.e., 38.8% over the conventional practice. Other demonstrations like STVs, Hybrid and DSR also recorded higher yield as compared to control; whereas under paddy transplanter a slight decrease in yield was observed.

Table 3.Performance of Interventions in Bihar (2017-18).

Name of the demonstration	Total no. of crop cuttings	Avg. Yield in Demonstration Plot (q/ha)	Increase in yield over control (%)
Control	2672	44.3	–
SRI	2765	61.5	38.8
Stress Tolerant Varieties	591	52.2	17.8
Hybrid	2569	55.6	25.7
Paddy Transplanter	361	44.1	-0.4
DSR	1611	48.7	9.9

6. Production and Productivity during BGREI and Pre-BGREI Years

There has been a significant jump in the productivity of rice from an average of 1.4 t ha^{-1} in pre-BGREI year (2007-2009) to an average of 2.3 t ha^{-1} during last three years (2015-2017). Despite drought and rainfall deficiency in intermittent years the yield of rice has been maintained above 2.0 t ha^{-1} during post BGREI years.

Rainfall has direct effect on the overall productivity of a crop under rainfed agriculture. In the year 2009, 2010 and 2012 the Bihar state suffered from slight drought and during 2013 and 2015 state suffered moderate drought. During the drought year's yield of the rice crop decreased. During the years of normal rainfall a higher productivity is obtained particularly in the year 2016-17.

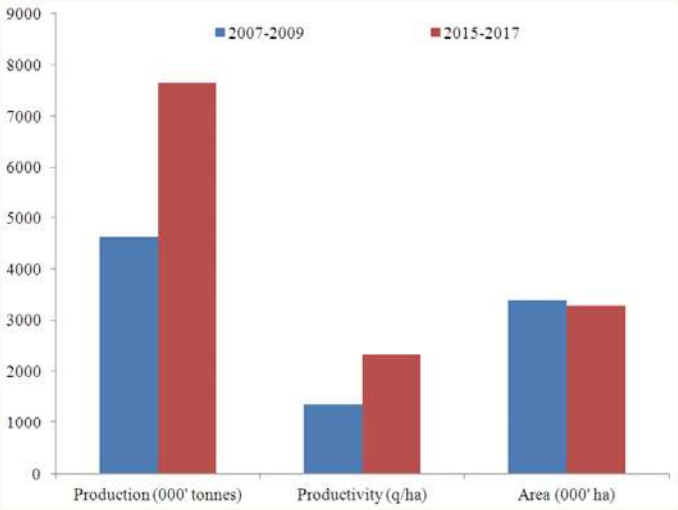

Fig. 3 Comparison of pre-BGREI (2007-2009) and BGREI years (2015-2017) in terms of production, productivity and area of rice in Bihar.

Table 4.Productivity of rice for different years along with the rainfall deficiency.

Year	Productivity (t/ha)	Rainfall Deficiency (%)	Remarks
2009-10	1.13	—	-
2010-11	1.09	-22	All 38 districts drought affected
2011-12	2.15	3	-
2012-13	2.28	-20	-
2013-14	1.76	-30	33 districts out of 38 districts drought affected
2014-15	1.95	-17	Due to hailstorm & cyclone, production of wheat is less than normal.
2015-16	2.02	-27	Deficient rainfall in some districts resulted less yield than previous year.
2016-17	2.47	-5	Being normal year yield increase over last year
2017-18	2.41	8	-

7. Suggestions

- SRI and stress tolerant variety demonstrations should be separated. SRI should be restricted to well drain irrigated areas with hybrids or HYVs. Cono-weeders may be supplied to the SRI demonstration farmers along with the seed and other inputs. Swarna sub 1 (flood tolerant variety) should be grown in flash flood areas with normal spacing and 20 - 25 days old seedling.
- In the upland and drought affected areas short duration varieties with drought tolerance trait such as Sahbhagi Dhan should be demonstrated.
- Timely availability of good quality seeds should be ensured.
- RiceXpert app launched by NRRI can be used by the extension workers and the farmers to get the answers of their queries.
- Village agricultural meets may be arranged once during vegetative stage and once at harvesting in demonstrating villages inviting non beneficiary farmers of the village and cross site visit of beneficiary farmers may be arranged at different stages of the demonstration.
- The BGREI Program is running successfully in the state with the participation of the farmers, state government machinery, state agricultural universities and ICAR institutions. For effective implementation of the program, there must be high synergy in all the stakeholders. The ground staffs who are involved in the implementation of this program need to be updated with the new technologies through trainings Programs.
- In mechanized transplanting of rice with transplanter, trainings on technique of nursery raising may be given priority. Along with the polythene sheet, wooden/iron frame or tray may be provided for better mat nursery. Farmers may be encouraged to purchase

more number of rice transplanters under the BGREI program, so that the felt shortage can be overcome.

- Farmers and the ground staff have limited knowledge on improved production technologies of rice and wheat. Therefore, ground level workers such as Agricultural coordinator and farmers may be trained on the latest technologies for effective implementation of the programme. Further the ground level staff should be provided with necessary logistics such as digital weighing balance, measuring tape, tirpal etc. for proper crop cutting activities.

Productivity of rice has shown a significant increase from an average of 1.4 t ha^{-1} in pre-BGREI year (2007-2009) to an average of 2.3 t/ha during last three years (2015-2017). Despite drought and rainfall deficiency in intermittent years the yield of rice has been maintained at above 2.0 t ha^{-1} during post BGREI years. From different interventions adopted through the program, it was observed that SRI demonstration has highest increase in yield i.e. 38.8% over the conventional practice based on the crop cutting data. Short duration variety like Sahbhagi Dhan with drought tolerant trait may be provided to the farmers for the upland and drought affected areas. Timely payment for the kits may be provided to the farmers to conduct the demonstrations.