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Yield trends and yield gap analysis of crops in eastern Uttar Pradesh

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Abstract
The yield gap and the production constraints in the field crops of various agro climatic zones 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 in all the cereals, pulses and oilseed crops in the region. The technological and socio-economic constraints have accounted for such huge yield gap in the system. The gap in the yields indicates that there is big scope to increase the yield of crops in the region at farmers' fields by adopting the recommended package of practices. Therefore, to bridge the gaps, there is a need to give due emphasis on transfer of improved technologies and management practices through strengthening of extension network. The yield gap for crops were higher also indicates that there is a need to train and educate to the farmers about improved technologies Efforts should, therefore, be made to minimize the yield gaps and increase and sustain production and productivity of crops by properly addressing the constraints. Concerted efforts are needed to bridge the yield gap through translation of prioritized 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.

Keywords: Production constraints, agro-climatic zone, yield gap, socio-economic constraints

Introduction
Yield enhancement in crop production derives from genetic potential of varieties and good agronomic practices. The interaction between genetic potential of crop varieties and agronomic practices is widely acknowledged as a major driven force for yield maximization. For instance, dwarfing genes in cereals and biotic/abiotic stress tolerance in pulses and oilseeds lead to physiological improvement in grain/stem partitioning of dry matter with direct consequences for yield, but also allowed various physiological changes in crops like higher rates of fertilisers with reduced risk of lodging in comparison with older and taller cultivars in cereals, synchronous maturity in pulses and vegetative growth in vegetables, sugarcane and fodders. The development and adoption of productivity enhancing technology can be influenced by various socio-economic factors (Sumberg, 2012).
The challenges of global agriculture have been analyzed exhaustively and the need has been established for sustainable improvement in agricultural production aimed at food security in a context of increasing pressure on natural resources (Cassman 2012; Connor and Mínguez 2012). Of a total global land area, arable land and permanent crops account for by 12%, permanent meadows and pastures for 26%, forests for 30% whereas 32% of the land is unsuitable for agriculture (FAO, 2011). It has been analyzed that the chances of converting

these unsuitable land into cultivable land for cropping and alternative land uses till 2050 is likely to be very less. Globally, 15% of arable land is irrigated and currently accounts for 42% of all crop production; 7100 km^3 of water are consumed annually to produce food globally whereas feeding the world population of around 9 billion by 2050 would require an additional 2100 $km^3$of water per year (Sumberg 2012; Rockstrom *et al*. 2012).

The production of food grains in India increased considerably since 1960s due to increase in arable area, large-scale cultivation of high yielding semi-dwarf varieties and increased applications of irrigation, fertilizers and pesticides. India became food secure in the last three decades, at gross level, because of increase in food production. The food security of India and other countries in South Asia is, however, now at risk due to increase in population. By 2050, India's population is expected to grow to 1.6 billion people from the current level of 1.1 billion. This implies a greater demand for food. The cereal requirement of India by 2020 will be between 257 and 296 million tonnes (Mt) depending on income growth (Kumar, 1998; Bhalla *et al.*, 1999). The demand for rice and wheat is expected to increase to 122 and 103 Mt, respectively, by 2020 assuming a medium income growth (Kumar, 1998). This will have to be produced from the same or even shrinking land resource. Thus, by 2020 the average yields of rice and wheat need to be increased by about 60%. Similar is the scenario for many other crops.

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. The annual rate of growth of cereal production and yield showed a peak during the early years of the green revolution but since 1980s there has been a decline in it in several intensive farming districts of Punjab and Haryana (Sinha *et al.*, 1998). Adding to the worry of food planners is the stagnant grain yields in experimental farms. The potential yield of rice in the tropics has not increased above 10 t/ha since IR 8 was released 30 years ago, despite making significant achievements in attaining yield stability, increasing per day productivity and improving grain quality (Aggarwal *et al.*, 1996). In wheat, some studies have shown an increase in yield potential with time (Nagarajan, 1998; Rajaram, 1998). However, a review of data of the regional statistics, agronomists' experiments, long-term field trials, breeders' variety evaluation trials and simulation studies also showed stagnation of yields in rice and wheat in northern India (Aggarwal *et al*., 2000). 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.

Thus, there is a tremendous challenges face by the agricultural scientists to develop technologies for increasing the food production in the coming decades. There is an urgent need to increase the potential yield and bridging the yield gaps between research farm yields and farmers' actual farm yields of major food crops. It is very important to know how much additional food can be produced in different regions to meet the increasing demand. In view of such stagnations, we need to know whether the genetic yield ceiling has been reached for critical crops or there are some other factors involve that are not allowing yields to increase. Estimates of these potentials can assist in quantifying the carrying capacity of agro-ecosystems (Aggarwal *et al.*, 2008).

For population rich and low-income regions as the eastern Uttar Pradesh, it is also important to know that at what cost the crop production can be taken with current technology and/or what alternative technologies will be needed to meet the desired production targets. The objective of this paper is, therefore, to estimate the magnitude of yield maximization and yield gaps of major food crops prevails in this zone of UP considering the spatial and temporal variation in climatic features and available agricultural technology. The concept of yield gaps in crops originated from different constraint studies carried out by International Rice Research Institute (IRRI) during the seventies. The yield gap comprises at least two components. The first component – yield gap I is the difference between experiment/research station yield and the potential farm yield. This component is exploitable by the researchers and scientists. The second component of yield gap II is the difference between the potential farm yield and the actual average farm yield. In this context, the common and often large gap between actual and attainable yield is a critical target. The yield gap II is exploitable and can be minimized by deploying research and extension approaches and government interventions, especially institutional issues. The yield gap II in this paper has been discussed as the 'yield gap'.

In India, despite the technologies developed by different National Agricultural Research System (NARS) institutes and disseminated by extension agencies to the end users, yield gaps exist in different crops of India, such as rice, wheat, potato, oilseeds, pulses, sugarcane, vegetables, etc. that may range from 15.5% to about 60% with the national average gap of 52.3% in the irrigated ecosystem (Siddiq, 2000). The existence of yield gaps was also observed in rice (16.70 q/ha), wheat (0.70 q/ha) mustard (4.60 q/ha), and cotton (7.70 q/ha) in rainfed regions of India (Aggarwal *et al*., 2008). Similarly, yield gaps exist in different crops of Bangladesh, such as rice, wheat, potato, oilseeds, pulses, etc. that may range from 19% to about 64% of the potential yield (Alam, 2006; Roy, 1997; Matin *et al.*, 1996).

Yield gaps in crops are real and the challenge needs to be addressed in the interest of increased and sustainable crop production. The objective of this review article is to discuss the causes contributing to yield gaps in crops, suggest strategies to minimize the gaps to increase yield and finally make recommendations mainly to the government/policy makers to develop guidelines or action plans to address the problem.

Methodology

Study area and sources of data

Eastern Uttar Pradesh comprises twenty eight districts, which classified into three agro climatic zones, namely eastern plain zone, north-eastern plain zone, and vindhyan zone, and occupies one-third of the net sown area of Uttar Pradesh. The districts fall under eastern plain zone are Varanasi, Chandauli, Ghazipur, Jaunpur, Faizabad, Ambedkar Nagar, Sultanpur, Amethi, Barabanki, Azamgarh, Mau and Ballia; under north eastern plain zone are Gorakhpur, Maharajganj, Deoria, Kushi Nagar, Basti, Siddharth Nagar, Sant Kabir Nagar, Gonda, Balrampur, Bahraich and Shravasti; and Mirzapur, Sonbhadra & Sant Ravi Das Nagar comes under vindhyan zone.

Secondary data collected from publication of Department of Agriculture, Government of Uttar Pradesh, annual progress reports of KVKs published at ANDUA&T, Ayodhya and used for gap analysis on the basis of agro climatic zones of eastern Uttar Pradesh. 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. The information regarding the farmers yield, demonstration yield and yield potential of various crops are taken from the annual progress reports of KVKs and the crop research stations of Acharya Narendra Dev University of Agriculture and Technology. The primary data are collected; compiled, processed and secondary data are generated on the zone basis level for different crops.

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 refer 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= [(YR - YD)/YR] × 100
Yield Gap II= [(YD-YF)/YD] × 100

Where, YR is the research station yield,
YD is the demonstration plot yield, and
YF is the actual farm yield.

Constraints involved in crop production

The severity of technological gap was assessed through estimation of various crop yield losses. The proportion of area affected, average yield loss and frequency of occurrence are indicators of severity of a constraint, information on these aspects was collected from the farmers and KVKs scientists based on their experience and perceptions. The production losses were calculated on the basis of yield loss per hectare due to a particular constraint in the region. All technological constraints and the socio-economic constraints were discussed and strategies for minimizing the yield gaps are also discussed and well documented.

Results and Discussion

Scenario of eastern Uttar Pradesh

The eastern Uttar Pradesh having 28 districts, located between 24^0 to 27.34^0 N latitudes and 81.13^0 to 84.11^0 E longitudes, has been divided into three agro-climatic zones namely, north eastern plain zone (NEPZ), eastern plain zone (EPZ) and vindhyan zone (VZ). Majority of the soils are under the order of inceptisol followed by alfisol, entisol, vertisol and mollisol. Although, the average annual rainfall in eastern U.P. is around 1100 mm, it is quite erratic and confined to July-September (85-90%). The water table varies from 1 to 14.5 m during pre-monsoon and 0.5 to 7.5 m during post monsoon.

The population of eastern U.P. is about 35% of the total population of the state. Nearly 85% populations live in rural areas. The zone wise rural population is 84%, 87% and 82% in EPZ, NEPZ and VZ, respectively. The people directly engaged in agriculture are about 54% in eastern U.P. The most of the families are illiterate (40%) because of their poor economic condition and very poor infrastructure for education. The size of land holding is also very small. Nearly 82% of the farmers possess holding size less than 1 ha (0.39ha) and 12% farmers hold in between 1-2 ha (1.41 ha) land. Irrigation status of agricultural land in eastern U.P. indicates that about 40% of net sown area is wholly rain dependent and remaining (60%) is irrigated out of which only 18% of area is fully irrigated. The major area of the region is occupied by rice-wheat cropping system having the cropping intensity of 150%. The eastern U.P. contributes about 30% of total food grain production of the state. The NPK fertilizer consumption data showed that the use of fertilizers is inadequate (130 kg NPK/ha) and imbalanced (6.8: 2.8: 1.0).

Scenario of crops grown in eastern Uttar Pradesh

The main cereal crops grown under eastern Uttar Pradesh are paddy, maize, jowar, bajra, wheat and barley; among pulses pigeon pea, chick pea, lentil, field pea, urdbean and mungbean; and among oilseeds rapeseed &mustard, sesame and linseed are grown in a considerable area. Rice and wheat are the major food grain crops of eastern Uttar Pradesh. The eastern Uttar Pradesh shares about 52% acreage and 51% production of rice, 34% acreage and 32% production of wheat to the state. This is also evident from the Fig. 1 rice and wheat is the two main crops in the region which contributes 87% and 81% of the total food grain acreage in *kharif* and *rabi* season, respectively. Rice (*Oryza sativa* L.) - wheat (*Triticum aestivum* L.) is the most important crop sequence in India, occupying 60-70% of the total cultivated area in eastern Uttar Pradesh.

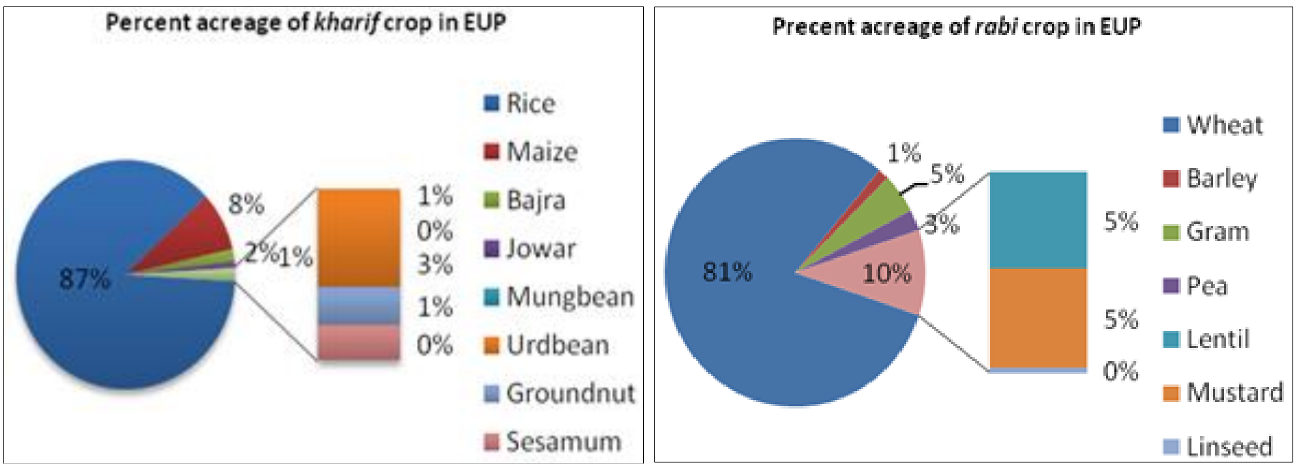

Fig 1: Acreage wise contribution of field crops in eastern Uttar Pradesh

Crop yield gaps in eastern Uttar Pradesh

As seen from Table 1, the yield of rice under farmers' practice were 21.45, 21.99 and 19.32 q/ha, while the potential yields with better management were 43.25, 45.02 and 32.22 q/ha at north eastern plain zone (NEPZ), eastern plain zone (EPZ) and vindhyan zone (VZ), respectively. The yield gaps were thus 21.80, 23.03 and 12.90 q/ha which were 50.40, 51.16 and 40.04% in terms of percentage of the potential yield at NEPZ, EPZ and VZ, respectively. Singh (2011) also reported yield gap II was 1.45 t/ha (42%) in the case of rainfed rice, while it was 2.03 t/ha (45%) in case of irrigated rice under Faizabad district of eastern Uttar Pradesh. Similarly other *kharif* crops grown under different plain zones of eastern Uttar Pradesh have varied yield gaps ranging from 4.13 to 17.00 q/ha in cereals; 2.70 to 7.91 q/ha in pulses; and 3.19 to 6.65 q/ha in oilseeds. Higher yield gaps in all the *kharif* growing crops in all zones of eastern UP suggest much scope for yield enhancement in these crops in the region.

Table 1: Yield gaps in *kharif* crops at different agro climatic zone in eastern Uttar Pradesh

Crop	Agro climatic zone	Yield (q/ha)			Yield gap (%)
		Average actual farm yield	Average demo yield	Yield gap or Extension gap	
Cereals					
Rice	NEPZ	21.45	43.25	21.80	50.40
	EPZ	21.99	45.02	23.03	51.16
	VZ	19.32	32.22	12.90	40.04
Maize	NEPZ	11.13	28.13	17.00	60.43
	EPZ	13.07	29.42	16.35	55.57
	VZ	08.81	18.94	10.13	53.48
Bajra	NEPZ	17.62	21.75	04.13	18.99
	EPZ	11.23	19.89	08.66	43.54
	VZ	12.52	15.28	02.76	18.06
Jowar	NEPZ	07.30	18.20	10.90	59.89
	EPZ	10.60	19.75	09.15	46.33
	VZ	08.27	13.20	04.93	37.35
Pulses					
Pigeon pea	NEPZ	07.09	15.00	07.91	52.73
	EPZ	09.47	15.45	05.98	38.71
	VZ	07.11	14.25	07.14	50.11
Urdbean	NEPZ	06.75	10.80	04.05	37.50
	EPZ	06.35	10.50	04.15	39.52
	VZ	05.80	08.50	02.70	31.76
Oilseed					
Groundnut	NEPZ	10.67	15.80	05.13	32.47
	EPZ	08.20	14.85	06.65	44.78
	VZ	17.31	20.50	03.19	15.56
Sesame	NEPZ	01.97	05.50	03.53	64.18
	EPZ	01.94	05.50	03.56	64.73
	VZ	01.81	05.00	03.19	63.80

Note: - NEPZ – North Eastern Plain Zone, EPZ – Eastern Plain Zone, VZ – Vindhyan Zone

Wheat and barley are the main cereal crops in *rabi* season, among pulses chickpea, field pea and lentil and in oilseeds mustard/rai and linseed are commonly grown in all the agro climatic regions of eastern Uttar Pradesh. Similar trends were observed in terms of yield gaps in *rabi* crops as found during *kharif* season. It was observed from the Table 2 that the better managed plot of wheat gave higher yield of 42.00, 41.36 and 30.45 q/ha, whereas the average farmers' plot yields were 29.34, 28.81 and 22.76 q/ha indicating yield gaps of 30.14, 30.34 and 25.25% at NEPZ, EPZ and VZ, respectively. Similar trends were also observed by Singh (2011) in wheat at Faizabad district of eastern UP and found yield gap of 38%, and Joshi *et al.* (2014) found yield gap of 15.42% in wheat at Amreli district of Gujrat. As far as *rabi* pulses is concerned, yield gaps range of 18.85 to 57.19% were observed particularly in rainfed condition of vindhyan zone. In oilseeds also yield gaps ranges from 30.64% in mustard crop at EPZ to 67.14% in linseed crop of same zone of the region. These findings indicate that there is large scope for the expansion in productivity of food crops growing in the region. Similar findings were also observed by various workers in different parts of country (Haque, 2010; Singh, 2011 in rice; Joshi *et al*., 2014 in wheat; Jeengar *et al*., 2006 in maize; Kumar *et al*., 2010 in bajra; Tiwari *et al*., 2003; Tomar, 2010; Poonia and Pithia, 2011 in chickpea; Singh *et. al*., 2014 in field pea; Raj *et al*., 2013 in pulses; Samui *et al.*, 2000 in groundnut; Mishra *et al.*, 2009 in potato; Hiremath and Nagaraju, 2010; Singh, 2000; Singh *et al.*, 2011 in various solanaceous vegetable crops).

Table 2: Yield gaps in *Rabi* crops at different agro climatic zone in eastern Uttar Pradesh

Crop	Agro climatic zone	Yield (q/ha)			Yield gap (%)
		Average actual farm yield	Average demo yield	Yield gap or Extension gap	
Cereals					
Wheat	NEPZ	29.34	42.00	12.66	30.14
	EPZ	28.81	41.36	12.55	30.34
	VZ	22.76	30.45	07.69	25.25
Barley	NEPZ	25.98	40.28	14.30	35.50

	EPZ	22.32	38.50	16.18	42.03
	VZ	10.36	28.75	18.39	63.97
Pulses					
Chick pea	NEPZ	09.11	14.50	05.39	37.17
	EPZ	10.82	15.68	04.86	30.99
	VZ	10.55	13.00	02.45	18.85
Field pea	NEPZ	11.65	16.28	04.63	28.44
	EPZ	13.71	18.15	04.44	24.46
	VZ	12.21	15.85	03.64	22.97
Lentil	NEPZ	07.66	15.20	07.54	49.61
	EPZ	08.98	15.90	06.92	43.52
	VZ	05.48	12.80	07.32	57.19
Oilseed					
Mustard	NEPZ	09.26	15.20	05.94	39.08
	EPZ	11.41	16.45	05.04	30.64
	VZ	05.67	11.65	05.98	51.33
Linseed	NEPZ	04.58	10.20	05.62	55.10
	EPZ	03.45	10.50	07.05	67.14
	VZ	03.79	07.25	03.46	47.72

Note: NEPZ – North Eastern Plain Zone, EPZ – Eastern Plain Zone, VZ – Vindhyan Zone

Yield gaps in crops were also observed in other countries, especially those of Asia region. Table 3 illustrates the rice yield gaps in Bangladesh, Nepal, Thailand, etc. Yield gaps in other Asian countries varied from 17 to 50 %, while it was only 3.38% in China, (Tran, 2000). China reached almost full potential in yield as exhibits in demo plots. This shows that yield gaps concern is a global phenomenon and much attention should be given to it for galloping the yield gaps.

Table 3: Yield levels and yield gaps in rice of neighbouring Asian countries

Country	National average yield (t/ha)	Irrigated/better managed yield (t/ha)	Yield gap (t/ha)	Yield gap (%)
Bangladesh	2.00	3.60	1.60	44.44
Nepal	2.50	4.20	1.70	40.47
Thailand	2.00	4.00	2.00	50.00
Vietnam	2.10	4.30	1.20	27.90
Indonesia	4.40	5.30	0.90	17.00
Philippines	2.80	3.40	0.60	17.65
China	5.70	5.90	0.20	03.38

***Source*:** Mondal, 2011

The higher yield gaps indicate that there is a gapexisted between the yield of demonstration and farmers' plots. It was observed that the complete recommended package of practices was not maintained under conventional crop production system. Thus, the farmers were failed to adopter commended package of practices under conventional system and lead to extension/yield gap. The gap in the yields indicates that there is big scope to increase the yield of crops in the regionat farmers' fields by adopting the recommended package of practices. Therefore, to bridge the gaps, there is a need to give due emphasison transfer of improved technologies and management practices through strengthening of extension network. The yield gap for crops were higher also indicates that there is a need to train and educate to the farmers about improved technologies. More and more use of latest production technologies during further years with high yielding varieties will subsequently change this alarming trend of galloping yield gaps. The new technologies will eventually lead to the farmers to discontinue the old existing practices and to adopt new technology.

Factors causing yield gaps in crops

The following major constraints of crop production which causes yield gaps in eastern Uttar Pradesh have been noticed:

Small and fragmented holdings: The adoption of well proven technology is constrained due to small size of holdings and poor farm resources. The small and marginal farmers (94% farmers having less than 1.5 ha land) do not dare to invest in the costly inputs due to high risk. The purchase capacity of these farmers is also very low.

Fertility management: Fertility management is main concern over the period of time. Previously application of FYM is common in most of the crops, but the quality and quantity both are poor and its method of application is defective. Now, in recent years farmers do no rear cattle due to various reasons, causes serious impact on soil fertility. Very less organic manures are incorporated in the soil in recent years. Burning of crop residues of rice and wheat added further concern over it. Other factors responsible for limited and imbalance use of fertilizers are non-availability of fertilizers in time, and poor purchasing power of the farmers.

Weed management: The non-availability of labourers has accentuated the serious weeds problem in the area. *Kharif* weeding is generally practiced when delay from critical growth stages, only when weeds become taller and the damage is visible. Generally, no weeding is practiced in *rabi* due to scarcity of labourers. Continuous cropping of same crops *viz.* rice-wheat and sugarcane-sugarcane-wheat system also promotes the problem of weeds particularly *Phalaris minor* and other associated weeds, and maize-wheat system promotes problem of wild oats.

Water management: Inspite of the fact that most of the rivers run through the eastern U.P., 40% of net sown area is rainfed. Only 18% area is fully irrigated and remaining 42% area is partly irrigated. The lack of water at the proper time especially due to roaster in canals and non-availability of power (electricity & diesel) constrains the crop production in the area. Farmers prefer to wait for rain rather than invest money in tube well irrigation due to their poor economic conditions.

Crop rotation: In general, cereal-cereal crop rotations, mostly rice-wheat, are being continuous practice in more than 75% the area. There is ample scope of introducing short duration crops like pulses, rapeseed, fodder etc, to diversify as well as to intensify the existing system for sustaining soil health and crop productivity.

Management of problematic soils: The eastern U.P. has a sizeable area of problem soils such as *bhat* (calcareous) soil and submergence (1-3 weeks) in north eastern plain zone; *diara* and waterlogged and sodic soils in eastern plain zone; and *karail* (black) soils and red lateritic soils in vindhyan zone. These soils need reclamation/specific management.

Lack of marketing facilities: Due to lack of proper marketing/industrial network, cultivation of certain commercial crops like safflower, sunflower, soybean, malt barley and a large number of aromatic/medicinal plants which are suitable for diversification for the area has lagged behind.

Lack of mechanization: Due to small and fragmented land holdings and poor socio-economic status of the farmers, there is very limited use of improved farm machinery which adversely affects the productivity of the crops.

Strategies for minimizing yield gaps

Promotion of good agronomic practice (GAP)

Yield gaps caused by biological, socio-economic, and institutional constraint scan be effectively addressed through good agronomic practices (GAP). Transfer of the technology through extension scientists/workers could effectively help farmers minimize yield gaps. Timely planting, irrigation, weeding, plant protection, and timely harvesting could account for more than 20% yield increase (Siddiq, 2000). However, input/output prices and employment opportunity influence farmers' decision on the level of inputs to be applied.

Research and extension support

The support of research and extension is necessary for narrowing yield gap. There searcher should understand farmers' constraints to high productivity and accordingly develop integrated technological package (appropriate variety, timely planting, fertilizer, irrigation, and pest management) for farmers for specific locations to bridge up the gaps. The extension service should at the same time ensure that the farmers apply correctly and systematically the recommended technological packages in fields through effective training, demonstrations, field visits, monitoring, etc. The judicious application of inputs from seeding to maturity in terms of quantity and timing will significantly contribute to reducing yield gaps and thereby increasing productivity of crops.

Adequate and timely supply of input and credit

Inputs play an important role in the productivity of crops and minimizing yield gaps. Farmers need adequate amounts of quality inputs at the right time to obtain high yields. It is also important that the fertilizer inputs are integrated with organic manures for balanced use of nutrients. Resource-poor small but productive farmers representing more than 80% of farm population are usually unable to purchase required quantities of the inputs for application for better yield. Therefore, these farmers need to be supported by adequate and timely supply of credit to narrow yield gaps. But the current credit system remains far below the needs of small farmers. They have very limited access toinstitutional credit mainly because of collateral requirement. Therefore, appropriate measures must be taken to simplify lending procedures, revise eligibility criteria and strengthen monitoring and supervision mechanism of the credit system. The action may also be taken for the expansion of rural bank branches under public sector.

Policy support

As mentioned earlier, socio-economic and institutional/policy constraints can cause yield gap significantly. It is thus necessary that the government address the issues seriously and come forward with solutions to the problems to increase productivity by minimizing the yield gaps. Hanson *et al.* (1982) recommended that the government find solutions to socio-economic and political questions for narrowing the agronomic gap between farmers' fields and the research stations.

Conclusions

The study has shown that there is a huge potential to increase crop yields at farm level. In many countries of the world, yield gaps in crops between potential and farmers' yields are still substantially high due to the combination of constraints, such as poor management and socio economic conditions of farmers and lack of resources, especially credit and knowledge and commitment of the government. The main socio-economic constraint reported to lack of knowledge about improved technologies, which could be addressed by strengthening extension services. Efforts should, therefore, be made to minimize the yield gaps and increase and sustain production and productivity of crops by properly addressing the constraints. Concerted efforts are needed to bridge the yield gap through translation of prioritized 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. It is also essential to promote collaboration among research, extension, NGOs, and private sector to develop appropriate technologies with a view to narrowing yield gaps.

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