Yield Gap and its Determinants in Pulse Crops of Bihar-Facts from plot level data of Cost of Cultivation Scheme

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ABSTRACT

In order to assess the yield gap in major pulse crops and factors causing yield gap in Bihar, plot level data of Cost of Cultivation Scheme, Govt. of India were used for the year 2015-16.Simple regression model was applied to identify the factors. Results of the study pointed out that yield gap-II i.e. demonstration plot yield and farmer's field yield for all the crops considered for investigation were recorded 36.33% in red gram (Tur/ arhar), 24.38% in gram, 23.40% in lentil and 49.39 % in green gram in the state of Bihar. The major factors influencing the yield gap were identified as irrigation, quality of seeds, age and education of farmers in the state. The study revealed that breeder for the varietal development should be linked with the extension worker in order to know the ground reality of farmers so that the recommended potential yield could be harvested in the farmers' field. Effective and rapid dissemination of technologies and their knowledge to the farmer is urgent in order to achieve this objective and further the farmers be provided quality seeds and made aware of new technological and agronomic practices as included in the National Food Security Mission-Pulses (NFSM-Pulses) and strengthened by Accelerated Pulses Production Program (A3P) should be ensured in time with extension and institutional support.

Key words: Yield Gap, Pulse crops, Potential yield Demonstration yield, Average farm yield

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INTRODUCTION

Estimation of yield gap was first conceptualized by International Rice Research Institute (IRRI) during seventies. The yield gap consists of at least two components. The first is yield gap-I, the difference in potential yield and research station yield or demonstration yield. This component is not exploitable. The second component is the difference between demonstration yield and actual average farm yield i.e. yield gap-II (Alam 2006, Rimal and Kumar 2015). The yield gap-II is exploitable and can be minimized by adopting new technological practices of farming, using quality inputs like seeds and fertilizers and deploying better management practices and government interventions. In the present study the yield gap-II is taken as yield gap and factors of yield gap are discussed.

Ensuring food and nutritional security by providing balanced diet to everyone is major challenge faced at global level. Overcoming hunger and malnutrition mean increasing food quantity and quality, while making sure we produce food sustainably and efficiently. Pulses have been an integral part of human diet for centuries. Yet nutritional value is not generally recognized and their consumption is frequently under appreciated. In India, pulses have long been considered as poor man's only source of protein. Hence, they play a crucial role in providing healthy diet to the poor masses.

The rain-fed regions support more than 40% of human population and ⅔ rd of livestock of the country. More than 80% of total pulses are grown in this region. Pulses, historically vital constituent of cropping and consumption pattern are the only rich source protein (20-25%) for 43 percent vegetarians (Urban – 48%, rural – 41%). Besides, they double the protein content of wheat and three times that of rice, food legumes tend to fix 72 to 350 kg per ha per year atmospheric nitrogen to N compounds to soil.

With the twin objectives i.e. achieving food and nutritional security vis-à-vis enhancing income of the rain-fed farmers, the government decided to harness the potential of pulses. In 2015-16, many farmer centric strategies and programmes such

as Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), Pradhan Mantri Fasal BimaYojana (PMFBY), Paramparagat Krishi Vikas Yojana (PKVY), Soil Health Management (SHM) and Soil Health Card (SHC), National Agriculture Market Scheme (eNAM) etc. was initiated to achieve the targeted outcomes. From 2016-17, distribution of pulses seed mini-kits, incentives on production of quality seeds, creation of seed hubs, enhancing breeder seed production, cluster frontline demonstrations through 578 KVKs etc also initiated for enhancing the production and productivity of pulses in the country. Massive awareness campaign in conformity with International year of Pulses (IYOP – 2016) coupled with implementation of PSS at enhanced MSP; provision of PSF, imposing import duties (30%-gram/lentil, 50%, yellow pea, 10% Tur) etc have paid dividends to consumers and pulse growers both. As a result of enhanced per hectare productivity, the year 2017-18 witnessed a record pulse production of 25.23 million tonnes, a grand success story and revolution in pulses self-sufficiency

India has about 35% share in area and production of pulse crops and is largest producer and consumer of pulses in the world. Improvement in pulses production technologies can reduce the cost of production and hence prices and create scope for further increase in demand for pulse crops. The intervention under NFSM has realized positive impact and during 2017-18, area under pulses has increased to the tune of 19%, production 34% and yield 13%, resulting in per capita availability of pulses has also increased.

In Bihar, pulses are grown in both the season kharif and rabi. Area under rabi pulses during 2017-18 was 4.39 lakh ha with national share of 2.76% and production was 3.74 lakh tonnes and production share was estimated to be 2.36% during the same year. Area under kharif pulses was about 0.55 lakh ha with production of 0.63 lakh tonnes during 2017-18. State average yield of total pulses during 2017-18 was reported 9.54 q/ha. The average state yields of major pulses under study i.e. red gram, gram, lentil and green gram were reported to be 15.48q/ha, 11.54 q/ha, 10.68q/ha and 7.43 q/ha, respectively. The national average yield of total pulses was 8.41 q/ha and average yields of red gram, gram, lentil and green gram were reported to be 9.60 q/ha, 10.63 q/ha, lentil 10.34 q/ha and 4.72 q/ha during the same period. Yield of all the pulse crops under study reported comparatively high yield that of national average yield (Anonymous 2018). Although the pulses has shown increasing yields due to

government initiatives (NFSM-Pulses) in the state (Ahmad *et al*., 2018, Singh *et al.,* 2016 and Kumar *et. al.,* 2016), but the yield is not up to the satisfactory level. Therefore, it always matter for the researcher and policy makers that real potential of pulses are harvested at farmer's fields. Yield gap analysis and factors responsible for yield gaps in major pulses crops like red gram, gram, lentil and green gram etc. are very few. Technological changes and cultivation practices used to bring variation in yield between research plot yield and farmer's field yield will be important to draw attention of researcher and policy makers to resolve the causes of yield gaps. The present study is aimed to estimate the yield gaps of major pulses grown in the state and assessing the factors responsible for yield gaps.

MATERIALS AND METHODS

Data and its sources

The present study was mainly based on plot level data of Comprehensive Cost of Cultivation Scheme running in the state of Bihar for the year, 2015-16. Most of the required secondary data were obtained from official websites and different publications of government of Bihar and India.

Yield gap analysis

The nature and extent of the yield gaps in pulse crops in the states were analyzed using the following Gap-I and Gap-II equation in the percentage form.

Gap-I: It is the gap between potential yield (Y_P) of a variety and the yield in the demonstration field (Y_{df}) i.e.

$$\text{Yield Gap} - \text{I (YG} - \text{ I)} = \frac{Y_p - Y_{df}}{Y_p} \text{x } 100$$

Gap-II: Similarly, Yield gap-II is the difference between the yield of variety in the demonstration field (Y_{df}) and at farmers' field (Y_{ff}), i.e.

$$\text{Yield Gap} - \text{II (YG} - \text{II)} = \frac{Y_{df} - Y_{ff}}{Y_{df}} \text{x } 100$$

In this investigation an attempt has been made to assess the exploitable yield reservoir in case of major pulse crops like red gram, gram, lentil and green gram using frontline demonstration data. But, the availability of the official record regarding frontline demonstration data for individual pulse crops in different districts threw limitation for

the analysis. Thus, with the recent data available for red gram, gram, lentil and green gram from different KVKs were collected and yield gaps were computed.

The demonstration yield data of different varieties of the respective crops were collected from different KVKs of Bihar. The values used in this paper are the averages of all such data, which include different seasons, varieties and locations within a state (note: individual varieties and locations may have higher values than the ones used in the present analysis).

Simple linear regression model was used to estimate the factors affecting yield gaps in the major pulse crops like red gram, gram, lentil and green gram. The factors considered in the regression model were as follow:

Y = Yield gap (q/ha) (yield gap between demonstration yield and farmer's (field yield

X_1= Amount of capital used in production excluding labour and seed

X_2 = Seed rate (kg/ha)

X3 = Human labour (Man-days/ha)

X_4= Mechanization Index (%)

X_5 = Family size (number)

X_6 = ratio of area under crop to the gross cropped area

X_7= Age of the farmer (years)

X_8= If educated 1, otherwise 0

X_9 = If irrigated 1, otherwise 0

X_{10}= Variety (improved 1 otherwise 0)

RESULTS AND DISCUSSION

Summary statistics of major pulse crops like red gram, gram, lentil and green gram are presented in the Table 1. Table revealed that mean yield gap was assessed comparatively low in case of lentil (23.01%) and high in case of green gram (49.39%).Yield gap in red gram and gram recorded 36.33% and 24.38%, respectively. The high yield gap in case of green gram which is generally grown in summer season in Bihar may probably be due to various abiotic and biotic constraints associated with this crop.

Table 2 presents the various factors influencing yield gaps of major pulse crops like red gram, gram, lentil and green gram in Bihar. A perusal of this Table reveals that; modern variety seed emerged as negatively significant in case of yield gap in red gram, meaning thereby that one unit increase in quality seed may reduce

the yield gap by 11.98 percent. Coefficients of other variables like family size, ratio of red gram area to GCA, age of farmer, education and irrigation were found negative; indicating that cultivation in larger area may encourage the cultivators for adopting better crop management practices. Large family size may reduce the dependency on labour, young and educated farmers may play vital role in bridging the yield gaps and availability of irrigation facility may help in further narrowing the gap. Frontline demonstrations have successfully shown that with adoption of improved technologies, yield of pulse crops can be increased substantially (Gautam *et. al.,* 2007). Young and educated farmers can adopt superior agronomic practices and new cultivation technologies in a better manner compared to old and uneducated.

In case of gram regression coefficients of the variables like human labour, age and irrigation were negative and significant. The result pointed out that proper management of these variables may help in narrowing down the yield gap. In case of lentil crop the coefficients of different variables like irrigation and seed variety were assessed to be negatively significant, reflecting that good quality of seed and irrigation facility may be helpful in reducing the yield gap.

In Bihar, lentil is generally grown on marginal lands and under rain-fed condition. Inputs, however, play an important role in the productivity of crops and minimizing the yield gaps. Farmers need adequate amount of quality inputs at the right time to obtain high yields. Since resource-poor, marginal and small farmers constitute about 91% of the farm population in Bihar, they are generally unable to purchase required quantity of inputs to obtain good productivity. On the other hand capital used for cultivation and education of farmers were also found positive and significant but coefficient of capital has negligible impact on yield gap, on the other hand, coefficient of education depicted positive impact indicating that as the education increases interest in agricultural activities by them decreases and there a preference for non-farm works.

In case of green gram, the coefficient of education was assessed to be negative and significant showing that the cultivators were not aware to new cultivation practices. They needed training on new agricultural technologies and demonstration of new technologies on a regular basis along with regular contact of extension agencies with farmers, all this may help improve the productivity of the crop and bridge the gap in yield.

In most of states of the country and also in Bihar, yield gap in pulses between potential and demonstration yield and demonstration yield and farmer's yield are very high due to combination of factors such as poor management and economic conditions of the farmers and lack of resources especially knowledge about the new technologies of cultivation. The yield gap was recorded 36.33% in red gram, 24.38% in gram, 23.01% in lentil and 49.39 % in green gram in the state of Bihar. The major factors influencing the yield gap were identified as irrigation, quality of seeds, age and education of farmers in the state. The study revealed that breeder for the varietal development should work closely with the extension workers in order to know the ground reality of farmers so that the recommended potential yield could be harvested in the farmers' field. Effective and rapid disseminations of technologies and their knowledge to the farmers are important in order to achieve this objective and further, the farmers should be provided with quality seeds on time and made aware of new technological and agronomic practices as included in the National Food Security Mission-Pulses (NFSM-Pulses) and strengthened by Accelerated Pulses Production Program (A3P) to ensure timely extension and institutional support.

CONCLUSION

In almost all the states of nation in general and Bihar particular yield gap in pulses between potential and farmer's yield and demonstration yield and farmer's yield are very high due to combination of constraints such as poor management and economic conditions of the farmers and lack of resources especially knowledge about the new technologies of cultivation. The yield gap-II was recorded 36.33% in red gram, 24.38% in gram, 23.40% in lentil and 49.39 % in green gram in the state of Bihar. The major factors influencing the yield gap were identified as irrigation, quality of seeds, age and education of farmers in the state. The study revealed that breeder for the varietal development should be linked with the extension worker in order to know the ground reality of farmers so that the recommended potential yield could be harvested in the farmers' field. Effective and rapid dissemination of technologies and their knowledge to the farmer is urgent in order to achieve this objective and further the farmers be provided quality seeds and made aware of new technological and agronomic practices as included in the National Food Security Mission-Pulses (NFSM-Pulses) and strengthened by Accelerated Pulses Production Program (A3P) should be ensured in time with extension and institutional support.

Note: The article is an outcome of Ph.D. research work carried out by first author

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Table 1: Summary statistics of major pulses

Particulars	Red gram		Gram		Lentil		Green gram	
	Mean	**Std. Error**	**Mean**	**Std. Error**	**Mean**	**Std. Error**	**Mean**	**Std. Error**
Yield gap	36.33	2.48	24.38	1.64	23.01	1.76	49.39	3.71
Capital (Rs/ha)	5968.57	354.83	5186.09	203.45	5430.96	194.24	3733.38	180.57
Human labour (hr/ha)	59.25	2.68	44.60	2.16	39.97	1.81	39.39	1.58
Seed (kg/ha)	22.71	2.91	74.49	0.75	30.92	0.58	24.81	0.67
Family size (number)	8.24	0.82	6.85	0.33	6.79	0.36	5.94	0.78

Table 2: Determinants of yield gap in major pulse crops

Variables	Coefficients			
	Redgram	**Gram**	**Lentil**	**Green gram**
Intercept	55.074* (12.233)	59.931* (12.863)	35.749* (9.335)	102.673** (31.245)
Capital	0.001 (0.002)	0.001 (0.001)	0.002* (0.001)	-0.005 (0.007)
Human labour(hr/ha)	0.018 (0.228)	-0.111** (0.051)	-0.020 (0.064)	-0.557 (0.417)
Seed quantity (kg/ha)	0.139 (0.165)	-0.160 (0.138)	-0.065 (0.206)	-0.001 (1.549)
Family Size (number)	-0.179 (0.711)	0.414 (0.317)	-0.171 (0.355)	3.067** (1.082)
Ratio of pulses area to Gross cropped area	-10.041 (18.640)	0.673 (4.846)	-5.095 (4.000)	6.846 (37.508)
Age (years)	-0.170 (0.213)	-0.113*** (0.066)	-0.028 (0.093)	-0.163 (0.277)
Education	-5.829 (6.885)	3.752 (3.184)	6.345** (2.954)	-17.802** (5.904)
Irrigation	-5.047 (8.219)	-30.719* (2.907)	-24.062* (2.708)	-5.575 (8.596)
Variety	-11.980*** (6.610)	6.026* (2.149)	-12.959* (2.752)	-9.510 (5.105)
R^2	0.81	0.76	0.70	0.89

Figures in parentheses are standard errors

*, ** and *** indicates significant at 1%, 5% and 10% level of probability, respectively.