**Original Research Article**

**Yield gap analysis of maize in different agro-climatic zones in Telangana**

**ABSTRACT**

Maize is a vital cereal crop worldwide, serving as a staple food, fodder, and industrial raw material. In India, it ranks third among cultivated cereals after rice and wheat, with Telangana being a significant contributor. This study examined yield gaps in maize production across the Northern Telangana Zone (NTZ), Central Telangana Zone (CTZ), and Southern Telangana Zone (STZ). The results highlighted that Yield Gap-I (difference between potential yield and progressive farmers’ yield) was highest in STZ at 5.4 quintals/acre and lowest in CTZ at 3.9 quintals/acre, with an average of 4.5 quintals/acre for the state. Yield Gap-II (difference between potential yield and actual farmers’ yield) was also highest in STZ at 13.5 quintals/acre and lowest in NTZ 9.3 quintals/acre with an overall average of 11.3 quintals per acre in Telangana. Indices of yield gap revealed that STZ had the highest unrealized yield potential (35.7%), while NTZ had the lowest (25.2%). Major factors contributing to these gaps included agro-climatic conditions, soil fertility, and irrigation infrastructure. This study also identified production and marketing constraints such as high costs of plant protection chemicals, seeds, and fertilizers, along with labour shortages, as the most significant production challenges. Marketing constraints such as insufficient market facilities, remunerative prices, storage facilities and untimely payment were the prominent marketing challenges. The study emphasizes the need for targeted interventions to reduce yield gaps through enhanced extension services, cost-effective inputs, and improved infrastructure. Strengthening the linkages among farmers, extension agents, and researchers is crucial to bridging resource and knowledge gaps, thereby boosting productivity and profitability in maize cultivation across Telangana.

**Keywords:** Maize, production and marketing constraints, Telangana zones, yield gap indices, yield gap analysis.

**1. INTRODUCTION**

Maize (*Zea mays L.*) is one of the most important staple crops globally and serves as a major source of food, fodder and industrial raw material (Shiferaw *et al*., 2011). Maize along with rice and wheat constitutes a significant share of cereal consumption, particularly in regions where diverse agro-climatic conditions exist (Erenstein *et al*., 2022). In India, maize occupies a prominent position in the agricultural landscape, with over 9.8 million hectares under cultivation and a production of 28.64 million tonnes in 2020-21 (Ministry of Agriculture & Farmers Welfare, 2021). India is the 5th largest producer in terms of area and 14th largest in terms of production, representing around 4 per cent of the world maize area and 2 per cent of total production, making it the third most cultivated cereal crop after rice and wheat. (IIMR, Annual report 2023)

In recent times, the state of Telangana has emerged as one of India's major hubs of maize production. It accounts for around 6 per cent of the country's total output. In Telangana maize crop is the second most cultivated crop after rice, nearly it is grown in 14 lakh acres, with a production of 16 lakh tonnes annually in both kharif and rabi seasons. Major producing districts include of Mahaboobnagar, Medak, Karimnagar, Warangal, Rangareddy, Nizamabad and other parts of north Telangana (Government of Telangana, 2024).

Despite the rising demand for diversified diets and the increasing focus on horticultural and livestock products, maize continues to play a crucial role in food and nutritional security. It is a rich source of carbohydrates and energy and is widely utilized in food, feed, and industrial applications. The domestic demand for maize is projected to grow significantly due to its versatile uses in human consumption, animal feed, and biofuel production.

With limited scope for area expansion under maize cultivation, achieving higher productivity remains essential. Recognizing the importance of this crop, the Government of India included maize in the ‘National Food Security Mission’ in 2014-15, with an objective to increase its productivity and production sustainably. However, similar to other crops, a considerable yield gap exists between farmers’ fields and research demonstration plots due to suboptimal adoption of recommended practices, resource constraints, and technological barriers (Ayalew and Sekar, 2016; Peramaiyan *et al*., 2022).

To address this issue, trials and demonstrations are conducted to evaluate the feasibility and suitability of improved technologies before scaling them up on farmers’ fields. Despite technological advancements in maize production, there is a pressing need to analyze and understand the yield gap comprehensively. Such an analysis will provide insights into bridging the productivity gap, improving farmers’ livelihoods, and ensuring food security.

The yield gap analysis is a potent research technique that has been introduced during 1970s. Developed by the International Rice Research Institute (IRRI), it is extensively used to measure and analyze determinants of the yield gaps. The concept of yield gap provides the information base in this regard. The findings of such research have many implications for policy formulation, aimed at alleviating the constraints causing the yield gaps (Gavali et al., 2011; Kalamkar, 2004; Nagaraj, 2002 and Rajagopalan, 1986).

The objectives of the study are to estimate the gap between actual, progressive farmers and research station yields and the production constraints that contribute to this yield gap.

**2. METHODOLOGY**

 This study is based on primary data collected through a well-designed, structured questionnaire. A multi-stage sampling design was adopted for the selection of zones, districts, mandals, villages, and finally, farmers. In the first stage, the three zones of Telangana, *viz.,* Northern Telangana Zone, Central Telangana Zone, and Southern Telangana Zone, were selected.

In the Northern Telangana Zone, three mandals - Jagtial, Jakranpally, and Bhiknur were selected. From these mandals, the villages were selected as: Laxmipuram from Jagtial mandal, Jakranpally village from Jakranpally mandal, and Bhiknur village from Bhiknur mandal.

In the Central Telangana Zone, Nellikuduru, Raghunathpally, and Kodumuru mandals were selected. From these, Chinnamupparam village was selected from Nellikuduru mandal, Govardhan Giri village from Raghunathpally mandal, and Chintakani village from Kodumuru mandal.

In the Southern Telangana Zone, the selected mandals were Shabad, Wanaparthy, and Peddavura. The selected villages were Manmarri from Shabad mandal, Chityala from Wanaparthy mandal, and Chalakurthy from Peddavura mandal.

From each selected village, 35 farmers (normal or non-progressive), 5 progressive farmers, and 1 sample from a research station were included, resulting in a total sample size of 105 farmers, 15 progressive farmers, and 3 research stations.

**2.1 Yield gap analysis**

The yield gap was measured using a method introduced by Manila, Philippines International Rice Research Institute (IRRI) as used by Singh (2015). Potential yield (PY) was defined as crop yield per hectare achieved at the research station. Potential farm yield (Yd)/ Progressive farm yield (Yd) is the maximum yield which is obtained by the grower in a category of farm size, and the actual yield (Ya) was derived as the per acre yield produced by the growers on their fields (Priyadarshini et al., 2022).

**Total yield gap (TYG)**

It is the difference between the potential yield (Yp) and the actual farm yield (Ya). This total yield gap comprises of yield gap-I and yield gap-II (Manivasagam *et al*., 2024 and Priyadarshini *et al*., 2022).

TYG = Yp - Ya .......(1)

 **Yield gap-I (YG-I)**

 It is the difference between potential yield (Yp) and the yield achieved by progressive farmers (Ypf). Yield gap-I is hypothesized to be caused by either the environmental differences between experiment station and farmers’ fields or by non-transferable technology (Rajnidevi and Sadvi, 2020).

YG-I = Yp – Ypf .......(2)

**Yield gap-II (YG-II)**

It is the difference between potential farm yield (Yd) and the actual farm yield (Ya).

YG-II = Yd - Ya ........(4)

It is hypothesized to be caused by biological and socio-economic constraints; biological constraints stem from the non-application of essential production inputs and the socio-economic constraints from the social or economic conditions that prevent farmers from using the recommended technology

**Index of yield gap (IYG)**It is the ratio of the difference between the potential yield (Yp) and the actual yield (Ya) to the potential yield (Yp), expressed in percentage.

IYG = [(Yp- Ya)/ Yp] x 100 ..........(5)

**Index of realized potential yield (IRPY)**It is the ratio of the actual yield (Ya) to the potential yield (Yp), expressed in percentage.

IRPY = [ Ya/ Yp] x 100 ..........(6)

**Index of realized potential farm yield (IRPFY):**
It is the ratio of the actual yield (Ya) to the potential farm yield (Yd), expressed in percentage.

IRPFY = [ Ya/ Yd] x 100 ..........(7)

**2.2 Garrett ranking test:**

The constraints in maize production and marketing were analyzed using Garrett’s ranking technique. The ranks given by each respondent were converted into per cent position by using formula:

Percent position = [100 × (Rij – 0.5)]/ Nj…….(8)

Where,

Rij = Rank given to ith constraint by the jth individual and

Nj = Number of constraints ranked by the jth individual.

The estimated per cent positions were converted into scores using Garrett’s table. The mean score values estimated for each factor were arranged in the descending order. The constraint with the highest mean value was considered as the most important one and the others followed in that order.

**3. RESULTS AND DISCUSSION**

**3.1 Yield gap analysis in maize**

The yield gap analysis conducted across the Northern Telangana Zone (NTZ), Central Telangana Zone (CTZ), and Southern Telangana Zone (STZ) revealed significant differences in maize productivity. From the table1 and Figure 1 yield gap-I (YG-I), representing the gap between potential yield and progressive farmers yield, was highest in the STZ at 5.4 quintals per acre, followed by 4.4 quintals in NTZ and 3.9 quintals in CTZ, with an overall average of 4.5 quintals per acre in Telangana. Yield gap-II (YG-II), denoting the difference between potential yield and actual farmers' yield, was also highest in STZ at 13.5 quintals per acre, compared to 10.9 quintals in CTZ and 9.5 quintals in NTZ, resulting in an overall average of 11.3 quintals per acre in Telangana which is mainly due to the social or economic conditions that prevent farmers from using the recommended technology.

In economic terms, YG-I translated to a loss of ₹389.5 per acre in STZ followed by ₹318 in NTZ, and ₹282.3 in CTZ, with an overall average of ₹325.2 per acre for overall Telangana. For YG-II, the loss was ₹968.4 per acre in STZ followed by ₹782.6 in CTZ and ₹682.5 in NTZ, with an overall average of ₹811.2 per acre for Telangana.

Thus, a remarkable difference in the productivity of maize under different situations was observed. This was the matter of great concern to extension functionaries involved in transferring new technology from research stations to the farmers’ fields. This gap was attributed mainly to the biological and socio-economic constraints operating on the farmers’ fields. The biological constraints related to the non-adoption of the recommended technology or non-application of the essential inputs at the recommended level. The farmers inability to take up the recommended management practices due to labour and financial constraints with a stipulated time could cause a noticeable decline in output. Therefore, yield gap-II could be termed as resource-cum-management-cum-extension gap.

Yield gap II is greater than yield gap I this may be due to the progressive farmers have considerably good amount of knowledge on crop management practices which helped them in realizing the better yields and lower the yield gap in all the zones and overall Telangana.

**Table 1:** **Yield Gap analysis of Telangana**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Yield Gap** | **NTZ** | **CTZ** | **STZ** | **Overall TG** |
| YG- I (Qtl per acre) | 4.4 | 3.9 | 5.4 | 4.5 |
| YG-II (Qtl per acre) | 9.5 | 10.9 | 13.5 | 11.3 |
| YG- I (Rs per acre) | 318 | 282.3 | 389.5 | 325.2 |
| YG-II (Rs per acre) | 682.5 | 782.6 | 968.4 | 811.2 |

Figure 1: Yield Gap analysis of Telangana

**3.2 Estimated yield gap indices in maize**

Various yield gap indices in maize were worked out and the same are presented in Table 2 . The index of yield gap was defined as the ratio of difference between the potential yield and the actual yield to the potential yield expressed in percentage. This ratio indicated the extent of unrealized yield potential. The data presented Table 2 revealed that Index of Yield Gap (IYG) was highest in the STZ at 35.7%, followed by 28.9% in CTZ and 25.2% in NTZ, with an overall index of 29.9% for the state.

The Index of Realized Potential Yield (IRPY) was defined as the ratio of actual yield to the potential yield expressed in terms of percentage. The data presented in the table indicated that for progressive farmers IRPY was relatively consistent across the three zones, with the highest being 89.6% in CTZ, followed by 88.3% in NTZ and 85.6% in STZ, resulting in an overall average of 88.0%. However, for non-progressive farmers, the IRPY was notably lower, with 74.8% in NTZ, 71.1% in CTZ, and 64.3% in STZ, yielding an overall average of 70.1%. the results were in line with the study

The differences in the Index of Realized Potential Yield (IRPY) among the three zones of Telangana viz., NTZ, CTZ and STZ are influenced by a combination of environmental, agronomic, and socio-economic factors. Environmental conditions such as agro-climatic variability plays a critical role. The STZ, with its higher temperatures and inconsistent rainfall, poses significant stress on maize crops compared to NTZ and CTZ, where relatively favourable climates enhance crop performance. Additionally, soil fertility in STZ is generally lower, with reduced organic matter and nutrient content, while NTZ and CTZ benefit from more fertile soils that support better crop yields. Irrigation infrastructure is more advanced in NTZ and CTZ, enabling progressive farmers to manage water requirements effectively, whereas STZ struggles with water scarcity, particularly affecting non-progressive farmers who lack the resources to mitigate these challenges.

These findings underscore the need for targeted interventions to address zone-specific constraints and improve the adoption of recommended practices, aiming to bridge both economic and productivity gaps in maize cultivation across Telangana.

**Table 2:** **Indices of yield gaps**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Yield gap indices** | **NTZ** | **CTZ** | **STZ** | **Overall TG** |
| Index of yield gap (IYG) | 25.2 | 28.9 | 35.7 | 29.9 |
| Index of realized potential yield (IRPY) of progressive farmers | 88.3 | 89.6 | 85.6 | 88.0 |
| Index of realized potential yield (IRPY) of non-progressive farmers | 74.8 | 71.1 | 64.3 | 70.1 |

**Table 3:** **Production and Marketing Constraints**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **S.No** | **Production Constraints** | **NTZ** | **CTZ** | **STZ** | **TG** |
| **GMS**  | **Zone rank** | **GMS** | **Zone rank** | **GMS** | **Zone****rank** | **GMS** | **Overall rank** |
| 1.   | High cost of seed | 60.53 | II | 52.78 | IV | 51.23 | V | 53.46 | III |
| 2.   | Unavailability of seed | 49.35 | V | 55.65 | III | 54.28 | II | 52.25 | IV |
| 3.   | High cost Plant Protection Chemicals | 63.10 | I | 64.33 | I | 53.33 | III | 60.73 | I |
| 4.   | High cost fertilizers | 49.85 | IV | 51.78 | V | 54.75 | I | 51.31 | V |
| 5.   | High Labour cost & unavailability | 59.53 | III | 56.78 | II | 53.08 | IV | 56.86 | II |

Note: GMS= Garrett’s Mean Score

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **S.No** | **Marketing Constraints** | **NTZ** | **CTZ** | **STZ** | **TG** |
| **GMS**  | **Zone rank** | **GMS** | **Zone rank** | **GMS** | **Zone****rank** | **GMS** | **Overall rank** |
| 1.   | Insufficient market facilities | 60.53 | II | 52.78 | III | 51.23 | IV | 53.46 | II |
| 2.   | Remunerative price | 49.35 | IV | 55.65 | II | 54.28 | II | 52.25 | III |
| 3.   | Storage facilities | 63.10 | I | 64.33 | I | 53.33 | III | 60.73 | I |
| 4.   | Untimely payment | 49.85 | III | 51.78 | IV | 54.75 | I | 51.31 | IV |

Note: GMS= Garrett’s Mean Score

**3.3 Production and Marketing Constraints**

The primary production and marketing constraints for maize cultivation in Telangana's three different zones viz., Northern Telangana Zone (NTZ), Central Telangana Zone (CTZ), and Southern Telangana Zone (STZ) were identified and ranked based on Garrett's Mean Scores (GMS). For production constraints, the high cost of plant protection chemicals was the top-ranked issue across all zones, with an overall GMS of 60.73, followed by high labour costs and unavailability, which ranked second with a GMS of 56.86. The high cost of seeds and unavailability of seeds ranked third and fourth, with GMS values of 53.46 and 52.25, respectively. High costs of fertilizers were ranked fifth (GMS 51.31) Gaddi et al. (2002).

Regarding marketing constraints, the lack of storage facilities was identified as the most critical issue across the zones, with an overall GMS of 60.73. Insufficient market facilities ranked second (GMS 56.86), followed by the unavailability of remunerative prices, which was ranked third with a GMS of 53.46. Untimely payment and inadequate market facilities were ranked fourth and fifth, with GMS values of 52.25 and 51.31, respectively.

The results highlight that yield gap II can be reduced by improving the managerial ability of the farmers, providing information about the package of practices and providing timely information by means of intensive extension activities, need for targeted interventions, including cost-effective inputs, improved market infrastructure and streamlined payment systems, to address these constraints effectively and boost maize production and marketing efficiency. Farmers must be motivated through farm visits to progressive farmers’ fields. Further providing farmers with location specific improved technology and information will help them to fill the wide gaps in yield due to location specific constraints in many areas (Sendhil et al., 2014). The link between farmers and extension agents, extension agents and the researchers should be strengthened. Scientists need to make more efforts to reduce the yield gap without increasing the cost.

**4. CONCLUSION**

Maize is a crucial cereal crop globally, serving as a staple food, fodder, and industrial raw material. In India, it holds the third position among cultivated cereals after rice and wheat, with significant production areas in states like Telangana. The study analyzed yield gaps in three zones of Telangana *viz.,* Northern Telangana Zone (NTZ), Central Telangana Zone (CTZ) and Southern Telangana Zone (STZ). The findings revealed that Yield Gap-I was highest in STZ (5.4 quintals/acre) and lowest in CTZ (3.9 quintals/acre), with an overall average of 4.5 quintals/acre in Telangana. Yield Gap-II was highest in STZ (13.5 quintals/acre), leading to significant economic losses of ₹968.4/acre, compared to NTZ and CTZ. Indices of yield gap (IYG) and realized potential yield (IRPY) further illustrated the differences in maize productivity among the zones. The STZ showed the highest unrealized yield potential (35.7%), while NTZ had the lowest (25.2%). Factors like agro-climatic conditions, soil fertility, and irrigation infrastructure played a pivotal role in influencing these gaps. The study also identified production and marketing constraints. High costs of plant protection chemicals, seeds, and fertilizers, along with labour shortages, were the most significant production challenges. On the marketing side, inadequate storage facilities, insufficient market infrastructure, and delayed payments emerged as critical issues.

Reducing the yield gap in maize production is essential for improving farmers' livelihoods and ensuring food security. While progressive farmers have demonstrated the potential for better yields through improved management practices, non-progressive farmers need targeted support to bridge the resource and knowledge gaps. With coordinated efforts and focused interventions, the productivity and profitability of maize cultivation in Telangana can be significantly enhanced.

**COMPETING INTERESTS**

Authors have declared that no competing interests exist.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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