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Enhancing food security of small and marginal farmers by technological interventions in East Champaran, Bihar

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Abstract
Agriculture is the primary source of livelihood in Bihar, but nutritional security in many regions is an issue of concern. The extension of new agricultural technologies in backward regions of the state is expected to improve crop yields which will be helpful in improving farmers' income and their socio-economic status. This study was undertaken in the East Champaran region, which is an economically backward, flood affected region of Bihar. A structured schedule was developed and data from 322 stakeholders was collected from four villages namely - Jasaulipatti, Chandrahiya, Chintamanpur and Khairimal Jamunia to determine their socio-economic status and also collect information on cropping patterns adopted and the productivity of major crops. Data were analyzed using simple descriptive statistics. It was observed that a majority of farmers (53.4%) belonged to middle age group *i.e.*, 35-50 years with a literacy rate of 80%, but 61.2% farmers were below the poverty line and 80% were small and marginal farmers which indicate lower economic status. Keeping in mind the low yield levels, technical intervention in the form of quality seed material of major crops *viz.* wheat, lentil, moong, chickpea, potato and sugarcane were distributed among the farmers which were sown over 117.8 ha. These field trials were laid out with recommended package of practices in the field of stakeholders with the aim of wider dissemination at the village level itself. The average yield in demonstration plots of wheat, lentil, moong, chickpea, potato and sugarcane was 39.38, 13.34, 9.50, 14.33, 281.15 and 711.47 q/ha, respectively, which are significantly higher as compared to yields obtained from non-beneficiary farmers. The average percentage increase in yield was 50% for all crops with maximum increase in chickpea (142.5%) and minimum in case of sugarcane (4%). This clearly indicated that seed replacement by improved varieties along with improved management practices is essential to obtain higher yields which will enhance the farmer income and also improve nutritional security in the region.

Keywords: East Champaran, demonstration trials, food security, socio-economic status, technical interventions

Introduction
Two integral objectives of India's agricultural policy after the inception of planned development (from 1950's) have been to raise food production to sustainable levels and to improve food availability to the masses. Technologies developed during the green revolution and successfully extended over large areas succeeded in raising food production within a short span of two decades to appreciable levels and subsequent initiatives have ensured a steady growth in food production matching with the increase in population.
Agriculture and allied sector provide employment to more than half of the Indian workforce and contributes nearly 16 per cent in the GDP of the country. The Government of India has set an ambitious target of doubling farmers' income by the year 2022, with huge investments in

improving infra-structure, warehouses, seed production and cold storage facilities. Provision of quality seeds and nutrients based on soil health of each field is one of the seven-point strategy which has been advocated to achieve this (DAC&FW, 2018) [2]. Moreover, there is a need to increase the productivity per unit area and decrease the cost of cultivation of various crops. It is pertinent to note, that while agricultural production will diversify further, cereals will continue to be important due to the National Food Security bill (Kadiyala *et al.*, 2012) [6].

However, in spite of the above measures and pursuing a wide range of grassroot level initiatives spread over the last six decades, the goal of ensuring food availability to millions of poor people across the country at affordable prices has remained more or less elusive. The limited access of affordable food for a large majority of people has put India in the league of countries with worst levels of malnutrition. Evidently, India ranks 63 among 120 countries covered in the Global Hunger Index 2013, with the food security status designated as 'alarming' (IFPRI/Welthungerhilfe/Concern Worldwide, 2013) [4]. The National Family Health Survey (NFHS) III (2005-06) that reports the key facts related to health and nutritional status of the sample households in the country, estimated that nearly 40.4 per cent of children under three are underweight and 44.9 per cent are stunted; 36 per cent of adult women and 34 per cent adult men suffer from chronic energy deficiency; 79 per cent of children and 56 per cent of women are anaemic and so on (IIPS and Macro International, 2007) [5].

The situation is more alarming in many backward states of India particularly concentrated in the eastern region like Bihar, Odisha, Jharkhand, Chhattisgarh, West Bengal, etc. The data from NFHS III reveals that nearly 50 per cent of children under 5 years of age are underweight and 20-35 per cent are stunted in the above states. Similarly, around 35 per cent or more of adult men and women of 15-49 years of age are found to be 'thin' in these states. Gulati *et al*, 2012 [3] classified the various Indian states based on two indices of malnutrition namely, Normalized Adult Malnutrition Index (NAMI) and Normalized Child Malnutrition Index (NCMI) and observed that all the eastern states fell in the top two categories of malnutrition, with Bihar faring the worst among them. A similar study conducted by MS Swaminathan Research Foundation (MSSRF, 2008) [7] classified various Indian states based on a composite index of food insecurity based on seven indicators and reported that the eastern states such as Chhattisgarh and Jharkhand fell under the category of 'very high' food insecurity, while Bihar and Odisha were classified under 'high' food insecurity.

The Eastern part of India has been identified by policy makers as the potential area for ensuring a Second Green revolution. Bihar is a state where nearly 75% of people depend on agriculture for their livelihood and rice, wheat, maize, sugarcane, cauliflower, jute etc., are major crops but productivity is low. The main reasons for low productivity and slow growth in agricultural development in Bihar are inadequate land tenure system, lack of consolidation, paucity of quality seeds and other agricultural inputs, low seed replacement rate, less use of fertilizers and poor access to extension services. Frequent droughts, floods and water logging and lack of diversification also contribute to low productivity. In order to meet these challenges, there is a need to increase the seed replacement rate by providing quality seeds of high yielding varieties of different crops followed with technological back stopping for enhancing yields.

During 2017-18 seed replacement rate in case of rice, wheat, pulses and oilseeds was 42, 31, 18 and 58% respectively in Bihar (Agriculture Road Map, 2017-22). The East Champaran district is thickly populated district and ranks 2nd in terms of population (50,99,371) and 3rd in terms of area (3,968 sq.km.) in the state. The district has 3.9 lakh hectare area under agriculture, out of which 55% area is rainfed. Rice, wheat, maize, lentil, sugarcane and jute are the major crops of the district. East Champaran is the highest wheat producing district of Bihar with an area of 1.18 m ha, with a production of 2,89,72 metric tonnes (DES, Bihar). Rice-wheat is a major cropping system while high variability in yield of food grains like maize, vegetables, fruits and fisheries has been reported. Sugarcane, potato and maize are other cash crops produced in the district. With this background, this study was undertaken in East Champaran to study the socio-economic status of farmers and the impact of high yielding quality seed on food production and nutritional security.

Material and Methods

This study was undertaken in East Champaran district of Bihar (Fig. 1), where three blocks namely - Motihari, Kotwa and Chakia representing diverse toposequences were selected purposively to assess the impact of quality seed as an input coupled with recommended package of practices and technical support. A structured schedule was developed and data was collected from randomly selected 322 farmers from four villages of selected blocks namely - Jasaulipatti (Kotwa), Chandrahiya (Motihari), Chintamanpur (Chakia) and Khairimal Jamunia (Chakia) to determine their socio-economic status, existing cropping practices and productivity of major crops. In order to increase the current productivity levels, demonstration trials for major crops of the district were laid out in the fields of 1172 beneficiary farmers in selected villages by providing them improved quality seeds of wheat, lentil, chickpea, *moong*, potato tubers and sugarcane setts. Technical support on improved package of practices was also provided on a regular basis covering improved agronomic practices, disease and insect-pests control, and weed management. These trials were monitored and yield data of these experimental plots were recorded by carrying out crop cutting surveys. Data on yields of selected crops was also collected from non-beneficiary farmers, so that a comparison could be made. Descriptive statistics like frequency and percentage were applied for analysis of data and drawing inferences. Duncan's Multiple Range Test (DMRT) was also applied to study the difference in mean yield of various crops among the selected villages.

Initial estimation of the nutrient status of soils in the selected villages had indicated that the soils are generally sandy loam in texture. The pH of soils in all locations is more than 8.2, hence the soils can be classified as alkali soils. Nearly all soil samples analyzed indicated that they are all in critical range in relation to available P, hence can be categorized as deficient soils. Except for soils samples analyzed for Chandrahiya, soil of all other villages are low in available K. In Chintamanpur Zn deficiency was also noticed (Table 2).

Results and Discussion

Socio-economic profile of respondents

Analysis of the socio-economic profile of farmers from the four villages revealed that a majority of farmers (53.42%) belonged to the middle age group *i.e.*, 35-50 years with moderate experience of farming. About 36.65% of farmers had passed High School, only 11% were graduates and nearly

one fifth were illiterate.. The average family size consisted of 4-5 family members. Pooled data of the selected villages revealed that a major population consists of other backward castes (57.7%) followed by general category (24.2%), scheduled caste (13.66%) and scheduled tribe (4.35%). Poverty level is an accepted indicator of the economic status of an individual and analyzed data indicated that a majority (61.2%) of farmers were holding BPL cards which indicated their poor income levels.

Land holding is an accepted indicator of the socio-economic status. It was observed that nearly 63.3% of sampled farmers belonged to the marginal category, having less than 1 ha land holding while 16.8% were small farmers (1-2 ha land). Only 3.73% of farmers had more than 4 ha of land. Thus, nearly 80% of farmers were marginal and small farmers and this can be attributed to be one of the reasons for low investment capacity and consequent low crop productivity.

Comparison of yield of different crops at district and state level

Increasing productivity of main crops grown by the farmers in the district was major concern of this study. As per secondary data of the state government, East Champaran had higher average yield as compared to the state average in case of pulses *i.e.*, lentil, moong and pigeon pea. However, the yield level of rice, wheat and maize were lower than the average yield of Bihar (Fig.2).

Effect of technical intervention on yield levels

Keeping this productivity gap in mind, it was decided to lay out demonstration of high yielding varieties of wheat, lentil, *moong*, chickpea, potato and sugarcane. For this purpose, a total quantity of 1541.2 quintals of seed was distributed among 1172 farmers of four adopted villages (Table 3). The seed distribution was complemented with technical support as well as use of fertilizers and plant protection chemicals in demonstration plots. A total of 117.8 ha area was covered with the given planting material with maximum area (41.8 ha) under wheat and minimum area (1.6 ha) under chickpea.

For estimating the impact of quality seed on yield level, data was collected from both beneficiary (experimental plots) as well as non-beneficiary farmers (control plots), which revealed that the average yield of wheat is 39.38 q/ha which is 24.27% higher than the non-beneficiary farmers who cultivated other varieties, did not carry out timely weeding, and also failed to provide timely irrigation and fertilizer application (Table 4). Sendhil *et. al.*, (2014) [9] reported that the major constraints and poor productivity of wheat in Bihar is late sowing, poor quality seed & fertilizers, occurrence of weeds and pests, deficiency of zinc and low plant population. Further they reported that average yield in Bihar from 2001-02 to 2010-11 was 19 q/ha while yields of improved varieties in the same period was 37.12 q/ha.

The mean productivity of lentil when taken together for beneficiary farmers of four villages yielded 13.34 q/ha, which was higher in comparison to the average yield of Bihar (10.68 q/ha) and at the same time it was 36.40% higher than the yields obtained by non-beneficiary farmers (9.78 q/ha) who cultivated traditional varieties of lentil. During *zaid* 2019, mean productivity of *moong* from fields of beneficiary farmers was 9.49 q/ha which was 19% higher than yields obtained by non-beneficiary farmers. Chickpea and potato showed highest level of increase in yield which was 142.5% and 109.3% higher respectively over non-beneficiary farmers. The minimum increase was observed in sugarcane, which can be attributed to the fact that sugarcane has been traditionally grown in the district and yield levels may have reached stagnated over a period of time, possibly due to increased nutrient deficiencies in soil and poor replacement. The mean productivity of sugarcane was 711.47 q/ha which was higher in comparison to average yield of Bihar (679 q/ha) but was only 4% higher than the yield achieved by non-beneficiary farmers. Yields obtained during 2018-19, clearly indicates that providing quality seeds with improved management practices and technical backstopping can significantly increase yields.

Village wise difference in mean yields

The mean yield of major crops in selected four villages were also compared among themselves to test for significant differences among the four sites, using Duncan's Multiple Range Test (DMRT). Yield data recorded after harvest of various crops showed significant variation in performance in different villages (Table 4). The productivity of wheat, chickpea, lentil, green gram, potato and sugarcane varied from 42.38 - 35.14 q/ha, 18.25-10.35 q/ha, 15.6-10.62 q/ha, 11.06-8.36 q/ha, 310.4-231.98 q/ha and 798.92-639.14 q/ha, respectively.

The maximum productivity of wheat was recorded in village Chintamanpur (42.38 q/ha) and lowest in village Jasaulipatti (35.14 q/ha) while the yield of other two villages were at par. The performance of chickpea was significantly superior in Khairimal Jamunia (18.25 q/ha) whereas in Chintamanpur yields of only 10.35 q/ha was recorded, while in the other two villages intermediate productivity (14.28-14.45 q/ha) was recorded. Highest yields of lentil was recorded from Khairimal Jamunia (15.60 q/ha) which was at par with Chintamanpur (15.04 q/ha), while lowest yields were recorded from Chandrahiya (10.62 q/ha). Maximum yield of potato (310.4 q/ha) and green gram (11.06 q/ha) was recorded from Jasaulipatti village whereas lowest productivity of potato (231.98 q/ha) and green gram (8.36 q/ha) was recorded in Chandrahiya. Sugarcane yield was highest in Chandrahiya (798.92 q/ha) while Jasaulipatti resulted in lowest productivity (639.14 q/ha), whereas Khairimal Jamunia (715.8 q/ha) and Chintamanpur (710.52 q/ha) were at par in terms of sugarcane productivity.

These differences can be attributed to site conditions, management practices adopted by farmers, investment capacity etc. Jasaulipatti is well endowed with sufficient water resources and has a canal running through the village with a problem of seepage leading to water logging in some pockets and easy availability of water either through borewells or canal. Further, farmers frequently irrigate their fields and accept technical guidance whenever provided, while in Chandrahiya water availability is a constraint and only a few farmers have irrigation facilities from bore wells. Further, they are not willing to provide irrigation to potato crops inspite of being advised to do so, leading to the lowest yields (Table 4). In case of sugarcane, the fields were regularly irrigated and FYM was applied in sufficient quantities leading to the high yields.

Chintamanpur and Khairimal Jamuniya are endowed with deep alluvial soils, with the latter being frequently affected by floods, since a large part is along a perennial river Dhanouti and nearly 60% of 2300 acres of cultivated land is affected by floods. Chick pea has been grown under sprinkler irrigation in Khirimal Jamunia while potato was irrigated twice.

Results of this study therefore clearly indicate that properly planned and executed technology extension and input supply

along with continued technical support can significantly increase crop yields and contribute to both nutritional security and increased income of small and marginal farmers. Constraints of the availability of quality seeds, other inputs and irrigation at critical periods are of crucial importance to achieve the goal of food security in the disadvantaged districts of Bihar.

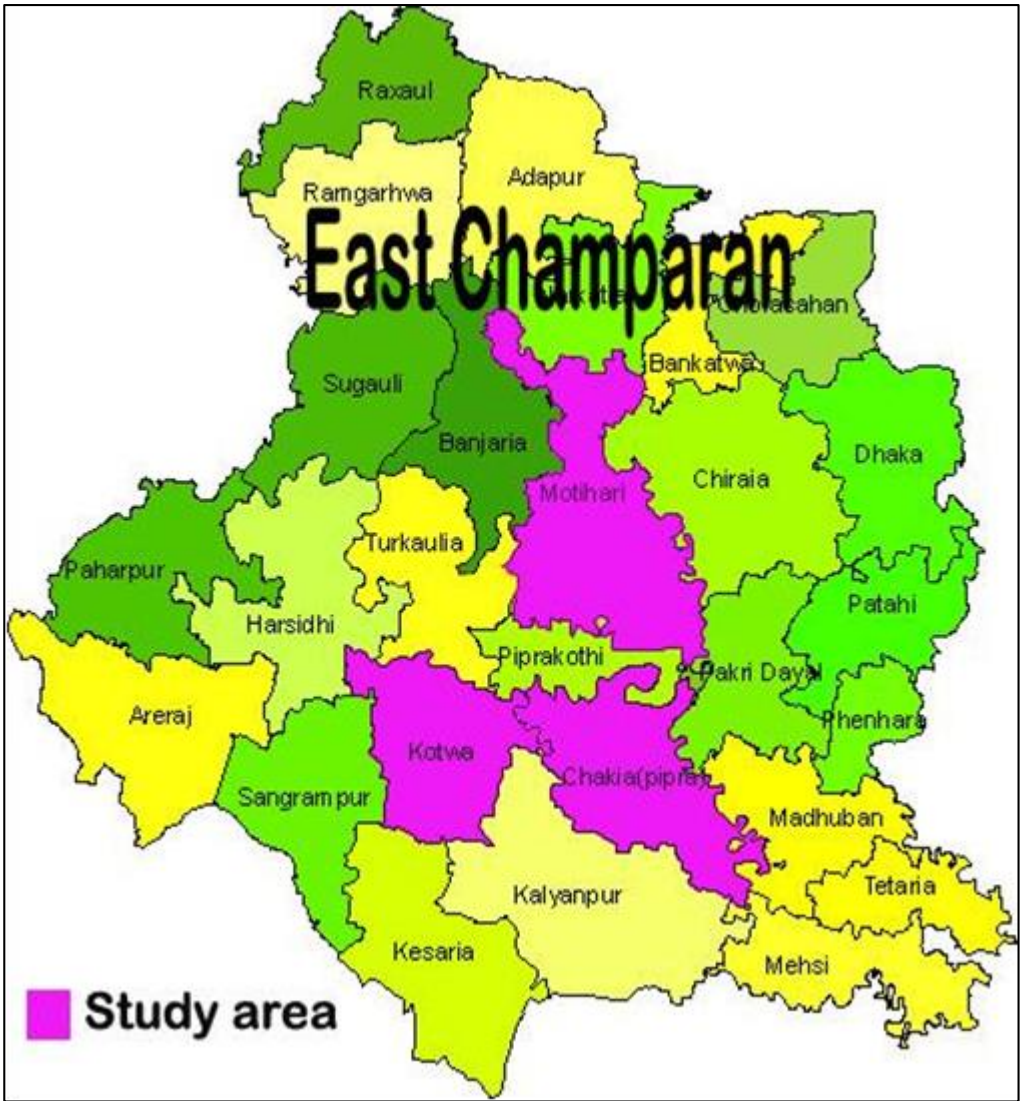

Fig 1: Map showing blocks of East Champaran and study area

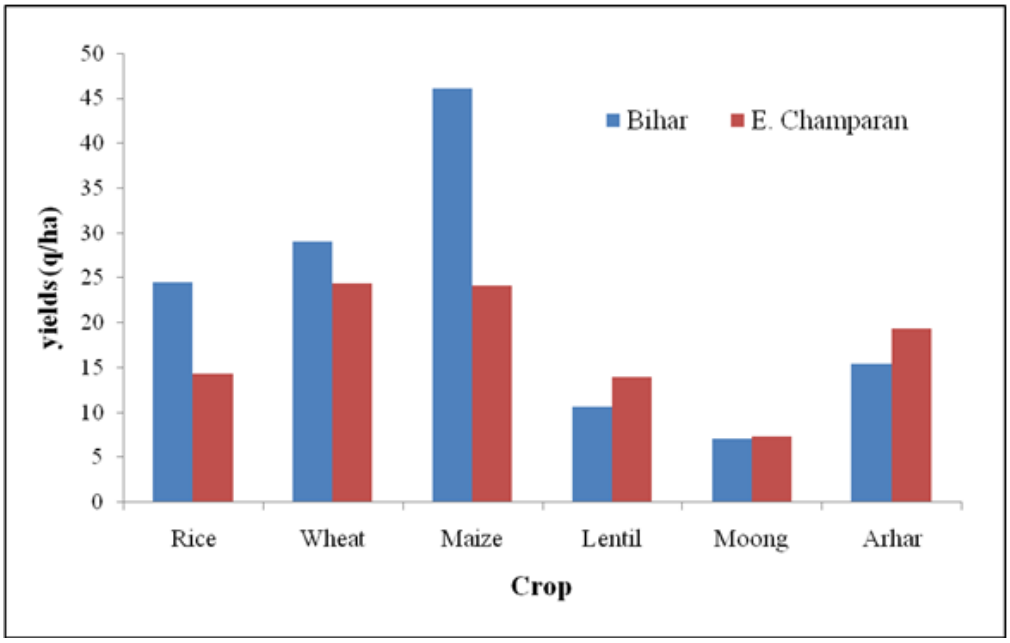

Fig 2: Comparative yield of major crops of East Champaran and Bihar

Table 1: Socio-economic profile of households in four selected villages

Socio-economic variables	Categories	Frequency	Percentage
Age	Young (< 35 Years)	67	20.81
	Middle (35-50 Years)	172	53.42
	Old (> 50 Years)	83	25.78
Education level	Illiterate	64	19.88
	Primary	74	22.98
	Middle	66	20.50
	High School	82	25.47
	Graduation and above	36	11.18
Caste	General	78	24.22
	OBC	186	57.76
	SC	44	13.66
	ST	14	4.35
Poverty level	BPL	197	61.18
	APL	125	38.82
Family size	Up to 3 members	39	12.11
	4 to 5 members	148	45.96
	> 5 members	135	41.93
Land holding	< 2.5 acre (Marginal)	204	63.35
	2.5 – 5 acre (Small)	54	16.77
	5 – 10 acre (Medium)	52	16.15
	> 10 acre (Large)	12	3.73

Table 2: Soil properties in three depths (cm) at the four locations

Parameters	Chintamanpur			Chandrahiya			Jasaulipatti			Khairimal Jamunia		
	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
Sand (%)	53.12	55.12	59.12	43.12	49.12	49.12	55.12	55.12	59.12	51.12	53.12	58.12
Silt (%)	32.72	30.72	27.72	38.72	34.72	36.72	31.72	30.72	26.72	33.72	32.72	28.72
Clay (%)	14.16	14.16	13.16	18.16	16.16	14.16	13.16	14.16	14.16	15.16	14.16	13.16
OC (%)	0.41±0.14	0.22±0.11	0.25±0.11	0.41±0.14	0.22±0.11	0.25±0.11	0.81±0.24	0.63±0.23	0.48±0.17	0.58±0.12	0.43±0.15	0.32±0.15
Olsen P (kg ha^{-1})	10.99±3.2	7.20±1.96	5.08±1.44	9.12±2.70	6.40±1.55	6.21±2.42	13.52±2.1	11.95±2.3	9.65±1.69	10.57±4.3	7.17±2.92	5.70±1.83
Available K (kg ha^{-1})	96.8±28.9	89.9±22.1	75.1±17.9	147±75	128±57	116±68	81.6±24.6	60.4±30.6	43.8±29.3	84.7±25.4	74.7±20.7	69.5±24.1
DTPA-Zn (mg kg^{-1})	0.56±0.28	0.42±0.19	0.42±0.11	1.10±0.48	0.91±0.32	0.80±0.27	0.92±0.32	0.88±0.32	0.75±0.33	0.99±0.67	0.91±0.38	0.81±0.36

Table 3: Quantity of seed of different crops supplied to farmers and area covered at beneficiary farmer's field (2018-19).

Sl. No.	Crop	Quantity of Seed (q)	Area covered (ha)	No. of beneficiaries
1.	Wheat	50	41.8	250
2.	Lentil	10	25.0	251
3.	Moong	5	20.0	138
4.	Chickpea	1.2	1.6	18
5.	Potato	200	10.2	484
6.	Sugarcane	1275	19.2	31
	Total	1541.2	117.8	1172

Table 4: Increase in yield of major crops due to quality seed and by adopting improved management practices at farmer's field during 2018-19.

Sl. No.	Crop	Yield of experimental plots(q/ha)	Yield of control plots(q/ha)	Absolute increase (q/ha)	Percentage Increase (%)
1.	Wheat	39.38	31.69	7.69	24.27
2.	Lentil	13.34	9.78	3.56	36.40
3.	*Moong*	9.49	7.98	1.51	18.92
4.	Chickpea	14.33	5.91	8.42	142.47
5.	Potato	281.1	134.3	146.8	109.31
6.	Sugarcane	711.47	684.06	27.41	4.01

Table 5: Crop yield under beneficiary farmer's field during 2018-19

Village	Yield (q/ha)					
	Wheat	Chickpea	Lentil	Potato	Moong	Sugarcane
Jasaulipatti	35.14^{c}	14.45^{b}	12.10^{b}	310.4^{a}	11.06^{a}	639.14^{c}
Chandrahiya	39.47^{b}	14.28^{b}	10.62^{b}	231.98^{c}	8.36^{c}	798.92^{a}
Khairimal Jamunia	40.52^{b}	18.25^{a}	15.60^{a}	289.39^{b}	9.69^{b}	715.80^{b}

Chintamanpur	42.38[a]	10.35[c]	15.04[a]	276.42[b]	8.86[bc]	710.52[b]
CV	7.11	12.80	12.92	16.62	13.58	24.73

Mean values followed by the same letters within a column are not significantly different (P>0.01, DMRT)

Conclusion

Results indicate that properly planned and executed technology extension and input supply along with continued technical support can significantly increase crop yields and contribute to both nutritional security and increased income of small and marginal farmers. Constraints of the availability of quality seeds, other inputs and irrigation at critical periods are of crucial importance to achieve the goal of food security in the dis-advantaged districts of Bihar.

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