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Yield gap analysis and the determinants of yield gap in major crops in eastern region of Uttar Pradesh

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Abstract

This study aims to quantify the gap between current and potential yields of major crops namely wheat, rice and sugarcane in eastern region of Uttar Pradesh, and the constraints that contribute to this yield gap. In the study area, yield gaps exist in different crops ranging up to 53%. In Uttar Pradesh, yield gap varied from 20.01 to 53.85 %, 15.56 t0 30.10% and 5.8 to 28.89% with the average gap of 28.26 %, 20.93% and 17.5% for rice, wheat and sugarcane crops respectively in the irrigated region of Uttar Pradesh. The yield gaps are mainly caused by socio-economic, credit institutional/policy related factors, extension services and lack of improved technology. Different strategies, such as integrated crop management (1CM) practices, timely supply of inputs including credit to farmers, research and extension collaboration to transfer the new technologies have been discussed as strategies to minimize yield gaps. Suggestions have been made to make credit available to resource-poor small farmers to buy necessary inputs. Efforts should be made to update farmers' knowledge on the causes of yield gaps in crops and measures to narrow the gaps through training, demonstrations, field visits and monitoring by extension agencies to achieve high yield. The government should realize that yield gaps exist in different crops of Uttar Pradesh and therefore, explore the scope to increase production as well as productivity of crops by narrowing the yield gap and thereby ensure food security.

Keywords: Potential yields, actual yields, yield constraints, yield gap, crop food security.

Increasing agricultural productivity or yield is critical to economic growth and development. This can be achieved by using improved agricultural technologies and management systems. Yield refers to production per unit area. Yield gap is calculated by subtracting achieved average yield from the yield potential (Lobell, Cassman, and Field, 2009). Understanding yield gap is very crucial for it can assist in crop yield predictions since yield potential shows the probable future productivity to be achieved. Also, information on determinants of yield gap can be used in policy interventions for enhancing crop production.

In order to meet increasing demands of food due to increasing population and income, food production in India need to be increased. However, lately there has been a significant slow-down in the growth rate in the cultivated area, production and yield. 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 tons (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. Although, there is a pressure to increase production, lately, there has been a significant slow-down of the growth rate in the cultivated area, production and yield. 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 (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-1 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). The gradual increase in environmental degradation through intensive cropping systems is further compounding the problem. There is now a great concern about decline in soil fertility, change in water table depth, rising salinity, resistance of harmful organisms to many pesticides and degradation of quality of irrigation water in north-western India (Sinha *et al.* 1998). 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 if the genetic yield ceiling has been reached for critical crops or if there are some other factors that are not allowing yields to increase. Estimates of these potentials can assist in quantifying the carrying capacity of agro ecosystems. Rain-fed agriculture in India is practiced on 94 million hectares (M ha). These areas generally have bypassed from the benefits of green revolution and as a result, grain yields remain low. These areas are considered to have vast untapped potential for increasing production in future by upgrading rain-fed agriculture (Rockstrom *et al.* 2007). The main objective of this analysis is, therefore, to estimate the rain-fed potential yield gap and factors responsible for yield gap in rice, wheat and sugarcane crops in eastern region of Uttar Pradesh.

Methodology and Technical Framework

Study Area and Sample Size

The study was conducted in Deoria district of Eastern region of Uttar Pradesh Keeping in mind the objectives of the study, multi stage stratified random sampling technique was used. Firstly a list of all (16 developmental blocks) the developmental blocks of the district was prepared and two blocks namely *Gauri bazaar* and *Rudrapur* were selected randomly. In the second stage one village from each selected block i.e. Pananha village from Gauri bazaar and Dharauli from Rudrapur block were selected randomly. Then two adjoining villages of *Pananha* and Dharauli namley Surajpur, Khairabanwa and Gahila, Tarasara were selected respectively. Thus in this way cluster of three villages ware formed in each selected block. In third stage farmers were classified into different categories of marginal (less than 1 ha of land), small (1-2 ha) medium (2-4 ha) and large (more than 4 ha). Then 20 farmers from each category were selected on the basis of probability proportion to their size from both the clusters of villages, respectively. Thus the total 80 farmers were surveyed.

Data and its sources

The present study was mainly based on primary data. The required primary data were collected from selected farmers for the agricultural year 2009-10. Most of the required secondary data were obtained from district agriculture office and block development office etc. Some other important information was collected through district's official website and publications.

Yield gap analysis

Experimental potential yields

The available data from several breeders' trials was collected from the recently published reports of the All India Coordinated Improvement Projects of the respective crops. Only those locations and trials were considered that were totally rain-fed. The values used in this paper are the averages of all such data, which include different seasons, varieties and locations within a state (note that individual varieties and locations may have higher values than the ones used in the present analysis).

On-farm potential yields

The on-farms yields were obtained from the frontline demonstrations data, available for different crops over the recent years. These yields are also average across different locations, seasons and varieties within the state. However, such data was available only for a few years and sites.

Measured yields

The cultivated area, production and yield of different crops were obtained from the published data of the Ministry of Agriculture, Government of India. These yields were considered as the measured yields to calculate yield gaps. It may be noted that state averages are the means of irrigated and rainfed areas and hence rain-fed yields will be overestimated, especially in crops such as wheat where irrigated areas are large.

The yield gaps were calculated from all three expressions of potential yields as follows:

1. Simulated rain-fed potential yield gap = simulated mean rain-fed potential yield measured yield (state average).
2. Experimental yield gap = experimental potential yield (plant breeder's trials) – measured yield (state average).
3. On-farm yield gap = on-farm potential yields – measured yield (state average).

The average of these yield gaps was also calculated as the expression of overall yield gap index as follows:

$$\left[I_{(yg)} = \frac{P_{(fy)} - A_{(fy)}}{P_{(fy)}} \times 100 \right]$$

Where,

$I_{(yg)}$ = Index of yield gap

$P_{(fy)}$ = Potential farm yield (average) obtained by the researchers of the areas

$A_{(FY)}$ = Actual farm yield (average) obtained by the different categories of farmers

Determinants of yield gap

To identify the determinants of yield gaps, multivariate regression analysis was done. Some important variables were taken on the bases of perceptions.

Regression model

To choose the best fitted production function the value of R^2 (Coefficient of multiple determination) and hypothesis of the study were taken into consideration. The following regression equation was estimated,

$Y = F(X_1, X_2, X_3, X_4, X_5, X_6)$

Where,

Y = Yield gap of i^{th} crop (qt/ha)

X_1 = Educational level of farmers

X_2 = Source of seed (purchased or on farm produced)

X_3 = Use of institutional credit (₹)

X_4 = Distance from KVK/ development block office (in km.)

X_5 = Meeting with ADO/Agricultural scientist (in number on Annual bases)

X_6 = Technology adoption index

1. Use of institutional credit

Amount of credit used by the farmers in rupees.

2. Technology adoption index

This variable was used in straight as in the regression analysis by taking the values of constructed technology adoption indices of all the farmers.

3. Source of seed

The variable was quantified as binary variable

Purchased seed = 1

Own farm produced seed = 0

4. Education level of farmers

This variable was also measured in numeric value.

5. Distance from KVK/development block

This variable was measured as distance in kilometer.

6. Meeting with ADO/Ag. Scientist

Number of meetings attended by the sample farmers with ADO/Agricultural scientist on annual basis was taken.

Results and Discussion

Potential yields and yield gaps

The yields of paddy, wheat and sugarcane obtained by the top ten farmers on the basis of productivity of the area were considered as potential and best yields for the area. This is treated as the farm level potential yields of paddy, wheat and sugarcane, which can be realized through proper input use and management, as was already being done by the selected top ten farmers of the area. And then average of yields obtained by the top ten best farmers was calculated to compare with the yield obtained by the other farmers for obtaining actual farm yield gap between the yields of best farmers and other farmers of all the categories. Thus the yield gap in present study was calculated crop wise for each category of farm size.

Table 1: Yield gaps in paddy across the farm size groups

Average Regional Yield of the Area (qt/ha)	55.00				
	Margi-nal	Small	Medium	Large	Overall
Average actual farm yield (qt/ha)	32.75	39.06	40.5	45.83	42.88
Yield gap in absolute term (qt/ha)	19.25	15.94	14.1	9.17	12.12
Yield gap in per cent	53.85	43.81	34.47	20.01	28.26

The yield gap for paddy is empirically presented in Table 1. The graphical presentation is given in figure the. The table depicts the% of yield gap on different categories of farms. The average actual farm yield (qt/ha) for marginal, small, medium and large farms were 32.75, 39.06, 40.5 and 42.88 respectively. The table indicates that the yield gap in absolute term was highest on marginal farms and lowest on large farms. The overall yield gap in% term was 28.82% for all the categories of farmers.

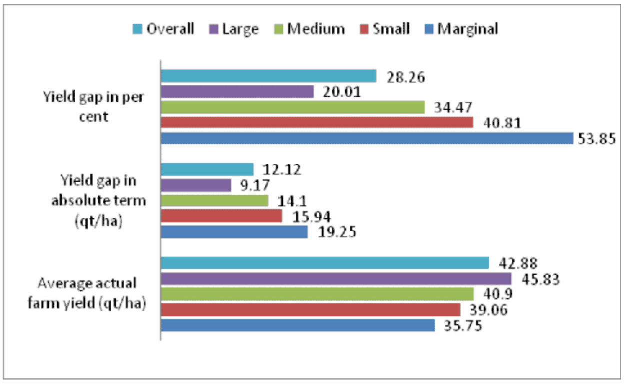

Fig 1. Yield gap in rice across the farm size groups

The same picture has been emerged from the figure, that marginal farmers had occupied first rank in yield gap while large farmers had placed on last rank, which means that the performance of marginal farmers were poor as compared to other categories of farmers. It can be concluded that the performance of farmers of all the categories were not up to the mark, so there is a scope to improve the yield of paddy crop in the district.

Yield gap in wheat crop

The pictorial presentation of yield gap in wheat crop is depicted in figure 2, while the% of yield gap, yield gap in absolute term and average actual farm yield obtained by different categories of farmers are presented in Table 2.

Table 2: Yield gaps in wheat crop across the farm size group

Average Regional yield (qt/ha)	52				
	Marginal	Small	Medium	Large	Over-all
Average actual farm yield (qt/ha)	39.95	40	42	44	43
Yield gap in absolute term (qt/ha)	12.05	12	10	7	9
Yield gap in per cent	30.10	30	23.81	15.56	20.93

Table 2 depicted that the potential yield of the study area was 52 quintal per hectare and average actual farm yield obtained by different categories of farmers were 39.95, 40, 42 and 43 quintals per hectare for marginal, small, medium and large farmers, respectively. Again yield performance of marginal and small farmers were very poor comparing to other categories of farmers. The overall yield gap in absolute term was 9 quintals per hectare which imply that as compared to potential yield of the study area other farmers were taking 43 quintals of wheat on per hectare of land. When we compare the% of yield gap among different categories of farmers then we found that marginal farmers had occupied first place in terms of maximum yield gap in wheat crop.

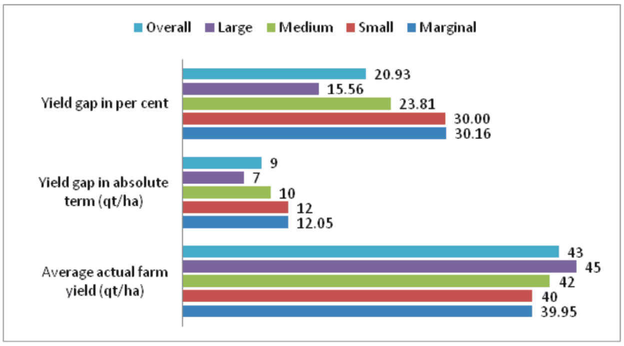

Fig 2: Yield gap in wheat across the farm size groups

The figure depicts that minimum yield gap was found on large farm size and they had occupied last place in yield gap, while maximum was found in marginal size of farm and stand first in yield gap. On the other hand small and medium farmers had occupied second and third place in yield gap. Thus it can be concluded that yield gap is adversely related with the farm size.

Estimation of yield gap in sugarcane

Sugarcane was more preferred by the farmers of the district as an annual crop, but the yield performance was not very good. Table 3 conveys that the average potential yield of the district was 1000 quintal per hectare. When we compared the average actual farm yield of sugarcane among different categories of farmers then we found that the average actual farm yield obtained by the large farmers was higher than the other categories of farmers.

Table 3: Yield gaps in sugarcane crop across the farm size groups

Average yield obtained by top 10 farmers (qt/ha)	1000				
	Margi-nal	Small	Medium	Large	Over-all
Average actual farm yield (qt/ha)	775.8	820.9	895	945	850.5
Yield gap in absolute term (qt/ha)	224.2	179.1	105	55	149.5
Yield gap in per cent	28.89	21.81	11.73	5.8	17.5

Again the yield performances of small and marginal farmers were very poor. Table depicts that marginal had the yield gap of more than 200 quintals per hectare, which implies that the yield performance was very poor as compared to other categories of farms in the study area. The average actual farm yield obtained by large farmers was more than 900 quintal per hectare and the overall average actual farm yield was 850.5 quintals per hectare.

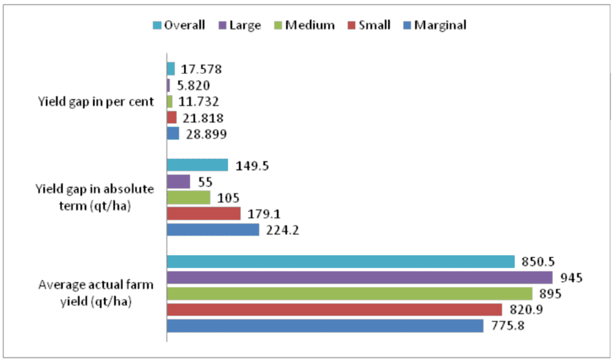

Fig 3. Yield gap in rice across the farm size groups

The figure depicts that more than 17% of yield gap was found across the farm size groups. First rank had been occupied by marginal farmers with the percent yield gap of 28.89%, while the last rank had been occupied by large farmers with the yield gap of 5.8%.

Yield gap in sugarcane also showed the negative relationship with the farm size. It can be concluded that in all the major crops the degree of yield gap was quite remarkable among all size group of farms. However, the extent of yield gap was comparatively very high on marginal and small farms. The yield gaps were found negatively associated with farm size groups. Thus, there is ample scope to increase the productivities of all the major crops across the farm size groups in the study area.

Determinants of yield gap

To identify the determinants of yield gap with respect to major crops in different categories of farms, correlation and regression analysis was done in step by step.

Determinants of yield gap in paddy

The regression results on determinants of yield gap in respect of paddy crop are given in table 4. The results suggested that 'source of seed(X_2), capital use (X_3), meeting with ADO/Ag. Scientist (X_5), Technology adoption level (X_6) had significant negative effect on yield gap across the farm size groups, indicating that an increase in the magnitude of these variables will minimize the gap in the paddy yield. The results suggested that 'Education level' (X_1), 'Source of seed' (X_2) and 'Technology adoption level' (X_6) had significant negative effect on yield gap in case of marginal and small farmers. But in case of medium farmers 'Source of seed' (X_2), 'Meeting with ADO/ Ag. scientist (X_5) and 'Technology adoption level' (X_6) played a significant negative role on yield gap. The regression coefficients of the variables 'source of seed(X_2), capital use (X_3), meeting with ADO/Ag. scientist(X_5), Technology adoption level (X_6) were found negatively significant at 20%, 20%, 10% and 5% level of significance, respectively.

Table 4. Determinants of yield gap in paddy crop

Farm size group Variables	Margi-nal	Small	Medium	Large	Over-all
Intercept (a)	4.37* (1.29)	2.90* (0.57)	8.56* (2.81)	7.34* (3.65)	7.027* (2.97)
Education level (X_1)	0.670 (0.209)	0.06 (0.016)	0.317 (0.0285)	0.131 (0.014)	0.068 (0.034)
Source of seed (X_2)	-1.37** (0.959)	-0.756** (0.397)	-0.592* (0.011)	-0.688* (0.475)	-0.954*** (0.683)
Capital Use (X_3)	-1.447** (0.546)	-1.73** (0.397)	1.532* (0.61)	0.373 (0.103)	-0.846*** (0.683)
Distance from ADO/ KVK (X_4)	1.561* (0.67)	0.396 (0.021)	0.034 (0.015)	0.1149 (0.010)	0.07 (0.492)
Meeting with ADO/ Ag. scientist (X_5)	0.819 (0.393)	0.280 (0.021)	-1.932*** (0.513)	-1.549** (0.976)	-1.82** (0.237)
Technology adoption level (X_6)	-0.65* (0.525)	-1.978*** (0.38)	-1.513*** (0.29)	1.158* (0.86)	-1.54* (0.329)
R^2	0.52	0.58	0.73	0.75	0.64

Note: *= significant at 5%, ** = significant at 10%, *** = significant at 20%
Figures in parentheses indicate standard error of regression coefficient

Thus, an increase in the magnitude of these five variables will help in minimizing the yield gap. The sign of variable education level' (X_1) and Distance from ADO/Ag. scientist (X_4) turned out to be positive but it was not found to be significantly affecting the yield gap, that's why it was not possible to conclude statistically that whether the education level and distance of ADO/KVK from village had any real impact on yield gap or not.

From the value of regression coefficient of the variables, Meeting with ADO/Ag. Scientist (X_5) and Technology adoption level (X_6), it is understood that 1% increase in technology adoption level and meeting with ADO/Ag. Scientist would cause 1.54 and 1.82% decrease in yield gap, respectively. From farmers point of view, Source of seed (X_2) and Capital use (X_3) also had great importance because 1% increase in these variables would reduce yield gap by 0.954 and 0.846%, respectively. Thus based on the results of the regression of the hypothesized variables, it is concluded that 'source of seed(X_2), capital use (X_3), meeting with ADO/Ag. Scintist(X_5), Technology adoption level (X_6)' played crucial role in determining the yield gap. The coefficient of multiple determination suggested that factors discussed above together explained variation of 52%, 58%, 73%, 75% and 64% for marginal, small, medium, large and overall farm size groups, respectively.

Determinants of yield gap in wheat crop

The regression results on determinants of yield gap with respect to wheat crop are given in table 5. The results suggested that 'source of seed (X_2), capital use (X_3) and Technology adoption level (X_6) had negatively significant effect on yield gap in case of marginal farmers. While in case of small farmers, 'Education level', (X_1) 'source of seed' (X_2), 'capital use' (X_3), 'meeting with ADO/Ag.scientist' (X_5), 'technology adoption level' (X_6) had significant negative effect on yield gap indicating that an increase in the magnitude of these variables will minimize the gap in the wheat yield. On the other hand in case of medium farmers 'Technology adoption level' (X_6) had played a significant positive role on the overall basis the regression coefficients of the variables Education level (X_1) 'source of seed(X_2), capital use (X_3), meeting with ADO/Ag. scientist (X_5) and technology adoption level (X_6) were found to have significant negative impact on yield gap. Thus, an increase in the magnitude of these five variables will help in minimizing the yield gap. The sign of variable 'Distance from ADO/KVK (X_4)' turned out to be negative but it was not found to be significantly affecting the yield gap, that's why it was not possible to conclude statistically that whether the distance of ADO/KVK from village had any real impact on yield gap or not.

From the values of regression coefficients of the variables, 'Capital use' (X_3) and 'Technology adoption level' (X_6), it is understood that 1% increase in technology adoption level and amount of capital use would cause 1.861 and 0.68% decrease in yield gap. From farmer's point of view, 'Education level' (X_1), 'Source of seed' (X_2) and 'Capital use' (X_3) also had great importance because 1% increase in these variables would reduce yield gap by 0.802, 1.62 and 0.68 per cent, respectively. Thus based on the results of the regression of the hypothesizes variable, it is concluded that Education level (X_1) Source of seed(X_2), Capital use (X_3), Meeting with ADO/Ag. Scientist (X_5), Technology adoption level (X_6)' played crucial role in determining the yield gap.

The value of R^2 indicated that combined effect of the six explanatory variables on variation in yield gaps were 58%, 76%, 81%, 84% and 78% for marginal, small, medium, large and overall farm size. So to reduce the yield gaps, higher level of technology adoption and more use of certified seed should be the utmost target for the district agriculture planning department, besides other factors.

Table 5. Determinants of yield gap in wheat crop

Farm size group Variables	Marginal	Small	Medium	Large	Overall
Intercept (a)	2.94* (0.209)	1.362** (0.568)	4.32* (1.83)	6.730* (1.59)	5.621* (1.90)
Education level (X_1)	0.230 (0.011)	-0.823* (0.0023)	-1.547** (0.413)	1.621* (0.520)	-0.802*** (0.012)
Source of seed and availability of quality seed at right time(X_2)	-1.85*** (0.53)	0.924 (0.0129)	-1.51** (0.091)	-1.83*** (0.112)	-1.62** (0.031)
Availability of finance and credit for crop production (X_3)	-0.972* (0.23)	-1.520** (0.321)	0.257 (0.012)	0.242 (0.023)	-0.68** (0.257)
Distance from ADO/KVK (X_4)	0.381 (0.012)	00.053 (0.018)	0.025 (0.001)	0.0242 (0.012)	0.0341 (0.015)
Meeting with ADO/Ag. Scientist (X_5)	0.128 (0.068)	-0.501** (0.024)	0.257 (0.045)	-0.6499 (0.121)	-0.525** (0.086)
Technology adoption level (X_6)	-1.95*** (0.59)	-1.810*** (0.46)	1.779* (0.31)	-1.732* (0.131)	-1.861*** (0.360)
R^2	0.58	0.76	0.81	0.84	0.78

Note *= significant at 5%, ** = significant at 10%, *** = significant at 20%

Figures in parentheses indicate standard error of regression coefficient

Determinants of yield gap in sugarcane

The regression results on determinants of yield gap in respect of sugarcane which is presented in the table 6 indicates that three independent variables, i.e. 'Source of seed' (X_2), 'Meeting with ADO/Ag. Scientist' (X_5), 'Technology adoption level' (X_6) have significant effect on yield gap and all of them have negative effect on the overall farm size group. While in case marginal farmers 'Source of seed' (X_2), 'Capital use' (X_3) and Technology adoption level' (X_6) had negatively significant impact. It implies that any increase in these variables will decrease the yield gap.

Table 6. Determinants of yield gap in sugarcane crop

Farm size group Variables	Marginal	Small	Medium	Large	Overall
Intercept (a)	7.997* (2.99)	10.90* (3.25)	6.61* (8.21)	8.74* (2.98)	5.93* (2.9)
Education level (X_1)	0.056 (0.031)	0.036 (0.011)	0.652 (0.320)	0.389 (0.011)	0.051 (0.321)
Source of seed and availability of quality seed at right time(X_2)	-2.846* (0.529)	-1.122** (0.271)	-1.011** (0.580)	1.308** (0.213)	-1.116** (0.58)
Availability of finance and credit for crop production (X_3)	-1.774* (0.013)	-0.622* (0.012)	1.531** (0.209)	0.960 (0.592)	-0.054* (0.014)
Distance from ADO/KVK (X_4)	0.619 (0.09)	0.525 (0.319)	1.531** (0.209)	0.960 (0.593)	-0.631* (0.209)
Meeting with ADO (X_5)	0.821 (0.557)	0.726 (0.129)	0.257 (0.139)	0.746 (0.235)	-0.572 (0.024)
Technology adoption level (X_6)	-1.543* (0.141)	-1.885* (0.253)	-1.55** (0.141)	2.257* (1.09)	-1.854** (0.141)
R^2	0.519	0.56	0.64	0.73	0.62

Note= *= significant at 5% ** = significant at 10, *** = significant at 20%

Figures in parentheses indicates standard error of regression coefficient

On the other hand the independent variable, 'Distance from ADO/KVK' (X_4) was also found significantly determining the yield gap across the farm size groups and it has positive effect on yield gap which means as the distance increases the yield performance of the farmer's decreases. It is observed that in case of sugarcane cultivation technology adoption level has the most significant effect on yield gap. When we talk about the large farmers than we found that 'Technology adoption level' (X_6) had positively significant effect on yield gaps which means as the technology adoption level increase the yield gap performance of large farmers increases.

From (Table 6) the value of regression coefficient (b_1) of the variable, Capital use (X_3), Technology adoption level (X_6) and Source of seed (X_2), it is understood that 1% increase in technology adoption level and source of seed would cause 1.854, 1.116 and 0.054% decrease in yield gap. From farmer's point of view, Distance from ADO/KVK (X_4) and Meeting with ADO/Ag. scientist (X_5), also had great importance because 1% increase in these variables would reduce yield gap by 0.631 and 0.572 per cent, respectively. Thus based on the results of the regression of the hypothesized variables, it was concluded that Education level (X_1) 'Source of seed (X_2), Capital use (X_3), Meeting with ADO/Ag. Scientist (X_5) and Technology adoption level (X_6)' played crucial role in determining the yield gap. The coefficients of multiple determination (R_2) suggested that factors discussed above together explained variation of 62% in yield gap of sugarcane.

Conclusion

This study has shown that there are still considerable yield gaps in rain-fed crops that can be bridged in future to meet the increasing food requirements. At the farm level, the gaps appeared to be the smallest in sugarcane (17.5%) and the largest in rice (28.26%). In all the crops the degree of yield gap was quite remarkable among all size groups of farms. However, the extent of yield gap was comparatively very high on marginal and small farms. The yield gaps were found negatively associated with farm size group. Thus there is ample scope to increase the productivity of all the major crops across the farm size group in the study area. It was observed that on the overall basis 'Source of seed, Capital use, Meeting with ADO/Ag. Scientist and Technology adoption level had significant negative impact on the yield gap of all the major crops. Regression results on determinants of yield gap revealed that technology adoption level is one of the important determinants of yield gap in all the three crops cultivated in the study area. Therefore, farmers are required to be educated to adopt full package of practice along with the provision of timely availability of agro inputs in required quantity. ADO/Ag. scientist meeting per year was also found important determinants of yield gap among all the crops. So increasing the frequency of meetings and interaction with ADO/Ag. scientist will help in increasing the yield of the crops.

The government must strengthen efforts to ensure timely supply of adequate quantities of quality inputs to the farmers to enable them to minimize yield gap in crops. Both public and private sectors should play a vital role in producing and distributing the inputs in time.

- ❒ Efforts must be made to update/enrich farmers' knowledge and skill on the causes of yield gaps and the strategies to minimize the gaps through training, demonstrations, field visits, and monitoring by extension agencies.
- ❒ Despite the training and skill provided to them, resource-poor small farmers may not be able to achieve high yield. This is because these farmers are not usually able to purchase required quantities of the inputs to obtain such yield. It is, therefore, essential for the government to take steps to timely supply adequate amounts of credit to these farmers. Actions should also be taken to reduce transaction costs, simplify lending procedures, revise eligibility criteria and strengthen monitoring and supervising mechanism of the current credit system.
- ❒ Socio-economic and institutional constraints, such as poor economic status of farmers, lack of supply of quality inputs, input/output price support and proper research-extension linkage can cause yield gaps in crops. It is recommended that the government address the issues seriously and come forward with appropriate solutions to the problem of yield gap.
- ❒ Support of research and extension is necessary for narrowing yield gap. The researcher should understand farmers' constraints to high productivity and accordingly develop integrated technological package (appropriate variety, timely planting, fertilizer, irrigation, and pest management) for specific locations to bridge up the gap. The extension service should at the same time ensure that the farmers properly apply recommended technological packages in fields through effective training, demonstrations, field visits, monitoring, etc.
- ❒ Efforts of the government are at present mainly confined to the use of modern varieties and hybrid technology to increase crop production. The government should realize the fact that yield gaps exist in different crops of Uttar Pradesh. It is, therefore, recommended that they seriously explore the scope to promote yield by narrowing the existing yield gaps in crops and thereby ensure food security.

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