

YIELD GAP OF POTATO IN MEGHALAYA: A SEASONAL ANALYSIS

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ABSTRACT: Potato cultivation in Meghalaya is peculiar owing to its high consumption and cultivation in all the four seasons. Hence, the study was conducted during the year of 2022-23 in the state to investigate the yield gap and factors affecting it in two seasons, *viz.*, summer and winter, by employing both primary and secondary data. The Yield Gap I and II (YG I and YG II) were higher for winter potato whereas, summer potato had higher realized experimental yield. Size of farm, late blight incidence, lack of access to markets and prices of chemicals were positively related with the yield gap having the highest effect. Among the negatively related factors, the climate had the highest significant effect followed by fertilizer application. The study found that winter potato was not cultivated by many farmers due to higher cost of cultivation and concluded that the YG I was higher than the YG II. Given that YG I is largely limited by environmental and genetic factors, efficient demonstrations of technologies in farmer's field by ICAR institutes and CAU scientists along with the low-cost organic inputs to farmers can narrow down the yield gap II even more efficiently.

KEYWORDS: Factors, Potato, Seasons, Yield and Yield gap

INTRODUCTION

Potato (*Solanum tuberosum*) is a major cash crop that grows in temperate climatic conditions, however, currently they are being cultivated under diverse climatic conditions. It is one of the world's widely cultivated tuber crops being often referred to as "King of Vegetables" (Bhajantri, 2011; Mondal and Lah, 2022). Potatoes are the rich source of carbohydrates with starch content varying from 70 to 90 per cent on a dry matter basis according to the varieties (Nofrarias *et al.*, 2009). Owing to high nutritional value and as a major player in food security across South America, Africa and Asia, potatoes rank third in terms of consumption after rice and wheat (Devaux *et al.*,

2014). Subsequently from 1960s, the expansion of production area of potato in emergent nations have rapidly overtaken all other food crops. As per the year of 2024, China is the world's largest producer of potato with a production of 94.81 million tonnes, followed by India with 57.05 million tonnes. These two countries, together, accounted for approximately 38.9 per cent of the global potato production of 390.32 million tonnes. (FAOSTAT, 2025).

In India, people were acquainted with potato cultivation during the early 17th century (Lama and Bordoloi, 2017), which has been currently adopted for cultivation in various agro-climatic conditions across all states of the country.

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However, due to the low temperature requirements to acquire the maximum yield, potatoes are cultivated extensively in the hilly regions of the country (CPRI, 2020). In the North-Eastern (NE) region of India, potato is grown in all states, accounting for 2.15 per cent of the country's total potato production (Indiastatagri, 2021). Assam, Meghalaya and Tripura had the highest production of potato in NER with the prominent cultivated varieties of *Kufri Jyoti* and *Kufri Megha* (GoM, 2020). Meghalaya is the second largest producer of potato after Assam in North East region. The unique cultivation of potatoes on a seasonal basis is identified in Meghalaya where the farmers cultivate the crop in all four seasons that varies based upon the districts. East Khasi and West Khasi hills districts are accustomed to the cultivation of spring and summer potatoes, whereas West Khasi hills and West Garo Hills are adapted to the cultivation of autumn and winter potatoes, respectively (GoM, 2020).

Potatoes are the highest produced vegetable in the country, with an estimated production of 59.89 million tonnes during 2025-26 (GoI, 2026). Numerous studies on potato (Rajavardhan *et al.*, 2020; Pandey *et al.*, 2018; Lama and Bordoloi, 2017; Sagolsem *et al.*, 2017; Rani and Mathur, 2013; Pandit and Chandran, 2011) only depicted the scenario of potato area, production and yield in terms of trend analysis that resulted in a positive growth over the years from all the three aspects in the country. However, the focus on yield of potato and its difference between the research field and farmers' field were relatively less in India.

Yield gap analysis studies the differences in the yield obtained at three different fields *viz.*, research station, demonstration fields and farmers' fields. This illustrates the extent of adoption of technologies and packages of practices by the farmers as recommended

by the scientists. Around the country, yield gap researches (Kemboi *et al.*, 2021; Singh and Sheikh, 2017; Lalit *et al.*, 2015; Kumbhare *et al.*, 2014) had been carried out in milk, rice cultivars, red gram and pigeon pea, respectively. However, studying this difference in the highest produced vegetable of the country, potato, was lacking, especially in Meghalaya. Hence, the present study was undertaken in the East Khasi Hills of Meghalaya with the following specific objectives:

1. To assess the yield gap of summer and winter potato cultivated in the study area
2. To identify the factors determining the yield gap of potato in the study area

MATERIALS AND METHODS

Study Area and Sampling

The study was conducted in the East Khasi Hills district of Meghalaya using a multi stage sampling technique, where the state and district were purposively selected owing to the highest area and production of potato (GoM, 2020). Followed by, the blocks of Mawryngkneng and Laitkroh Khatarshnong were selected due to the highest area and production of both summer and winter potatoes as per the secondary data provided by the district office, Department of Horticulture (DoH). Two villages each from the selected blocks were selected purposively based on the highest potato growers as reported by the Horticulture Development Officers (HDOs). Based on the proportionate to population technique, a sample size of 78 potato growers altogether were enumerated from the four villages. The quantitative data on yield of potato for summer and winter seasons were collected separately from each respondent and a combination of quantitative and qualitative data for factors were also gathered.

Data collection

The use of both primary and secondary data were carried out for the study. The primary data were collected from the respondents using a pre-tested and well-structured interview schedule. The secondary data for experimental station or research station yield was taken from the annual report of Central Potato Research Institute (CPRI, 2020) and the data on potential yield or demonstration yield was taken from the annual report of ICAR-Agricultural Technology Application Research Institute, Zone VII (ICAR-NEH ATARI, 2020). They were then used in the respective formulae of yield gap to obtain the difference.

Analytical Framework

Descriptive analysis

The inference from the results were drawn with the help of the descriptive tools such as sum, differences, averages and percentages for both the seasons of potato cultivation.

Empirical analysis

The analysis of yield gaps from cultivation of potato during the two seasons in the study area was carried out by employing the standardized yield gap concepts and formulae. The differences between the respective yields were calculated for both the seasons separately that resulted in two yield gaps *viz.*, YG I and YG II. Finally, the total yield gap was determined by summing up both the yield gap I and II.

Yield Gap I = Experimental Station Yield (Y_r) – Potential Farm Yield (Y_p)

Yield Gap II = Potential Farm Yield (Y_p) – Actual Farm Yield (Y_r)

Total Yield Gap = Yield Gap I + Yield Gap II

The index of the realized potential yield and index of realized potential farm yield

were also calculated for both the seasons separately resulting in two different indices.

Additionally, the percentage of yield gap was also calculated for YG I and percent of YG II using the below formulae;

$$\text{Percentage of yield gap (YGI)} = \left(\frac{\text{Yield gap}}{\text{Potential farm yield}} \right) \times 100$$

$$\text{Percentage of yield gap (YGII)} = \left(\frac{\text{Yield gap}}{\text{Actual farm yield}} \right) \times 100$$

Finally, for the factors affecting the yield gap, a total of 27 factors were taken into consideration and were grouped into six categories, *viz.*, producer factors (X_1, X_2, X_3), physical factors (X_4, X_5, X_6), production factors ($X_7, \dots, X_{15}$), biotic factors ($X_{16}, \dots, X_{19}$), economic factors ($X_{20}, \dots, X_{24}$) and extension factors ($X_{25}, \dots, X_{27}$). Multiple linear regression analysis was carried out with the total yield gap (summing up the yield gap I and II for both summer and winter potatoes for each respondent) as the dependent variable. The qualitative independent variables of desirable categories were regressed as dummy variables based on the response from the farmers as 0 for “Yes” and 1 for “No”. The model specified for the regression analysis with the independent variables are presented below.

$$Y = f(X_1, X_2, X_3, X_4, \dots, X_{27})$$

Where,

Y	Yield gap	X14	Availability of machine labour
X1	Size of farm	X15	Availability of human labour
X2	Experience	X16	Weed competition
X3	Education	X17	Seed-borne diseases
X4	Climate	X18	Late blight incidence
X5	Topography	X19	Bacterial wilt
X6	Landslides/ Erosion	X20	Price of tubers
X7	Variety of potato	X21	Cost of labour
X8	Planting practices	X22	Price of chemicals

X9 Prolonged usage of farm saved seeds	X23 Price of output
X10 Irrigation	X24 Lack of access to markets
X11 Application of fertilisers	X25 Lack of new technology
X12 Quantity of input application	X26 Adoption of technology
X13 Timing of input application	X27 Contact between farmers and extension workers

RESULTS AND DISCUSSION

In the study, efforts were taken to determine the yield gaps obtained during the cultivation of potato in summer and winter seasons individually and finally summing them up to obtain the total yield gap. Finally, the factors responsible for creating this gap were also evaluated and interpreted under two sections *viz.*, yield gap of potato across various seasons and various factors affecting yield gap of potato.

Yield Gap of potato across various seasons

The yield gap was calculated for two different seasons *viz.*, summer and winter, and finally the total yield gap was estimated as in Table 1. The yield gap I (YG I) and yield gap II (YG II) were the highest in winter potato than summer, contributing to 38.89 per cent and 29.07 per cent of yield gap, respectively (similarly reported by Kumar *et al.* (2011) on

Table 1. Seasonal variation in yield gaps and realized potential yield of potato

Particulars	Summer potato	Winter potato	Difference
Yield Gap I (kg/ha)	4217	5409	1192
Yield Gap II (kg/ha)	1434.49	2471.51	1037.02
Total Yield Gap (kg/ha)	5651.49	7880.51	2229.02
Percentage of Yield Gap I (%)	27.42	38.89	11.47
Percentage of Yield Gap II (%)	12.85	29.07	16.22
Index of realized potential yield	0.70	0.43	0.27
Index of realized potential farm yield	0.87	0.71	0.16

rapeseed and mustard and Mondal (2011) on Wheat). It may be because, most of the farmers did not cultivate potato during winter season owing to the bad weather, market conditions and higher cost of cultivation. On the other hand, the lower yield gap for summer potato may be attributed to the prevalent cultivation of potatoes during this season as the local demand used to be high. Similar findings were reported by Hiremath and Hilli (2012) on chilli and Mondal (2011) on potato.

The Index of realized potential yield revealed that farmers were able to realize about 70 per cent of the experimental yield in summer season and 43 per cent in winter. Similarly, 87 per cent of the demonstration yield was realized by the farmers in summer season and 71 per cent in winter season. This reveals that farmers were able to reach the higher level of experimental and potential yield during summer but only potential yield in winter season. Also, the farmers' cultivation practices were better and improving as they were nearing to achieve the potential yield (Front Line Demonstrations (FLDs) in both the seasons. However, the achievement of experimental yield by the farmers was more lacking in winter than summer, indicating that the technological gap (YG I) is greater than that of the extension gap (YG II). It reveals that farmers were better aware about the practices and technologies and applied it wisely to reap better returns.

Various factors affecting yield gap of potato

The information on factors affecting yield gap were collected from the potato growers and analyzed using multiple linear regression as presented in Table 2.

The null hypothesis stated that the factors were statistically insignificant. However, among 27 factors, 13 factors were significant

Table 2. Regression coefficients of independent variables influencing potato yield gaps

Categories	Independent variables	Regression coefficient	p-values
Producer factors	Size of farm	1016.72	0.013**
	Experience	6.7452	0.884
	Education	-1518.8	0.000***
Physical factors	Climatic conditions	-6242.57	0.000***
	Topography	-1730.68	0.008***
	Landslides/Erosion	-460.77	0.486
Production factors	Variety of potato	283.76	0.693
	Planting practices	-2308.16	0.009***
	Prolonged usage of farm saved seeds	616.16	0.540
	Irrigation	-2567.21	0.001***
	Application of fertilisers	-4112.94	0.000***
	Quantity of Input application	-77.56	0.904
	Timing of input application	834.05	0.191
	Availability of machine labour	-1774.64	0.008***
	Availability of human labour	829.77	0.284
Biotic factors	Weed competition	1420.35	0.134
	Seed-borne diseases	-12.99	0.989
	Late blight incidence	2288.46	0.014**
	Bacterial wilt incidence	110.75	0.903
Economic factors	Price of tubers	651.84	0.508
	Cost of labour	-845.54	0.397
	Price of chemicals	2358.74	0.011**
	Price of output	-17.13	0.985
	Lack of access to markets	1721.45	0.078*
Extension factors	Lack of new technology	-189.04	0.792
	Adoption of technology	-4108.66	0.000***
	Contact between farmers and extension workers	-4584.95	0.000***

Note: ***, ** & * indicates significance at 1, 5 and 10 per cent level

with lower p-values and hence, the null hypothesis was rejected. Of the 13 significant factors, 10 were significant at 1 per cent level indicating the highest effect of the factors on YG, whereas two were significant at 5 per cent level and one was significant at 10 per cent level.

The significant producer factors were Size of farm and Education, in which the former was positively related indicating the importance of utilization of recommended package of practices than the area of farm. The negative relationship of Education reveals that, if farmers are highly educated, efficient resource allocation and use was possibly, leading to decreased YG. Similarly, among the physical factors, climatic conditions and topography had significant but an inverse effect indicating that a state like Meghalaya with high rainfall pattern, crop losses occur which leads to widening of gap. Also, it was observed that during dry season incidence of cut worm caused crop losses and hence yield gap occurred.

Among the production factors, four factors were significant at 1 per cent level of significance with an inverse relationship to yield gap. The major factor was the non-adoption of recommended package of practices by the farmers, where majority were planting tubers in buns rather than ridges and furrows and none of them irrigate or apply fertilizer as recommended due to dependency on rainfall and higher cost of the chemicals, respectively. Moreover, given the slope of the study area, usage and hiring of machines became very tedious procedure for the farmers. In the biotic factors category, it was identified that the increase in the late blight incidence led to flaring of yield gap and it was directly related.

The major economic factors were price of chemicals and lack of access to markets, both having a direct effect on YG. The extension factors such as adoption of technology and contact of farmers with extension workers had inverse relationship with YG indicating that increased adoption and enhanced contact would narrow the yield gap.

CONCLUSION

The study revealed the existence of substantial yield gaps in cultivation of potato in Meghalaya, where potato cultivation in winter season recorded higher gaps. The farmers were able to realize yields beyond the experimental yields in both seasons and the realization of yield was highly observed during summer season. The findings highlight the scope for improving productivity through better management practices, identifying and promoting season-specific production practices suited to the agro-climatic conditions of the state. Hence, greater emphasis must be given to bridge the gap between the available production potential and its realization at the farm level. The significant factors such as farm size, late blight incidence, input prices and access to transportation highlights the need for affordable crop protection measures and improved access to locally suitable plant protection technologies. The strengthening of extension support for integrated nutrient, pest management and timely dissemination of location-specific advisories can contribute in narrowing the yield gap.

Therefore, the policy interventions should focus to improve the farmer's access to low-cost and environmentally sustainable inputs such as bio-fertilizers and bio-pesticides, in line with the state's emphasis on organic and sustainable agriculture. Seasonal recommendations should be developed based on local agro-climatic conditions, with greater attention to winter potato production as productivity constraints were more pronounced. Additionally, regular technical guidance from ICAR institutes, Central Agricultural University and the state agricultural extension system should be strengthened along with relevant government programs to translate the available production

potential into higher and more stable farm-level productivity. Hence, a coordinated approach of research institutions, extension agencies and state government would enhance potato productivity and strengthen potato-based livelihoods and food security in the state and the wider North-Eastern region.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

ETHICAL STATEMENT

The authors ensure that the study is completely original and does not contain any data or information from studies conducted by any of the authors.

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